National Park Service
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Natural Resource Program Center

Vegetation Classification and Mapping Project Report, Arches National Park

Natural Resource Technical Report NPS/NCPN/NRTR—2009/253



ON THE COVER
Devil’s Garden and La Sal Mountains, Arches National Park
Photograph by NPS-NCPN / Bruce Condie

Vegetation Classification and Mapping Project Report, Arches National Park

Natural Resource Technical Report NPS/NCPN/NRTR—2009/253

Janet Coles and Amy Tendick
National Park Service
Moab, Utah

Gerald Manis
Cartographer
Moab, Utah

Aneth Wight and Gery Wakefield
National Park Service
Moab, Utah

Jim Von Loh
engineering-environmental Management, Inc.
Englewood, Colorado

Angie Evenden
National Park Service
Reno, Nevada

October 2009

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

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Please cite this publication as:

Coles, J., A. Tendick, G. Manis, A. Wight, G. Wakefield, J. Von Loh, and A. Evenden. 2009. Vegetation classification and mapping project report, Arches National Park. Natural Resource Technical Report NPS/NCPN/NRTR-2009/253. National Park Service, Fort Collins, Colorado.

NPS 138/100533, October 2009

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Acronyms and Abbreviations

AA	Accuracy Assessment
APFO	Aerial Photography Field Office
ARCH	Arches National Park
BLM	United States Bureau of Land Management
BPU	Biophysical Unit
CEGL	Community Element Code (Global)
DBH	Diameter At Breast Height (4.5 feet)
DEM	Digital Elevation Model
DOQQ	Digital Orthophotograph Quarter Quadrangle
e^2M	engineering-environmental Management, Incorporated
ES	Ecological System
ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
ft	Feet
GIS	Geographic Information System
GPS	Global Positioning System
ha	Hectare
I&M	Inventory and Monitoring Program
MMU	Minimum Mapping Unit
NAD	North American Datum
NCPN	Northern Colorado Plateau Network
NPS	National Park Service
NRCS	Natural Resource Conservation Service
NVC	National Vegetation Classification
NVCS	National Vegetation Classification Standard
QA/QC	Quality Assurance/Quality Control
TNC	The Nature Conservancy
UNESCO	United Nations Education, Science, and Cultural Organization
USBOR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WRCC	Western Region Climate Center

Summary

The Northern Colorado Plateau Inventory and Monitoring Network, with the support of the U.S. Geological Survey - National Park Service Vegetation Mapping Program, undertook this project to describe and map existing vegetation at Arches National Park (ARCH). This collaborative effort involved many project partners, particularly the Natural Resources staff of the Southeast Utah Group of National Parks, the Western Region office of NatureServe, engineering-environmental Management, Inc., and their cooperators.

The mapping area is 52,556 hectares (129,868 acres), encompassing the entire park as well as an environs of adjacent public and private lands. Ecologists and photointerpreters identified plant associations for ARCH and determine how best to map them using 1:12,000-scale, true color aerial photography and digital orthophotography. The team collected vegetation and environmental data from 333 vegetation classification plots and 256 observation points. Map accuracy assessment entailed sampling another 792 plots. No supplemental fuels data were collected during the project. Fieldwork and mapping were completed between 2003 and 2005.

Analysis of the plot data revealed 75 National Vegetation Classification plant associations, alliances or park special vegetation types within the Park and environs. Five associations were documented from accuracy assessment data, the remainder from vegetation classification plots and observation points.

Vegetation and land use were interpreted to as detailed a level as possible from high-resolution, 9” x 9” stereo pairs of 1:12,000-scale true color aerial photography. Polygons representing vegetation or land use map classes were delineated on-screen in an ArcGIS environment. The project used the program standard minimum mapping unit of 0.5 ha with few exceptions.

Thirty-one (30 polygon and 1 point) natural and semi-natural vegetation map classes were developed for the ARCH mapping project, represented by 6,709 map polygons. Twelve land use map classes describe 193 other polygons within the mapping area. An additional 222 polygons represent exposures of two unvegetated geologic formations. Average polygon size across all map classes is 7.3 ha (18.0 acres). Natural and semi-natural vegetation classes cover 52,521 ha (124,171 acres / 95.6% of the project area). Map classes representing unvegetated bedrock total 1,295 ha (3,200 acres / 2.5% of the project area). Land use/land cover polygons, including roads, commercial developments, mining facilities and NPS facilities total 1,010 ha (2,497 acres / 1.9% of the project area). The most frequent vegetation mapping unit is Blackbrush Shrublands (Map Class 10 / S-BLAC) with 1,457 polygons covering 9,073 ha (22,407 acres) or 17% of the project area.

Map accuracy was assessed within the ARCH boundary only. Analysis of a thematic accuracy assessment of 30 polygon-based vegetation map classes indicated an estimate of 90.1% overall map accuracy (Kappa statistic = 89.9%). One map class did not meet the 80% standard for either producer’s or user’s accuracy, but was retained because of its uniqueness and value to park managers. The patterns of error are described in detail in the Accuracy Assessment section of this report, along with the justification for retaining the map class with relatively low accuracy.

Products resulting from the ARCH vegetation mapping project include:

Available in this report:

- project summary of methods and results
- illustrated dichotomous field key to the vegetation associations
- illustrated guide to the vegetation map classes
- detailed descriptions of vegetation associations
- samples of completed field forms
- field manual used to guide plot and observation point data collection

Available elsewhere[1]:

- geodatabase containing map polygon attribute, land use, aerial photography flight lines, plot data and park and project boundaries
- ground photography of vegetation plots, observation points, and accuracy assessment points in hard copy and digital formats
- all field data (plot, observation point, and accuracy assessment point) stored in a Microsoft Access database
- hard copy vegetation maps
- metadata for all digital products

Geospatial products are in Universal Transverse Mercator (UTM) projection, Zone 12, using the North American datum of 1983.

[1] This document and most of the digital products are available on the internet at: http://biology.usgs.gov/npsveg/. Hard copies of the orthophotos, stereo photos, and original data forms are retained by NCPN and the park.

Acknowledgments

This project was completed through the effort and dedication of numerous individuals and organizations. Details of the role of each person mentioned here are described in more detail in the Project Overview section. Angela Evenden (NPS), Tammy Hamer (NPS), Karl Brown (USGS/NPS) and Mike Mulligan (USGS) provided project oversight and coordination with support from Jim Von Loh of engineering-environmental Management, Inc (e^2M). Funding for this project was provided through the USGS-NPS National Vegetation Mapping Program, NPS Fire Pro, and the Northern Colorado Plateau Inventory and Monitoring Network.

Numerous individuals collected plot, observation point, and accuracy assessment field data. We appreciate the hard work of Liz Ballenger, Janet Coles, Bruce Condie, Lisa Hahn, Amy Schwarzbach, Amy Tendick, Sarah Topp, and Pete Williams. Aerial photointerpretation and map polygon attribution were skillfully performed by Gerald Manis, with substantial help from Amy Tendick. Bev Friesen of the USGS Rocky Mountain Mapping Center provided NCPN with preliminary linework used by Gerald as a basis for his photointerpretation. Bev also created a vegetation density layer for the woodlands and shrublands within the mapping project area.

Gery Wakefield of the NPS Southeast Utah Group (SEUG) produced the initial map GIS database from Gerald's photointerpretation. Gery and Aneth Wight of the NCPN provided random sample points and field maps for collecting accuracy assessment data. Liz Ballenger was instrumental in planning and coordinating accuracy assessment point sampling trips to insure they were accomplished as effectively and efficiently as possible. Janet, Gery, and Gerald were instrumental in convening an effective meeting to resolve the accuracy of the map. Aneth Wight and Russ DenBleyker constructed and populated the final geodatabase.

The ARCH preliminary vegetation classification was prepared by Karin Decker of the Colorado Natural Heritage Program and Janet Coles; the final vegetation classification was completed by Janet and Marion Reid of NatureServe. The classification enabled Jim Von Loh to prepare a draft field key and local association descriptions that facilitated completion of the accuracy assessment. Janet developed and applied a method to test and improve the field key for this project. Marion created the local plant association description template for this project and worked with Janet to prepare global plant association descriptions. Keith Schulz of NatureServe reviewed and edited the global descriptions.

Participation and guidance by the staff of Arches National Park, under the direction of Chief of Natural Resources Jeff Troutman, was key to making this project a success. Biologist Mary Moran was a wealth of information concerning the plants and their distribution within ARCH. Input by SEUG ecologist Charlie Schelz helped greatly with planning the project and with making sure that the final map was accurate and useful for park management.

For these and other contributors to the success of the project, we are grateful.

Introduction

Vegetation Classification and Mapping Project, Arches National Park

The Arches National Park (ARCH) Vegetation Mapping Project was organized and coordinated by the Northern Colorado Plateau Network (NCPN) Inventory and Monitoring (I&M) Program between 2003 and 2009, with the assistance of several cooperators. The purpose of this project was to describe and map existing vegetation on 52,556 ha (129,868 acres) within ARCH and its environs, and to provide this information in written, tabular, digital, and spatial formats useful to park resource managers, the NCPN I&M Program, and others. The basic project components consist of a classification and description of the Park's vegetation and a spatial database encompassing an interpretation of the vegetation from aerial imagery.

In 2001, the NCPN I&M Program launched a multi-year project to complete vegetation classifications and maps for network park units. Funding was provided by the U.S. Geological Survey (USGS) – National Park Service (NPS) Vegetation Mapping Program and the NCPN. The ARCH Vegetation Classification and Mapping Project was initiated and completed by the NCPN, engineering-environmental Management, Inc., and NatureServe. Project work was coordinated with the USGS-NPS Vegetation Mapping Program. Vegetation plot and observation point data collection occurred in 2003 and map accuracy assessment was completed in 2006.

Project methods, results, and products are documented in this report. This introductory section describes the NPS I&M Program and the USGS-NPS Vegetation Mapping Program, as well as the ARCH mapping project area. Later sections document the methods and results for each of the major steps in the project: scoping, vegetation classification and description, vegetation mapping, and map accuracy assessment.

The USGS-NPS Vegetation Mapping Program

The National Vegetation Mapping Program is a cooperative project between the USGS and the NPS to inventory, classify, describe, and map vegetation in more than 270 national park units within the United States. Consistent vegetation classification, mapping, and accuracy assessment protocols and standards are applied across projects supported by this program. The National Vegetation Mapping Program is administered by the USGS Center for Biological Informatics in cooperation with the NPS I&M Program. Through implementation of the NPS Natural Resource Challenge (NPS 1999), significant funding became available for completing important natural resource baseline inventories in park units, including vegetation classification and mapping. This support provided the NPS with the opportunity to move forward with dozens of new park unit vegetation classification and mapping projects, including ARCH. Vegetation classification and mapping products produced by this program are incorporated into the USGS National Biological Information Infrastructure Program, which serves as an information-sharing network (http://biology.usgs.gov/npsveg/).

Northern Colorado Plateau Network Inventory and Monitoring Program

The National Park Service developed an inventory and long-term monitoring program for park natural resources over the last two decades of the twentieth century. This effort was enhanced by the NPS Natural Resource Challenge (NPS 1999); as a part of this initiative, the NCPN was formed in 2000 to develop an integrated inventory and monitoring program for 16 NPS units in Utah, Colorado, Arizona, and Wyoming.

A goal of the NPS I&M Program is to complete baseline inventories of biological and geophysical resources for each park unit. These inventories cover 12 basic data sets needed by park staff to guide resource management. Vegetation classification and mapping constitute one of these data sets. Early in the development of its I&M program, the NCPN made completing vegetation maps for each network park unit a priority. In addition to assisting park management, vegetation maps and classification information were seen as contributing significantly to NCPN long-term monitoring efforts. In 2001, the network began implementation of a strategy to complete vegetation mapping in all network park units. The ARCH vegetation mapping project is the seventh of the network-coordinated projects to be completed.

Vegetation Mapping Program Standards

The NPS I&M Program established guidance and standards for all vegetation mapping projects in a series of documents:

Protocols

- National Vegetation Classification System (TNC and ESRI 1994a, NatureServe 2003a)
- Field methods and mapping procedures (TNC and ESRI 1994b)
- Statistically rigorous and consistent accuracy assessment procedures (ESRI and TNC 1994)
- Guidelines for using existing vegetation data (TNC 1996)

Standards

- National Vegetation Classification Standard (FGDC 1997)
- Spatial Data Transfer Standard (FGDC 1998b)
- Content Standard for Digital Geospatial Metadata (FGDC 1998a)
- United States National Map Accuracy Standards (USGS 1999)
- Integrated Taxonomic Information System
- Program-defined standards for map attribute accuracy and minimum mapping unit

These documents are available on the USGS-NPS Vegetation Program Web site (http://biology.usgs.gov/npsveg/standards.html).

National Vegetation Classification Standard

The National Vegetation Classification (NVC) is the system used in NCPN vegetation mapping projects (TNC and ESRI 1994a), and is based on the National Vegetation Classification Standard (NVCS) adopted by the Federal Geographic Data Committee (FGDC 1997). The NVC evolved from work conducted primarily by The Nature Conservancy (TNC), NatureServe, and the Natural Heritage Program network over more than two decades (Grossman et al. 1998). The structure of the NVC is based in part on an earlier international vegetation classification developed by the United Nations Educational, Cultural, and Scientific Organization (UNESCO 1973, Driscoll et al. 1984). Refinement of the NVC continues to the present; in particular, the data collected by the USGS-NPS Vegetation Mapping Program contributed significantly to the development of the NVC in the Colorado Plateau.

Use of a standardized classification system helps to ensure data compatibility throughout the National Park Service and other agencies. The FGDC Vegetation Subcommittee works to keep this standard current and relevant. The substantial revisions to the upper levels of the NVC hierarchy accepted by the FGDC Vegetation Subcommittee (2008) are not used in this project.

Vegetation classification systems attempt to recognize and describe repeating assemblages of plants in similar habitats. The NVC is a hierarchical system that incorporates physiognomic characters and floristic data to define seven levels of terrestrial vegetation classification. The five upper levels (class, subclass, group, subgroup, and formation) are based on physiognomic features. The two lower levels (alliance and association) are distinguished by differences in floristic composition. The physiognomic units have a broad geographic perspective and the floristic units have utility in local and site-specific applications (Grossman et al. 1998). The physiognomic levels of the NVC are based on physical, structural, and environmental characteristics identifiable from satellite imagery, aerial photography, or ground observations (Table 1). Specific criteria defining these physiognomic units are based on ecologic characteristics that vary among major vegetation groups (FGDC 1997).

The alliance and association levels form the base of the NVC hierarchy and are determined by the most abundant or diagnostic species comprising the various layers of a homogenous vegetation community. An association is here defined as a plant community type with a consistent species composition, uniform physiognomy, and similar habitat conditions (Flahault and Schroter 1910). Species composition differentiates associations (TNC and ERSI 1994a). An alliance is "a physiognomically uniform group of plant associations sharing one or more dominant or diagnostic species which, as a rule, are found in the uppermost strata of the vegetation." (Reid and Comer 1998). NatureServe coordinates plant association data for the NCPN vegetation mapping projects. Associations are added to the NVC and older concepts are refined as new data become available.

Table 1. National Vegetation Classification System hierarchy for terrestrial vegetation (FGDC 1997).

Level	Criteria Delineating Level	Example
Class	Structure (height, cover) of dominant vegetation strata	Woodland
Subclass	Growth form characters including leaf type (evergreen, deciduous) for woody plants and persistence (perennial, annual) for herbaceous species	Evergreen woodland
Group	Leaf morphology (broad leaf, microphyllous, xeromorphic), leaf phenology, and climatic conditions	Temperate or subpolar needle-leaved evergreen woodland
Subgroup	Relative degree of human disturbance	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation	Additional physiognomic characteristics, general environmental conditions, relative landscape position, and hydrologic regimes	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance	Dominant or diagnostic species of uppermost or dominant stratum	*Pinus edulis* – (*Juniperus* spp.) Woodland Alliance
Association	Other dominant or diagnostic species from any stratum	*Pinus edulis – Juniperus osteosperma / Amelanchier utahensis* Woodland

Other Standards

In addition to vegetation classification, the FGDC sets standards for map spatial accuracy and for metadata employed in NPS vegetation mapping projects. Standards for map products stipulate map scales of 1:24,000 or finer, and minimum polygon size of 0.5 ha (1.24 acres). Positional accuracy for vegetation maps must meet National Map Accuracy Standards, which specify horizontal errors of less than 10.2 m (33.5 ft) on the ground for 1:12,000-scale maps.

All digital vegetation products resulting from this project are accompanied by FGDC-compliant metadata. Metadata are “data about the data,” and describe the content, quality, condition, and other characteristics of the spatial dataset. Metadata are critical elements that expedite the interpretation and exchange of information among users.

Project Area Description

Location and Setting

In 1929, a proclamation by President Herbert Hoover established 1,829 ha (4,520 acres) of Utah desert as Arches National Monument. President Franklin Roosevelt expanded the park to nearly 13,760 ha (34,000 acres) in 1938 (Webb 1994). An act of Congress in 1971 expanded the boundary to 29,687 ha (73,359 acres) and changed the designation to Arches National Park (NPS 2008). Minor boundary adjustments in subsequent years, including the 1999 addition of Lost Spring Canyon, resulted in its present 30,977 ha (76,545 acres) configuration.

The original presidential proclamation identified the primary values of the new monument as "extraordinary examples of wind erosion in the form of gigantic arches, natural bridges, 'windows,' spires, balanced rocks and other unique wind-worn sand-stone formations, the preservation of which is desirable because of their education and scenic value." An ongoing inventory within the park boundary has documented more than 2,000 sandstone arches, which makes ARCH the greatest concentration of rock arches in the world. ARCH is also one of the most popular destinations among the many national parks and monuments in Utah and nearby states. Annual visitation to ARCH has grown steadily and has exceeded 800,000 visitors since 2005 (NPS 2008).

ARCH is located in Grand County, Utah, approximately 8 km (5 miles) north of Moab, 161 kilometers (100 miles) west of Grand Junction, Colorado, and 386 kilometers (240 miles) southeast of Salt Lake City, Utah. It lies near the geographic center of the Northern Colorado Plateau Network of national parks (Figure 1). Moab is the county seat and has a population of 4,779, 55% of the population of Grand County. The county outside of Moab has a very low population density of two people per square mile (1 person per km^2). Lands managed by the Bureau of Land Management (BLM) surround most of the ARCH boundary; a few parcels of state and private lands account for the remainder (Figure 2). The park can be entered from U.S. Highway 191 via the paved park road or by the dirt Salt Valley Road.

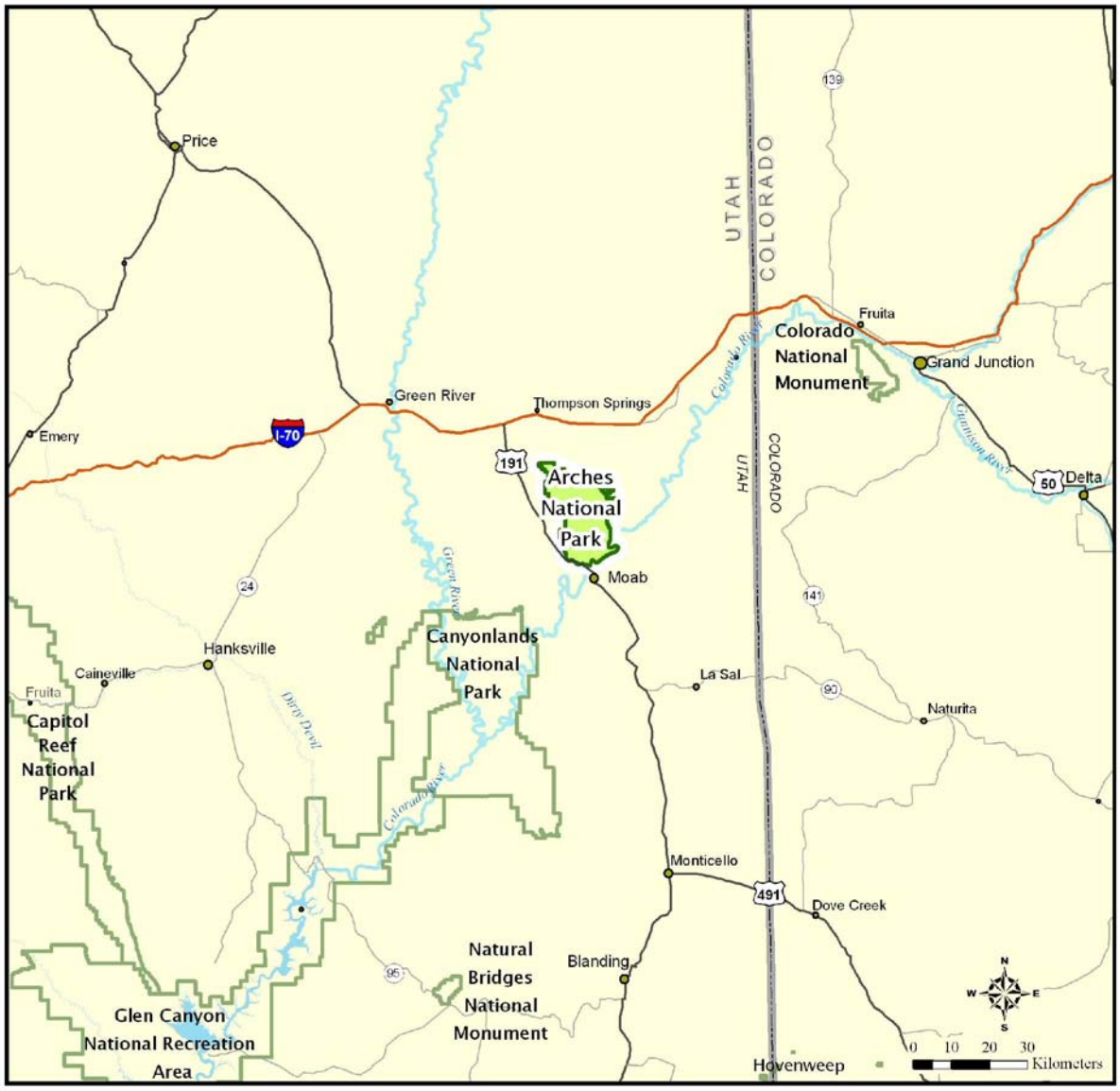


Figure 1. Location of ARCH in southeastern Utah.

The ARCH project mapping area includes the entire park, as well as an environs consisting of 21,579 ha (53,323 acres) of adjacent BLM, State of Utah, and private lands for a total project area of 52,556 ha (129,868 acres).

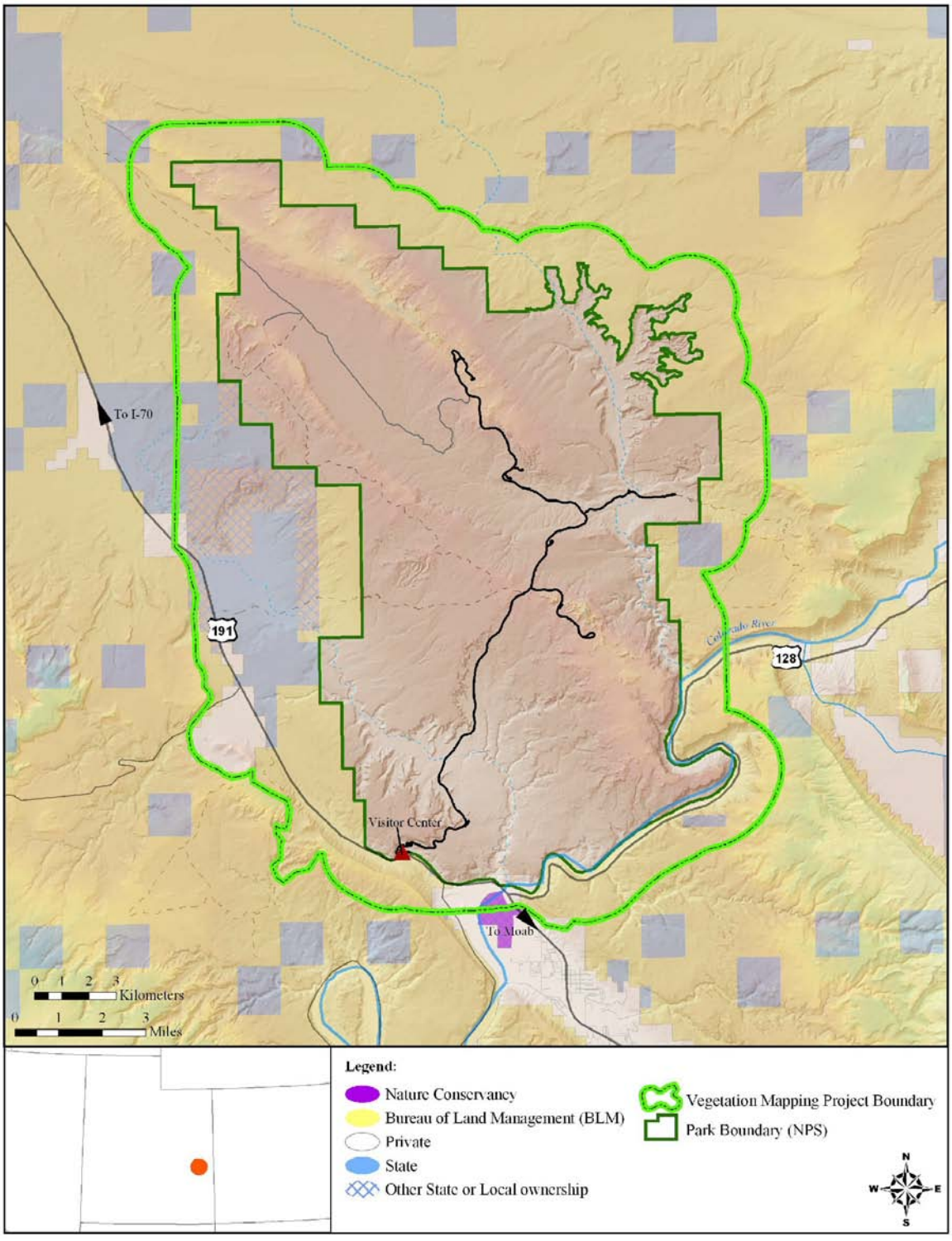


Figure 2. Map of the ARCH vegetation mapping project area boundary showing adjacent land ownership.

Topography and Geologic History

ARCH lies within the Canyon Lands Section of the Colorado Plateau physiographic province (Fenneman and Johnson 1946). The present ARCH landscape can be characterized as a broad, arching plateau partly covered by alluvial fans and eolian sand sheets and punctuated by sandstone towers and fins, broad, steep-sided valleys, and narrow canyons. Elevations within the park range from 1,213 m at the Colorado River to 1,723 m on top of Elephant Butte (3,981 to 5,653 ft).

The dramatic scenery of ARCH is the result of its geologic history and stratigraphy. The sandstones and shales exposed within the park originated as beaches, dune fields, tidal streams, and shallow ocean sediments in a near-shore environment. They were deposited over thick layers of salt resulting from the evaporation of a shallow ocean basin approximately 300 million years ago. Salt is less dense than most rocks and has a tendency to flow under pressure. It will flow laterally along bedding planes and vertically along faults. As it flows, the salt mass displaces and deforms adjacent rocks. At ARCH, evidence of both lateral and vertical salt movement is visible in the pattern of joints in the overlying Moab Tongue and Entrada sandstones. Furthermore, as the salt moved vertically along faults in the Moab, Cache Valley and Castle Valley fault systems, it encountered ground water and began to dissolve even before it reached the surface. Dissolution caused partial collapse of the salt structures, resulting in broad but steep-sided Salt and Cache valleys within the park, and Moab, Spanish, Professor, and Castle valleys just outside the park boundary. Subsequent erosion by wind and water deepened the joints and fractures in the sandstone, carving fins, arches, and slot canyons throughout the park (Figure 3).



Photo credit: Louis Maher - Geology by Lightplane

Figure 3. Oblique aerial view of Salt Valley within ARCH, created by the dissolution and collapse of a salt dome. View is to the northwest. The east limb of the Salt Valley anticline (foreground) contains many major features of the park, including Devil's Garden, Landscape Arch, and Dark Angel.

Climate

Records of climatic conditions have been maintained at the ARCH visitor center since 1980 (Figure 4). ARCH is characterized by an arid climate, averaging 22.4 cm (8.8 inches) of annual precipitation. Most precipitation falls during the months of July through October in the form of afternoon thunderstorms (Figure 5). Snowfall is usually light, especially at the lower elevations around the visitor center. Most of the park is 150 to 300 m (500 to 1,000 ft) higher and probably has slightly higher precipitation and slightly lower temperatures on average than recorded either in Moab or at the visitor center.

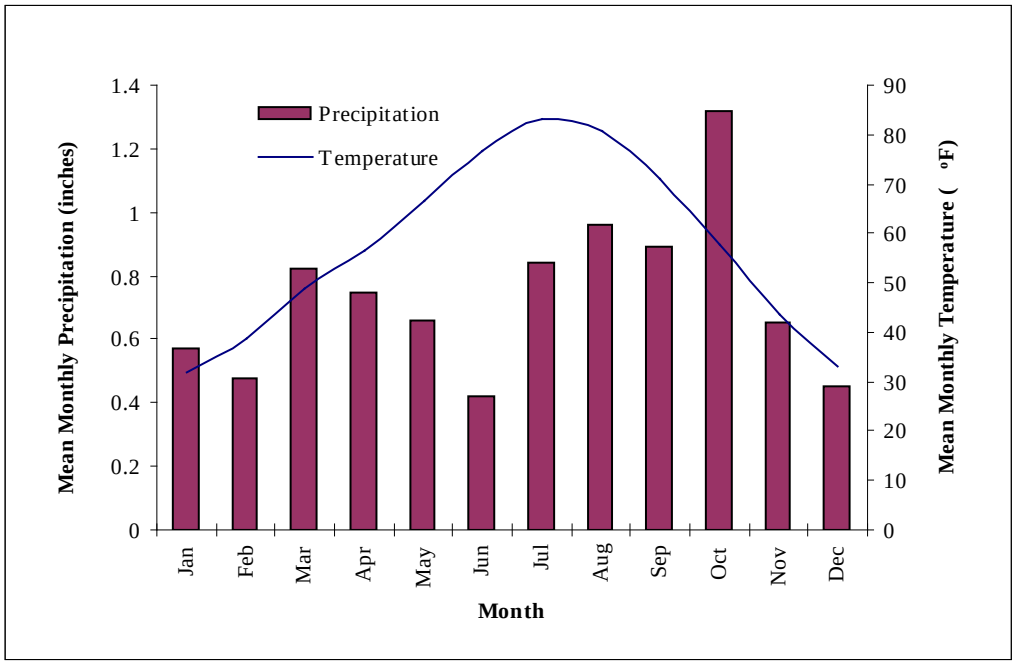


Figure 4. Climate data for ARCH visitor center (Western Regional Climate Center 2008). Records kept since 1890 in Moab are similar.

Conditions within the park are typical of moderate elevations in the continental interior. Summers are long with hot days averaging 36.7 °C (98.1 °F) and warm nights averaging 17.1 °C (62.8 °F) in July. Hot days can exceed 38 °C (100 °F). Winters are cool, with an average maximum temperature of 5.8 °C (42.4 °F) and an average minimum temperature of -7.7 °C (18.2 °F) occurring in January. The sun shines 75% of the time during the summer and 60% of the time during winter. Prevailing winds are from the east-southeast and average wind speed is at its highest (approximately 16.1 km / 10 miles per hour) during the summer months (Hansen 1989).

The climate of the Colorado Plateau south of ARCH is influenced by the Arizona summer monsoon. This event is driven by a dome of high pressure that develops in July and remains stationary over eastern New Mexico and western Texas, sometimes as late as September. This ridge directs warm, moist air from the Gulf of Mexico into the southwestern states to fuel widespread and occasionally intense thunderstorms. North of ARCH, the climate is similar to that of the Great Basin, with hot, dry summers. ARCH is located in an area where these two

climatic regimes overlap and therefore possesses an intermediate climate. Winter precipitation is derived from Pacific air masses; the heaviest snowfall occurs when one of these relatively warm, moist air masses intersects an Arctic cold front pushed south over Utah by the jet stream.



Photo credit: Jim Von Loh

Figure 5. Monsoon-type summer thunderstorm approaching ARCH.

Geology and Vegetation

Arches National Park has some of the most spectacular exposed geology in the western United States. It contains the greatest concentration of bedrock arches in the world, attracting nearly a million visitors each year. Other notable features includes striking mazes of sandstone fins at Devil's Garden and Fiery Furnace, the deep, cool canyons of Salt Wash and Courthouse Wash, the broad but dry Cache and Salt valleys, and the sandstone monuments of Park Avenue, Courthouse Towers, and Balanced Rock.

All of the rocks exposed in ARCH are sedimentary, ranging in age from Middle Pennsylvanian (about 300 million years ago) to Late Cretaceous (about 85 million years ago; Figure 6). The strata represent a variety of ancient environments including beach and shallow marine, sand dune desert, river, and delta (Doelling 2003). In some places, the bedrock is obscured by recent surficial deposits of sand, silt and gravel introduced by wind and water in the past few hundred to few thousand years. The arched structure of the Salt Valley anticline means that in general, the youngest rocks tend to appear on the edges of the park, while the oldest rocks are exposed near the center of the arch. The exception is that young rocks representing pieces of the collapsed anticline appear on the floor of Cache Valley.

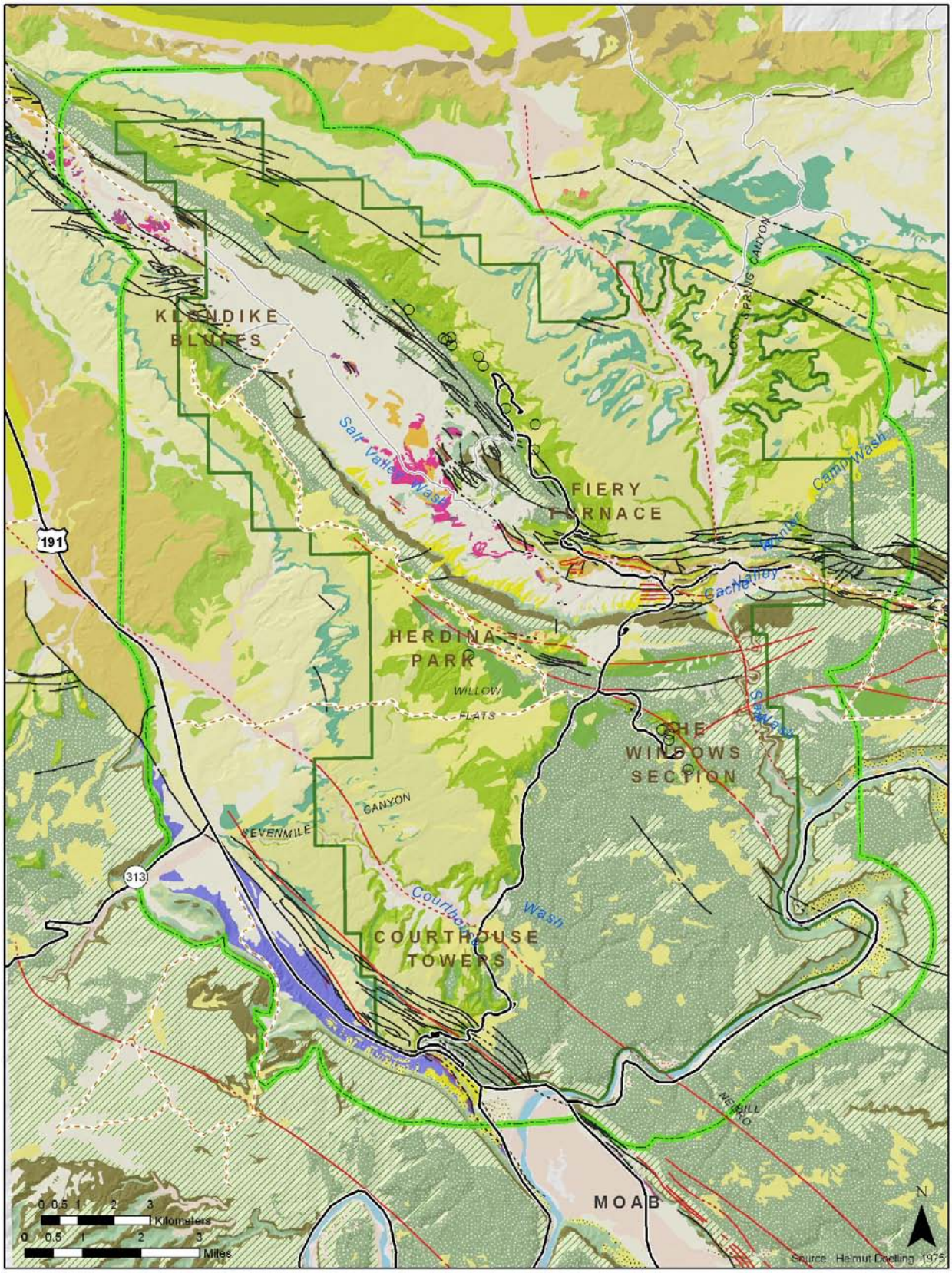


Figure 6a. Geology map of ARCH.



Figure 6b. Legend for the ARCH geology map.

The unique and diverse landscapes of ARCH reveal the dynamic and ever-changing interactions among geology, climate, and plant and animal communities. The park lies in the arid center of the Colorado Plateau. This high desert environment supports sparse pygmy forests of pinyon and juniper on the slickrock plateaus, desert shrublands on deeper soils, and grasslands on valley floors. The distribution of vegetation is controlled by primarily by substrate (geology and soils) and to a lesser extent, exposure. The remainder of this section is a summary of the general distribution of vegetation in relation to geology across the mapping area, organized from oldest to youngest rocks. Descriptions of each geological stratum are derived from Doelling (2003).

Paradox Formation (Pennsylvanian). This formation consists of sediments deposited in a closed ocean basin between 300 million and 250 million years ago. Layers of salts precipitated between layers of shale, siltstone, limestone, and gypsum during episodes when evaporation exceeded runoff entering the basin. The most visible outcrops of this formation within ARCH are the gypsum hills that occupy the southern part of Salt Valley. The high levels of calcium and sulfur in gypsum soils are toxic to all but a few plant species; the characteristic vegetation of Paradox Formation gypsum is dominated by specialized gypsophilous lichens with scattered shrubs of Torrey joint-fir (*Ephedra torreyana*) and fourwing saltbush (*Atriplex canescens*; Figure 7).



Figure 7. Characteristic plant community growing on Paradox Formation gypsum.

Honaker Trail Formation (Pennsylvanian). These sediments were deposited in a shallow ocean approximately 275 to 260 million years ago. The best exposures are low hills of shattered gray limestone rising above the floor of Salt Valley both inside and just north of the park boundary. These hills support a sparse community dominated by blackbrush (*Coleogyne ramosissima*) and James' galleta (*Pleuraphis jamesii;* Figure 8).



Figure 8. Characteristic blackbrush shrubland growing on shattered gray limestone of the Honaker Trail Formation in Salt Valley.

Moenkopi and Chinle formations (Triassic). These formations are poorly exposed at ARCH because the soft sandstones, mudstones, and siltstones form slopes usually covered by sandstone colluvium from Wingate cliffs above, or by eolian sands. The rocks preserve evidence of a near-shore environment of stream channels, tidal flats, muddy lagoons, and beaches that existed between 200 and 230 million years ago. The largest exposures of these formations occur in the Colorado River canyon, with lesser exposures in Cache Valley and Salt Valley. Scattered pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) may dot the slopes, but most of the vegetation is a diverse mix of shrubs, including Utah serviceberry (*Amelanchier utahensis*), mock-orange (*Philadelphus microphyllus*), skunkbush (*Rhus trilobata*), blackbrush, crispleaf buckwheat (*Eriogonum corymbosum*), shadscale (*Atriplex confertifolia*), Bigelow sagebrush (*Artemisia bigelovii*), green jointfir (*Ephedra viridis*), snakeweed (*Gutierrezia sarothrae*). Native grasses often contribute significant cover, including Indian ricegrass (*Achnatherum hymenoides*), Salina lyme grass (*Leymus salinus*), and James' galleta (Figure 9).



Figure 9. Shrub-dominated communities typical of colluvium-covered Chinle and Moenkopi formation slopes.

Wingate Sandstone (Jurassic). This unit describes 200 million-year-old sand dunes that form distinctive massive, vertically jointed cliffs. The best exposures of Wingate Sandstone are in the Colorado River canyon and lower Courthouse Wash. Exposures in Cache Valley and Salt Valley are more difficult to discern because the rock has been shattered by the rise and collapse of the salt domes underlying the park. Wingate cliffs are unvegetated; shattered slopes support colluvial slope vegetation similar to that of the underlying Chinle and Moenkopi formations, although often with higher cover by Utah juniper (Figure 10).



Figure 10. Sparse woodlands with a mixed shrub and grass understory occupy slopes of shattered Wingate Sandstone above Cache Valley.

Kayenta Formation (Jurassic). This formation represents streambed and floodplain sediments deposited between 180 and 190 million years ago. It forms sandstone steps and ledges topping the plateau between the Windows section of the park and the Colorado River. Exposures typically support sparse woodlands or wooded shrublands of pinyon pine, Utah juniper, littleleaf mountain mahogany (*Cercocarpus intricatus*), Utah serviceberry, Stansbury cliffrose (*Purshia stansburiana*), blackbrush, green Mormon-tea, desert needlegrass (*Achnatherum speciosum*), James' galleta, and grass-leaved rock goldenrod (*Petradoria pumila;* Figure 11).



Figure 11. Ledges of Kayenta sandstone support patchy pinyon-juniper woodlands with mixed shrubs, especially blackbrush and Stansbury cliffrose.

Navajo Sandstone (Jurassic). This formation originated as sand dunes deposited between 173 and 180 million years ago. Navajo Sandstone forms the broad bench south of the Great Wall to the Colorado River. Navajo Sandstone is characterized as "petrified dunes" in ARCH interpretive materials, because exposures often erode into landscapes of humps and potholes reminiscent of the original dunes. Most of the surface is unvegetated, with vegetation restricted to soil filling the potholes or areas where sheets of wind-deposited sand have collected. The potholes support a patchy woodland or wooded shrubland community of pinyon pine, Utah juniper, serviceberry, blackbrush, littleleaf mountain mahogany, Stansbury cliffrose, single-leaf ash (*Fraxinus anomalus*), green Mormon-tea, snakeweed, and yucca (*Yucca* spp.). Mountain pepperweed (*Lepidium montanum*) is the most common and consistent element of the herbaceous layer (Figure 12). The sandsheet communities are similar to those described for the Quaternary Deposits - Eolian Sands.



Figure 12. Typical pothole woodland vegetation on Navajo Sandstone.

Dewey Bridge Member (Jurassic). This unit is assigned to either the Entrada Formation or the Carmel Formation depending on the treatment. It was deposited in tidal flats between 160 and 172 million years ago. The best exposures are visible along the park road between Park Avenue and the Balanced Rock parking area, where the distinctive Dewey Bridge member clearly separates the massive sandstones of the Entrada Formation above and the Navajo Formation below. For the most part the Dewey Bridge is unvegetated, but north of the Fiery Furnace it is exposed as the surface layer on rolling benches, where it supports blackbrush shrublands with scattered Utah juniper (Figure 13).



Figure 13. Typical vegetation on a rare bench of the Dewey Bridge Member.

Entrada Sandstone (Jurassic). This unit is another dune sandstone, but is distinguished from the Navajo and Wingate sandstones because it forms most of the features that characterize the park's spectacular scenery. Deposited between 150 and 160 million years ago, the reddish Entrada Sandstone is exposed as arches throughout the park, including the Windows, Landscape Arch, Skyline Arch, and Double O Arch. In addition, it forms the vertical cliffs of The Courthouse Towers and The Great Wall, and the fins of the Fiery Furnace. Much of the Entrada Sandstone is unvegetated because it is vertical and/or actively eroding, but level to rolling surfaces catch sand and soil in potholes and joints to support a shrub-rich wooded community very similar to that of the Kayenta and Navajo formations (Figure 14).



Figure 14. Typical sandstone domes and vegetated potholes in the Entrada sandstone.

Moab Tongue (Jurassic). This unit (assigned to either the Entrada or the Curtis formation depending on the treatment) originated as sand dunes about 150 million years ago. This light-colored sandstone forms the cap on both sides of the Salt Valley anticline, continuing south into the Willow Flats area and east to the benches that surround Delicate Arch. Moab Tongue exposures tend to be unvegetated except where sand and soil have collected in potholes and joints (Figure 15). The vegetation is similar to that of the Kayenta and other sandstone benches, except that a few of the deepest joints hold water and may contain tiny wetlands or thickets of willows (*Salix* spp.), chokecherry (*Prunus virginianus*), or netleaf hackberry (*Celtis laevigata* var. *reticulata*). Many of the park's hanging gardens occur at the contact between the Moab Tongue and the Entrada Sandstone (Figure 16); these vertical wetlands support a unique community of Mancos columbine (*Aquilegia micrantha*), Eastwood monkeyflower (*Mimulus eastwoodiae*), giant helleborine (*Epipactis gigantea*), and Rydberg's thistle (*Cirsium rydbergii*).



Figure 15. (l) Vegetation growing on the Moab Tongue is limited to joints and potholes where sand collects and soil has developed. (r) Ground view of vegetation Moab Tongue vegetation.



Figure 16. Hanging garden occupying an alcove at the contact between the Moab Tongue (roof) and the Entrada Sandstone (slope with standing figure).

Morrison Formation (Jurassic). Three distinct units of the Morrison Formation occur at ARCH. Lowermost and lying on the Moab Tongue are the dark red siltstones of the Tidwell Member. These support sparse desert shrublands of blackbrush, sometimes with Torrey joint-fir or shadscale (Figure 17a). Capping the Tidwell Member is the Salt Wash Member, a weak, relatively thin, often highly fractured, coarse sandstone or conglomerate. The vegetation growing on the Salt Wash Member is a juniper-dominated woodland or woody shrubland similar to that of other sandstones, except that the shrub species tend to be more xeric; littleleaf mountain mahogany and Utah serviceberry are generally replaced by Stansbury cliffrose, blackbrush, yucca, and snakeweed (Figure 17b). The Brushy Basin Member is a colorful, variegated shale (purple, green, and gray layers are characteristic), originally deposited on a broad, marshy floodplain and now forming badlands on the margins of the park and in Cache Valley. The Brushy Basin Member tends to support sparse to extremely sparse desert shrublands of shadscale, siltbush (*Zuckia brandegeei*), crispleaf buckwheat, Torrey jointfir, bud sage (*Picrothamnus desertorum*), Gardner saltbush (*Atriplex gardneri*), mariposa lily (*Calochortus nuttallii*), desert parsley (*Cymopterus purpurascens*), Basin daisy (*Platyschkuhria integrifolia*), and charming woodyaster (*Xylorhiza venusta;* Figure 17c). North-facing Brushy Basin Member slopes may sometimes support a desert grassland dominated by Salina lyme grass (Figure 17d).

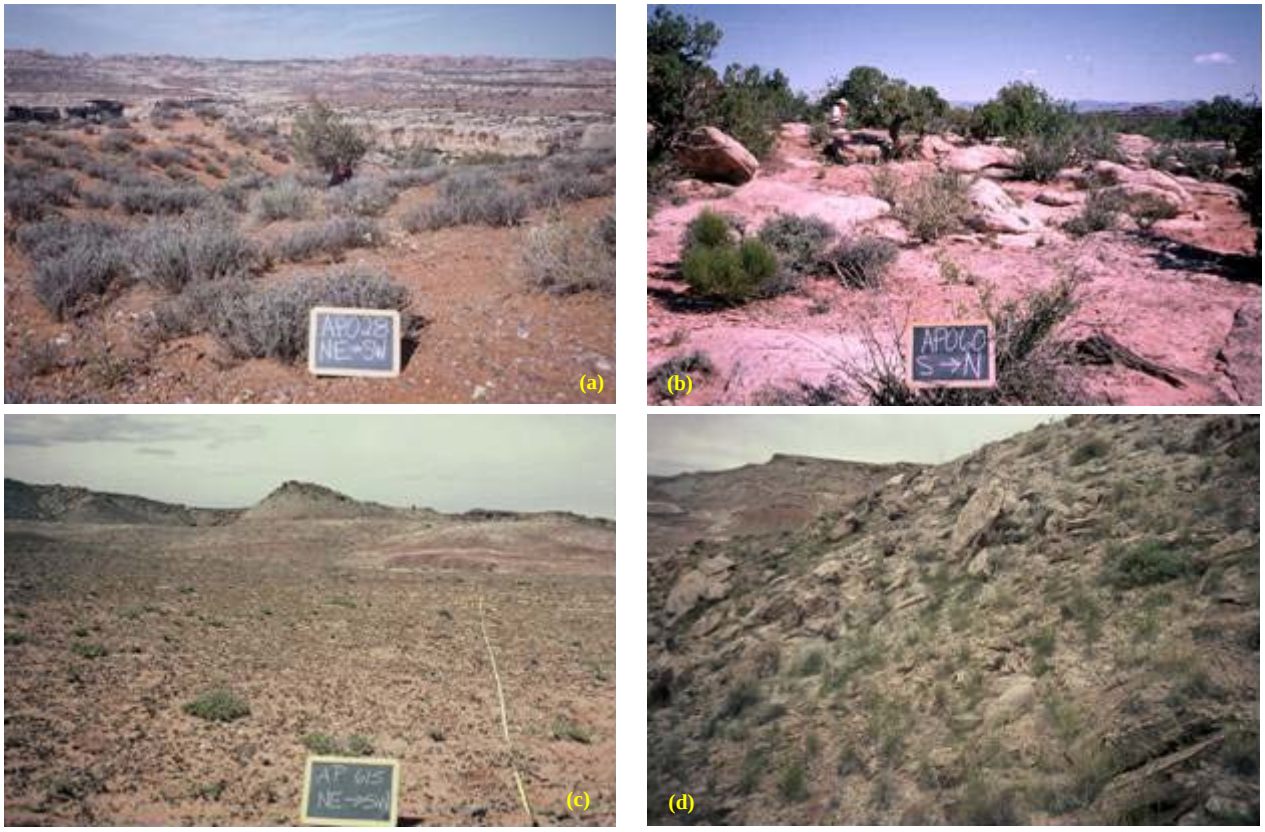


Figure 17. Typical vegetation found on the Tidwell (a), Salt Wash (b), and Brushy Basin (c) members of the Morrison Formation. A unique desert grassland of Salina lyme grass is restricted to north-facing Brushy Basin slopes (d).

Cedar Mountain Formation and Dakota Sandstone (Cretaceous). These 125 million-year-old sandstone units are thin and poorly exposed in the park, forming low, sharp-edged hogbacks in Cache Valley and in the environs. Unlike the other sandstone units exposed in the park, the Cedar Mountain Formation and Dakota Sandstone do not generally support woodlands, but are sparsely vegetated by an inconsistent mix of desert shrubs, forbs, and grasses (Figure 18).



Figure 18. Sparse, poorly-organized communities of mixed desert shrubs and grasses are typical of the few Dakota and Cedar Mountain outcrops within ARCH.

Mancos Shale (Cretaceous). This formation was deposited on a shallow sea floor between 80 and 125 million years ago and is exposed only on the floor of Cache Valley. Bentonite layers within the Mancos cause soils to exhibit extreme swell-shrink behavior when wetted, which discourages shallow-rooted herbaceous species. The structure and fine texture of Mancos shale-derived soils resists the deep infiltration of rainfall; only winter precipitation has a chance to penetrate deeply. High concentrations of calcium and selenium also discourage the growth of most plant species. The vegetation growing on Mancos Shale is therefore typically shrub-dominated and sparse. Shale exposures generally take the form of light gray badlands with scattered mat saltbush (*Atriplex corrugata*), crispleaf buckwheat, Gardner saltbush, shadscale, horsebrush (*Tetradymia spinosa*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), bicolor buckwheat (*Eriogonum bicolor*), Indian ricegrass, and desert trumpet (*Eriogonum inflatum;* Figure 19).



Figure 19. Sparse dwarf-shrublands of mat saltbush characterize the Mancos Shale.

Quaternary Deposits. Unconsolidated surficial deposits throughout the park are the products of weathering, erosion, and deposition. Sheets and dunes of wind-blown sand occur on valley bottoms and lower slopes. Alluvial deposits and slope wash cover floodplains, fill valleys, and modify gentle slopes. Talus, colluvium, and landslide deposits cover steeper slopes on canyon walls. In many parts of ARCH, several types of surficial deposits may occupy the same area; for example, sand dunes may cover part of an alluvial valley floor or form a sand ramp covering a colluvial slope.

Alluvial deposits. These sheets of water-deposited sands and gravels are scattered throughout the lowlands at ARCH. The sediments filling Cache and Salt valleys were primarily deposited by surface runoff from adjacent slopes, then redistributed by intermittent streams on the valley floors. In the canyons of the Colorado River, Courthouse Wash, and Salt Wash, alluvial terraces of varied ages and elevations fill the spaces between the active channel and the canyon wall. The vegetation growing on alluvial deposits varies depending on the coarseness of the alluvium, the availability of surface or groundwater, and the frequency of disturbance by flooding. Valley floors tend to support grasslands of James' galleta, needle-and-thread (*Hesperostipa comata*), and Indian ricegrass, although cheatgrass (*Bromus tectorum*) dominates in areas disturbed by grazing (Figure 20). Scattered shrubs or patches of fourwing saltbush and winterfat (*Krascheninnikovia lanata*) are common. Canyon terraces adjacent to the stream with frequent flooding and a high water table may support mesic riparian vegetation (Figure 21) including Fremont cottonwood (*Populus fremontii*), Goodding willow (*Salix gooddingii*), Gambel oak (*Quercus gambelii*), tamarisk (*Tamarix chinensis*), Russian-olive (*Elaeagnus angustifolia*), sandbar willow (*Salix exigua*), rushes (*Juncus* spp.), scouring rushes (*Equisetum* spp.), or sedges

(*Carex* spp.). Higher, drier terraces may support mixed shrublands of fourwing saltbush, sand sagebrush (*Artemisia filifolia*), and blackbrush, or open pinyon-juniper woodlands with Fremont barberry (*Mahonia fremontii*) and single-leaf ash. These terraces are often modified by eolian processes, and although they are too high to be flooded regularly, they may be destroyed by an exceptional flood event.



Figure 20. (L) Galleta-dominated grassland on the floor of Salt Valley within the park. (R) Cheatgrass and other weedy annuals dominate degraded grasslands in the environs.



Figure 21. Terraces of recent alluvium may support a range of communities depending on age, depth to the water table, and vulnerability to flooding. (L) Lower terraces support communities of cottonwood, willow, and mesic herbaceous species. (R) High terraces support species generally associated with upland sites, such as Gambel oak.

Eolian deposits. Wind-deposited sheets of sand (and to a much lesser extent, silt) at ARCH take many forms. They are primarily derived from local Entrada and Navajo sandstones and accumulate in bedrock hollows, ledges, between fins, and on valley floors. Sands blown off the top of cliffs may accumulate in a “sand ramp” or “falling dune” at the base of a slope. Likewise, sands migrating across a valley may form a “climbing dune” as they ascend the downwind valley wall. ARCH contains no true dune fields, but sand hummocks sometimes form around the base of large perennial plants such as Tucker oak (*Quercus havardii* var. *tuckeri*). The vegetation growing on eolian sands relates directly to the degree of stability. Loose, blowing sands usually

support a sparse shrubland containing a combination of hoary rosemarymint (*Poliomintha incana*), sand buckwheat (*Eriogonum leptocladon*), and pillar false gumweed (*Vanclevea stylosa;* Figure 22a). Sparse grasslands of Indian ricegrass also occur, but are rare. Sands with a degree of stabilization (usually indicated by the development of rudimentary biological soil crusts) may include sand sagebrush (*Artemisia filifolia*) and plains pricklypear (*Opuntia polyacantha;* Figure 22b). Sands that have been stable for some time include or are dominated by blackbrush and may include scattered Tucker oak (Figure 22c). Stable sand sheets may also support an unusual community of green Mormon-tea in a rhizomatous form (referred to as "mots" by field crews) with sparse to dense understory of Indian ricegrass, needle-and-thread, or James' galleta (Figure 22d).



Figure 22. Eolian sands at ARCH support a range of shrubland communities depending on the stability of the sand. Loose, blowing sands support a unique shrubland with hoary rosemarymint and sand buckwheat (a). Sand sagebrush occupies sand sheets that are newly stabilized (b). Blackbrush indicates a mature, stable sand sheet community (c) The rhizomatous form of green Mormon-tea forms a distinctive community with bunchgrasses as co-dominants (d).

Colluvial deposits. Shattered and fallen rocks cover the sides of Salt and Cache valleys and the lower slopes of the Colorado River canyon. The most visible elements of the colluvium are the rocks and boulders of sandstone fallen from cliffs above these slopes. Spaces between the fallen rocks are filled by sands and silt blown from adjacent valley floors and plateaus. The larger rocks provide islands of stability on otherwise mobile slopes for long-lived, woody plants to root. The most unstable slopes tend to be dominated by grasses, especially James' galleta and Salina lyme

grass. Because of the variability of substrate, stability, and exposure, there is no "typical" community on these slopes. Vegetation plots recorded as many as 16 species of trees and shrubs. Dry exposures tend to have more of the xeric shrubs, especially Torrey joint-fir, rubber rabbitbrush (*Ericameria nauseosa*), shadscale, and yellow rabbitbrush. Cooler exposures have scattered Utah juniper and more mesic shrubs such as skunkbush, fendlerbush, mountain mahogany (*Cercocarpus montanus*), Utah serviceberry, Bigelow sagebrush, green Mormon-tea, and Stansbury cliffrose (Figure 23). Vegetation density is limited by the amount of exposed soil.



Figure 23. Slopes covered by colluvium in the deeper canyons of ARCH typically support a sparse, but very diverse community of desert shrubs with scattered Utah juniper.

Soils

The Natural Resources Conservation Service (NRCS) is producing a new ecological site classification and soils map for ARCH (Dana Truman pers. comm. 2007), with an expected completion date of 2010. This section is based on existing soils information (Hansen 1989).

ARCH soils vary with differences in topographic position, parent material, local hydrology, slope, and other factors influencing soil formation. The 1989 soils map for ARCH identifies 21 map units representing 10 soil series, eight soil families and two unvegetated units (Table 2). These map units can be combined into two broad categories: (1) Rock outcrop-Nakai-Moenkopie (characterized by broad, sloping structural benches and cuestas) (2) Rock outcrop-Rizno-Begay (characterized by broad, sloping structural benches, cuestas, and deep canyons).

Soils at ARCH are formed either from bedrock exposed at the surface (residual, colluvial, and eolian soils) or from sediments deposited by flowing water (alluvial soils). Soil textures are mostly variations of loam and sand; gravels are present primarily in soils associated with

streambeds and floodplains and secondarily in soils derived from conglomerates such as the Salt Wash Member of the Morrison Formation.

Precipitation is the main factor controlling soil productivity at ARCH; the region's arid climate means that soil productivity is naturally low in most of the park. Low precipitation rates limit vegetative cover and primary productivity, and therefore soil organic matter. Soil susceptibility to water erosion is generally moderate, but can be severe in areas with low permeability such as shale badlands.

Soil chemistry and depth are also important factors that influence vegetation distribution. Deep soils tend to support bunchgrasses. Shrublands tend to occupy shallower or more alkaline soils. The most common woodland community in ARCH, (pinyon pine – Utah juniper with a mixed shrub understory), occupies rocky soils and fractured bedrock. Shale badlands and sandstone slickrock outcrops cover large areas within the park. These have little or no soil development due to their predominant erosive features.

Table 2. Soil complexes and associations mapped within ARCH (Hansen 1989).

Soil Unit (Map Unit #)	Description
Begay-Sazi complex (4)	Eolian and some alluvium; very deep to moderately deep; well drained; undulating on broad cuestas and structural benches; 2-10% slopes
Begay-Sazi-Rizno complex (5)	Eolian, alluvium, and residuum; very deep to very shallow; well drained; derived from sandstone; structural benches and cuestas; 10-20% slopes
Hanksville family - Badland complex (18)	Colluvium and residuum; moderately deep to very shallow; well drained to excessively drained; overlying shale or of exposed shale interbedded with gypsum and thin sandstone layers; side slopes, colluvial fans, and back slopes; 30-50% slopes
Hanksville family - Shalet complex (19)	Residuum and colluviums derived from shale and soft sandstone; moderately deep to very shallow; well drained; over residuum derived from sandstone and limestone; structural benches dissected by drainages; 3-50% slopes
Mido loamy fine sand (33)	Eolian derived from sandstone; very deep; excessively drained; cuestas and broad structural benches on the leeward side of ridges and depressional areas; 2-20% slopes
Mido-Sazi complex (34)	Eolian and alluvium derived from sandstone; very deep to moderately deep; excessively drained to well drained; broad cuestas and structural benches; 2-20% slopes
Moenkopie-Rock outcrop complex (35)	Residuum and eolian derived from sandstone; very shallow to shallow; well drained; some slickrock exposures; structural benches, mesas, and ridge tops; 3-20% slopes
Muff family-Badland complex (38)	Residuum, alluvium, and colluvium derived from shale; moderately deep; well drained; over residuum derived from weathered shale; hills and alluvial fans; 1-50% slopes
Myton family-Rock outcrop complex (39)	Residuum and colluvium derived from sandstone; moderately deep to deep; well drained; derived from sandstone; sides of deep canyons; 50-70% slopes
Nakai fine sandy loam (40)	Eolian, residuum, and alluvium derived from sandstone; deep; well drained; canyon floors and structural benches; 3-10% slopes
Nakai-Redlands complex (42)	Eolian and alluvium derived from sandstone; deep; well drained; structural benches and canyon floors; 1-10% slopes
Redbank-Flatnose families association (47)	Alluvium derived from sandstone and shale; very deep; well drained to somewhat poorly drained; floodplains; 0-3% slopes

Soil Unit (Map Unit #)	Description
Rizno-Begay complex (51)	Residuum and eolian derived from sandstone; very shallow and shallow to very deep; well drained; derived from shale; structural benches and cuestas; 2-10% slopes
Rizno-Rock outcrop complex (52)	Residuum and eolian material derived from sandstone; very shallow and shallow; well drained; slickrock, ledges, and monoliths present; edges of cuestas and structural benches; 2-10% slopes
Rock outcrop (53)	Massive sandstone slickrock dissected by crevices; structural benches, cuestas, ridges
Rock outcrop-Arches-Mido complex (54)	Sandstone outcrops as ledges, monoliths, and slickrock; Eolian deposits derived from sandstone; shallow to very deep; well drained to excessively drained; cuestas and structural benches; 2-20% slopes
Rock outcrop-Moenkopie association (55)	Residuum and eolian material formed in sandstone; very shallow and shallow; well drained; slickrock and ledges; toe slopes; 3-20% slopes
Shalet loam (64)	Residuum derived from interbedded sandstone and shale; very shallow and shallow; well drained; structural benches and cuestas; 3-10% slopes
Sheppard fine sand (66)	Eolian material derived from sandstone; very deep; excessively drained; valley fill and alluvial fans; 2-10% slopes
Thedalund family-Rock outcrop-Badland association (74)	Colluvium and residuum derived from sandstone and shale; moderately deep; well drained; exposed areas of sandstone cliffs and ledges and shale barrens interbedded with gypsum and sandstone; side slopes of pediments and canyon escarpments; 30-50% slopes
Toddler-Ravola-Glenton families association (75)	Alluvium derived from shale and sandstone; very deep; well drained; moderately saline to strongly alkaline; hills; 0-3% slopes; floodplains, drainages, and valley flats

Hydrology and Water Resources

Permanent surface water at ARCH is relatively rare; the park includes two intermittent streams, many ephemeral drainages, several small wetlands, and waterpockets that provide aquatic habitat for native vertebrates and invertebrates. The Colorado River is immediately adjacent to the park's southern boundary.

Surface flows in Salt Wash are restricted to parts of the drainage immediately downstream from major springs. Most of the streambed of Courthouse Wash is at least wet, and usually flowing. Both streams depend on spring flow and precipitation events to drive fluvial processes and support riparian vegetation. Salt Valley Wash is a large intermittent drainage in the northern part of the park. Many smaller, dry tributary canyons and washes dissect the park; these contain surface water only briefly during spring snowmelt and following summer thunderstorms. All drainages, intermittent or perennial, within ARCH are subject to flash floods, especially following thunderstorms. Floods erode and re-deposit bank sediments and tend to prevent the development of dense or extensive floodplain vegetation.

ARCH also contains limited water resources in the form of intermittent drainages, plunge pools, bedrock potholes (tinajas), seeps, and springs. Intermittent streams in side canyons may support stands of riparian and wetland vegetation, especially below bedrock pour-offs where plunge-pools form or where shallow bedrock keeps groundwater near the surface. Tinajas develop in solution pits formed in level exposures of sandstone. Most examples at ARCH are in the Navajo Sandstone, which lacks the cracks and joints of the other slickrock formations. Seeps and springs

provide sufficient water for localized surface flows and moist to saturated soils where they emerge from bedding planes and joints in sandstone cliffs. These seeps often provide hanging garden habitat and also deposit dissolved salts as the water evaporates, staining the cliff surfaces white. Most springs within ARCH emerge either at the contact of the Moab Tongue and the top of the Entrada Sandstone, or at the contact of the Dewey Bridge Member and the bottom of the Entrada Sandstone.

Riparian and wetland plant communities occur on the floodplain of the Colorado River, in mesic reaches of Salt and Courthouse washes, in tributary canyons, and below perennial seeps and springs. In terms of structure they range from deciduous forests and woodlands to shrublands and herbaceous vegetation types, including hanging gardens and marshes.

Biological Soil Crusts

Biological soil crusts occur throughout ARCH, particularly where thin, sandy soils overlie slickrock (Figure 24). On deeper soils, crusts occupy the nutrient-poor openings between tree canopies and clumps of vascular plants. These crusts are a complex community of cyanobacteria, green algae, lichens, mosses, microfungi, and other true bacteria (Belnap et al. 2001). The cyanobacteria and microfungi have filaments that weave through the top few millimeters of soil, creating a matrix that stabilizes and protects soil surfaces from wind and water erosion. Other attributes of biological soil crusts include fixing atmospheric nitrogen, building soil organic matter (Eldridge and Greene 1994), and retaining soil moisture (Belnap et al. 2001). They are diverse in terms of species composition, often including more species than the associated vascular plant community (Rosentreter 1986, Ponzetti et al. 1998). Where land uses such as livestock grazing have removed the crusts, they may take years to reestablish. Studies at ARCH of biological soil crusts and their ecological ties to vegetation include Belnap (1990, 1991, 1993), Belnap and Harper (1995), and Harper and Belnap (2001), among many others.



Photo credits: National Park Service

Figure 24. Example of well-developed biological soil crusts on the Colorado Plateau (a) and in ARCH (b).

Land Use and Settlement History

The following synopsis of the human history of ARCH is derived from Webb (1994) and NPS (2008). The history of human use of the area now know as Arches National Park extends back at least 3,000 and possibly as much as 10,000 years. Hunter-gatherers of several Archaic cultures (Barrier Canyon and Desert Native American) passed through the area, making use of the abundant outcrops of chert to form their distinctive tools and weapons and drawing their art on canyon walls. Between about 1,500 and 700 years ago, Puebloan peoples (Anasazi and/or Fremont) left signs of their presence in the form of rock art, dwelling sites and associated artifacts, although ARCH was on the northern edge of the territory occupied by the Puebloans. Bands of Utes succeeded the Puebloans, and amended some of the older rock art panels with figures riding horses, which were introduced by Spanish explorers in the 1500s.

Utes still occupied the Moab area at the time the first Europeans traveled the area: Juan Maria de Rivera, a Spanish trader, passed through Spanish Valley (now Moab) as early as 1765, and by the 1840s the Spanish Trail just west of the park was an established trading route. Denis Julien, a mountain man who inscribed his name in many places in the desert West, left an inscription dated 1844 in the Devil's Garden section of the park. Members of the Church of Jesus Christ of Latter Day Saints (Mormons) attempted to found a settlement near the river in 1855, only to be driven out by the Utes later that same year. White prospectors, ranchers, and farmers returned in force in the 1880s to found Moab and settle the area lying adjacent to the Colorado River known as Spanish Valley.

ARCH retains remnants of the homesteading and ranching history of the region, including the cabins of prospectors and ranchers. The Wolfe Ranch, now part of a National Historic District, is located on the floor of Cache Valley near Delicate Arch and is a well preserved example of a late 19th century homestead. John Wesley Wolfe, a disabled Civil War veteran, settled his family next to Salt Wash in 1898. A weathered log cabin, root cellar, and a corral remain from the ranch the family operated until 1910.

Because of its protected status, ARCH escaped the uranium prospecting boom of the 1950s, although significant evidence of prospecting and mining surrounds the park. In 1955-56, a natural gas pipeline was built through the northern sections of the park, leaving a scar that is still visible. Pipeline repair in 2009 created additional disturbance to the right-of-way.

Previous Vegetation Studies

ARCH supports pygmy woodlands, desert shrublands, and bunchgrass grasslands in a plateau and canyon setting. The sometimes complex juxtaposition of geology, soils, hydrology, and disturbance history results in a greater diversity of plant communities and species than might be expected for an area of this size. The vascular flora of ARCH includes 522 taxa that have been confirmed or reliably reported as occurring in the park (Fertig et al. 2009).

Because it is a relatively small but diverse park and because nearly all of it is accessible, ARCH has attracted many students of botany since the late 19th century. Fertig et al. (2009) wrote a

thorough review of vegetation studies at ARCH, which are summarized here. The history of plant collection in the vicinity of ARCH began with visits by pioneer botanist Alice Eastwood in 1892 followed by Per Axel Rydberg and A.O. Garrett in 1911. Most of the species now known from the park were collected during surveys by Brigham Young University botanists B.F. Harrison and colleagues (1947-1952) and by Stan Welsh and colleagues (1963). These studies raised the number of plant taxa known from within the park to 320. Most species added to the park list since 1963 came from vegetation mapping projects (e.g., Allan 1977), monitoring studies (e.g., Schelz and Moran 2002), and focused inventories of hanging gardens and springs (e.g., Springer et al. 2006), rare plants (Heil et al. 1993), and exotic species (Dewey and Anderson 2005).

Only a handful of taxa were discovered in ARCH between 1963 and the late 1970s, at which time a series of vegetation inventory, monitoring, and mapping projects renewed the pace of collecting and new species discoveries. BYU graduate student Allan described the composition and distribution of the park's major vegetation types and produced a vegetation map for ARCH (1977). Between 1984 and 1988, Jayne Belnap and colleagues established 19 long-term vegetation monitoring transects within ARCH, adding 130 voucher specimens and 37 new species to the park's herbarium. The purpose of the monitoring was to document baseline vegetation information (ground cover, cryptobiotic soil and plant species cover, and frequency), as well as response to disturbance (fire and grazing), and natural community variability. Park ecologist Charlie Schelz established five riparian transects (1999-2002) in Courthouse Wash and Lost Spring Canyon to track trends in vegetation and hydrology.

Exotic Plant Management

Seventy-five of the vascular plant species known to occur within ARCH are non-native; some were imported accidentally by livestock, maintenance and construction activities, or visitors (Schelz and Budelier 2000). ARCH manages for invasive species because of their negative effects on native plant communities and the wildlife that depend on them, disruption of riparian processes and aquatic resources, and concerns from neighboring land managers.

Early settlers to the area introduced some of the first non-native plants to the area for food and livestock forage. Accessible lands within ARCH have been grazed for more than 100 years; ranching began on a moderate scale in the 1880s and most of the park was used by livestock as recently as the 1970s. Since that time, development or expansion of roads, campgrounds, trails, picnic areas, and a new visitor center to accommodate increased visitation have all contributed to the establishment of non-native plant species.

Two natural processes, flooding and fire, have the potential to permit the establishment or expansion of exotic species within the park. Flash flood events such as occurred in October 2006, or sustained high spring runoff as occurred in 2008 eroded wash and river banks and provided establishment sites for new cohorts of tamarisk and Russian-olive. Two fire-adapted non-native species, cheatgrass and tamarisk, are widespread within ARCH and have altered the fire regime by creating dense vegetation to carry fire; fires in areas where cheatgrass or tamarisk dominate tend to occur more often and affect larger areas. One fire of 40.5 ha (100 acres) was

recorded in the Salt Valley since the park was established (Joss et al. 2005).

Invasive non-native plant species are common in some ARCH landscapes. Those considered most problematic are tamarisk, Russian-olive, cheatgrass, and Russian knapweed (Schelz and Moran 2002). Aggressive management of tamarisk and Russian-olive trees and shrubs has occurred since the 1990s, with positive results in terms of native riparian species re-establishment in treated areas. Both species occupy riparian habitats which include the Colorado River, Salt Wash, and Courthouse Wash within ARCH.

Tamarisk, a riparian Mediterranean shrub, was imported to North America during the 1800s as an ornamental species and was deliberately introduced to the Colorado River in Arizona to slow riverbank erosion (Schelz and Moran 2002). Spreading upriver at the rate of roughly 19.3 km (12 miles) per year, tamarisk has become established along all Colorado River tributary drainages in addition to seeps, springs, and canal and ditch systems.

Dense tamarisk stands increase fire frequency, lower plant and animal diversity, and significantly alter stream hydrology. Tamarisk consumes a great deal of water, and tends to convert broad, shallow braided channels to a single deep, incised channel. Overbank flooding is eliminated, the water table drops, and cottonwood and willow communities are converted to upland vegetation.

Courthouse Wash in ARCH is one of several sites where tamarisk and Russian-olive are controlled by NPS staff. Control treatments (hand cutting followed by spraying the stumps and sprouts with herbicide) began in 1999 and continue through the present. Several other small drainages within ARCH have been successfully cleared of tamarisk and Russian-olive and restored to native vegetation and hydrologic function.

Cheatgrass has altered the composition and function of vegetation within ARCH and throughout the American west. Cheatgrass is well adapted to the high desert climate and can out-compete many native plants. It usually forms dense stands that carry fire easily, whereas the sparser grasslands formed by native bunchgrasses would only carry fire for short distances. Cheatgrass is present throughout ARCH and is a significant component of the grasslands occupying the floor of Cache and Salt Valleys. The part of Salt Valley outside the park boundary is dominated by cheatgrass and represents a threat to the park's remaining grasslands both as a source of seed and as a ignition area for fire. Cheatgrass is not currently managed by the park except to discourage disturbance of areas where it occurs.

Project Overview

General Approach and Timeline

The goals of this project were to inventory, describe, and map the existing vegetation at ARCH and its environs to national program standards. The project at ARCH is part of a larger effort undertaken by the NCPN to classify and map vegetation in all network parks. In order to facilitate coordination among network mapping projects, the NCPN developed standardized databases, mapping conventions, reporting standards, and naming conventions.

The NCPN vegetation classification and mapping program was launched in July 2001 at a scoping meeting among network park staff, NCPN staff, and potential project cooperators. Following this meeting, NCPN prepared a multi-year, multi-park project proposal to the USGS-NPS Vegetation Mapping Program to cost-share network I&M funding with the National Vegetation Mapping Program funding in order to complete vegetation maps for all network parks (Evenden 2001). A meeting to determine the ARCH project boundary, review legacy data, determine plot sampling needs, discuss photointerpretation approaches, and define additional special park data was held in February 2003. Table 3 is a timeline for the completion of major project components.

NCPN negotiated interagency agreements with the USDA Aerial Photo Field Office and the USDI Bureau of Reclamation Remote Sensing and Geographic Information Group to acquire aerial photography for each park, including ARCH. Stereo and orthophotography for ARCH were flown during June 2002.

Table 3. Timeline for ARCH vegetation mapping project tasks.

Task Description	2002	2003	2004	2005	2006	2007	2008	2009
Planning and Scoping								
Acquire Aerial Imagery	X							
Field Data Collection								
Photo Interpretation								
Vegetation Classification					X		X	
Local & Global Descriptions								
Spatial Database								
Plant Association Field Key								
Accuracy Assessment								
Final Report and Products								

Vegetation plot and observation point data were collected at ARCH during the 2003 field season. A review of the preliminary plant association list (e^2M 2003) suggested that 300 to 500 plots would be needed to complete sampling of the full range of vegetation types within the park.

Vegetation plot data were entered into a MS Access database developed for the project and were analyzed following the 2003 field season. The data were analyzed by ecologists contracted by e^2M, who prepared a preliminary vegetation classification report (Decker and Coles 2003). The final assignment of plots to associations of the National Vegetation Classification was made by NatureServe ecologists in 2006, with minor revisions through 2008. Local plant association descriptions based on the classification were drafted in 2005 and completed in 2006 by e^2M ecologists; NatureServe completed the global association descriptions in 2009. An illustrated field key to ARCH plant associations was developed, illustrated, and tested prior to map accuracy assessment (AA) in 2006.

Interpretation of aerial photos and digital database development for the ARCH vegetation map began in 2003 and were completed in 2006. Map classes were defined for the project by the primary photointerpreter with input from other project ecologists. A traditional photo interpretation was performed, with interpreted polygons drawn on Mylar overlays on aerial orthoimagery, then scanned and attributed in a GIS. Polygon attribution followed standards developed by NCPN for all park mapping projects (Evenden 2004). A guide to the map classes was drafted in 2006 and revised in 2009.

A draft map and associated spatial database were completed in the spring of 2005. Accuracy assessment data were collected during the 2005 field season. AA data were entered into the ARCH project database and analyzed, with results tabulated into a contingency matrix. A meeting held among project cooperators in November 2006 determined which map classes should be retained and which should be modified, combined or eliminated because they failed to meet the 80% accuracy standard. Major revisions were made to the vegetation classification, map and spatial database in 2007 and 2008 as a result of these decisions. Final changes to the map and map class concepts in 2009 were needed to bring ARCH map concepts into congruence with map concepts developed for Canyonlands National Park (CANY).

Primary Partners and Project Roles

Many individuals working for several agencies and organizations were involved in completing the Arches National Park Vegetation Mapping Project. The roles of each contributor are described below.

engineering-environmental Management, Inc.

- *Jim Von Loh, Senior Biologist* – created draft field key, wrote draft association local descriptions, contributed to final report
- *Peter Williams, Consulting Ecologist* – collected plot, observation point, and AA data
- *Janet Coles, Consulting Ecologist* – collected plot and observation point data, trained field crews in plot data collection techniques
- *Karin Decker, Consulting Ecologist (Colorado Natural Heritage Program)* – completed preliminary vegetation classification, contributed to final report

National Park Service, Northern Colorado Plateau Network

- *Angie Evenden, Ph.D., Vegetation Program Manager* – overall project coordination and management, set NCPN project standards, organized project meetings, managed budgets, agreements and contracts
- *Mark Miller, Vegetation Ecologist* – participated in kickoff meetings and scoping
- *Janet Coles, Vegetation Ecologist* – technical editor of the final report; coordinated creation of final products, wrote sections of final report
- *Margaret Beer, Data Manager* – project database development
- *Helen Thomas* – project database support, photo database development
- *Russ DenBleyker* – project database and geodatabase support and QC
- *Amy Schwarzbach, Biological Technician* – collected plot and observation point data
- *Lisa Hahn, Biological Technician* – collected plot and observation point data
- *Liz Ballenger, Biological Technician* – collected AA data, entry and QC, revised map class guide and association field key
- *Amy Tendick, Biological Technician* – AA data collection, entry and QC, revised vegetation map and map class concepts, edited field key and map class guide, helped write final report
- *Bruce Condie, Biological Technician* – collected plot, observation point, and AA data
- *Sarah Topp, Biological Technician* – collected plot, observation point, and AA data
- *Aneth Wight, GIS Technician* – produced geodatabase; plots database support, project metadata

National Park Service, Arches National Park

- *Gery Wakefield, GIS Team Leader* – managed the GIS and remote sensing database construction, selected AA points and prepared maps to support the AA
- *Charlie Schelz, Ecologist* – participated in scoping and accuracy assessment analysis meetings
- *Mary Moran, Biological Technician* – contributed logistical assistance and plant identification

U.S. Department of Agriculture Aerial Photo Field Office

- *Cindy Sessions, Contracting Officer* – Procured aerial photography (9" x 9" stereo coverage)
- *Mark Cox, Photography Specialist* – Provided QA/QC of photography, developed photo index

USDI Bureau of Reclamation Remote Sensing and Geographic Information Group

- *Alan Bell, Photography Specialist* – Provided aerial photo contract specifications, subcontracted with Horizons, Inc. for aerial photography and production of color DOQQs for project area, provided QA/QC of orthoimagery

NatureServe

- *Marion Reid, Senior Regional Ecologist* – project manager, reviewed classification
- *Janet Coles, Regional Ecologist* – reviewed draft classification and prepared final classification, reviewed draft local descriptions, wrote global descriptions, trained AA field crews
- *Mary Russo, Ecology Data Manager* – Entered ARCH local and global descriptions into NatureServe's Biotics database, formatted descriptions, completed plant species crosswalk
- *Kristin Snow, Assistant Ecologist/Ecological Information Manager* – Developed format for NCPN plant association local and global descriptions

U.S. Geological Survey – National Park Service National Vegetation Mapping Program

- *Mike Story, NPS Program Leader* – Provided national level program oversight
- *Karl Brown, Ph.D., USGS Program Leader* – Provided national level program oversight
- *Tammy Hamer, Vegetation Mapping Program Biologist* – Facilitated generation of final products

Aerial Photography

High-quality aerial photography of an appropriate scale is an important part of all USGS-NPS National Vegetation Mapping Program projects. Orthophotography provides a base image for mapping vegetation in a digital format and is the basis for interpreting vegetation patterns. Stereo photographs acquired vertically from the air, with adequate overlap, allow three-dimensional, high-resolution photointerpretation when viewed under a stereoscope (Avery 1978). At the beginning of the NCPN vegetation mapping program, network staff decided to acquire new stereo aerial photography, as well as orthorectified imagery at a 1:12,000 scale for eleven park units, including ARCH.

To maximize cost savings, the NCPN acquired aerial photography concurrently for several park units. In order to minimize shadow effects associated with canyon topography and maximize vegetative expression, the goal was to minimize the sun angle by flying as close as possible to noon on the summer solstice (June 21). True color aerial photography was chosen because it minimizes the effects of shadows in deep canyons. It was also determined that true color photography would best illustrate the vegetation patterns of the park units being mapped.

Most NCPN park units are characterized by semi-arid and desert landscapes. Herbaceous vegetation in these systems tends to cure early. The year 2002 (the year the stereo and orthoimagery were acquired) presented special challenges due to extreme drought conditions across the Colorado Plateau. As a result, the imagery represents extremely arid conditions and did not capture average vegetation expression in the park. Most annual plants emerged minimally or not at all in 2002, and many perennial herbaceous plants, including dominant grasses, died or had dropped their leaves by the time the new photos were acquired.

Stereoscopic Aerial Photo Coverage

NCPN contracted with the USDA - Farm Services Agency Aerial Photo Field Office (APFO) to acquire new 23 cm x 23 cm (9 in x 9 in) true color aerial photographs for ARCH. The photographs were flown on June 26, 2002 by the subcontractor, Blue Skies Consulting, LLC of Albuquerque, New Mexico. The photography was acquired at a nominal elevation of 6,000 feet (1,829 m) above ground level in a Cessna T210N aircraft. A Wild RC10 camera with 15.2 cm (6 in) lens was used with Kodak Aerocolor negative film. The target scale for this photography was 1:12,000 (1 in = 1,000 ft). The mission was designed with approximately 30% sidelap between flight lines and 60% overlap between photos. The project encompassed 320 linear km (199 linear miles) divided among 14 flight lines and 304 individual photos (Figure 25).

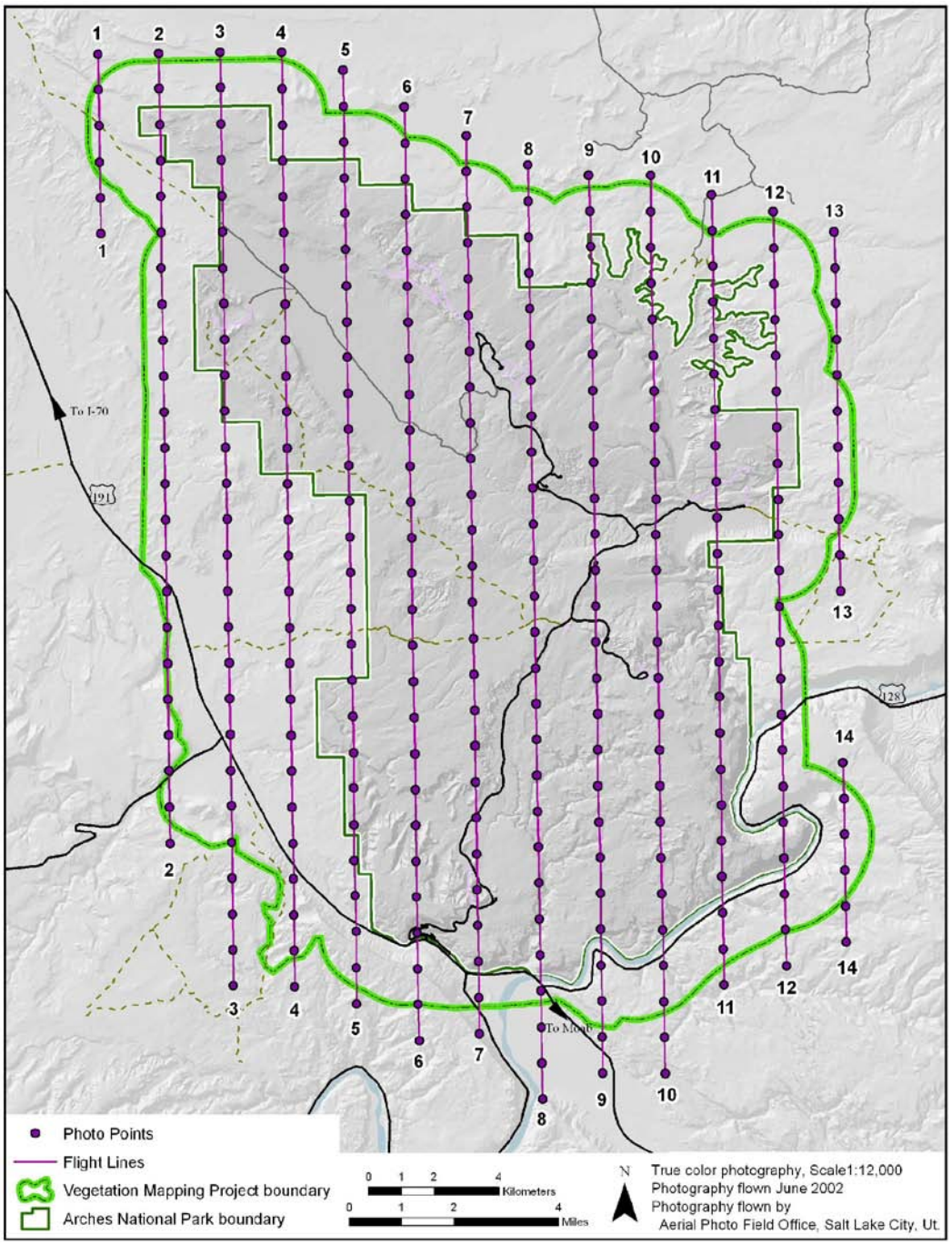


Figure 25. Flight lines for the 2002 stereo aerial photograph coverage of ARCH.

Figure 26 is an example of the 23 cm x 23 cm aerial stereo photographs acquired for ARCH. These photographs were used for photo interpretation during the mapping phase of the project, as well as by field crews during plot data collection. The film negatives for this aerial photo coverage are permanently stored at the APFO in Salt Lake City, Utah. The APFO made two sets of color prints. One of these was distributed to ARCH and the other is retained at the NCPN offices in Moab, Utah.

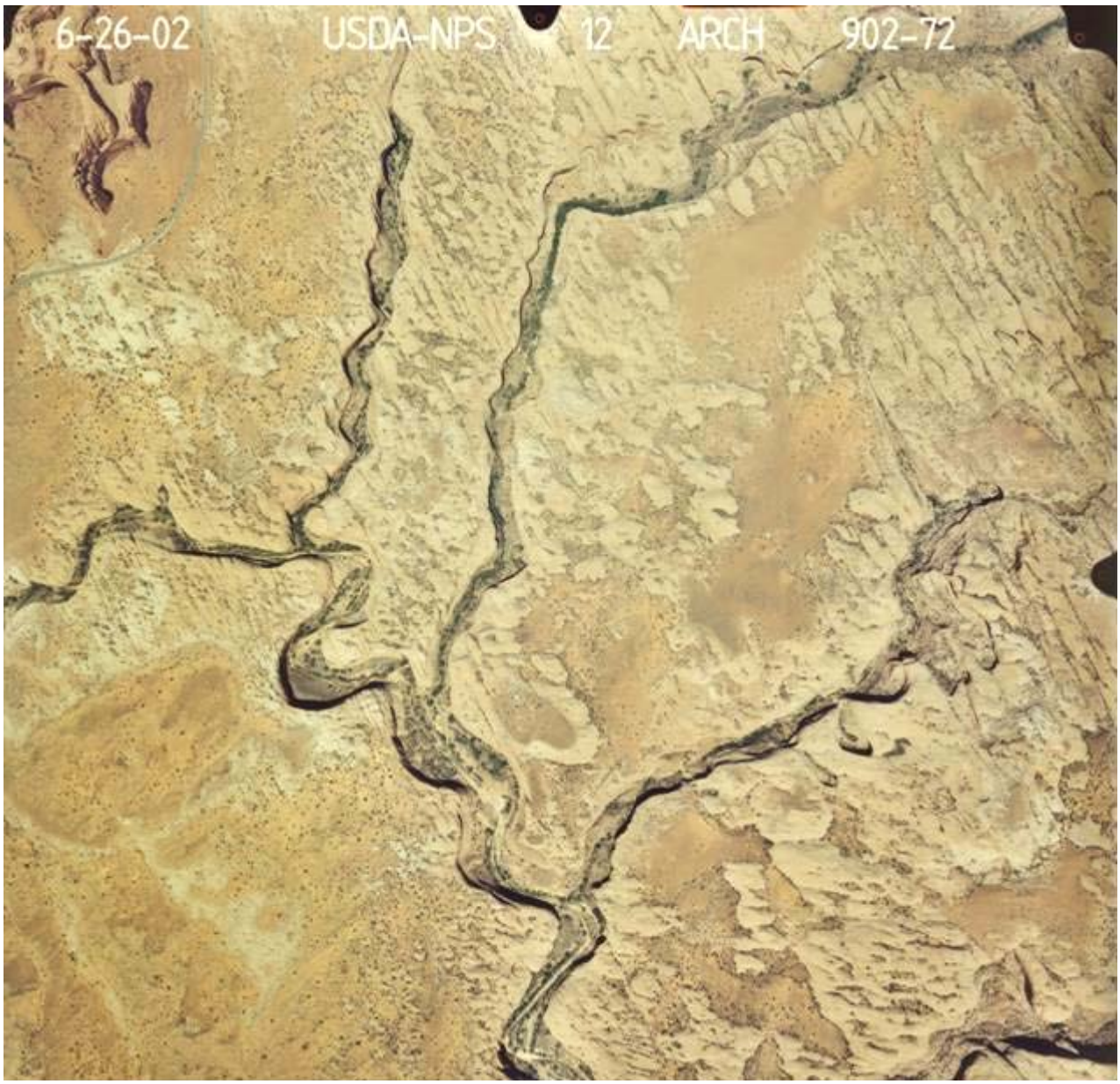


Figure 26. Example of a 9” x 9” aerial photograph acquired for the ARCH vegetation classification and mapping project.

Digital Orthophotos

The USDI Bureau of Reclamation Remote Sensing and Geographic Information Group (BOR) in Denver, Colorado, produced 1:12,000 scale digital orthophotography for ARCH from new imagery. This work was subcontracted to Horizons Inc. of Rapid City, South Dakota. The photography was flown on June 18, 2002, at a mean above ground level elevation of 6,096 m (20,000 ft). Sidelap was approximately 40% and overlap about 60%. Airborne global positioning system (GPS) data were collected for each exposure. A Zeiss RMK 15/23 camera with a 15.3 cm (6 in) lens was used with AGFA100 film. The project extended over 220 linear km (137 linear miles) divided among 6 flight lines and 66 individual photos (Figure 27).

The original film was scanned at 21 microns to create pixels of approximately 0.84 m. Horizons, Inc. created a photographic mosaic by extracting the high quality image area from the center of each photograph and stitching them together digitally. The photographic mosaic was then magnified to the 1:12,000 scale and corrected through a computational process that warps and stretches the image between known control points. The orthorectification process removes distortion caused by tilting of the camera and scale variation of the terrain. Control points for the orthorectification were obtained from USGS digital elevation model (DEM) 10 m data, aero triangulation data, and airborne GPS data. The X, Y, Z, omega, phi, and kappa for each photograph were calculated by Horizons, Inc. Final adjustments to the digital orthophoto database were solved using Erio Technologies ALBANY software. ALBANY is a simultaneous least squares bundle adjustment, which is designed for use with airborne GPS. Color adjustment of the final orthophoto coverage was achieved by visually matching the tone, contrast, and brightness to the original film. Each scanned image was checked for missing data.

The composite image covering the project area was inspected for tone balance and image distortion. In areas of image distortion, better imagery (usually from a slightly different angle on an adjacent photo) was inserted where possible. The final orthophotos were visually inspected for accuracy and consistency. Some areas of the final orthophoto imagery remain blurred due to the extreme terrain and limitations of the USGS DEM data. Film negatives for ARCH 2002 color digital orthophotos are permanently archived in airtight containers at the USBOR Remote Sensing and Geographic Information Group offices in Denver, Colorado.

Project Boundary and Map Extent

A project boundary of approximately 1.6 km (1.0 mile) around the edge of the park (environs) was chosen by network and ARCH staff during the February 2003 scoping meeting (Figure 1). The total project mapping area is 52,556 ha (129,868 acres). Of this area, 30,977 ha (76,545 acres) occur with the ARCH boundary and 21,579 ha (53,323 acres) are in the environs.

Minimum Mapping Unit

At the request of park staff, the photointerpreters agreed to map features as polygons to the extent that they could see them, including polygons smaller than the standard 0.5 ha (1.2 acre) minimum mapping unit (MMU). Polygons smaller than the MMU were used primarily to map special features, such as wetlands.

Ecological System Classification

The NCPN elected to use the Ecological System (ES) classification structure developed by NatureServe (Comer et al. 2003, NatureServe 2003b) as a framework for organizing and presenting plant community data. An Ecological System is defined as a group of plant associations from two or more alliances that tend to co-exist in a given landscape due to similar ecologic processes, substrates, and/or environmental gradients. The ES classification was developed to provide larger scale classification units for application to resource management, mapping, and conservation. Current estimates are that Utah contains more than 80 ecological systems (NatureServe Explorer 2006). This approach complements the NVC; the finer-scale

associations provide a basis for interpreting larger-scale ES patterns and concepts. A description of each of ecological system identified in ARCH appears in Appendix A.

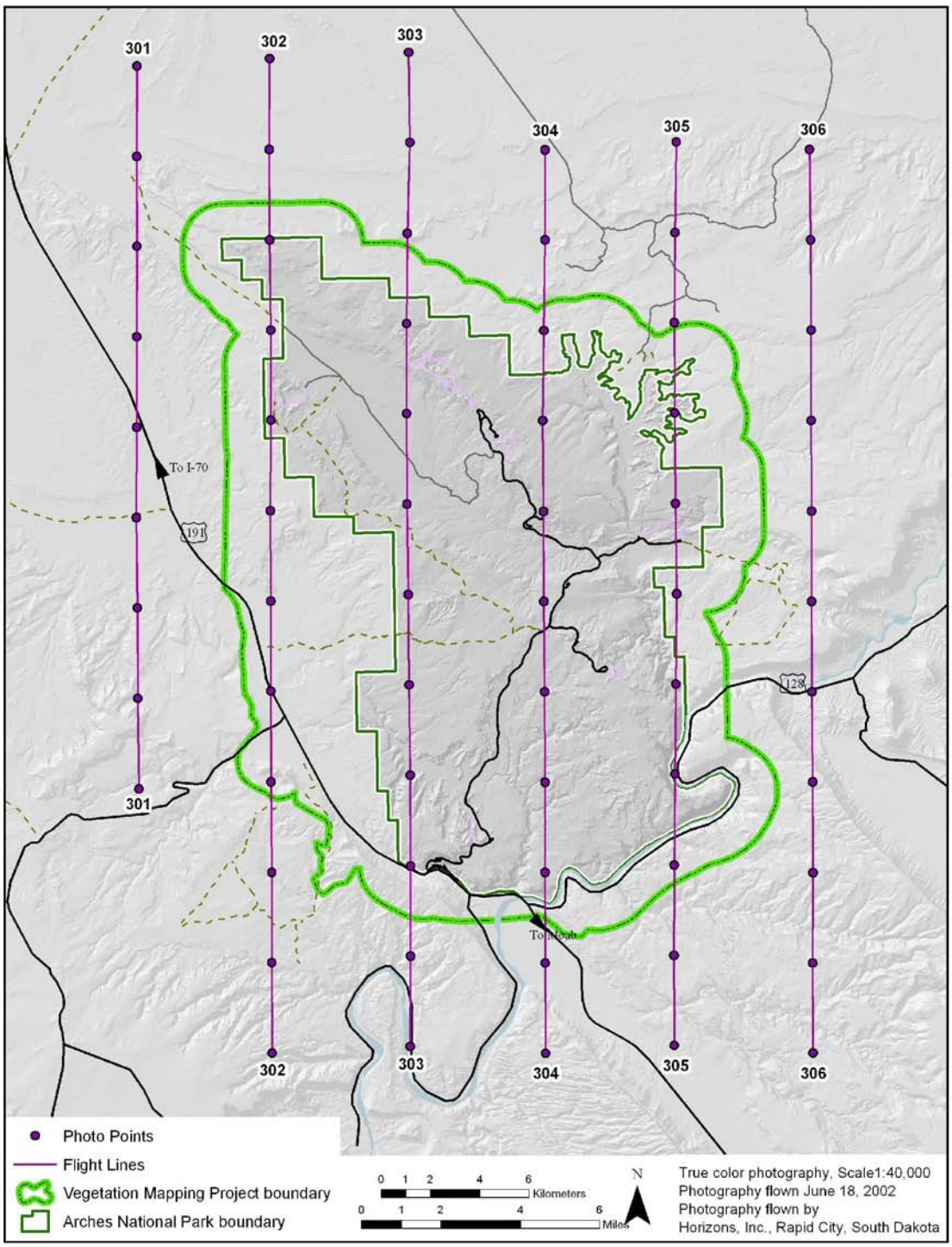


Figure 27. Flight lines for 2002 orthophotography coverage of ARCH.

The ecological system classification addresses natural landscapes. Land-use categories used to

identify developed areas are described elsewhere in this report. Sixteen ES units are known to occur within the ARCH vegetation mapping project area (with their NatureServe identifying codes):

- Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763)
- Colorado Plateau Hanging Garden (CES304.764)
- Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765)
- Colorado Plateau Pinyon-Juniper Woodland (CES304.767)
- Inter-Mountain Basins Active and Stabilized Dune (CES304.775)
- Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)
- Inter-Mountain Basins Greasewood Flat (CES304.780)
- Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784)
- Inter-Mountain Basins Semi-Desert Grassland (CES304.787)
- Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788)
- Inter-Mountain Basins Shale Badland (CES304.789)
- Inter-Mountain Basins Wash (CES304.781)
- Inter-Mountain Basins Playa (CES304.786)
- North American Arid West Emergent Marsh (CES300.729)
- Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)
- Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)

Vegetation Classification and Description

Pre-Field Methods

Preliminary Classification List

Project cooperators compiled a combined preliminary list of vegetation associations and alliances for Canyonlands and Arches national parks and Natural Bridges National Monument (e^2M 2003). This list was developed by intersecting NVC associations and alliances (e.g., NatureServe Explorer 2003) with Bailey ecoregions (2001). Previous plant community, exotic plant and rare plant inventory and monitoring work (e.g., Schelz and Moran 2002, Fowler 1995, Floyd-Hanna 1993), the park's plant species list, and expert local knowledge were used to refine the list. This process resulted in a preliminary list of 110 plant associations for the three park units. This association list was a useful gauge for estimating and planning field work and for assigning provisional association names to vegetation plots and observation points.

Legacy Data Review

Existing vegetation data for ARCH were reviewed for possible use in the classification and/or mapping. Long-term monitoring transects established in upland (1995) and riparian (1999-2001) communities by park resource management staff formed the primary dataset (24 plots). A review of the data using NPS-USGS Vegetation Mapping Program standard protocols determined the park data to be suitable as reference data for the NVC classification sampling and association descriptions (e^2M 2003). However, during the scoping meeting it was determined that 300 to 500 additional vegetation plots were needed at ARCH to cover the diversity of vegetation within the park as well as the full range of variation of each type.

Field Methods

The primary purpose of classification plot data was to document the composition and structure of ARCH vegetation and associated environmental conditions. These data became the basis for classifying the vegetation at the park. Field methods used in this project followed national program standards (e.g., TNC and ESRI 1994a, 1994b). Data gathered during this project contributed to understanding vegetation relationships across broader landscapes beyond the boundaries of the park. The plot dataset was enhanced by collecting observation point data, whose primary purpose was to support photo interpretation.

Field Sampling Approach

The sampling area included the entire park as well as BLM lands in the environs. Private lands in the environs were not visited. Because the project area is complex, the areas to be sampled were selected in advance of the 2003 field season. The selection was based on biophysical units designed to ensure that all major environmental settings were visited and a good spatial dispersion of sample plots was achieved.

The project area was divided into biophysical units (BPUs) constructed by layering solar budget (an index of sun exposure based on aspect and landscape position), geology, soils, and

topographic position information. The result was a set of polygons representing unique combinations of these environmental factors. The "cost" (distance from road or trail multiplied by a factor accounting for steep slopes) of accessing each polygon was calculated, and the polygons deemed too difficult or dangerous to access were withdrawn. A random sample of the remaining polygons representing each combination of factors became the sampling targets, although field crews were encouraged to use their judgment and sample areas outside the BPUs if they contained unusual vegetation types.

Field crews were led by ecologists with experience sampling plant communities in national parks and other landscapes. The list of 110 potential plant associations provided a starting point for naming communities sampled in the field. The sampling goal was to collect between three and five plots in every vegetation association within the ARCH project area. However, some common associations were sampled more often and some rare types were sampled less often. An effort was made to achieve good spatial distribution of plots across the landscape and to capture the full range of variation of each association. The field data collection was completed between May and August, 2003.

Plot Data Collection

Field crews located classification plots subjectively within the community of interest in order to best represent the association being sampled. Ecotones (areas where two or more plant communities intermix) were avoided. Highly disturbed areas were also avoided unless they covered several hectares. Plots were generally located in stands exceeding the minimum mapping unit (MMU) of 0.5 hectares. At the request of park staff, a few plots were sampled in smaller patches of distinctive vegetation or communities of rare species, such as hanging gardens and riparian terraces. Plot size and shape were consistent with national Vegetation Mapping Program guidelines (TNC and ESRI 1994a). Plot size was determined by the physiognomy of the community being sampled (Table 4). Plot shape was adjusted as needed to sample linear bands of vegetation in drainage bottoms. Plot size and shape were recorded for all plots.

Table 4. Plot sizes used for vegetation classification sampling at ARCH.

Vegetation Class	Area (m^2)	Radius (m)
Forest and Woodland	400	22.6
Shrubland	400	22.6
Herbaceous	100	11.3

Within each plot, field staff estimated and recorded an array of vegetation and environmental data using the field forms and methods in Appendix B. Four categories of data were collected in each vegetation plot (Table 5):

- location and plot identifiers
- environmental description
- vegetation description
- other information

Location and Plot Identifiers. ARCH staff requested that the vegetation plot locations not be permanently marked. The bounds of each plot were marked temporarily using measuring tapes. The Universal Transverse Mercator (UTM) coordinates were recorded at the center of each plot on Trimble or Garmin hand-held GPS receivers. Other data fields documenting the location of each plot are listed in Table 5 and are described in detail in Appendix B. Plot locations were recorded on topographic maps to avoid duplication of effort and ensure that the park was adequately sampled.

Table 5. General plot data categories and specific data components collected at each vegetation classification plot.

Plot Data Category	Data Components
Location and Plot Identifiers	Plot code, park name, site name, state, county, quad name, quad code, GPS unit, GPS file ID, UTM coordinates, UTM zone, GPS error, 3D differential, survey date, surveyor names, directions to plot, plot dimensions, photograph documentation
Environmental Description	Elevation, slope, aspect, topographic position, landform, geology, Cowardin wetland type, hydrologic regime, ground cover, soil texture, soil drainage, evidence of disturbance and animal use
Vegetation Description	Height and cover of all strata, cover by species, physiognomic type, provisional association name, plot representativeness
Other Information	Narrative description of the setting of the plot; describes adjacent communities, note unusual ecological processes, continue descriptions from other narrative fields

Environmental Description. The physical characteristics of each plot were documented in both categorical and narrative fields (Table 5; Appendix B). These included topographic site features (elevation, slope, aspect, topography), hydrology, geology, and soils. Characterization of the ground surface was made by estimating the cover of rocks, sand, litter, bare soil, biological soil crust, moss, and lichen. A narrative field was provided for a general description of the plot setting and the influence of physical factors on the vegetation.

Vegetation Description. Every vascular plant species in each plot was assigned to one of 14 physiognomic strata (Appendix B). Within each stratum, the investigator recorded average height and percent canopy cover for all species using the scales in Table 6. Consistent and repeatable cover estimates were obtained by relating the area occupied by an individual species to the area of the entire plot. When it was not possible to identify a species in the field, plant material was collected and pressed for later identification. All plant material collected for identification was destroyed in analysis. Provisional plant association names were assigned to each plot using the preliminary association list and professional judgment.

Other Information. Field crews were encouraged to record general observations on how well the plot represented the stand, the relationship of site conditions to vegetative patterns, characteristics of adjacent vegetation, and site disturbance history. The overall character of the vegetation and features of each plot were recorded in two 35 mm color slide photographs.

Table 6. Vegetation cover and height classes used in the ARCH vegetation mapping project.

Species and Strata Canopy Cover Classes				Strata Height Classes			
Code	*Range*	*Code*	*Range*	*Code*	*Range*	*Code*	*Range*
T	0-1%	5	> 45-55%	01	<0.5 m	06	>10-15 m
P	>1-5%	6	>55-65%	02	0.5-1 m	07	>15-20 m
1	>5-15%	7	>65-75%	03	>1-2 m	08	>20-35 m
2	>15-25%	8	>75-85%	04	>2-5 m	09	>35-50 m
3	>25-35%	9	>85-95%	05	>5-10 m	10	> 50 m
4	>35-45%	10	>95%				

Data Processing and Analysis

Three hundred thirty-three vegetation plots were sampled within the ARCH mapping project area during the 2003 field season (Figure 28). Plot data were manually entered into the project plots database developed by e²M and NCPN data management staff. This database is compatible with the data standards of the PLOTS Database System developed for the USGS-NPS Vegetation Mapping Program by TNC (1997). The NCPN database offers greater flexibility in overall data management than does the NatureServe PLOTS database, and is designed to accommodate all project field data recorded in plots, observation points, and accuracy assessment points. Data standards were established by NCPN for all network vegetation mapping projects, allowing compatibility of data across network park units. Fields associated with the ARCH plots database are described in Appendix C.

Each 35 mm slide associated with the project was scanned into digital format. The 535 digital images were stored in a photograph database. A unique identifier allows each photograph to be linked with the plots and spatial databases.

Observation Points

Data were collected at 256 observation points within ARCH. Data collected at observation points reflected the vegetation of a loosely undefined area around the point (the “stand”) rather than a measured plot, and were less detailed (Appendix B). These data were intended primarily to support modeling and interpretation of the aerial imagery, but were also used to help describe plant associations. Field crews could choose to sample an observation point instead of a full classification plot when:

- they were sampling the environs outside the park boundary
- the vegetation was highly disturbed, ecotonal, or otherwise anomalous and therefore unlikely to be classified under the NVC
- project photointerpreters requested documentation of a specific photo signature or area
- they wished to document special features as requested by park staff such as weed patches

- they wanted to document a vegetation type that consistently occurred in stands smaller than the minimum mapping unit of 0.5 ha (1.24 acres).

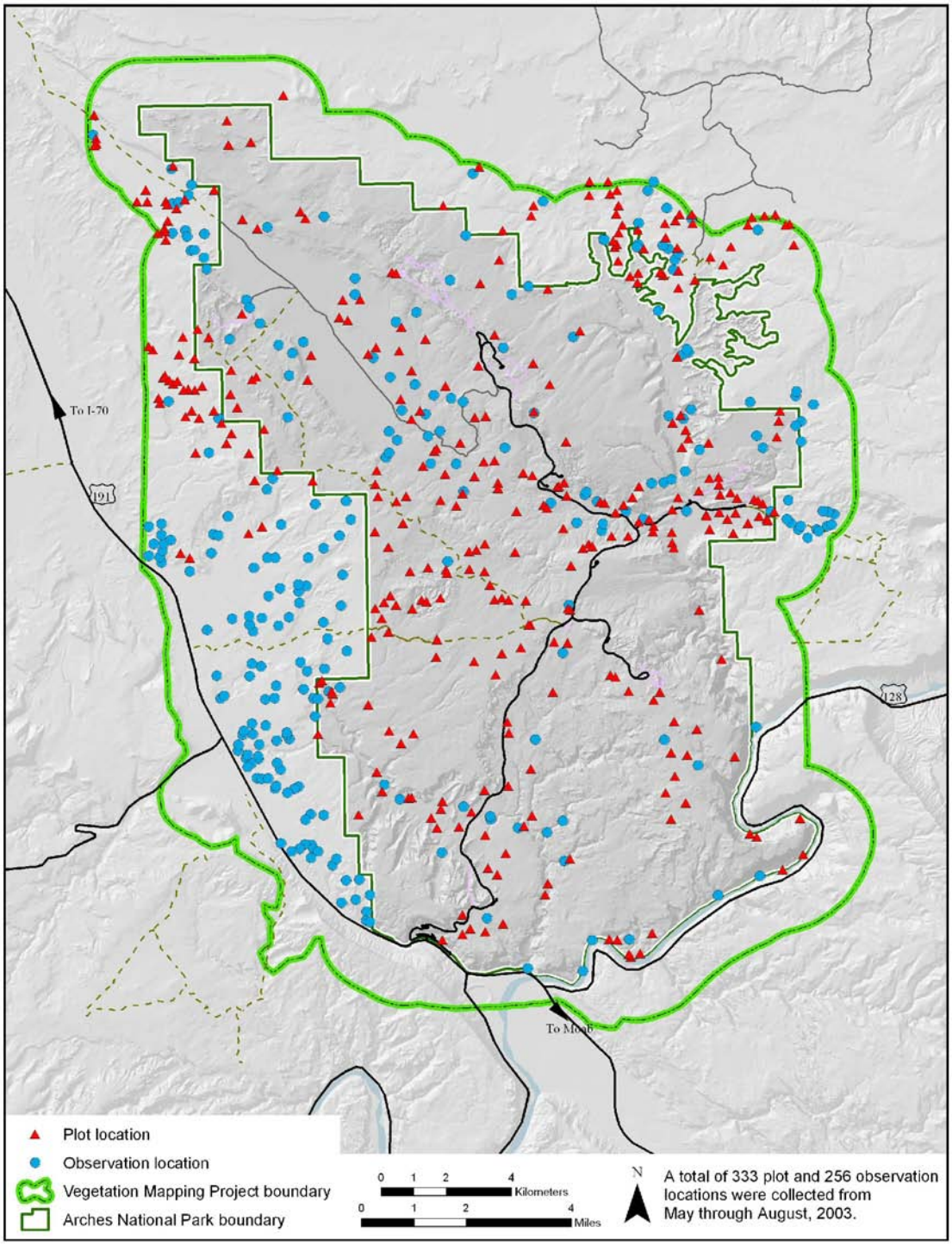


Figure 28. Vegetation plot and observation point locations in the ARCH mapping project area.

A thorough quality assessment and quality check (QA/QC) was performed on all plot and

observation point data following entry to the plots database. Individual plot data records were reviewed with the individual field data sheets in hand. Additional QA/QC was performed using a set of queries designed to identify inconsistencies across data fields and check for missing data. NCPN technicians standardized the scientific names in the database and noted name changes on the field forms. The primary authority used for plant names for the ARCH vegetation mapping project and all other NCPN I&M projects is *A Utah Flora* (Welsh et al. 2003). It is important to note that NatureServe, a primary project partner, follows Kartesz (1999) as its primary nomenclatural authority. As a result, nomenclature used in the body of this report follows Kartesz, whereas nomenclature in the project database follows Welsh et al. (2003). Differences between the two nomenclatural authorities are reconciled in a crosswalk table (Appendix D).

Following completion of QA/QC procedures, the database was made available to e^2M and NatureServe ecologists for vegetation classification analysis. Slide labels were printed from the database. A GIS data layer (point data) was developed to document classification plot locations.

Classification Data Analysis

Several multivariate analytic techniques were used to classify the vegetation of ARCH. Vegetation plot data (333 plots) formed the primary analysis matrix. Observation point data (256 points) were used to clarify the validity and composition of proposed plant associations. Species cover data were exported in list format from the plots database, then imported into PC-Ord (McCune and Mefford 1999). Midpoints of canopy cover classes were used in all data analysis procedures. Ten non-vascular taxa were removed prior to analysis, as they often contributed disproportionately to the total cover of the stand. Due to the frequency and possible importance of many species with habitually low cover, all other species were retained for the initial analyses. The initial analysis data set therefore contained 333 plots and 310 species.

A variety of exploratory data analyses, including summary statistics, outlier analysis, Bray-Curtis (polar) ordination, Detrended Correspondence Analysis (DCA), cluster analysis and Indicator Species Analysis (ISA), were used to characterize the data and identify groups appropriate for classification under the NVC. Cluster analysis was used to identify potential associations within the largest group isolated by ordination. Groups resulting from cluster analysis were validated by using ISA. When groups could not be parsed further with these methods, individual plots were inspected and assigned to appropriate associations or alliances, based on environmental factors and species composition and cover.

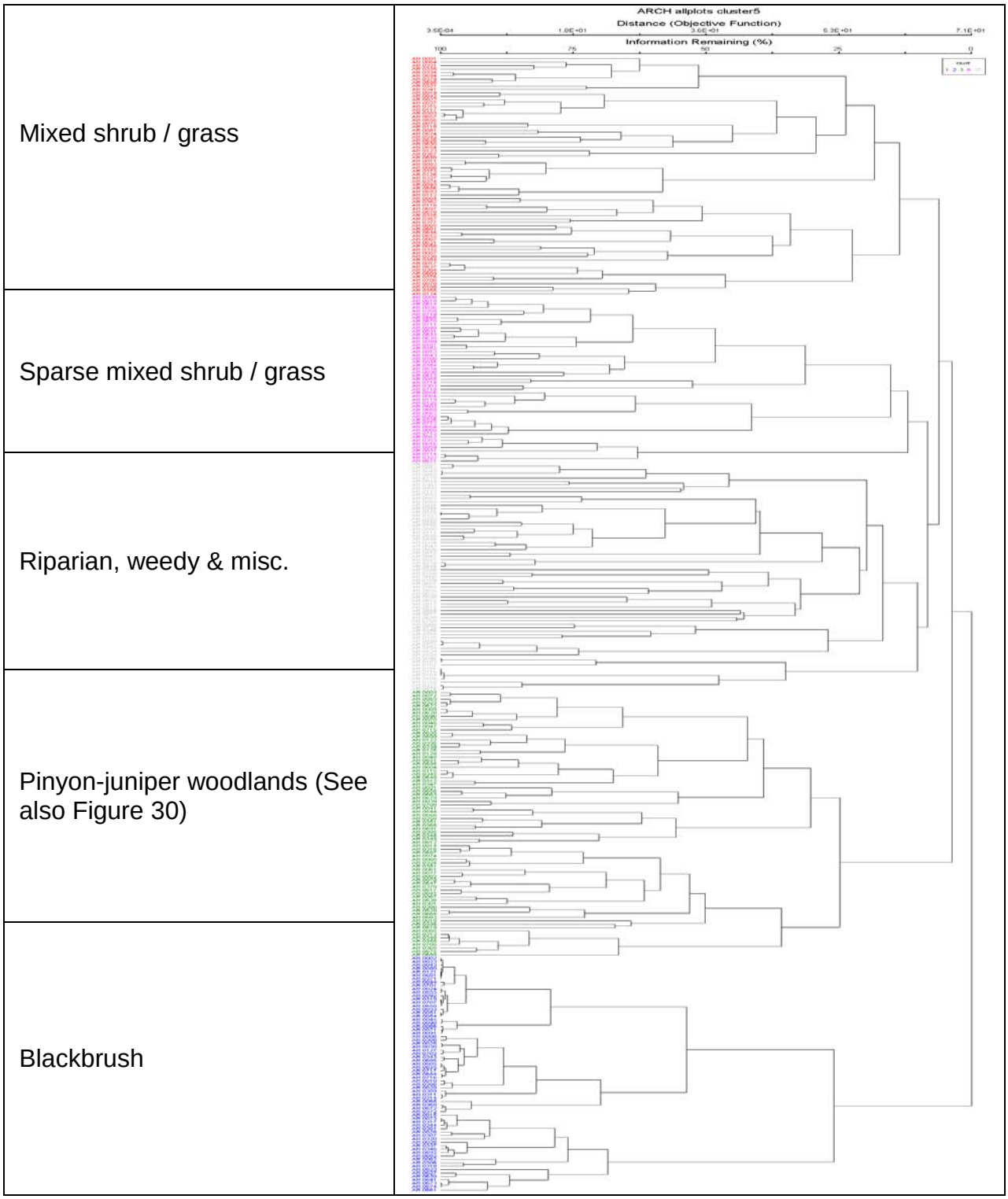


Figure 29. Cluster analysis dendrogram of ARCH plot data showing five clusters defined using the Sorensen Distance Measure and Flexible Beta group linkage method. The clusters were interpreted as (1) Mixed shrub or grassland, (2) Sparse mixed shrub or grassland, (3) Riparian, weedy, or other, (4) Pinyon-juniper and (5) Blackbrush.

Eight apparent outlier plots were identified in the dataset. All were plots at the extreme ends of cover distribution, either very high or very low. These outliers appeared to represent real vegetation types, and were retained for subsequent analyses. In order to stratify the large data set into smaller sets, we used cluster analysis (Sorensen Distance, flexible clustering linkage method, $\beta = -0.25$) and Indicator Species Analysis (Dufrêne and Legendre 1997) to search for possible subgroups. Both techniques were implemented in PC-Ord. The stratification identified five clusters (Figure 29) representing blackbrush shrublands, pinyon-juniper woodlands, mixed shrub or grasslands, sparsely vegetated mixed shrub/grasslands, and other types including riparian and weedy plots. Characteristics of each cluster were revealed by inspection of the original plot data, and summarized (Table 7).

Each of the five clusters identified in the initial stratification was then re-analyzed using cluster analysis, ISA, and ordination (Figure 30) to identify sub-groups of similar plots within the cluster. Plots within the sub-groups were assigned to associations by inspection, comparing species composition and cover with established NVC association descriptions previously reported from the Colorado Plateau Ecoregion, augmented by additional valid associations not previously reported from that ecoregion. Plots that did not fit either of these categories were either assigned to a provisional new association, or placed into tentative groups pending discussion with NPS and NatureServe ecologists.

The preliminary classification was reviewed by NatureServe ecologists to confirm each plot association assignment and make adjustments to ensure consistency with NVC concepts. NatureServe was also responsible for deciding whether to add new associations to the NVC or assign unusual types to a “Park Special” category.

Table 7. A summary of the ordination and Indicator Species Analysis results for the five main groups identified in the preliminary ARCH cluster analysis (Figure 29).

Group	Ordination and ISA results
Mixed shrub or grasslands	Seven groups representing stands of sand sagebrush, sand sagebrush-ricegrass, Mormon-tea, frosted mint, greasewood, Torrey joint-fir, fourwing saltbush/Torrey joint-fir, and some needle-and-thread grass
Sparsely vegetated mixed shrub/grasslands	Six groups: three represent Salinas lyme grass, Torrey joint-fir, and shadscale; three represent a gradient of mixed groups of blackbrush, shadscale, and Torrey joint-fir
Other types including riparian and weedy plots	Five groups representing cottonwood/willow, galleta grass, saltbush, and high cheatgrass cover, and a miscellaneous collection of plots including one common threesquare stand, a hanging garden community, mesic canyon bottom stands, and sparsely vegetated shale badlands
Pinyon-juniper woodlands	Four groups representing pinyon-juniper mixed shrub, juniper/sparse shrub, sparse juniper/blackbrush, and Tucker oak
Blackbrush shrublands	Two or three groups representing a gradient of blackbrush cover density, and few other distinguishing characteristics.

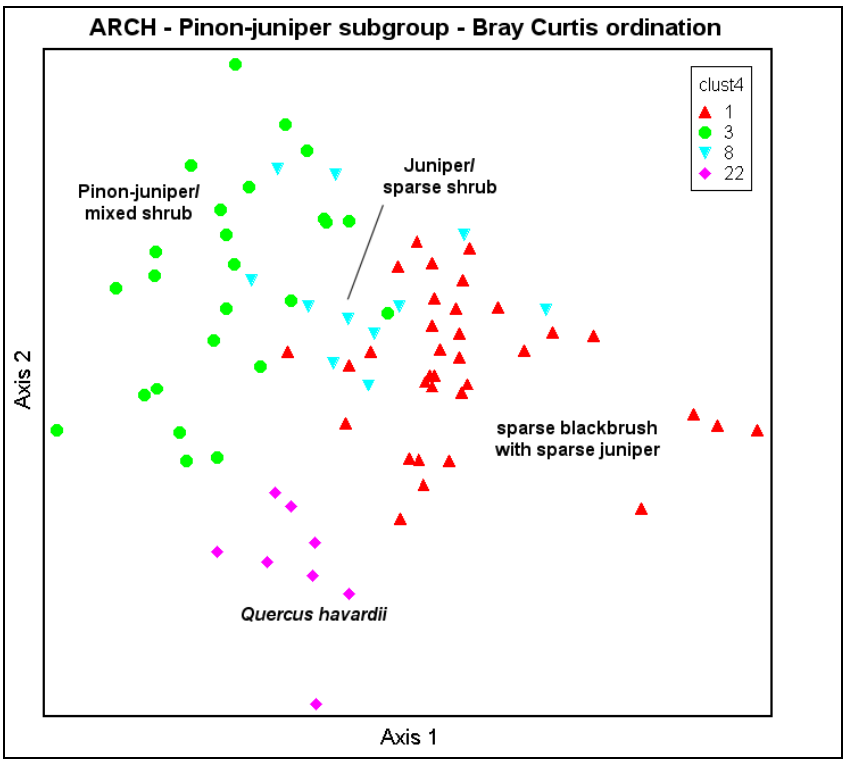


Figure 30. Example of the results of ordination analysis of one of the five main groups (pinyon-juniper woodlands).

Classification Results

The draft final classification for ARCH was issued by NatureServe in 2006, and underwent several revisions prior to release of the final classification in December 2008. Revisions included amending the classification to include new associations identified during the accuracy assessment phase and to update assignments of associations to ecological systems.

The vegetation of the ARCH mapping project area is classified into 75 community types (Table 8). Of these, 72 are described at the plant association level, one is described at the alliance level, and two are described as 'park specials' because they occur primarily in small stands and appear to be unique to ARCH. Park specials are not assigned to NVC associations or alliances. Five associations are documented exclusively from data gathered during accuracy assessment (Appendix E). The vegetation of the mapping project area is moderately diverse, including 47 NVC alliances and 16 ecological systems. Forty-two of the communities are shrubland types, including 38 upland shrubland associations, and four riparian shrubland types. Blackbrush was by far the most frequently sampled shrubland type. Twenty communities are classified as woodlands (six riparian), and 12 as herbaceous vegetation types (three wetland). One community (Slickrock Fin Pocket) is a complex of woodland and shrubland communities.

Each association, alliance, or park special is represented by between at least one and as many as 68 plot samples (Appendix E). Types with only one plot may have been rare in ARCH, or were simply undersampled as a result of difficult access or the limitations of the biophysical unit sampling design.

Table 8. Classified plant associations for the Arches National Park vegetation mapping project area, arranged by ecological system within each physiognomic group*.

NVCS Association	Common Name	Code†
UPLAND ASSOCATIONS		
UPLAND WOODLANDS		
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)		
Juniperus osteosperma / Artemisia tridentata ssp. *tridentata* Woodland	Utah Juniper / Basin Big Sagebrush Woodland	CEGL002360
Juniperus osteosperma / Cercocarpus intricatus Woodland	Utah Juniper / Littleleaf Mountain-mahogany Woodland	CEGL000733
Juniperus osteosperma / Coleogyne ramosissima Woodland	Utah Juniper / Blackbrush Woodland	CEGL002909
Juniperus osteosperma / Mixed Shrubs Talus Woodland	Utah Juniper / Mixed Shrubs Talus Woodland	CEGL002266
Juniperus osteosperma / Purshia stansburiana Woodland	Utah Juniper / Bitterbrush Woodland	Park Special
Juniperus osteosperma / Sparse Understory Woodland	Utah Juniper / Sparse Understory Woodland	CEGL000732
Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus Woodland	Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland	CEGL000779
Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima Woodland	Two-needle Pinyon - Utah Juniper / Blackbrush Woodland	CEGL000781
Pinus edulis - Juniperus osteosperma / Mixed Shrubs Talus Woodland	Two-needle Pinyon - Utah Juniper / Mixed Shrubs Talus Woodland	CEGL002328
Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland	Two-needle Pinyon - Utah Juniper / Stansbury's Cliffrose Woodland	CEGL000782
Pinus edulis - Juniperus osteosperma / Quercus havardii var. *tuckeri* Woodland	Two-needle Pinyon - Utah Juniper / Tucker Sand Shinnery Oak Woodland	CEGL002497
Pinus edulis - Juniperus spp. */ Cercocarpus montanus* - Mixed Shrubs Woodland	Two-needle Pinyon - Juniper species / Mountain-mahogany - Mixed Shrubs Woodland	CEGL000780
Pinus edulis - Juniperus spp. */ Quercus gambelii* Woodland	Two-needle Pinyon - Juniper species / Gambel Oak Woodland	CEGL000791
UPLAND SHRUBLANDS		
Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765)		
Artemisia bigelovii - Ephedra (viridis, torreyana) Talus Shrubland	Bigelow Sagebrush - (Mormon-tea, Torrey's Joint-fir) Talus Shrubland	CEGL003755
Fendlera rupicola Talus Shrubland	Fendlerbush Talus Shrubland	CEGL002765
Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia	Utah Juniper - (Two-needle Pinyon) / Blackbrush -	CEGL003774

Table 8. Classified plant associations for the Arches National Park vegetation mapping project area, arranged by ecological system within each physiognomic group*.

NVCS Association	Common Name	Code†
stansburiana - Quercus havardii var*. tuckeri* Wooded Shrubland	Stansbury's Cliffrose - Tucker Sand Shinnery Oak Wooded Shrubland	
Rhus trilobata - Ephedra (viridis, torreyana) Talus Shrubland	Skunkbush - (Mormon-tea, Torrey's Joint-fir) Talus Shrubland	CEGL003776
Slickrock Fin Pocket	Slickrock Fin Pocket [Park Special]	Park Special
Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)		
Quercus gambelii / Sparse Understory Shrubland	Gambel Oak / Sparse Understory Shrubland	CEGL002337
Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763)		
Coleogyne ramosissima - Purshia stansburiana - Quercus havardii var*. tuckeri* Shrubland	Blackbrush - Stansbury's Cliffrose - Tucker Sand Shinnery Oak Shrubland	CEGL002348
Coleogyne ramosissima Shrubland	Blackbrush Shrubland	CEGL001332
Ephedra torreyana / Achnatherum hymenoides - Pleuraphis jamesii Shrubland	Torrey's Joint-fir / Indian Ricegrass - James' Galleta Shrubland	CEGL002352
Ephedra torreyana / Pleuraphis jamesii Shrubland	Torrey's Joint-fir / James' Galleta Shrubland	CEGL003772
Ephedra viridis / (Achnatherum hymenoides, Hesperostipa comata) Shrubland	Mormon-tea / (Indian Ricegrass, Needle-and-Thread) Shrubland	CEGL002354
Ephedra viridis / Pleuraphis jamesii Shrubland	Mormon-tea / James' Galleta Shrubland	CEGL002356
Grayia spinosa Shrubland	Spiny Hop-sage Shrubland	CEGL002358
Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)		
Artemisia tridentata - (Ericameria nauseosa) / Bromus tectorum Semi-natural Shrubland	Basin Big Sagebrush - (Rubber Rabbitbrush) / Cheatgrass Semi-natural Shrubland	CEGL002699
Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784)		
Atriplex canescens / Sporobolus airoides Shrubland	Fourwing Saltbush / Alkali Sacaton Shrubland	CEGL001291
Atriplex canescens Shrubland	Fourwing Saltbush Shrubland	CEGL001281
Atriplex confertifolia - Picrothamnus desertorum Shrubland	Shadscale / Bud Sagebrush Shrubland	CEGL001295
Atriplex confertifolia - Sarcobatus vermiculatus Shrubland	Shadscale - Greasewood Shrubland	CEGL001313
Atriplex confertifolia / Pleuraphis jamesii Shrubland	Shadscale / James' Galleta Shrubland	CEGL001304
Atriplex confertifolia / Sporobolus cryptandrus Shrubland	Shadscale / Sand Dropseed Shrubland	CEGL003762

Table 8. Classified plant associations for the Arches National Park vegetation mapping project area, arranged by ecological system within each physiognomic group*.

NVCS Association	Common Name	Code†
Inter-Mountain Basins Active and Stabilized Dune (CES304.775)		
Artemisia filifolia Colorado Plateau Shrubland	Sand Sagebrush Colorado Plateau Shrubland	CEGL002697
Poliomintha incana - Artemisia filifolia - Vanclevea stylosa Shrubland	Hoary Rosemarymint - Sand Sagebrush - Pillar False Gumweed Shrubland	CEGL002418
Quercus havardii var. *tuckeri* Shrubland	Tucker Sand Shinnery Oak Shrubland	CEGL002486
Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788)		
Chrysothamnus viscidiflorus Shrubland Alliance	Green Rabbitbrush Shrubland Alliance	A.2651
Krascheninnikovia lanata / Pleuraphis jamesii Dwarf-shrubland	Winter-fat / James' Galleta Dwarf-shrubland	CEGL001322
Krascheninnikovia lanata Dwarf-shrubland	Winter-fat Dwarf-shrubland	CEGL001320
Inter-Mountain Basins Shale Badland (CES304.789)		
Atriplex corrugata Dwarf-shrubland	Mat Saltbush Dwarf-shrubland	CEGL001437
Atriplex gardneri / Pleuraphis jamesii Dwarf-shrubland	Gardner's Saltbush / James' Galleta Dwarf-shrubland	CEGL001441
Atriplex gardneri Dwarf-shrubland	Gardner's Saltbush Dwarf-shrubland	CEGL001438
Atriplex spp. Desert Pavement Sparse Vegetation	Saltbush species Desert Pavement Sparse Vegetation	CEGL003767
Ephedra torreyana Sparse Vegetation	Torrey's Joint-fir Sparse Vegetation	CEGL002353
Ephedra torreyana - (Atriplex spp.) / Nonvascular Gypsum Sparse Vegetation	Torrey Joint-fir - (Saltbush species) / Nonvascular Gypsum Sparse Vegetation	CEGL002349
Eriogonum corymbosum Badlands Sparse Vegetation	Crispleaf Wild Buckwheat Badlands Sparse Vegetation	CEGL002979
Leymus salinus Shale Sparse Vegetation	Salinas Lyme Grass Shale Sparse Vegetation	CEGL002745
Zuckia brandegeei Sparse Vegetation	Siltbush Sparse Vegetation	CEGL002493
Inter-Mountain Basins Greasewood Flat (CES304.780)		
Sarcobatus vermiculatus / Artemisia tridentata Shrubland	Black Greasewood / Basin Big Sagebrush Shrubland	CEGL001359
Sarcobatus vermiculatus / Sporobolus airoides Shrubland	Black Greasewood / Alkali Sacaton Shrubland	CEGL001368
Sarcobatus vermiculatus Disturbed Shrubland	Black Greasewood Disturbed Shrubland	CEGL001357
Inter-Mountain Basins Playa (CES304.786)		
Suaeda moquinii Shrubland	Shrubby Seepweed Shrubland	CEGL001991

Table 8. Classified plant associations for the Arches National Park vegetation mapping project area, arranged by ecological system within each physiognomic group*.

NVCS Association	Common Name	Code†
Allenrolfea occidentalis Shrubland	Iodinebush Shrubland	CEGL000988
Inter-Mountain Basins Wash (CES304.781)		
Ericameria nauseosa Desert Wash Shrubland	Rubber Rabbitbrush Desert Wash Shrubland	CEGL002261
Sporobolus airoides Southern Plains Herbaceous Vegetation	Alkali Sacaton Southern Plains Herbaceous Vegetation	CEGL001685
UPLAND GRASSLANDS		
Inter-Mountain Basins Semi-Desert Grassland (CES304.787)		
Achnatherum hymenoides Colorado Plateau Herbaceous Vegetation	Indian Ricegrass Colorado Plateau Herbaceous Vegetation	CEGL002343
Bromus tectorum Semi-natural Herbaceous Vegetation	Cheatgrass Semi-natural Herbaceous Vegetation	CEGL003019
Hesperostipa comata Great Basin Herbaceous Vegetation	Needle-and-Thread Great Basin Herbaceous Vegetation	CEGL001705
Pleuraphis jamesii Herbaceous Vegetation	James' Galleta Herbaceous Vegetation	CEGL001777
Pleuraphis jamesii - Sporobolus airoides Herbaceous Vegetation	James' Galleta - Alkali Sacaton Herbaceous Vegetation	CEGL001778
Sphaeralcea (coccinea, parvifolia) Herbaceous Vegetation	(Scarlet Globemallow, Narrowleaf Globemallow) Herbaceous Vegetation	CEGL005366
Sporobolus cryptandrus Great Basin Herbaceous Vegetation	Sand Dropseed Great Basin Herbaceous Vegetation	CEGL002691
RIPARIAN, WETLAND AND MESIC ASSOCIATIONS		
RIPARIAN AND WETLAND WOODLANDS AND SHRUBLANDS		
Rocky Mountain Lower Montane Riparian Woodland and Shrubland (CES306.821)		
Elaeagnus angustifolia Semi-natural Woodland	Russian-olive Semi-natural Woodland	CEGL005269
Populus fremontii / Artemisia tridentata Woodland	Fremont Cottonwood / Basin Big Sagebrush Woodland	CEGL005365
Populus fremontii / Equisetum spp. Woodland	Fremont Cottonwood / Horsetail species Woodland	CEGL003775
Populus fremontii / Ericameria nauseosa Woodland	Fremont Cottonwood / Rubber Rabbitbrush Woodland	CEGL002465
Populus fremontii / Salix exigua Forest	Fremont Cottonwood / Coyote Willow Forest	CEGL000666
Rhus trilobata Intermittently Flooded Shrubland	Skunkbush Intermittently Flooded Shrubland	CEGL001121
Salix exigua / Barren Shrubland	Coyote Willow / Barren Shrubland	CEGL001200

Table 8. Classified plant associations for the Arches National Park vegetation mapping project area, arranged by ecological system within each physiognomic group*.

NVCS Association	Common Name	Code†
Salix gooddingii / Salix exigua Woodland	Goodding's Willow / Coyote Willow Woodland	CEGL003778
Salix ligulifolia Shrubland	Strapleaf Willow Shrubland	CEGL001218
Tamarix spp. Temporarily Flooded Semi-natural Shrubland	Salt-cedar Temporarily Flooded Semi-natural Shrubland	CEGL003114
RIPARIAN AND WETLAND HERBACEOUS COMMUNITIES		
Colorado Plateau Hanging Garden (CES304.764)		
Aquilegia micrantha - Mimulus eastwoodiae Herbaceous Vegetation	Mancos Columbine - Eastwood's Monkeyflower Herbaceous Vegetation	CEGL002729
North American Arid West Emergent Marsh (CES300.729)		
Schoenoplectus pungens Herbaceous Vegetation	Threesquare Herbaceous Vegetation	CEGL001587
Typha (latifolia, angustifolia) Western Herbaceous Vegetation	(Broadleaf, Narrowleaf Cattail) Western Herbaceous Vegetation	CEGL002010

* Plant associations as determined from the vegetation plot, observation point and accuracy assessment point data. Associations are ordered by physiognomy and grouped by ES. Identification codes are provided for plant associations and ecological systems. Because ES units are not constrained by physiognomy, they may appear more than once in the table.

† NatureServe assigns CEGL codes to track NVC associations within their databases. Park Specials are not part of the NVC and therefore do not have a CEGL code. The NatureServe codes following each Ecological System unit name provide a means of tracking the evolution of the concept in NatureServe's Biotics Tracking Database.

Plant Community Descriptions

This section provides a summary of ARCH vegetation by physiognomic group. Appendix F provides detailed local and global descriptions of the 75 plant associations, alliances and park special vegetation types found within the park. Local descriptions are based on plot, observation point, and accuracy assessment point data from the park and environs, supplemented by input from knowledgeable park staff. Global descriptions characterize the association across its range and are based primarily on published and unpublished literature.

Most of the plant communities sampled at ARCH fit into existing NVC association concepts, or were considered significant enough to create new NVC associations for them. Two vegetation types were considered unique to the park, and were designated as Park Specials. One vegetation type fit into an alliance concept but lacked sufficient justification for creating a new association. Five types were documented from accuracy assessment data collected after the initial classification review by NatureServe was complete.

Upland Forest and Woodland Associations

Woodlands and forests are common and widely distributed vegetation types at ARCH. They occupy nearly every available habitat, from riparian corridors to rock outcrops to sand dunes. Canopy density is generally controlled by the availability of soil moisture or rooting sites. Most stands at ARCH do not have the closed tree canopy that usually characterizes forest, as opposed to more open woodland, associations. Although fire is not a major force in shaping communities at ARCH, stands on steep canyon walls are vulnerable to downslope soil movement or rock fall. The upland forest and woodland associations at ARCH include (in alphabetical order):

- *Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii* var. *tuckeri* Wooded Shrubland
- *Juniperus osteosperma / Artemisia tridentata* ssp. *tridentata* Woodland
- *Juniperus osteosperma / Cercocarpus intricatus* Woodland
- *Juniperus osteosperma / Coleogyne ramosissima* Woodland
- *Juniperus osteosperma /* Mixed Shrubs Talus Woodland
- *Juniperus osteosperma / Purshia stansburiana* Woodland [Park Special]
- *Juniperus osteosperma /* Sparse Understory Woodland
- *Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus* Woodland
- *Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima* Woodland
- *Pinus edulis - Juniperus osteosperma /* Mixed Shrubs Talus Woodland
- *Pinus edulis - Juniperus osteosperma / Purshia stansburiana* Woodland
- *Pinus edulis - Juniperus osteosperma / Quercus havardii* var. *tuckeri* Woodland
- *Pinus edulis - Juniperus* spp. */ Cercocarpus montanus* - Mixed Shrubs Woodland
- *Pinus edulis - Juniperus* spp. */ Quercus gambelii* Woodland

Woodland types are represented primarily by juniper woodlands; pinyon-juniper woodlands are less common because ARCH is near the dry end of pinyon pine's ecological tolerance. Many of the communities classified as woodlands might also be called wooded shrublands, because the trees are dwarfed by growing in slickrock cracks and shrubs may have as much or more cover than (and be as tall as) the trees. Pinyon-juniper stands on deep sand around the base of slickrock outcrops and in narrow dry canyon bottoms have trees with large crowns but little groundcover other than biological soil crusts.

Upland Shrubland Associations

Shrublands are the most diverse community type within the mapping area. Some communities on badlands are extremely sparse, while others on deep soils with good water holding capacity are relatively densely vegetated. The upland shrubland associations of ARCH include:

- *Allenrolfea occidentalis* Shrubland
- *Artemisia bigelovii - Ephedra (viridis, torreyana)* Talus Shrubland
- *Artemisia filifolia* Colorado Plateau Shrubland
- *Artemisia tridentata - (Ericameria nauseosa) / Bromus tectorum* Semi-natural Shrubland
- *Atriplex canescens / Sporobolus airoides* Shrubland
- *Atriplex confertifolia - Picrothamnus desertorum* Shrubland
- *Atriplex confertifolia / Pleuraphis jamesii* Shrubland
- *Atriplex corrugata* Dwarf-shrubland
- *Atriplex gardneri / Pleuraphis jamesii* Dwarf-shrubland
- *Atriplex* spp. Desert Pavement Sparse Vegetation
- *Chrysothamnus viscidiflorus* Shrubland Alliance
- *Coleogyne ramosissima - Purshia stansburiana - Quercus havardii* var. *tuckeri* Shrubland
- *Coleogyne ramosissima* Shrubland
- *Ephedra torreyana - (Atriplex* spp.*) /* Nonvascular Gypsum Sparse Vegetation
- *Ephedra viridis / (Achnatherum hymenoides, Hesperostipa comata)* Shrubland
- *Ephedra viridis / Pleuraphis jamesii* Shrubland
- *Eriogonum corymbosum* Badlands Sparse Vegetation
- *Fendlera rupicola* Talus Shrubland
- *Grayia spinosa* Shrubland
- *Krascheninnikovia lanata / Pleuraphis jamesii* Dwarf-shrubland
- *Poliomintha incana - Artemisia filifolia - Vanclevea stylosa* Shrubland
- *Quercus gambelii /* Sparse Understory Shrubland
- *Quercus havardii* var. *tuckeri* Shrubland
- *Rhus trilobata - Ephedra (viridis, torreyana)* Talus Shrubland
- *Sarcobatus vermiculatus / Artemisia tridentata* Shrubland
- *Sarcobatus vermiculatus / Sporobolus airoides* Shrubland
- *Sarcobatus vermiculatus* Disturbed Shrubland
- *Suaeda moquinii* Shrubland
- *Zuckia brandegeei* Sparse Vegetation

Desert shrublands are the most common within ARCH, occupying areas of shallow or poor soils throughout the park. Blackbrush, shadscale, Torrey joint-fir other desert shrubs dominate the sparse canopy, often in a mixed community of several species. Badlands formed from marine shales support a characteristic sparse community that may include mat saltbush, Gardner saltbush, or crispleaf buckwheat. Floodplains with alkaline soils support greasewood or iodinebush where an impermeable layer slows infiltration; basin big sagebrush, winterfat, rabbitbrush, or fourwing saltbush shrublands occur nearby on sandy, well-drained high terraces or valley floors. Deep, loose sands support unusual communities containing hoary rosemarymint, pillar false gumweed, and/or Tucker oak. More stable sands have sand sagebrush or blackbrush communities. Talus-covered canyon walls have diverse, mixed shrublands that may include Bigelow sagebrush, rabbitbrush, shadscale, Torrey joint-fir, skunkbush, fendlerbush, and/or green Mormon-tea. Rare shrublands include siltbush and spiny hopsage (*Grayia spinosa*) growing on specialized habitats.

Upland Herbaceous Associations

Grass-dominated associations are common but restricted in their distribution within the mapping area. Most grasslands occupy broad valley floors. Fire does not appear to be a major factor in creating or maintaining most of the grassland communities at ARCH, based on the fact that few show signs of encroachment by woody species. Forb-dominated types tend to result from severe disturbance and are generally weed-dominated. The upland herbaceous associations of ARCH include:

- *Achnatherum hymenoides* Colorado Plateau Herbaceous Vegetation
- *Bromus tectorum* Semi-natural Herbaceous Vegetation
- *Hesperostipa comata* Great Basin Herbaceous Vegetation
- *Leymus salinus* Shale Sparse Vegetation
- *Pleuraphis jamesii* Herbaceous Vegetation
- *Sphaeralcea (coccinea, parvifolia)* Herbaceous Vegetation
- *Sporobolus airoides* Southern Plains Herbaceous Vegetation
- *Sporobolus cryptandrus* Great Basin Herbaceous Vegetation

Valley floors of fine, windblown silt and sand support extensive grasslands dominated by James' galleta, or where degraded by grazing, cheatgrass. Loose, sandy sites will sometimes support grasslands of sand dropseed, alkali sacaton or Indian ricegrass. Disturbed marine shales will support exotic-dominated communities that may include kochia (*Kochia* spp.), halogeton (*Halogeton glomeratus*), and cheatgrass; sandy disturbed sites sometimes are dominated by native globemallow (*Sphaeralcea* spp.) or exotic Russian thistle (*Salsola* spp.).

Riparian and Wetland Forest and Woodland Associations

Riparian woodlands are restricted in their distribution to the Colorado River floodplain, tributary canyons, and below pouroffs. They vary according to the availability of water and tend to be dominated by Fremont cottonwood on canyon floors. Riparian forest and woodland associations of ARCH include:

- *Elaeagnus angustifolia* Semi-natural Woodland
- *Populus fremontii / Artemisia tridentata* Woodland
- *Populus fremontii / Equisetum* spp. Woodland
- *Populus fremontii / Ericameria nauseosa* Woodland
- *Populus fremontii / Salix exigua* Forest
- *Salix gooddingii / Salix exigua* Woodland

The Fremont cottonwood woodlands at ARCH generally have an open canopy and occur on intermittent streams in the tributary canyons. Because flood events are frequent, stands of many ages occur throughout the park. In older stands, the understory may have been crowded out by Russian-olive or tamarisk. Otherwise, it may consist of mesic herbaceous species (younger cottonwood stands), or upland shrubs and herbaceous species (older stands on higher terraces). Gooding willow is found in a few sheltered canyon stands.

Riparian and Wetland Shrubland Associations

Mesic and wetland shrub communities are very limited in their size and distribution within the

park. All are restricted to areas with high water tables, including stream and river banks and below pouroffs. Riparian and wetland shrubland associations of ARCH include:

- *Ericameria nauseosa* Desert Wash Shrubland
- *Rhus trilobata* Intermittently Flooded Shrubland
- *Salix exigua* / Barren Shrubland
- *Salix ligulifolia* Shrubland
- *Tamarix* spp. Temporarily Flooded Semi-natural Shrubland

The braided channels of intermittent washes contain sparse but distinctive shrub communities dominated by rubber rabbitbrush. Higher terraces along the Colorado River or below tributary canyon pouroffs may have dense clones of skunkbush. Coyote willow shrublands are most common on the banks of Courthouse Wash and sand bars of the Colorado River. Tamarisk has become dominant in may parts of the park, especially along the Colorado River, where it forms impenetrable thickets. Within Courthouse and Salt washes, a major tamarisk removal project has allowed native riparian vegetation to re-establish.

Riparian and Wetland Herbaceous Associations

Like mesic shrub communities, riparian and wetland herbaceous associations at ARCH are uncommon and limited in their distribution. All are restricted to areas with water at or near the surface for some or all of the growing season. Diversity is high, but most occur in patches smaller than the minimum mapping unit, such as hanging gardens. Riparian and wetland herbaceous associations of ARCH include:

- *Aquilegia micrantha - Mimulus eastwoodiae* Herbaceous Vegetation
- *Schoenoplectus pungens* Herbaceous Vegetation
- *Typha (latifolia, angustifolia)* Western Herbaceous Vegetation

Hanging gardens emerging from cracks or alcoves in canyon walls support communities of unusual species that are generally restricted to these habitats, including Mancos columbine, ditch reed grass (*Calamagrostis scopulorum*), shooting star (*Dodecatheon pulchellum*) and giant helleborine orchid. Other kinds of seeps support a variety of graminoid communities, depending on water chemistry. The banks of perennial streams support patches of spikerush (*Eleocharis* spp.) and bulrush (*Schoenoplectus* spp.); a beaver impoundment north of Wolfe Ranch supports a marsh dominated by cattail (*Typha latifolia*).

Field Key Preparation

An illustrated dichotomous field key to plant associations of the ARCH mapping area was developed for this project (Appendix G). The key is designed to assist users in identifying vegetation associations in the field. The key has two levels; the first level is defined by the physiognomy of the vegetation, i.e., forest, woodland, tall shrubland, shrubland, dwarf-shrubland, graminoid, or forb. The second level focuses on the dominant species' canopy cover. Brief environmental descriptions are included with the floristic descriptions to aid in identifying plant associations. To increase the utility of the key, individual plant associations are cross-referenced to map classes.

The association field key was constructed from data collected during the classification phase of the mapping project and revised following accuracy assessment of the map. Because the key is based on a sample of the vegetation, it probably does not account for all associations occurring within the park, nor does it explain the full range of variation of all associations as they appear in the park.

The field key was tested by NatureServe using ARCH vegetation plot data prior to its use by accuracy assessment field crews. A NatureServe ecologist selected random plots representing each association, removed the association identifier from the data and attempted to run each plot through the key using information contained in the plots database. Additional testing of the key occurred in the field during the accuracy assessment phase of this project. Areas where the key was confusing or unclear were identified and solutions proposed. The field key in Appendix G is the final version containing revisions based on these suggestions. It also contains the most important associations discovered during the accuracy assessment phase of the project.

Assessment of Global Rarity

ARCH is low enough in elevation and dry enough that it encompasses the boundary between pinyon-juniper and shrub-dominated semi-desert vegetation. Because water is a limiting factor, riparian and wetland species, although regionally common, are rare to uncommon within ARCH. Particularly rare are the plant species associated with hanging gardens that occur where porous sandstones contact impervious rock layers and seeps emerge. Few plant associations at ARCH are considered globally rare (NatureServe 2006); however, not enough is known about the global distribution of many associations to evaluate their rarity.

NatureServe and its network of state natural heritage programs indicate the rarity and degree of imperilment of plant communities by assigning state and global conservation status ranks to each. The rank scale ranges from 1 to 5; a rank of 1 indicates critical imperilment due to rarity, endemism, and/or threats, while a rank of 5 indicates little or no risk of extirpation of the plant community.

No ARCH plant associations are considered critically imperiled (G1). There are three associations considered imperiled or vulnerable (G2-G3): *Aquilegia micrantha - Mimulus eastwoodiae* Herbaceous Vegetation, *Pleuraphis jamesii - Sporobolus airoides* Herbaceous Vegetation and *Salix ligulifolia* Shrubland; two associations considered imperiled to secure (G2-G4): *Hesperostipa comata* Great Basin Herbaceous Vegetation and *Pleuraphis jamesii* Herbaceous Vegetation; and four associations considered vulnerable (G3) *Allenrolfea occidentalis* Shrubland, *Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus* Woodland, *Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima* Woodland and *Rhus trilobata* Intermittently Flooded Shrubland. Nine associations are considered possibly vulnerable (ranked G3?, G3-G4, G3-G5, or G3Q), but more survey and review is needed to confirm this assessment. The remaining associations are either ranked as secure (fifteen G4 or G5), or are not yet ranked (35). Four associations are semi-natural types that are not ranked. The high number of unranked associations reflects current uncertainty about the relative vulnerability of vegetation associations to extirpation both at ARCH and throughout much of the Colorado Plateau. Further review is needed to rank recent associations and improve confidence of existing global ranks.

All vegetation communities within ARCH are subject to change over time; drought and insect outbreaks are the most likely agents of change in woodland communities, whereas encroachment of exotic plants threaten the other vegetation types. Fire is not a significant factor in establishing or maintaining any of the natural plant associations at ARCH. Because of recent regional drought and a predicted change over time to a warmer and drier climate, all riparian, hanging garden, and wetland plant communities within ARCH are threatened to some degree. This threat is heightened due to the introduction of non-native plant species that invade mesic habitats more readily than dry upland habitats.

Fuels Data Collection

Natural fire is not an important factor in shaping the distribution or composition of vegetation at ARCH. In much of the park, vegetation too sparse to carry fire over large areas. Naturally ignited fires are typically confined to lightning strikes burning a few trees of pinyon pine and Utah juniper totaling no more than a few hundred square meters (Joss et al. 2005). Fuels data were not analyzed as part of this project and data pertinent only to fuels modeling were not collected. The plot photographs and some of the data collected for vegetation classification (see below) may be useful for fuels management.

Fuels Data

Data collected in the vegetation plots at ARCH that are potentially useful for fuels modeling include stem diameter at root crown for pinyon and juniper trees. Sampled pinyon-juniper stands were assigned to one of four age-class categories: old-growth, mature, young, or invasive. Structural height and density classes for each vegetation stratum may also be useful for fuels modeling.

Vegetation Mapping

Methods

The process of mapping vegetation and land use in the ARCH project area followed four steps:

1. Field reconnaissance
2. Map class development
3. Mapping
4. Spatial database development

Each step built upon the previous one. Field reconnaissance was intended to familiarize the photointerpreters with the park, patterns of vegetation distribution, and environmental factors useful for developing mapping models. Map class development followed this reconnaissance and was based on intensive review of the aerial imagery in concert with data from the first year of vegetation plot sampling. The mapping phase applied the map class concepts in order to draw consistent, homogenous polygons on the base orthoimagery. The draft polygon set was digitized and given additional attributes (spatial database development).

Field Reconnaissance and Map Class Development

The goal of map class development was to identify meaningful units to represent existing vegetation and land uses for the ARCH vegetation mapping project area. Map classes specific to this project were developed to characterize distinctive vegetation within the park and the environs. Standard land-use map classes (Anderson et al. 2002) were used to map developed parts of the mapping area such as park facilities and roads. The same map classes were used within the park and in the environs.

The project photointerpreter developed a preliminary set map class concepts in 2003 based on a review of the ortho- and aerial photography combined with several drive-through visits to ARCH. The ecologist responsible for collecting the classification plot data reviewed the preliminary map classes and preliminary vegetation classification in the field with the photointerpreter in 2004. Map class concepts were continually refined during the project as the photointerpreter gained more experience with the imagery and made additional field trips to resolve cryptic photosignatures.

The ARCH vegetation mapping project was completed using the original USGS-NPS Vegetation Mapping Program standard of mapping to the plant association level of the NVC. However, the level of detail possible in a vegetation map is limited by the imagery, the skill and experience of the photointerpreter, and the availability of supporting information. At ARCH, the relationships between the map class concepts and plant associations are complex. In some cases, distinct plant associations were grouped into a single map class because they occur in similar habitats and could not be distinguished consistently or accurately using remote sensing. In other cases, plant associations that occur on a variety of substrates e.g., blackbrush shrublands, were assigned to more than one map class.

Polygon Attributes

In order to facilitate use of vegetation maps and mapping data across multiple parks, the NCPN adopted a convention for naming and presenting map classes. For each map class representing an NVC plant association, the NatureServe common name (e.g., Blackbrush Shrublands) was used. Names for map classes representing complexes of associations followed the convention of using the unifying botanic and environmental factors, e.g., Shale Barrens Desert Scrub.

To facilitate tracking and management of vegetation map class information, NCPN developed a map class coding system. Photointerpreters tend to assign a unique number to each map class as a shorthand for labeling polygons. These numeric codes have been retained within the spatial database and map class guide (Appendix J). NCPN developed five-letter alphacode system for map classes to be used in all park vegetation mapping projects. Each alphacode begins with the first letter of the corresponding NVC Class (F = Forest, W = Woodland, S = Shrubland, H = Herbaceous, N = nonvascular, and C = Complex). The subsequent four letters generally abbreviate the map class name. For example, the Black Greasewood Shrubland Complex map class is represented by the alphacode "S-BLGR." For map classes representing coarser levels of the NVC, geologic exposures, and other non-vegetated features, generic names incorporating vegetation and landscape features were used. Geologic exposures were given the prefix G = geology and developed sites the prefix L = land cover/land use.

Photo interpretation and polygon labeling and attribution procedures were standardized for all park vegetation mapping projects (Evenden 2004). After a map class was assigned to each polygon, the polygon was assigned attributes to characterize vegetation structure (density, pattern, height; Table 9), land use and disturbance. All map polygons were assigned to a land cover / land use type (Anderson et al. 2002; Appendix H). In addition, all polygons were assigned to higher levels of the NVC hierarchy, with the exception of non-vegetated map classes, which were coded as 'unclassified' or 'unvegetated' in the NVC columns.

Table 9. Physiognomic attributes of polygons. In some cases, these attributes were assigned to individual polygons. Otherwise, they were assigned to an entire map class.

Category	Attribute	Description
Vegetation Canopy Density (Applied to forest, woodland, and shrub-dominated map classes)	A	Closed Tree Canopy/Continuous (> 60% cover)
	B	Open Tree Canopy/Discontinuous (25- 60% cover)
	C	Dispersed – Sparse Tree Canopy (10-25% cover)
	D	Dense Shrub Canopy (> 40% cover)
	E	Light Shrub Canopy (10 – 40% cover)
Vegetation Pattern (Applied to all vegetation map classes)	1	Clumped/Bunched
	2	Linear
	3	Gradational/Transitional
	4	Regularly Alternating
	5	Homogenous

Category	Attribute	Description
Vegetation Height (Applied to woody terrestrial vegetation map classes only)	F G H I J K L M	Forest and Woodlands > 30 meters tall Forest and Woodlands 15 – 30 meters Forest and Woodlands 5 – 15 meters Forest and Woodlands 1 – 5 meters Forest and Woodlands < 0.5 meters Shrublands 1 – 5 meters Shrublands 0.5 – 1 meters Shrublands 0 – 0.5 meters

NCPN photointerpretation standards (Evenden 2004) defined a suite of polygon modifiers to describe altered vegetation, landforms, transportation and utilities, and other situations. Table 10 is a list of the modifiers used in the ARCH project.

Table 10. Modifiers used to provide additional information for map polygons in the ARCH vegetation mapping project area.

Category	Code	Name	Description
Vegetation Modifiers	a	Altered	Applies when some alteration is present, but the type is visually indistinguishable from unaltered stands
	o	*Allenrolfea occidentalis*	Applies to polygons where *Allenrolfea* is documented to occur from a plot or AA point
	d	(Abandoned) Drill pad	Applies to small polygons where drill pads fill most if not the whole polygon (no active wells)
	h	*Hesperostipa comata*	Applies to polygons where *Hesperostipa comata* is documented to occur from a plot or AA point, and predicted to occur on identical habitats nearby
	i	Invasive	Applies to systems invaded or dominated by exotic plant species
	j	Juniper – pinyon understory	Applies to systems with a cottonwood woodland canopy and a juniper – (pinyon) sub canopy
	k	Sparse greasewood	Applies to greasewood shrublands with very low cover (<10%) on salt flat terraces
	m	Mesic herbaceous understory	Applies to systems with a cottonwood woodland canopy and a mesic herbaceous understory, generally dominated by rushes and sedges
	t	Juniper – pinyon overstory	Applies to shrubland systems where there is a sparse juniper – (pinyon) canopy (wooded shrublands) of generally <5% total tree cover
	x	Tamarisk over/understory	Applies to systems where there is invasion by tamarisk in the overstory or understory

Table 10. Modifiers used to provide additional information for map polygons in the ARCH vegetation mapping project area.

Category	Code	Name	Description
Transportation Modifiers	p	Paved road	A transportation corridor consisting of a roadbed topped by an asphalt or concrete surface. Right-of-way typically extends to the limit of the cut and fill slopes
	u	Gravel/dirt road	A transportation corridor consisting of a roadbed of imported gravel or graded native soil. Cut and fill slopes may or may not be present
	v	Railroad	A transportation corridor consisting of a roadbed of imported rock and gravel overlain by wooden ties and steel rails.
	w	Pipeline corridor	A conduit for water, sewage, hydrocarbons, etc., that is entrenched with a right-of-way, resulting in disturbed soil and subsoil in various stages of revegetation by native or exotic species. Older corridors may have been reseeded with exotic grass species.

Natural Resource Features of Special Interest

In the scoping phase of the project, park staff identified several natural resource features of interest that might otherwise not be noted by field crews while sampling at ARCH:

- Hanging gardens, springs, and seeps (record locations at a minimum)
- Grasslands being invaded by juniper (where juniper is probably less than 2% cover)
- Gypsiferous soils
- Terraces in drainages

These features were photographed and noted by field workers as encountered, but were not sampled or mapped unless they were associated with vegetation that was of interest (e.g., gypsiferous soils). Information describing the location of these features was provided directly to park staff and is not otherwise included in this report.

Mapping

The mapping component of the ARCH project used a combination of methods to interpret and delineate vegetation polygons. The project photointerpreter visually examined the 9 x 9-inch photographs in stereo to identify vegetation polygons. Polygons were drawn on Mylar overlays that were later scanned, or were drawn digitally on a computer screen. Digitizing was performed using vector editing in ArcGIS. Each vegetation and land use polygon so produced was given map class and other descriptive attributes. The park and the environs were interpreted and mapped to the same level of detail.

Spatial Database Development

Each polygon was assigned a map class number, alpha code and name, Anderson land use class,

and vegetation density, pattern, and height attributes. In order to improve the utility of the map and related data, the spatial database was moved into a geodatabase format, the general structure of which is illustrated in Figure 31. This format allows text and image information to be incorporated and linked to spatial coordinates. A more detailed description of the geodatabase and its component data fields appears in Appendix C.

Map Classes

The original set of mapping concepts developed for ARCH was based on the preliminary vegetation classification developed by NatureServe from 2003 plot data. The intent was to map individual associations, if possible, through photointerpretation or ecological modeling. In practice, the set of map classes was reduced throughout the mapping phase of the project, as the photointerpreter and project ecologists realized that some associations were difficult to recognize consistently on the imagery. These associations were combined into complex or mosaic map classes based on ecological and morphological similarity. Changes to the map classes made following the 2005 accuracy assessment are discussed in a later section of this report.

NCPN ecologists made final adjustments to the ARCH vegetation map in December, 2008 to make it more accurate and consistent with the CANY vegetation map. Changes made at this time included (1) correcting errors in polygon delineation (deleting and/or adding new lines), (2) assigning a new map class to polygons when the map class concept had changed, and (3) adding polygons to represent four new map classes based on plot and AA field data and observations by the project photointerpreter.

The final map legend for ARCH consists of forty-five map classes (Table 11). Of these, 31 are vegetation map classes, 12 are land-use map classes, and two are geologic map classes. Of the 31 vegetation map classes, one is represented by points only and five represent single NVC plant associations. The remaining 25 vegetation map classes represent polygons delineating multiple plant associations.

Ecological systems (Comer et al. 2003) are used to organize the vegetation map classes (see discussion in the Project Overview section and Appendix A). They were developed by NatureServe to complement the NVC by creating a mappable classification unit representing groups of biologic communities in similar environments and shaped by similar ecologic processes. Ecological systems typically occur in patches of tens to thousands of hectares and are expected to persist for 50 or more years. The timeframe allows successional dynamics to be integrated into the concept of each ecological system.

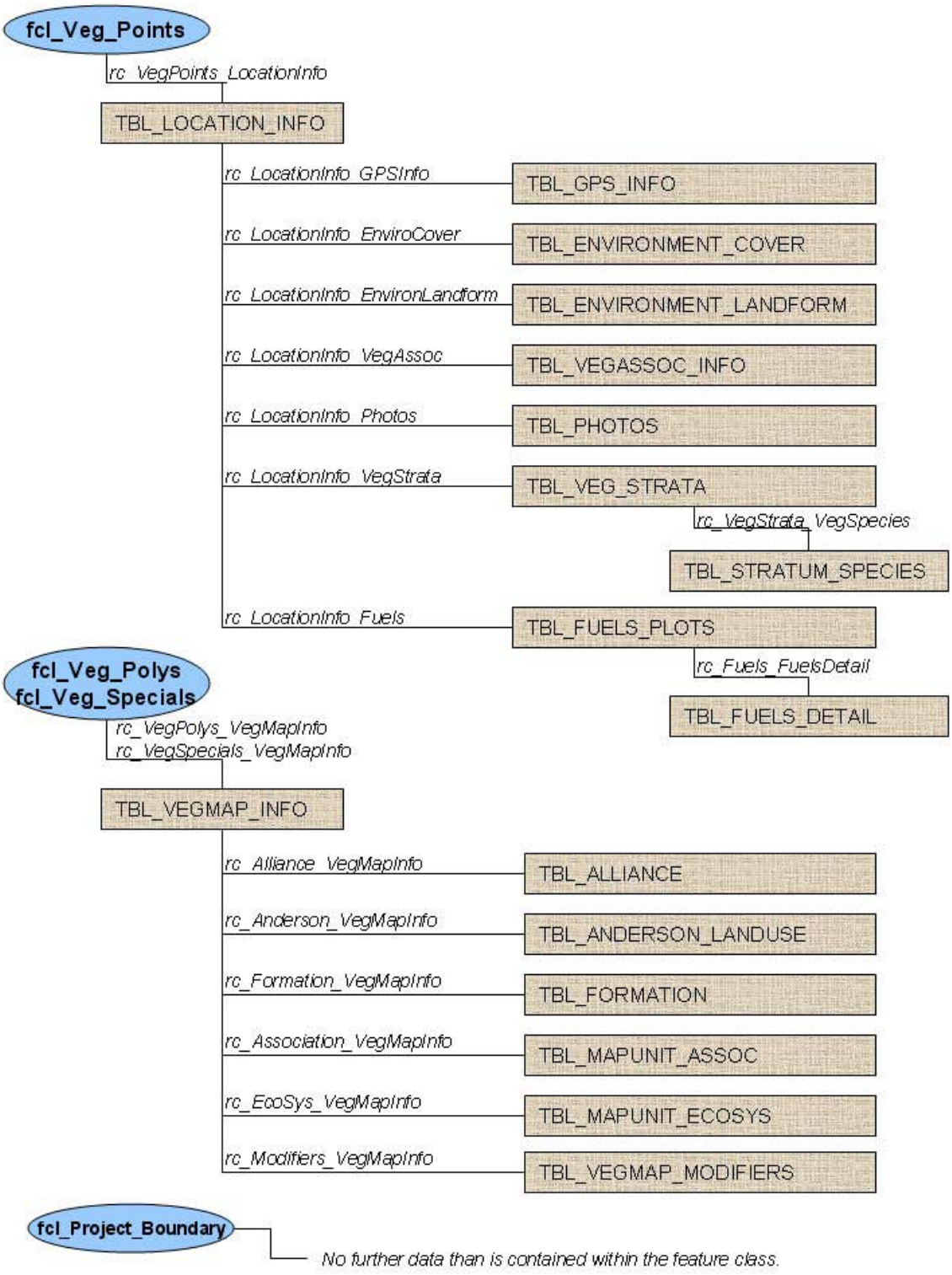


Figure 31. Structure of the ARCH geodatabase**.**

Results

Table 11 shows the relationship of vegetation map classes to ecological systems, ordered roughly by physiognomy: upland forests, woodlands, shrublands, grasslands, riparian communities. Appendix A provides summary descriptions of each ecological system. The geologic and Anderson land use map classes could not be placed within the ecological system classification.

Table 11. Map classes used in the final (post-AA) ARCH vegetation map, with map class number, code and name, crosswalk to NVC association, and the relationship of map class to plant associations. ARCH vegetation map classes are arranged using the NatureServe ecological systems classification.

Map Class #	Map Class Code	Map Class Name	Description or Associations Assigned to Map Class	Relation
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)				
20	W-PJBB	Pinyon - Juniper / Blackbrush Woodlands	Juniperus osteosperma / Coleogyne ramosissima Woodland Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima Woodland	1 : many
Multiple Ecological Systems: Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765) Colorado Plateau Pinyon-Juniper Woodland (CES304.767)				
25	W-PJSD	Sand Dune Woodlands	Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii Wooded Shrubland Juniperus osteosperma / Sparse Understory Woodland Pinus edulis - Juniperus osteosperma / Quercus havardii var. tuckeri Woodland	1 : many
30	C-TALS	Talus Sparse Vegetation Complex	Artemisia bigelovii - Ephedra (torreyana, viridis) Talus Shrubland Fendlera rupicola Talus Shrubland Juniperus osteosperma / Mixed Shrubs Talus Woodland Pinus edulis - Juniperus osteosperma / Mixed Shrubs Talus Woodland Rhus trilobata - Ephedra (viridis, torreyana) Talus Shrubland	1 : many
31	W-MTSW	Moab Tongue Slickrock Woodlands	Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii Wooded Shrubland Juniperus osteosperma / Cercocarpus intricatus Woodland Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus Woodland Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland	1 : many
32	W-PJSW	Pothole and Jointed Sandstone Woodlands	Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii Wooded Shrubland Juniperus osteosperma / Cercocarpus intricatus Woodland Juniperus osteosperma / Sparse Understory Woodland Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus Woodland Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland	1 : many
33	W-LEDG	Sandstone Ledges Woodlands	Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii Wooded Shrubland Juniperus osteosperma / Purshia stansburiana Woodland [Park Special] Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima Woodland Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland Pinus edulis - Juniperus spp. / Cercocarpus montanus - Mixed Shrub Woodland	1 : many

Table 11. Map classes used in the final (post-AA) ARCH vegetation map, with map class number, code and name, crosswalk to NVC association, and the relationship of map class to plant associations. ARCH vegetation map classes are arranged using the NatureServe ecological systems classification.

Map Class #	Map Class Code	Map Class Name	Description or Associations Assigned to Map Class	Relation
341	C-FINS	Entrada Fin / Swale Woodland Mosaic	Pinus edulis - Juniperus osteosperma / Quercus havardii var. tuckeri Woodland Pinus edulis - Juniperus spp. / Cercocarpus montanus - Mixed Shrub Woodland Slickrock Fin Pocket [Park Special]	1 : many
Multiple Ecological Systems: Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765) Colorado Plateau Pinyon-Juniper Woodland (CES304.767) Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)				
7	W-PJIF	Pinyon - Juniper Intermittently Flooded Woodlands	Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii Wooded Shrubland Juniperus osteosperma / Artemisia tridentata ssp. tridentata Woodland Pinus edulis - Juniperus osteosperma / Quercus havardii var. tuckeri Woodland Rhus trilobata Intermittently Flooded Shrubland	1 : many
Multiple Ecological Systems: Colorado Plateau Pinyon-Juniper Woodland (CES304.767) Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)				
97	C-ALCO	Cliff and Alcove Complex	Pinus edulis - Juniperus spp. / Quercus gambelii Woodland Quercus gambelii / Sparse Understory Shrubland	1 : many
Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)				
4	S-GOTS	Gambel Oak Terrace Shrubland	Quercus gambelii / Sparse Understory Shrubland	1 : 1
Multiple Ecological Systems: Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777) Inter-Mountain Basins Greasewood Flat (CES304.780)				
8	S-ARTR	Basin Big Sagebrush Terrace Shrublands	Artemisia tridentata - (Ericameria nauseosa) / Bromus tectorum Semi-natural Shrubland Sarcobatus vermiculatus / Artemisia tridentata Shrubland	1 : many
Multiple Ecological Systems: Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) Inter-Mountain Basins Active and Stabilized Dune (CES304.775) Inter-Mountain Basins Wash (CES304.781)				
90	S-WASH	Dry Wash Shrublands	Coleogyne ramosissima - Purshia stansburiana - Quercus havardii Shrubland Ericameria nauseosa Desert Wash Shrubland Quercus havardii var. tuckeri Shrubland	1 : many
Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788)				
71	S-WINT	Winterfat Shrublands	Krascheninnikovia lanata / Pleuraphis jamesii Dwarf-shrubland Krascheninnikovia lanata Dwarf-shrubland Alliance	1 : many

Table 11. Map classes used in the final (post-AA) ARCH vegetation map, with map class number, code and name, crosswalk to NVC association, and the relationship of map class to plant associations. ARCH vegetation map classes are arranged using the NatureServe ecological systems classification.

Map Class #	Map Class Code	Map Class Name	Description or Associations Assigned to Map Class	Relation
Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763)				
10	S-BLAC	Blackbrush Shrublands	Coleogyne ramosissima Shrubland Grayia spinosa Shrubland	1 : 1
11	S-SAND	Sandsheet Shrublands	Artemisia filifolia Colorado Plateau Shrubland Coleogyne ramosissima - Purshia stansburiana - Quercus havardii Shrubland Coleogyne ramosissima Shrubland Ephedra viridis / (Achnatherum hymenoides - Hesperostipa comata) Shrubland	1 : many
Inter-Mountain Basins Active and Stabilized Dune (CES304.775)				
13	S-DUNE	Dune Complex	Artemisia filifolia Colorado Plateau Shrubland Poliomintha incana - Artemisia filifolia - Vanclevea stylosa Shrubland Quercus havardii var. tuckeri Shrubland	1 : many
Multiple Ecological Systems: Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) Inter-Mountain Basins Semi-Desert Grassland (CES304.787)				
14	C-EVGR	Mormon Tea - Mixed Grass Shrublands	Achnatherum hymenoides Colorado Plateau Herbaceous Vegetation Ephedra viridis / (Achnatherum hymenoides - Hesperostipa comata) Shrubland Ephedra viridis / Pleuraphis jamesii Shrubland Pleuraphis jamesii Herbaceous Vegetation	1 : many
Multiple Ecological Systems: Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784) Inter-Mountain Basins Shale Badland (CES304.789)				
15	S-SBDS		Atriplex confertifolia - Picrothamnus desertorum Shrubland Atriplex confertifolia - Sarcobatus vermiculatus Shrubland Atriplex confertifolia / Pleuraphis jamesii Shrubland Atriplex confertifolia / Sporobolus cryptandrus Shrubland [Provisional] Atriplex spp. Desert Pavement Sparse Vegetation Coleogyne ramosissima Shrubland Ephedra torreyana / Achnatherum hymenoides - Pleuraphis jamesii Shrubland Ephedra torreyana / Pleuraphis jamesii Shrubland Ephedra torreyana Sparse Vegetation	1 : many
Multiple Ecological Systems: Inter-Mountain Basins Active and Stabilized Dune (CES304.775) Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784) Inter-Mountain Basins Semi-Desert Grassland (CES304.787) Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788)				
18	C-TERR	High Terrace Shrub Herbaceous Complex	Artemisia filifolia Colorado Plateau Shrubland Atriplex canescens / Sporobolus airoides Shrubland Atriplex canescens Shrubland Chrysothamnus viscidiflorus Shrubland Alliance Hesperostipa comata Great Basin Herbaceous Vegetation Pleuraphis jamesii - Sporobolus airoides Herbaceous Vegetation	1 : many

Table 11. Map classes used in the final (post-AA) ARCH vegetation map, with map class number, code and name, crosswalk to NVC association, and the relationship of map class to plant associations. ARCH vegetation map classes are arranged using the NatureServe ecological systems classification.

Map Class #	Map Class Code	Map Class Name	Description or Associations Assigned to Map Class	Relation
Multiple Ecological Systems: Inter-Mountain Basins Greasewood Flat (CES304.780) Inter-Mountain Basins Playa (CES304.786)				
6	S-SAVE	Greasewood Flats	Allenrolfea occidentalis Shrubland Sarcobatus vermiculatus / Sporobolus airoides Sparse Vegetation Suaeda moquinii Shrubland	1 : many
Inter-Mountain Basins Shale Badland (CES304.789)				
5	S-BADS	Badlands Sparse Vegetation	Atriplex gardneri / Pleuraphis jamesii Dwarf-shrubland Atriplex gardneri Dwarf-shrubland Eriogonum corymbosum Badlands Sparse Vegetation Zuckia brandegeei Sparse Vegetation	1 : many
26	S-MATS	Mat Saltbush Sparse Vegetation	Atriplex corrugata Dwarf-shrubland Atriplex gardneri Dwarf-shrubland	1 : many
27	H-LESA	Salina Lyme Grass Sparse Vegetation	Leymus salinus Shale Sparse Vegetation	1 : 1
Multiple Ecological Systems: Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) Inter-Mountain Basins Shale Badland (CES304.789)				
35	S-GYPS	Gypsum Badlands Sparse Vegetation	Ephedra torreyana / Pleuraphis jamesii Shrubland Ephedra torreyana - (Atriplex spp.) / Nonvascular Gypsum Sparse Vegetation	1 : many
Inter-Mountain Basins Semi-Desert Grassland (CES304.787)				
17	H-WEED	Weedy Herbaceous Vegetation	Bromus tectorum Semi-natural Herbaceous Vegetation Pleuraphis jamesii Herbaceous Vegetation Sphaeralcea (coccinea, parvifolia) Herbaceous Vegetation Sporobolus cryptandrus Great Basin Herbaceous Vegetation	1 : many
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)				
1	S-TARC	Tamarisk River Corridor Shrublands	Tamarix spp. Temporarily Flooded Shrubland	1 : 1
2	S-RSSW	Riverine Sandbar Sparse Willow Shrublands	Salix exigua / Barren Shrubland	1 : 1
93	W-POFR	Tributary Woodland Complex	Elaeagnus angustifolia Semi-natural Woodland Populus fremontii / Artemisia tridentata Woodland Populus fremontii / Equisetum spp. Woodland Populus fremontii / Ericameria nauseosa Woodland Populus fremontii / Salix exigua Forest Salix goodingii / Salix exigua Woodland Sporobolus airoides Southern Plains Herbaceous Vegetation	1 : many
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)				

Table 11. Map classes used in the final (post-AA) ARCH vegetation map, with map class number, code and name, crosswalk to NVC association, and the relationship of map class to plant associations. ARCH vegetation map classes are arranged using the NatureServe ecological systems classification.

Map Class #	Map Class Code	Map Class Name	Description or Associations Assigned to Map Class	Relation
9	S-TTSS	Tributary Tamarisk / Salix Shrubland Mosaic	Salix exigua / Barren Shrubland Salix ligulifolia Shrubland Tamarix spp. Temporarily Flooded Shrubland	1 : many
North American Arid West Emergent Marsh (CES300.729)				
92	H-TMHC	Tributary Mesic Herbaceous Complex	Schoenoplectus pungens Herbaceous Vegetation Typha (latifolia, angustifolia) Western Herbaceous Vegetation	1 : many
Colorado Plateau Hanging Garden (CES304.764)				
100	H-HANG	Hanging Gardens	Aquilegia micrantha - Mimulus eastwoodiae Herbaceous Vegetation	1 : 1
Non-Vegetated and Anderson Land Use Map Classes:				
111	L-RIVE	Colorado River	Water within the channel of the Colorado River	N/A
114	L-RESV	Pond (artificial)		N/A
130	G-ENTR	Entrada Sandstone	Unvegetated slickrock outcrops	N/A
136	G-WING	Wingate sandstone	Cliffs and sparsely vegetated ledges	N/A
210	L-RESI	Residential	Residential areas within the town of Moab	N/A
222	L-SERV	Minor Retail and Services	Gas stations, restaurants, waterpark	N/A
223	L-FACI	Government building	Buildings associated with the administration of ARCH: Visitor Center, other office buildings	N/A
224	L-INDU	Light industry	Secondary buildings associated with a mining/quarry site	N/A
226	L-CORR	Transportation corridors	Highways, paved park roads, major (graded) dirt roads, railroad, pipeline right of way.	N/A
227	L-RVPK	Urban RV park	Recreational vehicle camping facility on the edge of Moab	N/A
310	L-TRAN	Transitional	Bare areas mostly near roads and developments	N/A
320	L-TAIL	Tailings pile	Uranium tailings pile under UMTRA administration	N/A
330	L-BARE	Bare ground	Unvegetated dirt, usually associated with developed facilities	N/A
422	L-CROP	Planted fields	Cultivated fields and hay meadows	N/A

Map Class Descriptions

Appendix J provides detailed descriptions of all vegetation map classes used in the final version of the ARCH vegetation mapping project. Each map class description includes:

- a summary of the ecological concept of the map class. Reference is made to the

abundance and distribution of the map class within the park as well as the entire project area

- a list of plant associations and common plant species occurring within the map class
- a qualitative description of the photographic signature along with representative samples from the orthophotography
- ground photographs
- statistics and accuracy assessment results

Map Polygons

The ARCH vegetation map consists of 7,124 polygons totaling 52,556 ha (129,868 acres). Average polygon size is 7.4 ha (18.2 acres). Lands within the park make up 30,977 ha (76,545 acres) or 58.9% of the total project area. Of the total, 6,709 polygons (94.2%) represent natural or semi-natural vegetation map classes covering 95.6% of the mapping project area. Map classes representing non-vegetated rock outcrops and developed areas account for the remaining 415 polygons (5.8% of polygons and 4.4% of the area).

The polygon count includes adjacent polygons that have the same map code but different density or pattern attributes. The most common map class is Blackbrush Shrublands (S-BLAC) with 1,457 polygons covering 17.3% of the mapping area. The largest average polygon size belongs to Entrada Fin / Swale Woodland Mosaic (C-FINS) at 29.8 ha (73.5 acres) per polygon.

Hanging gardens at ARCH occupy vertical sites on cliff faces or alcoves under cliff overhangs and are generally not visible on aerial imagery. All stands of this community within the park are also much smaller than the 0.5 ha MMU. This vegetation type was therefore mapped as a point layer based on field observations.

Figure 32 is an example of a map of the vegetation of ARCH created from the GIS spatial database. Because we used a geodatabase format to store and organize spatial information, there are far more data in the spatial database than can be conveyed in a two-dimensional map. Maps can be produced with vegetation polygons labeled in many different ways at different levels of resolution. Table 12 provides summary statistics for ARCH vegetation map polygons.

Table 12. Summary statistics for polygons of each map class developed for the ARCH vegetation mapping project.

Map Code	Map Class Common Name	Polygons			Area (hectares)		
		Park	Environs	Total Area*	Park	Environs	Total Area
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)							
W-PJBB	Pinyon - Juniper / Blackbrush Woodlands	78	43	121	500.2	329.2	829.4
	Subtotal	*78*	*43*	*121*	*500.2*	*329.2*	*829.4*
Multiple Ecological Systems: Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765) Colorado Plateau Pinyon-Juniper Woodland (CES304.767)							
W-PJSD	Sand Dune Woodlands	512	197	709	2,091.9	645.4	2,737.3
C-TALS	Talus Sparse Vegetation Complex	157	120	277	1,385.2	1,876.5	3,261.7
W-MTSW	Moab Tongue Slickrock Woodlands	160	87	247	4,395.6	2,090.1	6,485.7
W-PJSW	Pothole and Jointed Sandstone Woodlands	263	130	393	3,776.4	1,897.9	5,674.3
W-LEDG	Sandstone Ledges Woodlands	226	271	497	3,056.0	2,950.3	6,006.3
C-FINS	Entrada Fin / Swale Woodland Mosaic	27	0	27	803.3	0	803.3
	Subtotal	*1,345*	*805*	*2,150*	*15,508.4*	*9,460.2*	*24,968.6*
Multiple Ecological Systems: Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765) Colorado Plateau Pinyon-Juniper Woodland (CES304.767) Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)							
W-PJIF	Pinyon - Juniper Intermittently Flooded Woodlands	384	159	543	461.4	205.6	667.0
	Subtotal	*384*	*159*	*546*	*461.4*	*205.6*	*667*
Multiple Ecological Systems: Colorado Plateau Pinyon-Juniper Woodland (CES304.767) Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)							
C-ALCO	Cliff and Alcove Complex	135	56	191	86.8	29.4	116.1

Table 12. Summary statistics for polygons of each map class developed for the ARCH vegetation mapping project.

Map Code	Map Class Common Name	Polygons			Area (hectares)		
		Park	Environs	Total Area*	Park	Environs	Total Area
	Subtotal	*135*	*56*	*191*	*86.8*	*29.4*	*116.1*
Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)							
S-GOTS	Gambel Oak Terrace Shrubland	9	12	21	5.4	5.3	10.7
	Subtotal	*9*	*12*	*21*	*5.4*	*5.3*	*10.7*
Multiple Ecological Systems: Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777) Inter-Mountain Basins Greasewood Flat (CES304.780)							
S-ARTR	Basin Big Sagebrush Terrace Shrublands	143	23	166	145.1	53.4	198.5
	Subtotal	*143*	*23*	*166*	*145.1*	*53.4*	*198.5*
Multiple Ecological Systems: Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) Inter-Mountain Basins Active and Stabilized Dune (CES304.775) Inter-Mountain Basins Wash (CES304.781)							
S-WASH	Dry Wash Shrublands	29	24	53	91.2	83.5	174.7
	Subtotal	*29*	*24*	*53*	*91.2*	*83.5*	*174.7*
Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788)							
S-WINT	Winterfat Shrublands	23	1	24	335.1	2.4	337.6
	Subtotal	*23*	*1*	*24*	*335.1*	*2.4*	*337.6*
Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763)							
S-BLAC	Blackbrush Shrublands	993	464	1457	5,988.6	3,085.1	9,073.6
S-SAND	Sandsheet Shrublands	251	73	324	1,023.3	352.7	1,375.9
	Subtotal	*1244*	*537*	*1781*	*7,011.9*	*3,437.8*	*10,449.5*

Table 12. Summary statistics for polygons of each map class developed for the ARCH vegetation mapping project.

Map Code	Map Class Common Name	Polygons			Area (hectares)		
		Park	Environs	Total Area*	Park	Environs	Total Area
Inter-Mountain Basins Active and Stabilized Dune (CES304.775)							
S-DUNE	Dune Complex	54	18	72	131.3	54.8	186.2
	Subtotal	*54*	*18*	*72*	*131.3*	*54.8*	*186.2*
Multiple Ecological Systems: Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) Inter-Mountain Basins Semi-Desert Grassland (CES304.787)							
C-EVGR	Mormon Tea - Mixed Grass Shrublands	109	46	155	1,277.6	285.9	1,563.4
	Subtotal	*109*	*46*	*155*	*1,277.6*	*285.9*	*1,563.4*
Multiple Ecological Systems: Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784) Inter-Mountain Basins Shale Badland (CES304.789)							
S-SBDS	Shale Barrens Desert Scrub	197	190	387	1,217.2	2,985.1	4,202.3
	Subtotal	*197*	*190*	*387*	*1,217.2*	*2,985.1*	*4,202.3*
Multiple Ecological Systems: Inter-Mountain Basins Active and Stabilized Dune (CES304.775) Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784) Inter-Mountain Basins Semi-Desert Grassland (CES304.787) Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788)							
C-TERR	High Terrace Shrub Herbaceous Complex	183	61	244	722.1	207.7	929.8
	Subtotal	*183*	*61*	*244*	*722.1*	*207.7*	*929.8*
Multiple Ecological Systems: Inter-Mountain Basins Greasewood Flat (CES304.780) Inter-Mountain Basins Playa (CES304.786)							
S-SAVE	Greasewood Flats	138	79	217	456.8	515.2	972.0
	Subtotal	*139*	*79*	*217*	*456.8*	*515.2*	*972*

Table 12. Summary statistics for polygons of each map class developed for the ARCH vegetation mapping project.

Map Code	Map Class Common Name	Polygons			Area (hectares)		
		Park	Environs	Total Area*	Park	Environs	Total Area
Inter-Mountain Basins Shale Badland (CES304.789)							
C-BADS	Badlands Sparse Vegetation	16	19	35	134.2	594.4	728.6
C-MATS	Mat Saltbush Sparse Vegetation	24	0	24	27.1	0	27.1
H-LESA	Salina Lyme Grass Sparse Vegetation	15	32	47	34.2	155.5	189.7
	Subtotal	*55*	*51*	*106*	*195.5*	*749.9*	*945.4*
Multiple Ecological Systems: Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) Inter-Mountain Basins Shale Badland (CES304.789)							
S-GYPS	Gypsum Badlands Sparse Vegetation	20	0	20	163.5	0	163.5
	Subtotal	*20*	*0*	*20*	*163.5*	*0*	*163.5*
Inter-Mountain Basins Semi-Desert Grassland (CES304.787)							
H-WEED	Weedy Herbaceous Vegetation	71	94	165	908.5	1,831.2	2,739.7
	Subtotal	*71*	*94*	*165*	*908.5*	*1,831.2*	*2,739.7*
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)							
S-TARC	Tamarisk River Corridor Shrublands	14	81	95	34.4	135.8	170.2
S-RSSW	Riverine Sandbar Sparse Willow Shrublands	15	36	51	6.5	19.9	26.4
W-POFR	Tributary Woodland Complex	74	17	91	284.0	39.8	323.8
	Subtotal	*103*	*134*	*237*	*324.9*	*195.5*	*520.4*
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)							
S-TTSS	Tributary Tamarisk / Salix Shrubland Mosaic	32	22	54	129.7	138.3	268.0
	Subtotal	*32*	*22*	*54*	*129.7*	*138.3*	*268*
North American Arid West Emergent Marsh (CES300.729)							

Table 12. Summary statistics for polygons of each map class developed for the ARCH vegetation mapping project.

Map Code	Map Class Common Name	Polygons			Area (hectares)		
		Park	Environs	Total Area*	Park	Environs	Total Area
H-TMHC	Tributary Mesic Herbaceous Complex	2	0	2	8.5	0	8.5
	Subtotal	*2*	*0*	*2*	*8.5*	*0*	*8.5*
Mapped Using Points, Not Polygons: Colorado Plateau Hanging Garden (CES304.764)							
H-HANG	Hanging Gardens	N/A	N/A	N/A	N/A	N/A	N/A
	Subtotal	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
UNVEGETATED AND ANDERSON LAND USE MAP CLASSES							
L-RIVE	Colorado River	75	2	77	8.3	181.3	189.7
L-RESV	Pond / Reservoir (artificial)	0	4	4	0	1.6	1.6
G-ENTR	Entrada Sandstone	139	48	187	1,060.3	21.7	1,082.0
G-WING	Wingate Sandstone	8	27	35	57.4	154.7	212.1
L-RESI	Residential	2	4	6	0.6	1.1	1.6
L-SERV	Minor Retail and Services	0	4	4	0	2.5	2.5
L-FACI	Government Building	5	0	5	1.3	0	1.3
L-INDU	Light Industry	0	2	2	0	2.3	2.3
L-CORR	Transportation Corridors	19	47	66	167.8	358.3	526.0
L-RVPK	Campground / Urban Park	0	7	7	0	18.1	18.1
L-TRAN	Transitional	0	16	16	0	89.6	89.6
L-TAIL	Tailings Pile	0	1	1	0	115.6	115.6
L-BARE	Bare Ground	0	3	3	0	10.2	10.2
L-CROP	Planted Fields	0	2	2	0	51.7	51.7
	Subtotal	*248*	*167*	*415*	*1,295.7*	*1008.7*	*2,304.3*

Table 12. Summary statistics for polygons of each map class developed for the ARCH vegetation mapping project.

Map Code	Map Class Common Name	Polygons			Area (hectares)		
		Park	Environs	Total Area*	Park	Environs	Total Area
	Total All Map Classes	**4,602**	**2,522**	**7,124**	**30,977**	**21,579**	**52,556**

* Note: Total polygon area may be less in the full mapping project area because of cumulative rounding error.

Discussion

Mapping the parks of the Colorado Plateau, including ARCH, is made more challenging by the sheer cliffs that are a common feature of the Plateau. The cliffs make field access difficult, confound the generation of slope and aspect data, and create problematic shadows on the aerial and orthophotography. The mapping process, although largely successful, revealed opportunities for improvement, which are discussed below.

Things that worked well: Field data and local descriptions of the associations provided by project ecologists were extremely important ancillary data sources used by the cartographers to delineate map classes. High-quality plot and observation point data, as well as thorough local descriptions helped provide information for direct image interpretation. ARCH had a very high density of vegetation plots, higher than any other medium to large park in the NCPN. Additional data collected by the project photo interpreter on field reconnaissance trips provided a stronger basis for conducting the interpretation and mapping.

Quality base data is essential to high quality scientific work. For the vegetation mapping at ARCH, high quality orthophotography allowed for both confident manual interpretation and a solid source for deriving physiognomic classes and vegetation density. The geologic data was detailed and had high horizontal spatial accuracy, both of which are important in GIS applications.

Areas for Improvement: The mapping concepts used at ARCH were based primarily on substrate, and secondarily vegetative similarity. This created cross-walking problems with the vegetation classification that carried through the entire project and were never completely resolved. One major issue was that most of the initial map classes were complexes of several different physiognomic types (i.e., woodlands and shrublands, or shrubland and herbaceous communities). This problem was resolved in most cases by defining additional map classes to separate the clearly distinct physiognomic types within each complex.

The more serious issue was that some of the common associations were assigned to as many as seven different map classes, creating a great deal of overlap among those map classes. For example, the four major slickrock units at ARCH (Entrada Sandstone, Moab Tongue, Kayenta Formation, and Navajo Sandstone), have distinct joint and weathering patterns leading to differences in vegetation density and distribution. However, the associations growing on all four rock types are essentially the same. The method of mapping employed at ARCH makes the vegetation appear more diverse than it really is by in effect multiplying the numbers of mappable associations by the number of bedrock units.

One way to resolve this issue and bring the ARCH map into better congruence with other NCPN vegetation maps would have been to attempt to map the associations growing on these four slickrock units into a few ecologically meaningful and floristically consistent map classes (e.g., Pinyon-Juniper / Mixed Tall Shrub Woodland, Pinyon-Juniper / Mesic Tall Shrub Woodland, and Pinyon-Juniper / Blackbrush Shrubland), with a modifier added to indicate the particular slickrock substrate. However, this would have entailed re-mapping a significant portion (more than half) of the park and completely invalidating the accuracy assessment, so it was not attempted.

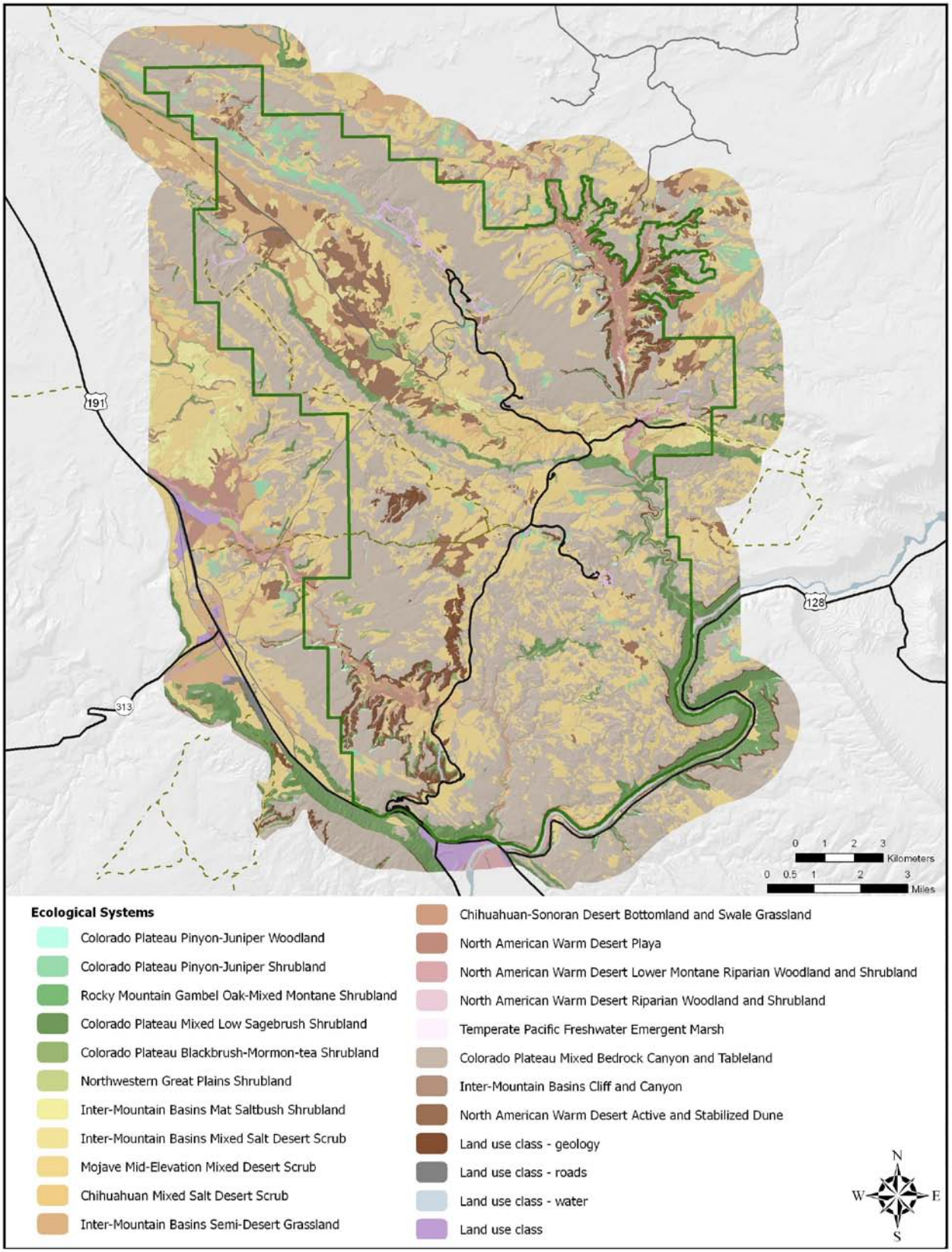


Figure 32. The ARCH vegetation map based on ecological system groups of map classes.

Accuracy Assessment

Methods

Introduction

Accuracy assessment (AA) is a statistical test of how well polygon map class attributes represent vegetation on the ground. The AA compares field observations with the map class assignment of the sampled polygon. Errors occur when mapped polygon labels differ from field observations. Results of the AA allow users to evaluate the utility of the vegetation mapping data for particular applications. Accuracy assessment results come in two forms (Hop et al. 2005): "producer's accuracy" (the probability that an AA point was mapped correctly, also referred to as "errors of omission"), and "user's accuracy" (the probability that the map represents what was found on the ground, also referred to as "errors of commission"). High producer's accuracy combined with low user's accuracy indicates that the map class is under-mapped. Conversely, low producer's accuracy combined with high user's accuracy indicates that a type is over-mapped. Ideally, a map has both high user's and producer's accuracy.

Sampling Design

A stratified random sampling approach was used to determine AA sampling locations. The AA included most vegetation map classes and was limited to lands within the ARCH boundary; private and federal outside of the Park were not included in the accuracy evaluation. Sample sizes for each evaluated map class were selected using the USGS-NPS Vegetation Mapping Program guidelines (ESRI and TNC 1994):

Scenario A: The class is abundant. It covers more than 50 ha (124 acres) and consists of at least 30 polygons. The recommended sample size is 30.

Scenario B: The class is relatively abundant. It covers more than 50 ha, but consists of fewer than 30 polygons. The recommended sample size is 20. The rationale for reducing the sample size for this type of class is that sample sites are more difficult to find because of the lower frequency of the class.

Scenario C: The class is relatively rare. It covers less than 50 ha but consists of more than 30 polygons. The recommended sample size is 20. The rationale for reducing the sample size is that the class occupies a small area. At the same time, however, the class consists of a considerable number of distinct polygons that are possibly widely distributed. The number of samples therefore remains relatively high because of the high frequency of the class.

Scenario D: The class is rare. It has more than five but fewer than 30 polygons and covers less than 50 ha. The recommended number of samples is five. The rationale for reducing the sample size is that the class consists of small polygons and the frequency of the polygons is low. Specifying more than five sample sites will likely result in multiple samples within the same (small) polygon. Collecting five samples will allow accuracy to be estimated, although the estimate will not be very precise.

Scenario E: The class is very rare. It has fewer than five polygons and occupies less than 50 ha. In this case, it is recommended that the existence of the class be confirmed by a visit to each polygon. The rationale for the recommendation is that with fewer than five sample sites (assuming one site per polygon), no estimate of level of confidence can be established for the sample and the accuracy of the class can only be confirmed through a field census.

All but two of the original vegetated map classes were included in the accuracy assessment. One of the excluded map classes (H-HANG) represents hanging gardens and was not interpreted because it occurs on near-vertical cliff faces or beneath cliff overhangs that are invisible on the aerial imagery. Instead, this type is documented by point data derived from the plots database and from field observations marked on copies of the aerial imagery. The other map class (Cliff and Alcove Complex) was excluded because the areas available for sampling after dangerously steep slopes were eliminated were too small to sample. Fourteen land-use and geologic map classes (L-XXXX, G-XXXX) were excluded because they are essentially unvegetated or occur exclusively outside of the park boundary.

Accuracy assessment sampling points were selected for each vegetation map class using guidelines A–E. The primary set of AA evaluation sites included 797 points. Secondary and tertiary sets of points were generated in case some of the points in the primary set could not be accessed safely. A 12.5 m interior buffer from polygon edges was generated for the map coverage to help ensure that 0.5 ha sampling points would fall cleanly within the polygon. The 12.5 m buffer worked in most situations; however, for small or linear polygons the buffer was reduced or eliminated. Sheer cliffs and steep talus were excluded from the AA point selection pool due to poor or dangerous access. Location (UTM) coordinates for all AA points were downloaded to GPS units for field sampling.

Field Data Collection

Accuracy assessment point data were collected at ARCH during the 2006 field season. Field crews used GPS receivers and topographic maps to navigate precisely to each pre-selected AA point. They used paper maps of the sample point locations and polygon boundaries (without polygon labels) on an orthoimage base to help locate and determine the representativeness of each AA point. The crews evaluated an area approximately 5,000 m^2 centered on the AA point coordinates (Appendix B). Environmental data collected in the field included elevation, slope, aspect, topographic position, landform, unvegetated surface elements, and descriptive comments. Vegetation data included leaf type and physiognomic class, as well as height and canopy cover for the dominant species in each stratum. The illustrated field key was used to identify the plant association that best described the vegetation in the plot. In most cases, only one plant association name was recorded. When vegetation relationships were less clear, a secondary or tertiary plant association name was also recorded. Plant associations occurring within 50 m of the AA point boundary were recorded if they differed from the plant association within the sampling area. One or more 35 mm color slides were taken at each AA point to provide visual documentation of the site.

The field team collected data at 792 AA points (Figure 33). AA point data were manually entered into the plots database and a thorough quality assessment/quality check (QA/QC) was performed on the data prior to analysis. Nomenclature standards and other data management

procedures were the same as for the classification plot data (see Vegetation Classification and Description section). Photographic slides were converted to digital format and catalogued in the same database as the classification plot photographs.

Data Analysis

All but 16 of the 792 AA data points collected in 2006 were used in the data analysis. These 16 points were excluded from AA data analysis because they fell in unvegetated polygons (e.g., in a gravel dump, the middle of a road, or on barren slickrock domes). The field data were converted into a spatial data layer with coordinates and attributes. The first step in the AA analysis intersected the AA point data with the map polygon data. The primary, secondary and tertiary plant association names, and, if listed, the association name within 50 m, assigned in the field to each AA point were compared to the map class code for that polygon. If any of these names agreed with the labeled map class for a given polygon, the point was considered correct. All other points were considered mismatches and marked incorrect.

The results of the initial analysis were arrayed in a preliminary contingency table in which producer's and user's accuracy were calculated for each map class. Producer's accuracy is computed by dividing the number of samples that agreed with their corresponding map class by the total number of samples in that class. User's accuracy was calculated by dividing the number of samples that agreed with their corresponding map class by the total number of samples whose field call belonged to that category.

The primary photointerpreter and project ecologists met to analyze the map errors revealed in the preliminary contingency table. Each AA point mismatch (disagreement between field call and polygon label) was evaluated for the type of error (true or false). Sources of "false" error include GPS position error, questionable field determinations, edge error, and inclusions (small patches of vegetation within larger map polygons). Mismatches were corrected when a false error was identified. All other mismatches were deemed true errors. Patterns of error were analyzed and possible solutions for raising map class accuracy formulated (Appendix I).

In November, 2006, a meeting was held among the Park staff and project cooperators to complete the AA process. Participants discussed the alternative solutions developed during the analysis, and decided on the best solution for the purposes of natural resource management. In some cases, meeting participants recommended combining certain map classes to achieve higher levels of accuracy and more meaningful vegetation map classes. In other cases, the group recommended retaining map classes with lower accuracy, discussed below. A final contingency table was produced by project cartographers (Table 13). The spatial database was revised to reflect the final combinations of map classes. The original set of 32 vegetated map classes was reduced to 27 by consensus among project participants. In December, 2008, four map classes were added to the map (Appendix I and Table 17) in order to increase congruity between the ARCH and CANY vegetation maps.

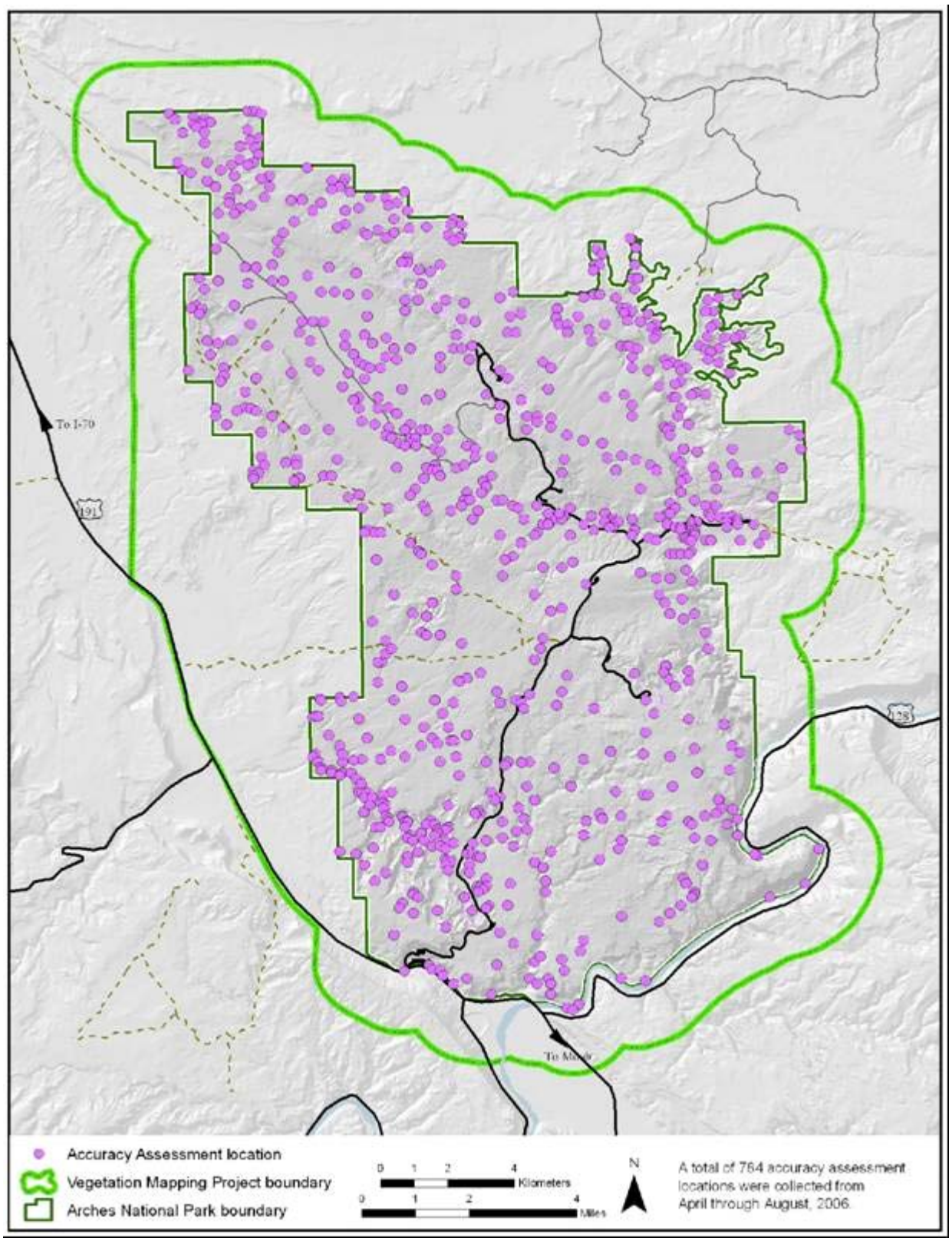


Figure 33. Location of accuracy assessment points sampled within ARCH. The accuracy of the map outside of the park boundary was not assessed.

Table 13. Final contingency table for ARCH. This table represents the 30 polygon map classes retained following accuracy assessment and revision whose accuracy was assessed[1]. Shaded boxes indicate the number of AA points that agree with the assigned map class. To read the table, columns represent the map class observed in the field, while the rows represent the map class assigned by the photointerpreter. Overall accuracy is 90.1% (Kappa statistic = 89.9%). User's and producer's accuracy values with 90% confidence intervals for each map class appear in Tables 14, 15, and 16.

Map Class	1	2	4	5	6	7	8	9	10	11	13	14	15	17	18	20	25	26	27	30	31	32	33	35	71	90	92	93	97	341	# Pts	Prod Acc %
1	3																														3	100
2	1	3																													4	75
4			2																												2	100
5				14					1				2											1	1						19	74
6	1				44		1																					1			47	94
7						37		1														1				1					40	93
8						1	13																					1			15	87
9								20																							20	100
10									75	2						5				1			4			1					88	85
11										18	1				1																20	90
13											16															1					17	94
14												31	1																		32	97
15									3	2			11			1						1	2		1						21	52
17									1					21	1																23	91
18															23											1					24	96
20																12						1									13	92
25						1				1	3						30						1							1	37	81
26																		3													3	100
27																			5												5	100
30																				22								1			23	96
31						1										1					57	1	2						2	64	89
32										1										1		45	1								48	94
33																1				3	1		58								63	92
35									1															25							26	96
71														1											11						12	92
90											1				1											9					11	82
92																											1				1	100
93								1																				56			57	98
97														1															8		9	89
341																				1		2								26	29	90
# Points	5	3	2	14	44	40	14	22	81	24	21	31	14	23	26	20	30	3	5	28	58	51	68	26	13	13	1	59	8	29	776 total points	
User's Acc %	60	100	100	100	100	93	93	91	93	75	76	100	79	91	88	60	100	100	100	79	98	88	85	96	85	69	100	95	100	90	90.1 % accuracy	

[1]Vegetation map classes 100 and 97 were not accuracy assessed, and map classes 4, 8, 71 and 92 were developed post-AA analysis and so did not have random AA points generated for them. The accuracy values shown for these six classes are therefore not valid. Map class 100 does not appear on the contingency table because it is represented by points, not polygons and was mapped only where known. No geologic or land use map classes were accuracy assessed.

Results and Discussion

The map classes shown in tables and figures in this document represent those that remained or were created following adjustment of map classes to improve ARCH thematic accuracy. Appendix I contains the complete analysis of all map classes used in the draft map and evaluated during AA. Final overall map accuracy is 90.1% (Kappa correction = 89.9%). Individual map class producer's and user's accuracy values are given in the tables below with their 90% confidence intervals. The width of each confidence interval is affected by sample size; larger sample sizes result in narrower confidence intervals. Individual map class accuracy ranges from 52% to 100% (Table 14, Table 15, and Table 16).

Table 14. Final ARCH vegetation map classes that met or exceeded the 80% program standard for both user's and producer's accuracy.

Map Class	Map Class #	Map Class Name	Producer's Accuracy (±90% CI)	User's Accuracy (±90% CI)
S-SAVE	6	Greasewood Flats	94% ± 7%	100%
W-PJIF	7	Pinyon - Juniper Intermittently Flooded Woodlands	93% ± 8%	93% ± 8%
S-TTSS	9	Tributary Tamarisk / Salix Shrubland Mosaic	100%	91% ± 12%
S-BLAC	10	Blackbrush Shrublands	85% ± 7%	93% ± 5%
S-EVGR	14	Mormon Tea - Mixed Grass Shrublands	97% ± 7%	100%
H-WEED	17	Weedy Herbaceous Vegetation	91% ± 12%	91% ± 12%
C-TERR	18	High Terrace Shrub Herbaceous Complex	96% ± 9%	88% ± 12%
W-PJSD	25	Sand Dune Woodlands	81% ± 12%	100%
S-MATS	26	Mat Saltbush Sparse Vegetation	100%	100%
H-LESA	27	Salina Lyme Grass Sparse Vegetation	100%	100%
W-MTSW	31	Moab Tongue Slickrock Woodlands	89% ± 7%	98% ± 4%
W-PJSW	32	Pothole and Jointed Sandstone Woodlands	94% ± 7%	88% ± 8%
W-LEDG	33	Sandstone Ledges Woodland	92% ± 6%	85% ± 8%
S-GYPS	35	Gypsum Badlands Sparse Vegetation	96% ± 8%	96% ± 8%
W-POFR	93	Tributary Woodland Complex	98% ± 4%	95% ± 6%
C-FINS	341	Entrada Fin / Swale Woodland Mosaic	90% ± 11%	90% ± 11%

Table 15. ARCH vegetation map classes where either the user's or producer's accuracy did not meet the 80% program standard.

Map Class Code	Map Class #	Map Class Name	Producer's Accuracy (±90% CI)	User's Accuracy (±90% CI)	Confused with Map Class #
S-TARC	1	Tamarisk River Corridor Shrublands	100%	60% ± 46%	2
S-RSSW	2	Riverine Sandbar Sparse Willow Shrublands	75% ± 48%	100%	1
S-BADS	5	Badlands Sparse Vegetation	74% ± 19%	100%	10, 15, 35
S-SAND	11	Sandsheet Shrublands	90% ± 14%	75% ± 17%	10, 13, 15, 18, 25
S-DUNE	13	Dune Complex	94% ± 12%	76% ± 18%	11, 25
W-PJBB	20	Pinyon – Juniper / Blackbrush Woodlands	92% ± 16%	60% ± 21%	10, 15, 33
C-TALS	30	Talus Sparse Vegetation Complex	96% ± 9%	79% ± 14%	32, 33
S-WASH	90	Dry Wash Shrublands	82% ± 24%	69% ± 25%	7, 13, 18

As shown in Table 15, 8 map classes were retained in the final vegetation map for ARCH when either user's or producer's accuracy did not meet the 80% program standard. In many cases, the 90% confidence interval includes 80%; park staff therefore deemed the results to be acceptable. In other cases, park staff also accepted a lower accuracy because the map class was rare in the park and the accuracy was based on only a few points. They felt they could correct these polygons on a case-by-case basis. In the remaining cases, park staff accepted less than 80% accuracy either because the classes were ecologically significant and therefore they wanted to keep them even with low accuracy, or because the errors were with closely related map classes or were a matter of a few percent cover of a diagnostic species.

One map class did not achieve the 80% standard for either user's or producer's accuracy (Table 16). This map class was most often confused with two closely related map classes (10 and 11), with all three sharing the *Coleogyne ramosissima* Shrubland association, and with one other closely related map class (5) which often adjoins polygons of map class 15. This map class was generally over-mapped in areas where blackbrush cover was high and where bedrock cover was significant (confused with map class 33). Park staff wanted to retain this map class because it is very common and widespread, and the map classes with which it was most often confused were closely related.

Table 16. ARCH vegetation map classes where neither the user's or producer's accuracy met the 80% program standard.

Map Class Code	Map Class #	Map Class Name	Producer's Accuracy (±90% CI)	User's Accuracy (±90% CI)	Confused with Map Class #

S-SBDS	15	Shale Barrens Desert Scrub	52% ± 20%	79% ± 21%	5, 10, 11, 33

Four map classes were not accuracy assessed because they were developed after the AA analysis and for reasons other than those generated by that analysis. Even though all of the new map classes contain AA points, the true accuracy has not been tested because they were not part of the original AA sampling design. The primary reason for adding these map classes to the ARCH project was to increase the consistency of vegetation mapping and map class concepts between ARCH and CANY. These four types are mapped in CANY and it was determined only after the ARCH AA that they could also be identified and mapped in ARCH.

Table 17. ARCH vegetation map classes that were developed and mapped post-AA analysis and did not have a valid accuracy assessment performed.

Map Class	Map Class #	Map Class Name	Producer's Accuracy (±90% CI)	User's Accuracy (±90% CI)
S-GOTS	4	Gambel Oak Terrace Shrubland	100%	100%
S-ARTR	8	Basin Big Sagebrush Terrace Shrubland	87% ± 18%	93% ± 15%
S-WINT	71	Winterfat Shrublands	92% ± 17%	85% ± 20%
H-TMHC	92	Tributary Mesic Herbaceous Complex	100%	100%

***S-GOTS (Map Class 4) - Gambel Oak Terrace Shrubland*:** This map class was photo-interpreted post-AA analysis. It was a map class developed for Canyonlands NP, but was also found in Arches within the Colorado River corridor. Two AA points fell in polygons of this map class, because both described Gambel oak shrublands they were called correct.

S-ARTR (Map Class 8) - Basin Big Sagebrush Terrace Shrubland: This map class was photo-interpreted post-AA analysis. It was a map class developed for Canyonlands NP, but was also found to occur in Arches on terraces of upper Salt and Courthouse washes. Fifteen AA points fell in polygons of this map class. Two of these points were not called correct because they fell in woodlands, but they did have a basin big sagebrush understory.

S-WINT (Map Class 71) - Winterfat Shrublands: This map class was photo-interpreted post-AA analysis. It was a map class developed for Canyonlands NP, but was also found to occur in Arches on the floor or Salt Valley. Twelve AA points fell in polygons of this map class. One of these points was not called correct because it fell in an anomalous weed patch described in the field notes.

H-TMHC (Map Class 92) - Tributary Mesic Herbaceous Complex: This map class was photo-interpreted post-AA analysis. It was a map class developed for Canyonlands NP, but was also found to occur in Arches in the active channels of Salt and Courthouse washes. Only two polygons of this map class were mapped within Arches, based on a plot and AA point describing the vegetation. This type may be more common in the park than is currently mapped; however, many recognizable stands of mesic herbaceous vegetation were too small to pull out separately from the surrounding vegetation, usually cottonwood woodlands.

Literature Cited

Allan, J.S. 1977. The plant communities of Arches National Park. Unpublished thesis, Brigham Young University, Provo, Utah. 98 pp.

Anderson, J.R., E. Hardy, J. Roach, and R. Witter. 2002. A land use and land cover classification system for use with Remote Sensor Data. Geological Survey Professional Paper 964. U.S. Government Printing Office, Washington, D.C.

Avery, T. 1978. Forester's guide to aerial photo interpretation. Agriculture Handbook 308. U.S. Department of Agriculture, Forest Service, U.S. Gov. Printing Office, Washington, D.C.

Bailey, R.G. 2001. Descriptions of the ecoregions of the United States, 2nd ed. Misc. Publ. No. 1391 (rev.), Washington, D.C.: USDA Forest Service. 108 pp. with 1:7,500,000-scale map.

Belnap J. 1990. Microbiotic crusts: Their role in past and present ecosystems. Park Science: A Resource Management Bulletin 10(3):3-4.

Belnap J. 1991. Sensitivity of desert cryptogams to air pollutants: soil crusts and rock lichens. In: D. Mangis, J. Baron, and K. Stolte, editors. Acid Rain and Air Pollution in Desert Park Areas, USDI, National Park Service Technical Report NPS/NRAQD/NRTR-91/02, Proceeding of a Workshop, May 16-18, 1988. Tucson, Arizona, pp.112-119.

Belnap J. 1993. Recovery rates of cryptobiotic crusts: Inoculant use and assessment methods. Great Basin Naturalist 53(1):89-95.

Belnap J., and K.T. Harper. 1995. Influence of cryptobiotic soil crusts on elemental content of tissue of two desert seed plants. Arid Soil Research and Rehabilitation 9:107-115.

Belnap, J., J. Kaltenecker, R. Rosentreter, J. Williams, S. Leonard, and D. Eldridge. 2001. Biological Soil Crusts: Ecology and Management. USDI, Bureau of Land Management Technical Reference TR-1730-2. Denver, Colorado. 119 p.

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, Virginia.

Decker, K. and J. Coles. 2003. Preliminary Vegetation Classification Report for Arches National Park. Prepared for engineering-environmental Management, Inc. Englewood, Colorado and NPS-NCPN, Moab, Utah.

Dewey, S. and K. Andersen. 2005. An inventory of invasive non-native plants in Arches National Park (2003-2004) - Final report. Utah State University; Plants, Soils, and Biometeorology Department, Logan, Utah. Weed Science Research Project Report No. SD0510A.

Doelling, H.H. 2003. Geology of Arches National Park, Grand County, Utah. *In*: Sprinkel, D.A., T.C. Chidsey, Jr., and P.B. Anderson. Geology of Utah's Parks and Monuments. Utah Geological Association Publication 28. Publisher's Press, Salt Lake City, Utah.

Driscoll, R., D. Merkel, R. Radloff, D. Snyder, and J. Hagihara. 1984. An ecological land classification framework for the United States. United States Department of Agriculture, Forest Service Miscellaneous Publication Number 1439. Washington, D.C. 56 pp.

Dufrêne, M. and P. Legendre. 1997. Species assemblages and indicator species: The need for a flexible asymmetrical approach. *Ecological Monographs* 67: 3: 345-66.

Eldridge, D.J. and R.S.B. Greene. 1994. Microbiotic soil crusts: a review of their roles in soil and ecological processes in the rangelands of Australia. Australian Journal of Soil Research 32: 389-415.

engineering-environmental Management, Inc. 2003. Vegetation Classification and Mapping Work Plan: Canyonlands National Park, Arches National Park, Natural Bridges National Monument. Report prepared for NPS. Englewood, Colorado.

Environmental Systems Research Institute, National Center for Geographic Information and Analysis, and The Nature Conservancy (ESRI and TNC). 1994. Final draft accuracy assessment procedures. NBS/NPS Vegetation Mapping Program. Prepared for the United States Department of Interior, Biological Resources Division and National Park Service. November 1994.

Evenden, A. 2001. Vegetation mapping and classification project proposal: eleven Northern Colorado Plateau Network Parks, September 2001. Northern Colorado Plateau Network, National Park Service, Moab, Utah. 10 p.

Evenden, A. 2004. Guidelines for photo interpreters working on vegetation mapping in Northern Colorado Plateau Network Parks, January 21, 2004. Northern Colorado Plateau Network, National Park Service, Moab, Utah. 20 p.

Federal Geographic Data Committee (FGDC). 1997. Vegetation classification standard [online]. Available from http://biology.usgs.gov/fgdc.veg/standards/vegstd.htm [Cited 1 March 2004].

Federal Geographic Data Committee. 1998a. Content standard for digital geospatial metadata, FGDC-STD-001-1998. Available online: http://www.fgdc.gov/metadata/contstan.html.

Federal Geographic Data Committee. 1998b. Spatial data transfer standard, FGDC-STC-002 (modified version ANSI NCITS 20:19998). Available online: http://www.fgdc.gov/standards/status/textstatus.html.

Federal Geographic Data Committee - Vegetation Subcommittee. 2008. National Vegetation Classification Standard (Version 2). FGDC-STD-005-2008. Available online: http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation

Fenneman, N.M. and D.W. Johnson. 1946. Map of physical divisions of the United States: U.S. Geological Survey, Physiographic Committee. Scale = 1:7,000,000.

Fertig, W., S. Topp, and M. Moran. 2009. Annotated Checklist of Vascular Flora of Arches National Park. Natural Resource Technical Report NPS/NCPN/NRTR—2009/220. National Park Service, Fort Collins, Colorado.

Flahault, C., and C. Schroter. 1910. Rapport sur la nomenclature phytogeopraphique. Proceedings of the Third International Botanical Congress, Brussels 1:131-164.

Floyd-Hanna, L. 1993. Population biology of selected taxa in Arches and Canyonlands NP. Annual report. Prescott College, Prescott, Arizona. 12 pp.

Fowler, J.F., N.L. Stanton, S.J. Buskirk, and R.L. Hartman. 1995. Biogeography of hanging gardens on the Colorado Plateau. PhD dissertation, University of Wyoming, Laramie. 209 pp.

Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K.D. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume I. The National Vegetation Classification System: development, status, and applications. The Nature Conservancy, Arlington, Virginia, U.S.

Hansen, D.T. 1989. Soil Survey of Grand County, Utah – Central Part. USDA-Soil Conservation Service in cooperation with USDI Bureau of Land Management and Utah Agricultural Experiment Station. 200 pp.

Harper K., and J. Belnap. 2001. The influence of biological soil crusts on mineral uptake by associated vascular plants. Journal of Arid Environments 47(3):347-357.

Heil, K.D., L. Floyd-Hanna, L. Reeves, D. Hyder and R. Fleming. 1993. Composition, distribution, abundance and habitat requirements of endangered, threatened and rare plant species in the Southeast Utah Group of National Parks. San Juan College, Farmington, New Mexico.

Hop, K., S. Lubinski, and S. Menard. 2005. USGS-NPS Vegetation Mapping Program: Effigy Mounds National Monument, Iowa. USGS, Upper Midwest Environmental Sciences Center. La Crosse, WI. January 2005. 62 pp + Appendices A-I.

Joss, L.E., C.S. Hays, and A.J. Schetzle. 2005. Southeast Utah Group Fire and Fuels Management Plan. NPS, prepared for Arches, Canyonlands, Hovenweep, and Natural Bridges units. Moab, Utah.

Kartesz, J. 1999. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. First Edition. In: Kartesz, J.T., and C.A. Meacham. Synthesis of the North American Flora, Version 1.0. North Carolina Botanical

Garden, Chapel Hill, North Carolina.

McCune, B., and M.J. Mefford. 1999. PC-ORD. Multivariate Analysis of Ecological Data, ver. 4. MjM Software Design. Gleneden Beach, Oregon.

National Park Service (NPS). 1999. Natural Resource Challenge: The National Park Service's Action Plan for Preserving Natural Resources. In-house publication. U.S. Department of Interior, National Park Service, Washington, D.C. 21p.

National Park Service. 2008. Arches National Park – public information page. Available online: http://www.nps.gov/arch.

NatureServe Explorer 2003. An online encyclopedia of life, Version 1.8. Arlington, Virginia. Available online: http://www.natureserve.org/explorer.

NatureServe Explorer 2006. An online encyclopedia of life, Version 6.4. Arlington, Virginia. Available online: http://www.natureserve.org/explorer.

NatureServe. 2003a. International Ecological Classification Standard: International Vegetation Classification. Natural Heritage Central Databases, NatureServe, Arlington, Virginia.

NatureServe. 2003b. International Ecological Classification Standard: Terrestrial Ecological Systems of the United States. Natural Heritage Central Databases. NatureServe. Arlington, Virginia. Available online: http://www.natureserve.org/explorer .

Ponzettii, J., B. Youtie, D. Salzer, and T. Kimes. 1998. The effects of fire and herbicides on microbiotic crust dynamics in high desert ecosystems. Unpublished report submitted to the USGS, Biological Resources Division, Forest and Rangeland Ecosystem Science Center. Portland, Oregon. 89 pp.

Reid, M. and P. Comer. 1998. Vegetation Alliance Descriptions of the Western U.S. NatureServe – Western Region Office, Boulder, Colorado. Available online: http://www.gap.uidaho.edu/Bulletins/7/VADWUS.htm

Rosentreter, R. 1986. Compositional patterns within a rabbitbrush (*Chrysothamnus*) community of the Idaho Snake River Plain. *In*: McArthur, E.D., and B.L. Welch, editors. Proceedings – Symposium on the biology of *Artemisia* and *Chrysothamnus*. General Technical Report INT-200. USDA Forest Service, Intermountain Research Station. Ogden, Utah. pp. 273-277.

Schelz, C. and M. Moran. 2002. Vegetation long-term monitoring at Arches National Park. 2001 annual report. USDI-NPS, Southeast Utah Group, Moab, Utah. 154 pp.

Schelz, C. and S. Budelier. 2000. List of Exotic Plant Species for Southeast Utah Group Parks. NPS-SEUG, Resource Management Division. Moab, Utah.

Springer, A.E., L.E. Stevens and R. Harms. 2006. Inventory and classification of selected

National Park Service springs on the Colorado Plateau. Northern Arizona University, Flagstaff, Arizona. NPS Cooperative Agreement Number CA 1200-99-009; Task # NAU-118.

The Nature Conservancy (TNC). 1996. Final Draft Methodology for Assessing the Utility of Existing Data for Vegetation Mapping. NBS/NPS Vegetation Mapping Program. Prepared for the United States Department of Interior, Biological Resources Division and National Park Service. December 1996.

The Nature Conservancy and Environmental Systems Research Institute (TNC and ESRI). 1994a. NBS/NPS Vegetation Mapping Program: Final Draft, Standardized National Vegetation Classification System. Prepared for USDI – National Biological Survey and National Park Service. Arlington, Virginia.

The Nature Conservancy and Environmental Systems Research Institute. 1994b. NBS/NPS Vegetation Mapping Program: Final Draft, Field Methods for Vegetation Mapping. Prepared for USDI – National Biological Survey and National Park Service. Arlington, Virginia.

The Nature Conservancy. 1997. PLOTS database system, Version 1.1. The Nature Conservancy. Arlington, Virginia.

Truman, Dana. 2007. Personal communication from the soil conservationist leading the soil mapping project at ARCH.

United Nations Educational Scientific, and Cultural Organization (UNESCO). 1973. International classification and mapping of vegetation. Series 6. Ecology and Conservation. UNESCO, Paris, France.

United States Geological Survey. 1999. Map accuracy standards. Fact sheet FS-171-99. Available online at: http://mac.usgs.gov/mac/isb/pubs/factsheets/fs17199.html.

Webb, R. 1994. Arches National Park. In: Powell, A.K., editor. Utah History Encyclopedia. University of Utah Press, Salt Lake City, Utah 84112. Available online at: http://www.media.utah.edu/UHE/

Welsh, S.L., N.D. Atwood, S. Goodrich, and L.C. Higgins. 2003. A Utah Flora, 3rd edition. Brigham Young University Print Services. Provo, Utah. 912 p.

Western Regional Climate Center (WRCC). 2008. Reno, Nevada. Available online at: http://www.wrcc.dri.edu/weather/nnsc.html.

Appendix A

Ecological Systems of Arches National Park

Introduction

This appendix contains summary descriptions of 16 terrestrial and riparian/wetland ecological system (ES) units (NatureServe 2003b, Comer et al. 2003) occurring at Arches National Park. Each ecological system represents one or more National Vegetation Classification (NVC) plant associations or alliances (Table 8 within the main report). Map classes were also crosswalked to ES units (Table 11 within the main report).

The ecological systems classification was developed in consultation with many individuals and agencies and incorporates information from a variety of publications and other classifications. One purpose of ecological systems is to provide a coarse-scale mapping unit that can be applied across management boundaries.

UPLAND ECOLOGICAL SYSTEMS

CES304.767 COLORADO PLATEAU PINYON-JUNIPER WOODLAND
Division 304 (Inter-Mountain Basins); Forest and Woodland

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Montane [Lower Montane]; Lowland [Foothill]; Mesa; Ridge/Summit/Upper Slope; Sedimentary Rock; Temperate Xeric; Aridic; *Pinus edulis, Juniperus osteosperma*
Concept Summary: This ecological system occurs in dry mountain slopes, mesas, plateaus, and ridges of the Colorado Plateau region including the Western Slope of Colorado to the Wasatch Range, south to the Mogollon Rim and the northwestern corner of New Mexico. It is typically found at lower elevations (1500-2440 m). Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on mountainsides. Soils supporting this system vary in texture ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. *Pinus edulis* and/or *Juniperus osteosperma* dominate the tree canopy. In northern Arizona and northwestern New Mexico, *Juniperus monosperma* and hybrids of *Juniperus* spp. may dominate or codominate the tree canopy. *Juniperus scopulorum* may codominate or replace *Juniperus osteosperma* at higher elevations. Understory layers are variable and may be dominated by shrubs, graminoids, or be absent. Associated species include *Arctostaphylos patula, Artemisia tridentata, Cercocarpus intricatus, Cercocarpus montanus, Coleogyne ramosissima, Purshia stansburiana, Purshia tridentata, Quercus gambelii, Bouteloua gracilis, Pleuraphis jamesii,* or *Poa fendleriana*. This system occurs at higher elevations than Great Basin Pinyon-Juniper Woodland (CES304.773) and Colorado Plateau shrubland systems.
Range: Occurs on dry mountains and foothills of the Colorado Plateau region from the Western Slope of Colorado to the Wasatch Range, south to the Mogollon Rim. It is typically found at elevations ranging from 1500-2440 m.
Subnations: AZ, CO, NM, UT

CES304.765 COLORADO PLATEAU MIXED BEDROCK CANYON AND TABLELAND
Division 304 (Inter-Mountain Basins); Barren

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural; Unvegetated (<10% vasc.); Upland
Diagnostic Classifiers: Montane, Lower Montane; Lowland, Foothill; Shrubland; Ridge/Summit/Upper Slope; Sedimentary Rock; Temperate Xeric; Alkaline Soil; Aridic
Concept Summary: The distribution of this ecological system is centered on the Colorado Plateau where it is comprised of barren and sparsely vegetated landscapes (generally <10% plant cover) of steep cliff faces, narrow canyons, and open tablelands of predominantly sedimentary rocks, such as sandstone, shale, and limestone. Some eroding shale layers similar to Inter-Mountain Basins Shale Badland (CES304.789) may be interbedded between the harder rocks. The vegetation is characterized by very open tree canopy or scattered trees and shrubs with a

sparse herbaceous layer. Common species includes *Pinus edulis*, *Pinus ponderosa*, *Juniperus* spp., *Cercocarpus intricatus*, and other short-shrub and herbaceous species, rooted in cracks and pockets where soil accumulates.
Comments: Geographically restricted and distinct from the related Inter-Mountain Basins Cliff and Canyon (CES304.779). Shale areas are not extensive as in shale badlands.
Range: Colorado Plateau.
Subnations: AZ, CO, NM, UT

CES306.818 ROCKY MOUNTAIN GAMBEL OAK-MIXED MONTANE SHRUBLAND
Division 306 (Rocky Mountain); Shrubland

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Shrubland; Shallow Soil; Mineral w/ A-Horizon <10 cm; Loam Soil Texture; Sand Soil Texture; Ustic; Unconsolidated; Intermediate Disturbance Interval [Periodicity/Polycyclic Disturbance]; Broad-Leaved Deciduous Shrub
Concept Summary: This ecological system occurs in the mountains, plateaus, and foothills in the southern Rocky Mountains and Colorado Plateau, including the Uinta and Wasatch ranges and the Mogollon Rim. These shrublands are commonly found on dry foothills, lower mountain slopes, and at the edge of the western Great Plains from approximately 2000 to 2900 m in elevation, and are often situated above pinyon-juniper woodlands. Substrates include soil types ranging from calcareous, fine-grained loams to sandy loams, gravelly loams, clay loams, deep alluvial sand, or coarse gravel. The vegetation is typically dominated by *Quercus gambelii* alone or with *Amelanchier alnifolia, Amelanchier utahensis, Artemisia tridentata, Cercocarpus montanus, Prunus virginiana, Purshia stansburiana, Purshia tridentata, Robinia neomexicana, Symphoricarpos oreophilus*, or *Symphoricarpos rotundifolius*. There may be inclusions of other mesic montane shrublands with *Quercus gambelii* absent or as a minor component. This ecological system intergrades with the lower montane-foothills shrubland system and shares many of the same site characteristics. Density and cover of *Quercus gambelii* and *Amelanchier* spp. often increase after fire.
Range: Occurs in the mountains, plateaus and foothills in the southern Rocky Mountains and Colorado Plateau including the Uinta and Wasatch ranges and the Mogollon Rim.
Subnations: AZ, CO, NM, UT, WY

CES304.763 COLORADO PLATEAU BLACKBRUSH-MORMON TEA SHRUBLAND
Division 304 (Inter-Mountain Basins); Shrubland

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Lowland [Foothill]; Shrubland; Temperate Xeric; Aridic
Concept Summary: This ecological system occurs in the Colorado Plateau on benchlands, colluvial slopes, pediments or bajadas. Elevation ranges from 560-1650 m. Substrates are shallow, typically calcareous, non-saline and gravelly or sandy soils over sandstone or limestone bedrock, caliche or limestone alluvium. It also occurs in deeper soils on sandy plains where it may have invaded desert grasslands. The vegetation is characterized by extensive open

shrublands dominated by *Coleogyne ramosissima* often with *Ephedra viridis, Ephedra torreyana,* or *Grayia spinosa*. Sandy portions may include *Artemisia filifolia* as codominant. The herbaceous layer is sparse and composed of graminoids such as *Achnatherum hymenoides, Pleuraphis jamesii,* or *Sporobolus cryptandrus*.
Range: Occurs in the Colorado Plateau on benchlands, colluvial slopes, pediments or bajadas. Elevation ranges from 560-1600 m.
Subnations: AZ, CO, NM, UT

CES304.788 INTER-MOUNTAIN BASINS SEMI-DESERT SHRUB-STEPPE
Division 304 (Inter-Mountain Basins); Steppe-Savanna

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Lowland [Foothill]; Woody-Herbaceous; Temperate Xeric; Alkaline Soil; Aridic; Very Short Disturbance Interval; G-Landscape/High Intensity; Graminoid
Concept Summary: This ecological system occurs throughout the arid intermountain western U.S., typically at lower elevations on alluvial fans and flats with moderate to deep soils, and extends into south-central Montana between the Pryor and Beartooth ranges where a distinct rainshadow effect occurs. This semi-arid shrub-steppe is typically dominated by graminoids (>25% cover) with an open to moderately dense shrub layer. The most widespread (but not always dominant) species is *Pseudoroegneria spicata*, which occurs from the Columbia Basin to the northern Rockies. Other characteristic grasses include *Achnatherum hymenoides, Bouteloua gracilis, Distichlis spicata, Poa secunda, Poa fendleriana, Sporobolus airoides, Hesperostipa comata, Pleuraphis jamesii*, and *Leymus salinus*. The woody layer is often a mixture of shrubs and dwarf-shrubs, although it may be dominated by a single species. Characteristic species include *Atriplex canescens, Artemisia tridentata, Chrysothamnus greenei, Chrysothamnus viscidiflorus, Ephedra* spp., *Ericameria nauseosa, Gutierrezia sarothrae,* and *Krascheninnikovia lanata*. *Artemisia tridentata* or *Atriplex canescens* may be present but does not dominate. Annual grasses, especially the exotics *Bromus japonicus* and *Bromus tectorum,* may be present to abundant. Forbs are generally of low importance and are highly variable across the range but may be diverse in some occurrences. The general aspect of occurrences may be either open shrubland with patchy grasses or patchy open herbaceous layers. Disturbance may be important in maintaining the woody component. Microphytic crust is very important in some stands.
Range: This system occurs throughout the intermountain western U.S., typically at lower elevations, and extends into Wyoming and Montana across the Great Divide Basin. It barely gets as far north into north-central Montana (mapzone 20) but is unlikely to be mapped.
Subnations: AZ, CA, CO, ID, MT, NM, NV, OR, UT, WY

CES304.777 INTER-MOUNTAIN BASINS BIG SAGEBRUSH SHRUBLAND
Division 304 (Inter-Mountain Basins); Shrubland

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Lowland; Shrubland; Toeslope/Valley Bottom; Deep Soil; Aridic; *Artemisia tridentata* ssp. *tridentata*

Concept Summary: This ecological system occurs throughout much of the western U.S., typically in basins, plains and foothills between 1500 and 2300 m elevation. Soils are typically deep, well-drained and non-saline. These shrublands are dominated by *Artemisia tridentata ssp. tridentata* and/or *Artemisia tridentata ssp. wyomingensis*. Scattered *Juniperus* spp., *Sarcobatus vermiculatus,* and *Atriplex* spp. may be present in some stands. *Ericameria nauseosa, Chrysothamnus viscidiflorus, Purshia tridentata,* or *Symphoricarpos oreophilus* may codominate disturbed stands. Perennial herbaceous components typically contribute less than 25% vegetative cover. Common graminoid species include *Achnatherum hymenoides, Bouteloua gracilis, Elymus lanceolatus, Festuca idahoensis, Hesperostipa comata, Leymus cinereus, Pleuraphis jamesii, Pascopyrum smithii, Poa secunda,* or *Pseudoroegneria spicata*.
Range: Occurs throughout much of the western U.S., typically in broad basins between mountain ranges, plains and foothills between 1500-2300 m elevation.
Subnations: CA, CO, ID, MT, NV, OR, UT, WA, WY

CES304.775 INTER-MOUNTAIN BASINS ACTIVE AND STABILIZED DUNE
Division 304 (Inter-Mountain Basins); Barren

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural; Unvegetated (<10% vasc.); Upland
Diagnostic Classifiers: Lowland; Shrub-dominated; Dune; Temperate Continental; Sand Soil Texture; Aridic; W-Landscape/High Intensity
Concept Summary: This ecological system occurs in the Intermountain western U.S. on basins, valleys and plains. Often it is composed of a mosaic of migrating, bare dunes; anchored dunes with sparse to moderately dense vegetation (<10-30% canopy cover); and stabilized dunes. The system is defined by the presence of migrating dunes or, where the dunes are entirely anchored or stabilized, evidence that the substrate is eolian and not residual, that the vegetation is early- or mid-seral, and that the substrate is likely to become actively migrating again with disturbance or increased aridity. In the Colorado Plateau, there are many small active and partially vegetated dunes along some of the larger washes and playas (where sand is blown out of wash and forms dunes) and some larger dunes such as Coral Pink Dunes in southwestern Utah. Substrates are usually eolian sand, but small dunes composed of silt and clay downwind from playas in the Wyoming Basins (which usually support greasewood vegetation) also are included here. Species occupying these environments are often adapted to shifting, coarse-textured substrates (usually quartz sand) and form patchy or open grasslands, shrublands or steppe, and occasionally woodlands. Vegetation varies and may be composed of *Achnatherum hymenoides, Artemisia filifolia, Artemisia tridentata ssp. tridentata, Atriplex canescens, Ephedra* spp., *Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ericameria nauseosa, Hesperostipa comata, Leymus flavescens, Muhlenbergia pungens, Psoralidium lanceolatum, Purshia tridentata, Redfieldia flexuosa, Sporobolus airoides, Sarcobatus vermiculatus, Tetradymia tetrameres,* or *Tiquilia* spp. Herbaceous species such as *Achnatherum hymenoides, Redfieldia flexuosa*, and *Psoralidium lanceolatum* are characteristic of early-seral vegetation through much of this system's range. Shrubs are commonly dominant on mid- to late-seral stands, and *Ericameria nauseosa* can be found at any stage.
Comments: Rules should be devised for deciding whether shrub or shrub-steppe vegetation on completely stabilized dunes should be considered part of this active and stabilized dune system, or part of another system. The areas include Inter-Mountain Basins Mixed Salt Desert Scrub

(CES304.784), Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777), and Inter-Mountain Basins Big Sagebrush Steppe (CES304.778) on sand, and Inter-Mountain Basins Greasewood Flat (CES304.780) on clay and silt.
Range: This system occurs in intermountain basins of the western U.S. including southwestern Montana in the Centennial Valley.
Subnations: AZ, CO, ID, MT, NM, NV, OR, UT, WA, WY

CES304.781 INTER-MOUNTAIN BASINS WASH
Division 304 (Inter-Mountain Basins); Barren

Spatial Scale & Pattern: Linear
Required Classifiers: Natural/Semi-natural; Unvegetated (<10% vasc.); Upland; Wetland
Diagnostic Classifiers: Lowland; Shrubland; Wash; Toeslope/Valley Bottom; Riverine / Alluvial; Alkaline Soil; Xeromorphic Shrub; *Sarcobatus vermiculatus*
Concept Summary: This barren and sparsely vegetated (generally <10% plant cover) ecological system is restricted to intermittently flooded streambeds and banks that are often lined with shrubs such as *Sarcobatus vermiculatus, Ericameria nauseosa, Fallugia paradoxa*, and/or *Artemisia cana ssp. cana* (in more northern and mesic stands). *Grayia spinosa* may dominate in the Great Basin. Shrubs form a continuous or intermittent linear canopy in and along drainages but do not extend out into flats. Typically it includes patches of saltgrass meadow where water remains for the longest periods. Soils are generally less alkaline than those found in the playa system. Desert scrub species (e.g., *Acacia greggii, Prosopis* spp.), that are common in the Mojave, Sonoran and Chihuahuan desert washes, are not present. This type can occur in limited portions of the southwestern Great Plains.
Comments: Compare with Inter-Mountain Basins Greasewood Flat (CES304.780); should it include nonsparse shrublands? Invasive, exotic shrubs shrub as *Tamarix* spp. or *Chamaebatiaria millefolium* may be present to dominant in these washes where disturbed.
Range: This system occurs throughout the Intermountain U.S. into the western Great Plains.
Subnations: AZ, CA, CO, ID, MT, NV, OR, UT, WA, WY

CES304.780 INTER-MOUNTAIN BASINS GREASEWOOD FLAT
Division 304 (Inter-Mountain Basins); Mixed Upland and Wetland

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland; Wetland
Diagnostic Classifiers: Lowland; Shrubland; Toeslope/Valley Bottom; Alkaline Soil; Deep Soil; Xeromorphic Shrub
Concept Summary: This ecological system occurs throughout the intermountain basins of the western U.S. and extends onto the western Great Plains. It typically occurs on stream terraces and flats associated with drainages or it may form rings around sparsely vegetated playas. Sites typically have saline soils, a shallow water table and flood intermittently, but remain dry for most growing seasons. The water table remains high enough to maintain vegetation, despite salt accumulations. This system usually occurs as a mosaic of multiple communities, with open to moderately dense shrublands dominated or codominated by *Sarcobatus vermiculatus*. *Atriplex canescens, Atriplex confertifolia*, or *Krascheninnikovia lanata* may be present to codominant.

Occurrences are often surrounded by mixed salt desert scrub. The herbaceous layer, if present, is usually dominated by graminoids. There may be inclusions of *Sporobolus airoides, Distichlis spicata* (where water remains ponded the longest), or *Eleocharis palustris* herbaceous types.
Range: Occurs throughout much of the western U.S. in Intermountain basins and extends onto the western Great Plains.
Subnations: AZ, CA, CO, ID, MT, NM, NV, OR, UT, WA, WY

CES304.786 INTER-MOUNTAIN BASINS PLAYA
Division 304 (Inter-Mountain Basins); Barren

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Unvegetated (<10% vasc.); Upland; Wetland
Diagnostic Classifiers: Lowland; Playa; Temperate Xeric; Depressional; Alkaline Soil; Saline Substrate Chemistry; Aridic; Alkaline Water; Saline Water Chemistry; Caliche Layer; Impermeable Layer; Intermittent Flooding
Concept Summary: This ecological system is composed of barren and sparsely vegetated playas (generally <10% plant cover) found in the intermountain western U.S. Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. These systems are intermittently flooded. The water is prevented from percolating through the soil by an impermeable soil subhorizon and is left to evaporate. Soil salinity varies greatly with soil moisture and greatly affects species composition. Characteristic species may include *Allenrolfea occidentalis, Sarcobatus vermiculatus, Grayia spinosa, Puccinellia lemmonii, Leymus cinereus, Distichlis spicata,* and/or *Atriplex* spp.
Range: This system occurs throughout the Intermountain western U.S., extending east into the southwestern Great Plains.
Subnations: CA, CO, ID, NM, NV, OR, UT, WA?, WY

CES304.784 INTER-MOUNTAIN BASINS MIXED SALT DESERT SCRUB
Division 304 (Inter-Mountain Basins); Shrubland

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Lowland; Shrubland; Alluvial flat; Alkaline Soil; Calcareous; Silt Soil Texture; Clay Soil Texture; Xeromorphic Shrub; Dwarf-Shrub; *Atriplex* spp.
Concept Summary: This ecological system includes open-canopied shrublands of typically saline basins, alluvial slopes and plains across the Intermountain U.S. This type also extends in limited distribution into the southern Great Plains. Substrates are often saline and calcareous, medium- to fine-textured, alkaline soils, but include some coarser-textured soils. The vegetation is characterized by a typically open to moderately dense shrubland composed of one or more *Atriplex* species such as *Atriplex confertifolia, Atriplex canescens, Atriplex polycarpa*, or *Atriplex spinifera*. Other shrubs present to codominant may include *Artemisia tridentata ssp. wyomingensis, Chrysothamnus viscidiflorus, Ericameria nauseosa, Ephedra nevadensis, Grayia spinosa, Krascheninnikovia lanata, Lycium* spp., *Picrothamnus desertorum,* or *Tetradymia* spp. *Sarcobatus vermiculatus* is generally absent, but if present is not dominant. The herbaceous layer varies from sparse to moderately dense and is dominated by perennial graminoids such as

Achnatherum hymenoides, Bouteloua gracilis, Elymus lanceolatus ssp. lanceolatus, Pascopyrum smithii, Pleuraphis jamesii, Pleuraphis rigida, Poa secunda, or *Sporobolus airoides*.
Range: Intermountain western U.S., extending into the southern Great Plains.
Subnations: AZ, CA, CO, ID, MT, NM, NV, OR, UT, WA, WY

CES304.789 INTER-MOUNTAIN BASINS SHALE BADLAND
Division 304 (Inter-Mountain Basins); Barren

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (<10% vasc.); Upland
Diagnostic Classifiers: Lowland; Badlands; Alkaline Soil; Shale and Mudstone; Silt Soil Texture; Clay Soil Texture
Concept Summary: This widespread system of the intermountain western U.S. is composed of barren and sparsely vegetated substrates (<10% plant cover) typically derived from marine shales but also from siltstones and mudstones (clay). Landforms are typically rounded hills and plains that form a rolling topography. The harsh soil properties and high rate of erosion and deposition are driving environmental variables supporting sparse dwarf-shrubs, e.g., *Atriplex corrugata, Atriplex gardneri, Artemisia pedatifida,* and herbaceous vegetation.
Range: This system is found in the intermountain western U.S. It is confirmed by Oregon and Washington review to not occur in either of those states.
Subnations: AZ, CA, CO, ID, MT, NM, NV, UT, WY

CES304.787 INTER-MOUNTAIN BASINS SEMI-DESERT GRASSLAND
Division 304 (Inter-Mountain Basins); Herbaceous

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Lowland Foothill; Herbaceous; Temperate Xeric; Alkaline Soil; Aridic; Graminoid
Concept Summary: This widespread ecological system occurs throughout the intermountain western U.S. on dry plains and mesas, at approximately 1450 to 2320 m (4750-7610 feet) elevation. These grasslands occur in lowland and upland areas and may occupy swales, playas, mesatops, plateau parks, alluvial flats, and plains, but sites are typically xeric. Substrates are often well-drained sandy or loamy-textured soils derived from sedimentary parent materials but are quite variable and may include fine-textured soils derived from igneous and metamorphic rocks. When they occur near foothill grasslands they will be at lower elevations. The dominant perennial bunch grasses and shrubs within this system are all very drought-resistant plants. These grasslands are typically dominated or by *Achnatherum hymenoides, Aristida* spp., *Bouteloua gracilis, Hesperostipa comata, Muhlenbergia* sp., or *Pleuraphis jamesii* and may include scattered shrubs and dwarf-shrubs of species of *Artemisia, Atriplex, Coleogyne, Ephedra, Gutierrezia,* or *Krascheninnikovia lanata*.
Range: Occurs throughout the Intermountain western U.S. on dry plains and mesas, at approximately 1450 to 2320 m (4750-7610 feet) in elevation.
Subnations: AZ, CA, CO, ID, MT?, NM, NV, OR, UT, WA, WY

RIPARIAN AND WETLAND ECOLOGICAL SYSTEMS

CES306.821 ROCKY MOUNTAIN LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND

Division 306 (Rocky Mountain); Woody Wetland

Spatial Scale & Pattern: Linear
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.)
Diagnostic Classifiers: Lower Montane; Riverine / Alluvial; Mineral: W/ A-Horizon <10 cm; Unconsolidated; Short (<5 yrs) Flooding Interval; Short (50-100 yrs) Persistence
Concept Summary: This system is found throughout the Rocky Mountain and Colorado Plateau regions within a broad elevation range from approximately 900 to 2800 m. This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. This system is dependent on a natural hydrologic regime, especially annual to episodic flooding. Occurrences are found within the flood zone of rivers, on islands, sand or cobble bars, and immediate streambanks. They can form large, wide occurrences on mid-channel islands in larger rivers or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplains swales and irrigation ditches. Dominant trees may include *Acer negundo, P. angustifolia, P. balsamifera, P. deltoides, P. fremontii, Pseudotsuga menziesii, Picea pungens, Salix amygdaloides*, or *Juniperus scopulorum*. Dominant shrubs include *Acer glabrum, Alnus incana, Betula occidentalis, Cornus sericea, Crataegus rivularis, Forestiera pubescens, Prunus virginiana, Rhus trilobata, Salix monticola, Salix drummondiana, Salix exigua, Salix irrorata, Salix lucida, Shepherdia argentea*, or *Symphoricarpos* spp. Exotic trees of *Elaeagnus angustifolia* and *Tamarix* spp. are common in some stands. Generally, the upland vegetation surrounding this riparian system is different and ranges from grasslands to forests.
Range: Found throughout the Rocky Mountain and Colorado Plateau regions within a broad elevation range from approximately 900 to 2800 m.
Subnations: AZ, CO, ID, MT, NM, NV, OR, SD, UT, WY

CES300.729 NORTH AMERICAN ARID WEST EMERGENT MARSH

Division 300 (North American Continental); Herbaceous Wetland

Spatial Scale & Pattern: Small patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.)
Diagnostic Classifiers: Herbaceous; Depressional [Lakeshore, Pond]; Mineral: W/ A-Horizon >10 cm; Aquatic Herb; Graminoid; Deep (>15 cm) Water; Saturated Soil
Concept Summary: This widespread ecological system occurs throughout much of the arid and semi-arid regions of western North America, typically surrounded by savanna, shrub steppe, steppe, or desert vegetation. Natural marshes may occur in depressions in the landscape (e.g., kettle ponds), as fringes around lakes, and along slow-flowing streams and rivers. Marshes are frequently or continually inundated, with water depths up to 2 m. Water levels may be stable, or may fluctuate 1 m or more over the course of the growing season. Water chemistry may include some alkaline situations, but the alkalinity is highly variable even within the same complex of wetlands. Marsh soils have characteristics typical of long periods of anaerobic conditions (e.g.,

gley colors, high organic content, redoximorphic features). The vegetation is characterized by herbaceous plants that are adapted to saturated soil conditions. Common emergent and floating vegetation includes species of *Schoenoplectus, Typha, Juncus, Potamogeton, Polygonum, Nuphar,* and *Phalaris*. This system may also include areas of relatively deep water with floating-leaved plants (*Potamogeton, Lemna,* and *Brasenia*) and submergent and floating plants (*Myriophyllum, Ceratophyllum,* and *Elodea*).
Comments: This ecological system occurs in the arid and semi-arid regions of western North America, in semipermanently flooded habitats within a relatively dry landscape.
Range: Occurs throughout much of the arid and semi-arid regions of western North America.
Subnations: AZ, CA, CO, ID, MT, ND, NE, NM, NV, OK, OR, SD, TX, UT, WA, WY

CES304.764 COLORADO PLATEAU HANGING GARDEN
Division 304 (Inter-Mountain Basins); Herbaceous Wetland

Spatial Scale & Pattern: Small patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.)
Diagnostic Classifiers: Montane, Lower Montane; Cliff; Sedimentary Rock; Temperate Xeric; Seepage-Fed Sloping; Forb; Fern; Graminoid; Saturated Soil
Concept Summary: Hanging gardens in the Colorado Plateau region are surrounded by an arid environment and associated with canyon country. These highly localized environments include canyons with perennial seeps forming pocketed wetlands and draping vegetation across wet cliff faces. Three main garden types exist: alcove, terrace, or windowblind. Each is determined by the nature of the geological formation and the presence or absence of joint systems. They tend to occur on all exposures, but they are always shaded for much of each day. Temperature and humidity are stable compared to surrounding habitats. Most hanging gardens are dominated by herbaceous plants, a number of which are endemic to this region. Common species include *Adiantum capillus-veneris, Adiantum pedatum, Mimulus eastwoodiae, Mimulus guttatus, Sullivantia hapemanii, Cirsium rydbergii,* and several species of *Aquilegia*.
Range: Colorado Plateau.
Subnations: AZ, CO, NV?, UT

Appendix B

Plot, Observation Point, Accuracy Assessment Point Instructions and Data Forms

Introduction

This appendix contains the forms and instruction manuals used in collecting field data for the Vegetation Mapping Project at Arches National Park. Three types of data were collected: vegetation plot, observation point, and accuracy assessment point. Vegetation plots were used primarily in developing the NVC classification for the park. They were also used by photointerpreters to help recognize aerial photo signatures. Observation points were used primarily for assisting with photointerpretation, and secondarily for supporting NVC association descriptions and documenting non-standard vegetation types. Accuracy assessment data were used primarily for testing the thematic accuracy of the vegetation map and secondarily to support NVC association descriptions.

B.1. Plot and Observation Point Field Sampling Manual

FIELD SAMPLING AT ARCHES NATIONAL PARK

A Basic Guide for Field Work – 2003

NAVIGATING TO PLOT

You will navigate towards each selected Biophysical Unit (BPU) using BPU maps, park maps, topographic maps, handheld GPS receivers and aerial photos.

- BPU maps will identify the location, size and shape of the polygon.
- Topography (Topo) maps are useful in identifying the landscape through which you will be navigating, and in determining the elevation of a plot. You will find them more legible than the BPU maps in reading the names of features as well.
- GPS receivers indicate the direction and the distance (as the crow flies) to the centroid, the center of the BPU. The centroid is the center of the measured area of a given BPU, but that center does not always land in what appears to be the center of oddly shaped polygons. Regardless of where the centroid is within the polygon, it is an important navigational guide to get you within the vegetative stand you need to sample. ***Note***: *In very homogenous terrain, you may want to GPS the location of your vehicle or track your route, which is also useful in writing the directions to your plot.*
- Aerial photos aid in navigating through the landscape, and are essential in determining where to establish a plot (this will be explained in more detail). **Please** record the vegetation, and its condition, that you walk through and sample on the photo. Feel free to write comments regarding unique features as well.

Along the way...look around. Context is everything – you will have a much better sense of how your plots represent the landscape if you are always in analysis mode. Keep in mind that the goal of this field work is to sample **all** the different vegetation types that occur at the park. If, on the way to a BPU or plot, you see an assemblage of plants that seems unique, **please** sample if time allows, or at least complete an observation form. As the season progresses, you will be better able to recognize new plant alliances and associations. Similarly, when you see unique features or vegetative stands too small to sample, GPS them and mark them on aerial photos and maps. These GPS points will be added to the final production map as "Park Special Features" (examples include large potholes, hanging gardens, a small patch of cattails, etc).

ESTABLISHING A PLOT

Placement of Plot

Figuring out where to place your plot is a subjective process. You'll want to place your plots in areas that seem to be both relatively **homogenous** and **representative** of the vegetation of the polygon as a whole. In other words, avoid areas where the vegetation appears to be transitioning from one type to another and areas with anomalous or heterogeneous structure or species composition. The photos will help you identify the different vegetation types available in each BPU to sample – similar color, pattern and texture usually indicate similar vegetation. Take some time and do this carefully, because some of the plots you set up may be re-sampled over time in order to determine responses to management and other useful things. Look at *all* the vegetation layers to determine if the area is structurally and floristically uniform and generally try to place your plots **at least** 30 m (100 feet) from what you see as the 'boundary' between this vegetation type and neighboring, different types. The exception to this rule is when you are

sampling a unique type that is always going to occur in small patches, such as a spring seep. ***Note***: In cases where a polygon is very heterogeneous, more than one plot may be needed. Again, look around; use your acquired knowledge and judgment.

Size and Shape of Plot

The chart below indicates what size plot should be for each vegetation type. As for shape, you may find yourself more comfortable with a given shape, which is fine. However, the landscape will often determine for you what shape a plot should be. For example, rectangles are ideal for ridgelines, hillsides, and riparian zones. Circles and squares are well suited to very large, homogenous vegetative stands. Selecting the shape of the plot to fit it into a given sample area is fine, but please try not to make a plot smaller than the sizes listed below. **Make sure the type you are describing occupies an area of at least ½ hectare** (a circle approximately 40m in radius!!). This is because the standard plot is about the size of a pencil point to the photo interpreter – even ½ hectare is only the size of a pea. Vegetative communities too small for a plot should be sampled as an Observation Point (instructions for points are after plots in this packet).

If you're in a ...	**You should usually make your plot...**	**Giving you a plot area of...**
Forest (i.e., trees have their crowns overlapping, usually 60-100% total cover)	11.3 m radius OR 20 m x 20 m	400 m^2 400 m^2
Woodland (i.e., stands of trees with crowns usually not touching. Canopy tree cover is 10-60% **or** exceeds total shrub, dwarf-shrub, herb, and nonvascular cover).	11.3 m radius OR 20 m x 20 m	400 m^2 400 m^2
Shrubland (i.e., shrubs greater than 0.5 m tall are dominant, usually with more than 25% cover **or** exceeding tree, dwarf-shrub, herb, and nonvascular cover).	5.65 m radius OR 10 m x 10 m	100 m^2 100 m^2
Dwarf-shrubland (i.e., shrubs less than 0.5 m tall are dominant, usually with more than 25% cover OR exceeding tree, shrub, herb, and nonvascular cover).	5.65 m radius OR 10 m x 10 m	100 m^2 100 m^2
Shrub Herbaceous (i.e., forb and/or grass cover roughly equal to shrubs or dwarf shrubs).	5.65 m radius OR 10 m x 10 m	100 m^2 100 m^2
Herbaceous (i.e., herbs or grasses dominant, usually forming more than 25 percent cover).	5.65 m radius OR 10 m x 10 m	100 m^2 100 m^2
Nonvascular (i.e., lichen or moss cover dominant, usually forming more than 10% cover).	2.82 m radius OR 5 m x 5 m	25 m^2 25 m^2

PLOT SURVEY FORM INSTRUCTIONS

IDENTIFIERS/LOCATORS SECTION (Top Half of First Sheet)

Plot Code
This is a unique identifier you give each sample plot using the format “PARK.XXX”. Each field crew will be assigned a set of numbers to use (e.g., 100-299, 300-499, etc.). Circle the appropriate park acronym, and write the plot number on the blank line. The same numbering convention will be used for observation points.

BPU Code
The biophysical unit identified is the polygon identifier on the DRG map. If you have encountered a unique or new vegetative community that is not in a designated BPU, enter "None". Indicate whether the plot is inside the park boundary or in the buffer by writing “park” or “buffer” next to the BPU code (a field may be created for this, in which case, make the appropriate mark on the data sheet).

Provisional Community Name
If you have been provided a list of potential Alliances and Associations, assign the name of the vegetation type which most closely resembles this type. If a list has not been made for the park you are working in, write what you think is appropriate. To do this, identify the dominant species of the dominant strata, and indicate the physiognomic class (this must match the physiognomic class checked on the back side the datasheet). The ‘provisional community name’ will be used in tallying how many of each plant community has been sampled.

State
This is likely to be filled in for you. If not, write in the state (e.g., UT), or circle the state if a selection is provided.

Park Name
Circle the appropriate park acronym. The standard abbreviation is four letters, such as ARCH for Arches National Park.

Park Site Name
This is best determined from a topo map. Select a nearby feature that an obvious waypoint, such as the name of a canyon, road or arch.

Quad Name
Record the **full name** of the 7.5-minute quadrangle, such as “The Knoll”. Locate your plot on the map, and mark your location with a dot in a circle and the plot number.

Quad Code
This is the USGS code of 7.5 minute quadrangle map, which is not necessary to record in the field.

Aerial Photo Number
The photo number is in the upper right hand corner of the photo in the format FLIGHTLINE-FRAME #. Record this number on the form. Locate your plot on the photo, and mark your location with a dot in a circle and the plot number. Again, please draw and comment on the photo regarding the vegetation of the plot and the surroundings.

GPS File Name
This is the name you give to the waypoint when you map the plot with the GPS unit. The GPS reading should be taken from the center of the plot. Please give the waypoint the same number as the plot, and the prefix "AP" for an Arches plot (e.g., AP241 for plot #241). If doing an observation point, the file name would be "AO" and the number (e.g., AO101 for point #101). Mark the plot location on the BPU map using the same method that you marked the aerial photo with (a dot with a circle around it and the plot number, "AP241"). If you are unable to get a GPS reading in the plot, first try from a higher point outside the plot. Otherwise, estimate the UTM coordinates from the topo map, and manually enter these UTMs into the GPS unit.

These next instructions are not in the order they appear on the data sheet, but rather, the order you may find yourself entering them in the field:

Comments/GPS device used:
VERY IMPORTANT: If you resorted to estimating the plot location UTMs on the topo map, note that in this field. Also, if you left the plot to get a reading from a high point, record that here.

Field UTM X
Record UTM numbers of the easting as shown on the GPS, or determined from the topo map.

Field UTM Y
Record UTM numbers of the northing as shown on the GPS, or determined from the topo map.

GPS Error
Note the "Estimated Position Error" (EPE) displayed on your GPS unit. The longer you wait to mark the waypoint, the longer the GPS has to gather satellite information and determine your location more accurately, and using the antenna will also help get a more accurate reading. The lower the number, the more accurate your reading. Also, 3D Differential is the most accurate level of reading - you may have to resort to 3D GPS or 2D GPS in canyons or other landforms.

3D Differential?
Circle Y or N accordingly.

Datum
ALWAYS check this on your GPS unit. It should **always** be NAD83. This information is **CRITICAL** for correctly applying your waypoints to the final vegetation map. If it is anything other than NAD83, please, please, please record this on the form. This step will keep your work from being wasted.

UTM Zone
Enter the value displayed on your GPS. It should be either 13S or 12S.

Survey Date
Date the plot was sampled. Please use this format: Month - Day - Year.

Surveyors
Last names of the field team members present.

Directions to Plot
Give precise directions to the plot beginning with a landmark (e.g., a named point on the topo map, a major highway) readily locatable on a 7.5 minute topo map as the starting point. Use clear sentences that

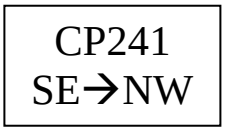
will be understandable to someone who is unfamiliar with the area and has only your directions to follow. Give distances and use compass directions. Be aware of the ambiguity of words like "above", "near", beyond", "on the back side of", "past". The GPS unit can be helpful in measuring distances if you remember to mark your starting point. If plot locations lack major landmark features as guides, use township, range and sections from the topo maps.
Note: Although the plots will not be permanently marked, park staff very much want to be able to relocate them for long-term vegetation monitoring purposes. Careful documentation of the stand characteristics, access route, obvious landmarks and vegetation is therefore extremely important.

Plot Length, Azimuth, Width, and Diameter
Enter width and length dimensions for square or rectangular plots, and the diameter for circular plots. Record the azimuth for the long side of rectangles, or any side of squares.

Plot Photos/ Roll Number/Frame Numbers
Indicate (Y or N) if photos of the plot were taken, and the roll and frame numbers of any photos. Roll numbers should be a team member's initials plus a sequential number, which are written on the film before it goes into the camera.

Photo comments:
Record the directions the photos were taken from and towards (e.g., SE→NW), and record notes regarding any scenery photos taken. Also, representativeness of the biological crust photo can be commented on here. Record the photographer's last name as well.

Taking photographs
Take two color slides of each plot. The purpose is to get a good representation of the vegetation of the plot, not individual species. For circular and square plots, please take the two photos from adjacent sides of the plot. Photos at rectangular plots should be taken from opposite ends of the long side. Use a chalkboard to record the plot number and the direction the photo is taken. Thus, for plot 241, the board in the photo taken from the SE side of the plot, facing NW, will read "CP241, SE→NW". Take the photograph looking across the contour if plot is on a steep slope. In addition, you may want to keep a photograph log for all photos, most importantly for scenic photos not taken at plots.



If you are in a particularly nice, rare or representative stand, please take a third slide, without the signboard in it, from any position as long as it illustrates the community well.

Biological Crust Frame #
Record the frame number of a soil photo, if taken. Take the photo with a 6" ruler for scale in it, and position yourself so that the photo encompasses an area that is ½ meter squared.

Plot Permanent
Since none of the plots will be permanently marked, this field is already filled in with "NO".

Plot Representativeness
a. *Representativeness of association:* Does this plot fit within the established concept of the association in the entire mapping area? How does it differ? It is better to leave this blank than to guess; as you gain experience you will have a better feel for how to answer this.
b. *Representativeness of plot in stand:* Does this sample represent the vegetative community within the surrounding area or polygon? If not, were additional plots taken? Note additional species occurring outside the plot but characteristic of the stand.

1. An example could be: "This BPU is relatively large and very homogenous in species composition, although species density varies slightly. Pinyons are sparsely scattered throughout BPU but none are located inside the plot."
2. Another example: "This polygon encompasses a variety of elevations and aspects, but similar slopes. Multiple plots will be done in this stand. This plot represents a predominantly herbaceous community on a northern aspect."

***Note**: Sometimes variation within a polygon is not large enough to sample, in which case you would describe surrounding communities in the "Other Comments" field on the back of the first data sheet.*

ENVIRONMENTAL DESCRIPTION SECTION (Bottom Half of First Sheet)

Elevation
Elevation of the plot. Take this measurement from the topo map, not the GPS unit. The reading you get from a topo map, provided you are certain where you are, is often more accurate than the average reading from the GPS unit. Specify whether in feet or meters.

Slope
Measure the slope in degrees using a clinometer.

Aspect
Measure the plot aspect in degrees using a compass (set for local magnetic declination).

Topographic Position
This is the position of the plot on its related landform. Determining this requires you to think of the landform in cross-section, which is roughly diagramed on the back of your cheat sheet. You **must** use the descriptions listed below:

Interfluve (crest, summit, ridge). Linear top of ridge, hill, or mountain; the elevated area between two fluves drainages that sheds water to the drainages.
High slope (shoulder slope, upper slope, convex creep slope). The uppermost inclined surface at the top of a slope. Includes the transition zone from backslope to summit. Surface is dominantly convex in profile and erosional in origin.
High level (mesa, summit). Level top of a plateau.
Midslope (transportational midslope). Intermediate slope position.
Backslope (dipslope). Subset of midslopes that are steep, linear, and may include cliff segments.
Step in slope (ledge, terracette). Nearly level shelf interrupting a steep slope, rock wall, or cliff face.
Lowslope (lower slope, foot slope, colluvial footslope). Inner gently inclined surface at the base of a slope. Surface profile is generally concave and a transition between midslope or backslope, and toeslope.
Toeslope (alluvial toeslope). Outermost gently inclined surface at base of a slope. In profile, usually gentle, linear and characterized by alluvial deposition.
Low level (terrace). Valley floor or shoreline representing the former position of an alluvial plain, lake, or shore.

Landform
Enter the landform(s) that describes the site where the plot was sampled. Referring to the topo map for the landscape context may help you decide what landform(s) to choose. Note that the landform choices may

describe different scales, or that a landform feature can be described by more than one term. For example, your plot may be on a ledge on the rim of a canyon. A suggested list of landforms and definitions is provided in **APPENDIX 1.**

Note: The topographic position selected above should relate to the scale of the landform chosen here.

Surficial Geology

Note the geologic substrate where plant community occurs. The geology map should help, but if you can't tell the geology at all or you do not have the geology map with you at the plot, put a general description (e.g., coarse sandstone, green shale, aeolian sands or obscured by soils).

Cowardin System

The majority of the plots you'll be conducting will be "Uplands". Any wetland plots will be one of the three following categories:

Riverine: Characterized by unidirectional flow from upstream to downstream within a channel, with vegetation and habitats contained within that channel. (www.mip.Berkele.edu)
Palustrine: "Palustrine" comes from the Latin word "Palus" or marsh. These systems include any inland, freshwater wetland that lacks flowing water. (www.ecn.purdue.edu)
Lacustrine: "Lacustrine" is related to the word "lake", meaning that the wetland is associated with a lake and is situated in a depression or damned river channel. (www.ecn.purdue.edu)

Hydrology

This field will only be completed if you are in a wetland. Select from the following definitions (from Cowardin et al. 1979):

Permanently flooded. Water covers the land surface at all times of the year in all years.
Semipermanently flooded. Surface water persists throughout growing season in most years except during periods of drought. Land surface is normally saturated when water level drops below soil surface.
Seasonally flooded. Surface water is present for extended periods during the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is very variable, extending from saturated to a water table well below the ground surface.
Saturated. Surface water is seldom present, but substrate is saturated to surface for extended periods during the growing season.
Temporarily flooded. Surface water present for brief periods during growing season, but water table usually lies well below soil surface. Often characterizes flood-plain wetlands.
Intermittently flooded. Substrate is usually exposed, but surface water can be present for variable periods without detectable seasonal periodicity. Inundation is not predictable to a given season and is dependent upon highly localized rain storms. This modifier was developed for use in the arid West for water regimes of playa lakes, intermittent streams, and dry washes but can be used in other parts of the U.S. where appropriate. This modifier can be applied to both wetland and non-wetland situations.
Unknown. The water regime of the area is not known. The unit is labeled a non-tidal wetland.

Environmental Comments

Enter any additional noteworthy comments on the environmental setting and its effect on the vegetation. Examples include: stunted trees due to shallow soils, vegetation only where pockets of soil occur, or large colluvial boulders and small rocks litter surface of soil. This field can also be used to describe site history such as fire events.

Ground Cover

Estimate the approximate percentage of the *total* surface area covered by each category. A helpful hint in making ocular estimates is that in a 200 square meter plot, 2 square meters is equal to 1%. The sum of the cover values should equal 100%. For estimating live litter and live wood, visualize cutting the vegetation off at ground level. The percent ground cover is how much space the stems take up. Estimating lichens, dark cyanobacteria and moss also takes an extra step in visualization. Lichens often are growing on dark cyano mounds or on exposed bedrock, but your estimate needs to reflect the percentage of ground covered by lichens, and your estimates for dark cyano or bedrock will be for non-lichen-covered surfaces. Also note that it is possible to have bare soil and sand in a plot if sand has blown in, or to have sand on the surface of the plot but the soil test results in a texture other than sand because you are sampling below the surface.

Soil Texture

Use a trowel to dig a hole a few inches deep (this will vary with soil depth, of course) to expose the soil at root level, from where you will take a small handful of soil to sample. **APPENDIX 2** is a key to use when sampling soil texture, and an abbreviated version is on the cheat sheet.

Soil Drainage

Soil drainage classes are defined in terms of (1) actual moisture content in excess of field moisture capacity and (2) the extent of the period during which excess water is present in the plant-root zone. Permeability, level of groundwater, and seepage are factors affecting moisture status. However, because these are not easily observed or measured in the field, they cannot generally be used as criteria of moisture status. Use the following definitions to determine soil drainage at your plot:

Rapidly drained. The soil moisture content seldom exceeds field capacity in any horizon except immediately after precipitation. Nearly all of the soils outside of wetlands, springs and floodplains will fall into this category. Rapidly drained soils are commonly coarse textured or soils on steep slopes located well above the water table. ***These soils are characterized by strictly upland species.***

Well drained. The soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year. Soils are usually free from mottling in the upper 3 feet, but may be mottled below this depth. B horizons, if present, are reddish, brownish, or yellowish. ***Look for species that indicate periodic saturation, such as western wheatgrass, Great Basin wildrye, arctic rush or black greasewood.***

Moderately well drained. The soil moisture in excess of field capacity remains for a small but significant period of the year. Soils are commonly mottled (chroma < 2) in the lower B and C horizons or below a depth of 2 feet. The Ae horizon, if present, may be faintly mottled in fine-textured soils and in medium-textured soils that have a slowly permeable layer below the solum. In grassland soils the B and C horizons may be only faintly mottled and the A horizon may be relatively thick and dark. ***Soils in this category and the next three will typically support wetland plants.***

Somewhat poorly drained. The soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year. Soils are commonly mottled in the B and C horizons; the Ae horizon, if present, may be mottled. The matrix generally has a lower chroma than in the well-drained soil on similar parent material.

Poorly drained. The soil moisture in excess of field capacity remains in all horizons for a large part of the year. The soils are usually very strongly gleyed. Except in high-chroma parent materials the B, if present, and upper C horizons usually have matrix colors of low chroma. Faint mottling may occur throughout.

Very poorly drained. Free water remains at or within 12 inches of the surface most of the year. The soils are usually very strongly gleyed. Subsurface horizons usually are of low chroma and yellowish to bluish hues. Mottling may be present but at the depth in the profile. Very poorly drained soils usually have a mucky or peaty surface horizon.

VEGETATION DESCRIPTION SECTION (Back Side of First Sheet)

Leaf Phenology
Select the best description for the leaf phenology of the **dominant** stratum. The dominant stratum is the tallest stratum that contains at least 10% cover. Leave blank for non-vascular plots.

Evergreen. Greater than 75% of the total woody cover is never without green foliage. See list of evergreen plants for this field.
Cold deciduous. Greater than 75% of the total woody cover sheds its foliage in connection with an unfavorable season mainly characterized by winter frost.
Mixed evergreen - cold deciduous. Evergreen and deciduous species are mixed within the type and generally contribute 25-75% of the total woody cover.
Perennial. Herbaceous vegetation composed of more than 50% perennial species.
Annual. Herbaceous vegetation composed of more than 50% annual species.

Leaf Type
Select the best description for the leaf form of the dominant stratum. The dominant stratum is the uppermost stratum that contains at least 10% total plot coverage. Within that dominant stratum, the species that makes up greater than 50% of cover defines the leaf type.

Broad-leaved. Woody vegetation that is primarily broad-leaved (Sagebrush, oak, mountain mahogany).
Needle-leaved. Woody vegetation that is primarily needle-leaved (Juniper, pinyon).
Microphyllous. Woody cover primarily microphyllous (Ephedra).
Graminoid. Herbaceous vegetation composed of more than 50 percent graminoid species (grasses, sedges, rushes, etc).
Forb (broad-leaf-herbaceous). Herbaceous vegetation composed of more than 50% broad-leaf forb species (Phlox, Astragalus, Erigeron, etc).
Pteridophyte. Herbaceous vegetation composed of more than 50 percent ferns or fern allies (scouring rushes).
Non-vascular. Dominated by lichens or mosses.
Mixed. As with leaf phenology, the dominant stratum may be composed approximately equally of species with several different leaf types. Describe the mix briefly or circle leaf types that apply.

Physiognomic Class
This represents what you see when you are standing in the plot looking across at the vegetation. The following definitions can be used as guidelines, but may not always apply in desert locals. For example, areas with scattered pinyon and juniper may not fit the cover classes below but they would best be described as a woodland.

Forest. Trees with their crowns overlapping (generally forming 60-100% cover).
Woodland. Open stands of trees with crowns not usually touching (generally forming 25-60% cover). Canopy tree cover may be less than 25% in cases where it exceeds shrub, dwarf-shrub, herb, and nonvascular cover, respectively.
Shrubland. Shrubs generally greater than 0.5 m tall with individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees generally less than 10% cover). Shrub cover may be less than 25% where it exceeds tree, dwarf-shrub, herb, and nonvascular cover, respectively. Vegetation composed of woody vines is included this class.
Dwarf-Shrubland. Low-growing shrubs usually under 0.5 m tall. Individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees and tall shrubs generally less than 10% cover). Dwarf-shrub cover may be less than 25% where it exceeds tree, shrub, herb, and nonvascular cover, respectively.

Shrub Herbaceous. Low or taller shrubs forming approximately equal cover with a grass or forb component. Individuals or clumps of shrubs generally not touching and usually forming more than 25% cover; trees less than 10% cover. Spaces between shrubs are generally mostly occupied by grasses and/or forbs.
Herbaceous. Perennial herbs (graminoids or forbs) dominant (generally forming at least 25% cover; trees, shrubs, and dwarf-shrubs generally with less than 10% cover). Herb cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and nonvascular cover, respectively.
Nonvascular. Nonvascular cover (bryophytes, non-crustose lichens, and algae) dominant (generally forming at least 25% cover). Nonvascular perennial vegetation cover may be less than 25%, as long as it exceeds tree, shrub, dwarf-shrub, and herb cover.
Sparsely Vegetated. Abiotic substrate features dominant. Perennial vegetation is scattered to nearly absent and generally restricted to areas of concentrated resources. Total vegetation cover is typically less than 5% and greater than 0%. Badlands or sand dunes supporting communities of annual plants should be included in this category, regardless of cover.

Height Class, Cover Class, and Dominant Species
This chart summarizes the plant information of the plot and should be filled in after the second page (plant species list) is completed.

1. Indicate the average height class of the stratum in the first column, using the Height Scale in the upper right hand corner of the form.
2. Enter the average percent cover class of the whole stratum in the second column, using the Cover Scale in the upper right hand corner of the form.
3. List the dominant species of each stratum in order of their cover class. For example, if you have two canopy species and one is cover class "2" and one is "P", list them in that order. If you have ten forb species, and two are "P" while the others are "T", list the first two in order of which one is more abundant. If all species are the same cover, writing "mixed" is acceptable. However, if there is only one species and it is "T", list that one plant.

ALWAYS fill in the Height Class and Cover Class for "Ht Herbaceous", which represents total herbaceous species in plot (H1, H2, H3 and H4).

Animal Use Evidence
Comment on any evidence of use of the plot and BPU by non-domestic animals (i.e., tracks, scat, burrows, etc.). Notes on domestic animals should be made in the next field.

Natural and Anthropogenic Disturbance
Comment on any evidence of natural or anthropogenic disturbance and specify the source, severity and effects on the vegetation. Common disturbances in ARCH plots are water gullies, colluvial deposition of rocks on slopes and sometimes old tin cans from cowboys or miners.

Other Comments
Any other comments, or continue comments from other sections. Describe the landscape context of the community. What are the adjacent plant communities? Are there any other landscape features or processes influencing this community? Is there a species that occurs in the BPU but is not within your plot? Is there a large amount of a dead species in the plot?

PLANT SPECIES LIST (Front Side of Second Sheet)

Plot Code
Circle the correct acronym for the park you are working in. Write the plot number on the blank line. This field is a **must** so that in the event that the two data sheets get separated, they can be paired up again.

Species / Percent Cover Table

This table is composed of the following four different columns, three duplicate to allow for many plant names:

1. **Stratum:** This column is where you write the code corresponding to a given strata. The codes are listed in the lower right hand corner of the table. A park plant list with life forms will be provided to you to help determine how to describe some relatively confusing species.
2. **Species Name:** Refer to the plant list you have been provided for plant names used in this area (from *Utah Flora*). For **very** common species, the use of 6-letter codes in this field is fine, but you **MUST** use to the provided list for accurate 6-letter codes. The 6-letter codes are simply the first three letters of the genus name and the first three letters of the species name (e.g., PINEDU stands for *Pinus edulis*). If plants are not **very** common, you are still learning a given plant, or you just keyed it out, write out the majority if not the whole name so there is absolutely no confusion regarding that plant.
3. **Cover Class:** Estimate the aerial / crown cover of **each** plant listed, using the codes listed in the lower right hand corner of the table.
4. **TOTALS:** This column summarizes the cover class totals for each stratum. For example, if you have two canopy species─let's say juniper and pinyon─and their cover classes are "01" for 12% and "P" for 5%, your total cover class would be "02" for 17%.

   ***Note**: The "TOTALS" column is the same as the "Cover Class" column on the back of the first sheet, in the "Dominant Species" chart. The "TOTALS" column is intended to aid in the accuracy of transcribing information from one data sheet to the other.*

Begin by assessing the strata at your plot. Pinyon and juniper make up the majority of Arches' "canopy", but where they are absent you would begin with the shrubs, or herbaceous species if no shrubs are present either. If the tree crowns in your plot are mostly touching and similar in height, but a given tree species is much taller that species would be an "emergent", which is not typical of vegetative communities in this area. Occasionally, you will sample an area where there may be several tall, scattered cottonwoods and then shorter scattered junipers. In this case, the cottonwoods would be your "canopy" and the junipers would be the "subcanopy".

Note: Trees are defined as single-stemmed woody plants, generally 5 m in height or greater at maturity and under optimal growing conditions. Shrubs are defined as multiple-stemmed woody plants generally less than 5 m in height at maturity and under optimal growing conditions. The exception is mature pinyon and juniper plants, which are considered trees regardless of their height.

The remaining vegetative strata are (remember to check with plant list for consistency):

S1 Tall Shrub. >2 meters tall. For example, *Fraxinus anomalous* and *Purshia mexicana.*
S2 Short Shrub. <2 meters tall. For example, *Coleogyne ramosissimum.*
S3 Dwarf Shrub. <0.5 meters tall. For example, *Opuntia polycantha.*
H1 Graminoid. All grass species, including *Juncus arcticus.*
H2 Forb. All forbs.
H3 Fern or Fern Ally. All ferns, including *Equisetum hyemale.*
H4 Tree Seedlings. Seedlings are trees with vertical stems less than 1.5 m tall, but that may vary by species.
N Nonvascular. This is mainly dark cyanobacteria, mosses and lichens.
V Vine/liana. All vine species.
E Epiphyte. All epiphytic species.

Once you have identified your strata, write the uppermost strata code in the corresponding column. List all plant species in that strata, as well as their class cover code. Then list the next strata. Skipping several lines between strata will allow you to fill in plant names and cover classes as you move through the plot and identify plants. Be thorough in looking for plant species in your plot, but do not spend excessive amounts of time looking for new or different plants. Remember that these plot data are to be used to classify the vegetation of the Park, not to make a complete species list for it. If you had to spend much more than 20 minutes to find a species, it probably isn't going to be important in characterizing the vegetation type.

If you can't identify or easily key out the plant at the plot, assign a name to it to be recorded on your data sheet. For example, if you know what family it is in or its genus, label it "unknown Asteraceae sp." or "Unk. Erigeron sp.". If there are more than one unknown in a family, add a number to the name you give them. If you do not know the family, label the plant "Unknown 1", using consecutive numbers for additional unknowns. Record the cover class and other data for the unknown as you would for any other species. Then, take a sample of the species with as much of the plant as possible, especially intact sexual parts, if present. Place the sample in a plastic baggie, and either label the plant (if you are putting more than one plant in the baggie) or label the baggie with the plot code, the date and the name you gave it on the data form. Plant samples in baggies can be stored in coolers or refrigerators for short periods. If you are not able to key the plant out soon after collecting it, or you intend to keep the sample for the park collection, press the plant and with a label stating the plot or location of its collection (include UTMs if the sample is not from a plot), date, collectors name and name you assigned the plant. Also, thoroughly label any plant specimens collected as proof of plant occurrence for plants not listed on park plant list.

TREE DBH FORM (Back Side of Second Page)

DBH and Fuels Data Form
In plots containing pinyon and/or juniper trees, record the species and diameter at root crown (ground level) of all stems belonging to trees taller than 4.5 feet. Also record crown width and crown height in meters. If there are more than about 25 trees more than 4.5 feet tall, divide the plot into quarters and measure the DBH of trees in the southeast quadrant. NOTE on the form that this is what you've done.

Pinyon-juniper Age Class.
If you are in a plot that contains pinyon and/or juniper trees (whether or not you have called the plot in PJ alliance/association), check the box that best describes the age class of the stand based on these criteria:

Old-growth (>500 years). Ancient trees with flat crowns, much dead wood, dead trees on ground, some younger trees occupying canopy gaps. "You know it when you're in it". Is extremely rare.
Mature (350-500 years). Large old trees with flat crowns, some with gnarled trunks, lightning scars and dead wood, others without. Tends not to have much understory, depending on soils.
Young (100-500 years). Developed canopy of large trees, but some or all junipers have pointed crowns. There tends to be a well-developed understory of shrubs and sometimes forbs and grasses.
Invasive (<80 years). Scattered smaller trees, all with pointed crowns, in a community clearly dominated by shrubs or grasses.

OBSERVATION POINT FORM INSTRUCTIONS

These instructions correspond to the 2003 version of the Observation Point Forms.
Many fields are identical to fields on the Plot Survey Forms and will not be re-defined here.

Observation Point Forms are to be used when, (1) you find a unique vegetative stand too small to conduct a plot in, (2) you are unable to access a BPU but can view it well enough to collect some data, (3) enough plots have been conducted for a given community type and the project supervisor instructs you to do Observation Points for BPUs encompassing that community, or (4) you do not have time to conduct a plot and the area you are in is time consuming to access at a later date. You will notice that these forms are not as extensive as Plot Survey Forms. The role of Observation Point forms is to further aid in aerial photo interpretation.

IDENTIFIERS / LOCATORS SECTION (Top of Front Page)

This entire section should be filled out exactly as you completed this section on the Plot Survey Form. Please refer to the Plot Survey Form instructions for this section. As with the procedures for Plots, you must mark the location of the Observation Point on the corresponding aerial photo and BPU map.

You will not need to measure the area you are surveying for this form, although an estimated area can be noted in your comments. In terms of photographing this sample area, you are asked to take one photo that accurately captures the vegetative stand. Use the chalkboard as you would at a plot.

Observation Points should be assigned a code similar to Plot Survey codes to be used as a file name and on the chalkboard in the photo. This code will be "AO", for Arches Observation Point, and the number of the point (e.g., "AO101" for point number 101).

ENVIRONMENTAL DESCRIPTION SECTION (Middle of Front Page)

The majority of this section is the same as the Plot Survey Form for which the instructions are stated previously. These fields are as follows: Elevation, Slope, Aspect, Topographic Position, Landform, Geology, Cowardin Wetland Classification System, and Hydrologic Regime - Non Tidal.

Environmental Comments
This field is also on the Plot Survey Form. However, it is the only comments field on the Observation Point Form. Please use this space to record comments like you would have at plots, as well as any comments you would have made in the "Animal Use Evidence", "Natural and Anthropogenic Disturbance Comments" and "Other Comments" fields on the Plot Survey Form. Also note why an Observation Point was done instead of a Plot Survey.

Unvegetated Surface
This field is an ocular estimate of ground cover, so plants should be visualized as being cut off at ground level. Because there is no designated sample size for areas surveyed as Observation Points, you will have to estimate percent covers for whatever size the area is. For this estimation, you must use the cover classes listed in the bottom right hand corner of the data sheet. If an unvegetated surface category is not present in your observation point area (e.g., water is very uncommon in the sampling units), leave the corresponding line blank. The cover class "01" represents occurrences greater than 0% but less than 10%.

> ***Note:*** *These cover classes are very broad, especially for desert species occurrences. If a species is not accurately represented by these cover classes, note this in the comments field.*

VEGETATION DESCRIPTION SECTION (Bottom of Front Page)

These three fields: Leaf Phenology, Leaf Type and Physiognomic Class, are the same as those on the Plot Survey Form. Please refer to the previously listed instructions for these fields.

DOMINANT PLANT SPECIES LIST (Back Page)

There are four columns that correspond to the "Stratum" column in this table. The strata have been discussed in the Plot Survey Form instructions, which you should refer to for this form. As for the blank columns:

1. **Height.** Use the number code that best describes the heights of all plant species within a given stratum. The number codes are listed in the bottom left had corner of the data sheet.
2. **Cover Class.** For this ocular estimation you are looking at the aerial cover of **all** plants within a given stratum. Use the cover class codes listed in the bottom right hand corner of the data sheet.
3. **Dominant Species (mark diagnostic spp with a *).** List the plant species using the 6-letter code discussed in the Plot Survey Form instructions. You may find that there are not enough lines, in which case you can write in the blank area under the stratum name and number codes. Mark the dominant plant(s) with an asterisk (*).
4. **% Cover.** Estimate the percent aerial cover for each plant species. Again, use the cover class codes listed in the bottom right hand corner of the data sheet.

SOIL TEXTURE KEY

(Brewer and McCann 1982)

Soil primarily organic:

0a. Soil is black, is saturated with water, and often smells of rotten eggs ...……..**muck**
0b. Soil is dark brown, usually saturated, and consists of clearly identifiable plant parts ……...**peat**

Soil primarily mineral:

1a. Soil does not remain in a ball when squeezed, leaves your fingers clean ..…….....**sand**
1b. Soil remains in a ball when squeezed ……..…….....2

Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you push up over your finger.

2a. Soil makes no ribbon but leaves your fingers dirty ……..……**loamy sand**
2b. Soil makes at least a very short ribbon .....……...3

3a. Ribbon extends less than 1 inch before breaking …….....4
3b. Ribbon extends 1 inch or more before breaking ….……..…….....5

4a. Add excess water to small amount of soil. Soil feels at least slightly gritty
……..…… ……..…**loam or sandy loam**
4b. Soil feels smooth....……..... **silt loam**

5a. Soil makes a ribbon that breaks when 1-2 inches long; cracks if bent into a ring 6
5b. Soil makes a ribbon 2+ inches long; does not crack when bent into a ring ……..…7

6a. Add excess water to small amount of soil; soil feels at least slightly gritty
…… **sandy clay loam**
6b. Soil feels smooth..……..... **silty clay loam**

7a. Add excess water to a small amount of soil; soil feels at least slightly gritty
…….……... **sandy clay**
7b. Soil feels smooth.....…….…….... **silty clay or clay**

CONSIDERATIONS FOR PLANNING

Planning for the day:

1. Safety and sustenance: Plenty of food, water, first-aid kit, raingear, sunscreen.
2. Field communications:
   a. Develop a plan with other team(s) for radio check-in time.
   b. Do you have a radio and are batteries charged? If you have a walkie talkie, do you have extra batteries for it? Does park staff know the area in which you will be working?
3. Make sure you have the right maps and photos.
4. Check your GPS (Datum set to NAD83? Needs new batteries?).
5. Plan the day's mission before departing using a) USGS quads, b) aerial photo, c) park/BLM maps.
6. Considerations for mission planning:
   a. Plan travel based on topography, best access routes, density and complexity of vegetation (more time for forest and woodland plots, less for herbaceous and scrub).
   b. Plan data collection based on priority needs; new types get higher priority.
   c. Communicate with the other team(s) to make sure you aren't duplicating effort.

Planning for the Week (do this on the first day of the trip)

1. Do you have all appropriate maps, photos?
2. Develop a reasonable estimate of the number of plots for each team broken up by day and based on an estimate of individual team's travel logistics for the week.
3. Develop plan of attack for the week to capture all essential associations in the work area.
4. Balance points two and three above with the expected work schedule of the teams and ensure adequate time-off and reduce over-time concerns.
5. Do you have all necessary information and backups for the week's planning? E.g., blank field forms, film, plenty of AA batteries.

Wrapup (Do this on the last day of the trip, after you have returned to base)

1. Clean, recharge and repair equipment.
2. Hold brief meeting to discuss data collection issues, things that came up during the work week, and plan for next work hitch.
3. Edit field forms and file them systematically. File observation points separately.
4. Re-file the aerial photos and maps.
5. Send exposed roles of film to be developed.
6. Key unknown plants.
7. Enter edited data into database.

Communicate among teams / Topics for wrap-up meetings.

1. What were your questions about the polygons visited during the week?
2. Do you have any questions about the forms or fields?
3. What was accomplished, what was not accomplished?
4. Pass on developments and questions after every trip. Don't let them build up. For example, should we sample the new types we saw? Were there problems with interpreting the aerial photos, or are there personnel issues, problems in consistency in interpreting the forms, or with park-related logistics?

Vegetation Plot Sampling Materials Checklist

- Park research permit
- Topo maps
- Park and BLM maps for general navigation
- Maps of BPU locations
- Geology map
- Aerial photos
- DBH tape and 2 tape measure(s)
- Trowel or U-dig-it, soil water bottle
- Compass with adjustable declination
- Clinometer
- GPS unit
- Plenty of AA batteries for GPS and walkie talkie
- Radio or walkie talkie and/or cell phone
- 35 mm camera & film (allow at least 2 exposures per plot plus general and scenic photos)
- Baggies for temporary storage of unknown plants, and masking tape for labeling
- Plant press & paper
- Plant Keys / Flora(s)
- Pens / sharpies / dry erase marker
- Forms: plot survey (both pages) and observation point
- Clipboard/forms holder and clear page protector sleeve
- Pens, pencils, pencil lead, chalk (for slate board), and chalkboard eraser
- Stapler and extra staples
- Most recent version of provisional classification of the park, with the number of plots still needed per type (updated approx. every 2 weeks)
- All ancillary information (cheat sheet, species list, floras, sampling priority list for zone, main sampling protocol).
- First aid kit, personal gear (food, water, rain gear, etc.)

ARCHES CHEATSHEET

LANDFORM

Alluvial fan
Alluvial flat
Arroyo
Badlands
Bajada
Bank
Basin
Bench
Blowout
Box canyon
Butte
Canyon
Channel
Cliff
Colluvial Slope
Cuesta
Debris flow
Deflation basin
Depression
Dike
Dune
Eolian deposit
Escarpment
Fan remnant
Floodplain
Gap
Gorge
Hill
Hogback
Interfluve
Intermitt. stream
Knob
Knoll
Landslide
Meander scroll
Mountain
Mud flat
Overflow channel
Peak
Piedmont
Plain
Plateau
Playa
Ravine
Ridge
Rim
River

LANDFORM

Rockfall
Rotational slide
Saddle
Scree slope
Seep
Slide
Slot canyon
Slough
Stream terrace
Swale
Talus slope
Terrace
Valley floor
Valley side
Wash

ASPECT

Flat
Azimuth (deg.)
Variable

PLOT SIZE

400m^2 (11.3m r):
Forests
Woodlands
Shrublands

100m^2 (5.6 m r):
Dwarf Shrublands
Shrub-Herbaceous
Herbaceous

25m^2 (2.8m r):
Non vascular

You may adapt plot size and shape to fit the situation; but never choose a plot size **smaller** than listed here.

TOPOGRAPHIC POSITION

Designation	Synonym(s)
Interfluve	crest, summit, ridge
High slope	shoulder slope, upper slope, convex creep slope
High level	mesa, plateau
Midslope	transportational midslope,
Backslope	dipslope, cliff
Step in slope	ledge, terracette, bench
Lowslope	lower slope, foot slope, colluvial footslope
Toeslope	alluvial toeslope
Low level	terrace, valley floor, floodplain

SEE ALSO THE DIAGRAM OTHER SIDE

VEGETATIVE STRATA

T1 = emergent tree
T2 = tree canopy
T3 = tree sub-canopy.
S1 = tall shrub, > 2m
S2 = short shrub, < 2m
S3 = dwarf shrub. < 0.5m
H1 = graminoid
H2 = forb
H3 = fern or fern ally
H4 = Tree seedlings
N = nonvascular other than ferns
V = vine/liana
E = epiphyte

PARK SPECIALS (keep an eye out for)

Rare plants
Raptor nesting sites
Upland springs and seeps or Hanging Gardens
Flammable historic/archaeological sites
Invasive weeds (ignore cheatgrass, dandelions)
Abandoned agricultural fields (e.g., old alfalfa)

Physiognomic Class

Forest: Crowns touching
Woodland: Trees>25%, crowns not touching
Shrubland: Shrubs> grass, forbs or trees
Dwarf Shrubland: Shrubland <0.5 m tall
Shrub Herbaceous: Shrubs = Forbs/grasses
Herbaceous: Grass/forbs > trees or shrubs

SOIL TEXTURE

Sand: clean, no ball
Loamy sand: ball, no ribbon
Sandy loam: gritty weak ribbon
Silt loam: smooth weak ribbon
Clay loam: long ribbon, no ring
Clay: smooth ribbon/ring, edible
Sandy Clay; gritty ribbon & ring
Silty Clay: smooth ribbon/ring
Peat: still has plant parts
Muck: smelly black ooze

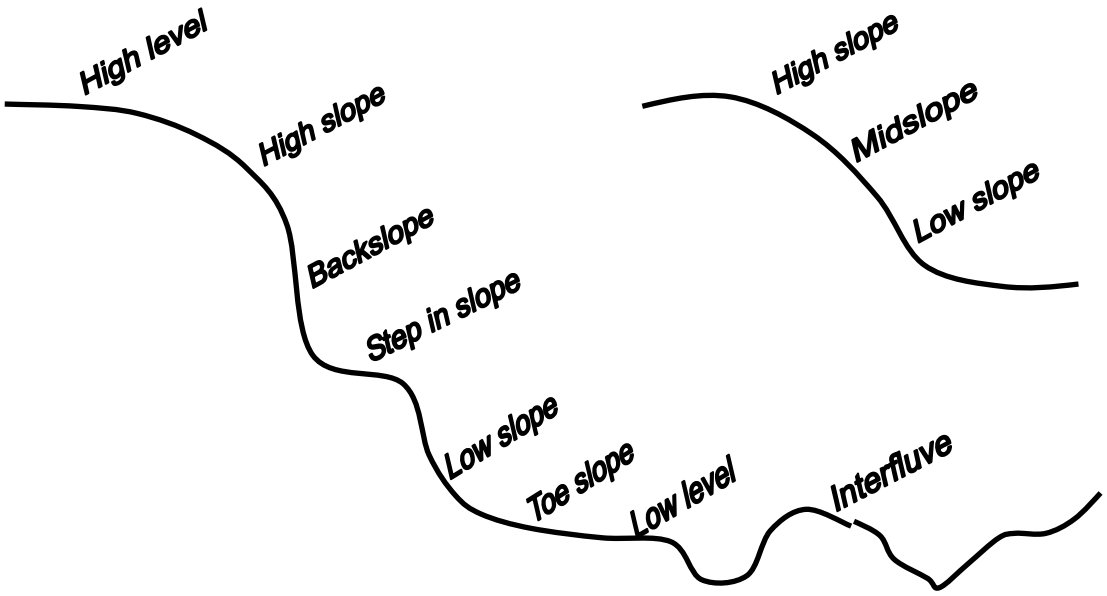
SURFICIAL GEOLOGY

Obscured by soil
Aeolian sands
Alluvial deposits
Older Alluvium (pre Holocene)
Talus / Colluvium / Landslides
Mancos Shale
Cedar Mesa Sandstone
Dakota Sandstone
Morrison - Brushy Basin Member
Morrison - Salt Wash Member
Morrison - Tidwell Member
Moab Tongue- Curtis Fm
Entrada Sandstone
Dewey Bridge
Navajo Sandstone
Organ Rock Shale- Cutler Group
Kayenta Formation
Wingate Sandstone
Chinle Formation
Moenkopi Fm
Cutler Group (undiff)
Halgaito Shale
Honaker Trail Formation Paradox Formation

IMPACTS

Fire or fire suppression activity
Mountain pine beetle damage
Mistletoe (specify tree species)
Grazing evidence
Development, historic structures
ORV use or Recreation (campsites, etc.)
Wildlife concentration

TOPOGRAPHIC POSITION - CHEAT SHEET



B.2. Accuracy Assessment Point Field Sampling Manual

Accuracy Assessment Field Manual - 2006
Arches National Park and Fossil Butte National Monument

This manual documents accuracy assessment (AA) data collection procedures for Arches National Park (ARCH), and Fossil Butte National Monument (FOBU). This project is directed by the Northern Colorado Plateau Network (NCPN) with assistance from engineering environmental Management, Inc. (E2M) and NatureServe.

The primary purpose of accuracy assessment (AA) fieldwork is to supply data that will test the accuracy of vegetation maps. It is also a continuation of the sampling of vegetation communities. The main uses of the AA data are:

- Verify accuracy of polygons drawn on the map (map units)
- Verify relationships between associations and mapping units
- Verify that field key works well to classify vegetation to association
- Check for classification completeness –undescribed associations not sampled during inventory
- Clarify concepts and augment descriptions of existing associations and possibly develop new associations

There are a number of factors that contribute to error on a vegetation map and some of these are listed below. It is important for the field investigator to be aware of these situations and to take actions to minimize error when at all possible.

- Locational error (when it is not possible to get a good GPS point, the AA point data collected may look like it is in another polygon, or if the polygons are small/narrow and the GPS isn't working well, it may be difficult to know which polygon is supposed to be sampled).
- Field key is difficult to use, leading the investigator to assign the point to the wrong association.
- Field key does not include all plant associations in the park, also leading to confusion in which association to assign to a point.
- Field data error- either by mis-identifying diagnostic species, or by not reading the key carefully, resulting in a bad field call when the map is actually accurate.
- AA point falls within an ecotone, which is impossible to classify but still has to be mapped as something
- Relationships between plant associations and map units (modeling) are flawed.
- The polygon is heterogeneous, including patches of varying vegetation that are too small to map individually. The AA point may happen to fall in a part of the polygon with a different community than what the photo interpreter saw in the bigger picture.

NAVIGATING TO A POINT

The field investigator will navigate to each selected AA point using handheld GPS receivers and maps consisting of a digital orthophoto (DOQQ) base overlaid with AA point locations, mapped vegetation polygons and USGS 7.5 minute topographic quadrangle maps.

- The DOQQ maps will identify the location of the AA points, as well as the location, size and shape of the polygons.
- Topographic maps are useful in identifying the landscape when navigating to a point, and in determining the elevation of a point. They are also helpful for obtaining names of topographic features used for assigning site names.
- GPS receivers indicate the direction and the distance (as the crow flies) to the AA point. This can obviously lead to trouble if one were to navigate as the crow flies to AA points, not being aware of canyons or other obstacles in the way. Use the DOQQ and topo maps to plan the route! ***Note***: *In very homogenous terrain, GPS the location of the field vehicle so one can find their way back!*

Use the GPS unit to locate the point within 5-10 m of coordinates, but do not spend a lot of time trying to be exact. A 5000m2 area around each point will be evaluated, which is the size of Minimum Mapping Unit (MMU = 0.5 ha). The MMU is the smallest area that the photo interpreters are required to map to vegetation class. (However, mappers can choose to delineate smaller polygons if the map class is distinctive). Typically the AA plot will be circular in shape (40 m radius), however, in some situations the plot shape will need to be varied to accommodate the map unit being samples (e.g. a long-narrow riparian area, or point falling too close to the edge of a polygon).

At each AA point the investigator will key the vegetation to plant association within half a hectare around each point. The MMU is a relatively large area - approximately the size of a football field with endzones (50m x100m rectangle, 71m x71m square, 80m diameter circle). The shape of the MMU may need to vary depending on the shape of the mapping polygon, but for large polygons, an 80m diameter circle is easiest. If the polygon is smaller than the MMU, evaluate the whole polygon

Along the way... Identify the polygons that the target AA points are in, and if possible walk through part of the polygons on the way to the points, noting polygon boundaries. Is the map polygon uniform or variable? Is the AA point representative of the polygon? Record these observations on the AA form upon arrival at the point.

A word about safety… As with all fieldwork, navigation will occur through rough terrain, often off-trail, to reach the destination. However, particularly in AA work, there is a desire to reach as many points as possible in a day, and to get as close to each point as feasible. No AA point is worth risking one's life! Use good judgment. A list of alternate points will be provided in case an AA point cannot be reached due to difficult terrain or other reasons. If this happens, PLEASE document that the point was not reachable so that the effort is not repeated by someone else.

Occasionally the AA point will fall on the edge of two vegetation types, or at the edge of a polygon. In these instances the field crew member will need to use judgment on how to handle. If two distinct plant associations are present on a site, it may be helpful to record separate species lists for each of the communities on the field form. In addition, both types would be keyed and recorded on the field form. There will be many times where the point falls at the edge of a polygon. In selecting AA points a 12.5 m buffer from the polygon edge is used, therefore hopefully ensuring that most AA points fall cleanly with the polygon boundaries. However, in some cases the AA point will partially include some of the adjacent polygon. In this situation, the field crew member will shift the center of their AA point away from the polygon edge so that it will not fall in the adjacent polygon. The AA point will be gps-ed at this new location, the checkbox "other" for plot shape will be checked, and this shifting of location will be documented by the observer at the end of the "Classification Comments" section.

AA POINT FORM INSTRUCTIONS – 2005

This section documents field by field instructions for AA point data collection and serves as guidance for completing the AA Point Data Form for ARCH. Upon arrival at an AA point location, the field investigator will take a waypoint with the GPS unit. Please make sure the GPS unit is set for NAD83, and that the WAAS is on (see 3D differential, below). If a Trimble unit is used, then several data fields will be collected electronically in the GPS data dictionary as well as manually recorded on the forms. Manual recording of data serves as a backup in case of GPS failure. Park-specific cheatsheets are provided at the end of this section to assist with field workers with data collection.

IDENTIFIERS / LOCATORS SECTION

AA Point code:
Accuracy assessment point codes are derived from the codes assigned to points on the DOQQ photo map, with "_AA." inserted between the 4-letter park alphacode and point number. Four letter park codes for this project are ARCH or FOBU. An example of an AA point at Arches would be ARCH_AA.0101. Please note that park specific datasheets already have the parkcode and '_AA.' delimiter listed. The field investigator will only need to record the 4-digit AA point number on the form.

Quad name:
Record the full name of the 7.5 minute quadrangle.

County, State:
This will be completed in the office.

Park Site Name:
This is best determined from the topographic map. Select a nearby feature that is an obvious waypoint, such as the name of a canyon, road, arch, etc. This name does not need to be unique. If a number of AA points are sampled in a small area the same site name may be used for all of them.

Survey Date:
Enter the date the AA point was sampled. Please use the format Month- Day- Year.

Surveyor(s):
Full last name(s) of the field team member(s) collecting data.

AA Point Shape:
Select one of the following choices to describe plot shape: circular or other. (Remember, other must be circled if the AA point center is shifted away from the coordinates you were given). In the case of other please provide comments in the classification comments field below.

GPS file:
This field only needs to be completed if a GPS unit other than Trimble GeoXM is being used. For instance, if a Garmin unit is being used then enter the name given to the waypoint when the AA point was marked in the GPS unit. It would be useful to assign a name that incorporates the AA point number.

Field UTMX, Field UTMY

Record the UTM easting and northing that was saved as a waypoint in the GPS. Please double check to make sure the easting is six digits and the northing is seven digits.

In deep canyon country, it is often difficult to obtain a GPS reading (the GPS has to be able to 'see' at least three or four satellites). If it is not possible to get a GPS reading in the point, or if the PDOP is greater than 8 (or EPE is greater than ±50m), first try to get a signal from a higher point outside (but still close to) the point. If that fails, then estimate the UTM coordinates from the topo map, and manually enter these UTMs into the GPS unit.

Use a map that is in NAD 83 if at all possible, since the project standard is the NAD83 datum. However, USGS 7.5 minute maps use the NAD27 datum. The difference in this part of the world is that the NAD83 grid is shifted about 60m west and 200m north of NAD27.

Coordinates derived from NAD27 topographic map?
If coordinates are manually derived from a NAD27 USGS topographic map please check the appropriate box on the field form. To ensure that all AA points show up in the right place, please use this procedure when estimating UTM coordinates from a NAD27 topo map:

1. Locate the AA point as accurately as possible on the topo map, using triangulation or climbing to a high point.
2. Use the topo map, straightedge, pencil and a transparent overlay grid to obtain UTM coordinates in NAD27 (done carefully, one should be able to get to the nearest 10m). Write these coordinates down in the GPS Comments Field with the note "UTM coordinates derived from NAD27 topo map". DO NOT enter these in the UTM X and UTM Y fields.
3. Update the settings in the GPS unit to the NAD27 datum.
4. Create a new waypoint, give it the code of the AA point, and enter the UTM coordinates that were recorded.
5. Update the settings in the GPS unit to the NAD83 datum. This will convert the NAD27 coordinates to NAD83 without screwing up the coordinates already in the machine (there may be rounding error). Enter the converted coordinates (now in NAD 83) into the UTM X and UTM Y fields.
6. Try to do this only once per hitch, because the more often it is done then the more likely it is that the rounding error will change the coordinates of other (non-topo-derived) points. This can be done back in the office during datasheet review and data entry.

GPS Unit:
Record the name and model of the GPS unit being used to record data for the point. If a GPS unit was not used to determine UTMs record 'none' here and be sure to complete the 'GPS Comments' field below.

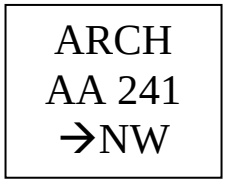
GPS Error
Note the PDOP (or "Estimated Position Error" (EPE), if a Garmin unit is being used) displayed on the GPS unit. The lower the number, the more accurate the reading.

3D Differential?
3D differential is obtained when the GPS unit can "see" a satellite that does nothing but correct the tiny errors in the positioning or clocks of other GPS satellites. This satellite broadcasts a real-time differential correction so that the location coordinates are as accurate as possible. It is in geosynchronous orbit in the southern sky, so if the southern sky is visible, one will generally be able to get 3D differential. This system is known as the Wide-Area Augmentation System, or WAAS. The Garmin and Trimble units have a field in their setup pages for turning WAAS on or off. Please make sure that WAAS is **always** on.

GPS Comments:
VERY IMPORTANT: If the field investigator resorted to estimating the AA point location UTMs on the topo map, note that in this field. If the usual GPS croaked and an old Magellan had to be borrowed from a friend, note that. Also, if the investigator had to leave the point to get a reading from a high point, record that here, along with the compass bearing and distance of the GPS location from the point center (unless offset function was used on the Trimble GeoXM- in that case, enter "point offset.")

Camera:
Circle the appropriate camera name and model, or enter it next to "other" if it is not on the datasheet.

Taking photographs
Take one color slide of each AA point, two if there is more than one community present. The purpose is to get a good representation that accurately captures the vegetative stand of the AA point. If the area is heterogeneous, please represent this in the photos. Try to include a little sky for perspective. Use a chalkboard to record the point number and the direction the photo is taken. Thus, for AA point 241, the board in the photo taken from the SE facing NW across the point will read "ARCH AA 241, →NW". Take the photographs looking across the contour if point is on a steep slope. In addition, a photograph log for all photos not taken at AA points will need to be maintained. It is not anticipated that crews would routinely take additional photos, however, if a crew member finds a new vegetation type not previously described, please document this situation with a photograph without the signboard.



Photos: Type/Roll Number/Frame Number/Photographer/Direction and Comments
For each photo taken at the AA point record the following: *Roll number*: record roll number (Roll numbers should be a team member's initials plus a sequential number, which are written on the film before it goes into the camera.) *Frame number*: record frame number of photo. *Photographer*: record last name of person taking photograph. *Directions/Comments*: record the direction the photos were taken from and towards (SE→NW) and any other comments to clarify contents of the photo.

ASSOCIATION INFORMATION SECTION

Primary Name, Secondary Name, Tertiary Name:
Fill out this section last, after all the vegetation information has been collected. Using the environmental, stratum and cover data, key the vegetation in the half-hectare area around the AA point to association. Choose carefully! Write the name of the association in the primary association field. If the situation is borderline between two associations (e.g., some sagebrush, but also some muttongrass), write other association name in the secondary association field. A tertiary name field has also been provided for the few occasions where a third call is needed. If vegetation near point does not key well, make the best effort to fit it into one or two of the associations listed in the manual, then make detailed comments in the "Classification Comments" field to justify the selection and/or reasoning.

If vegetation near the point does not fit the plant association key at all, then create a new name using the dominant species of each strata (as would be done for a plot). Provide information to characterize the new association in the comments field.

Is Primary/Secondary/Tertiary Name a New Association?
If the investigator encountered a new vegetation type and applied a new name (not in the field key) then please check the 'box' to the right of the name indicating that the name is a new association. Please be sure to provide comments in the classification comments field.

Other Vegetation Associations Within 50 m
List associations that are within 50m of the outside border of the half-hectare AA point being evaluated.

Representativeness of AA point:
Because AA points are randomly located within a polygon, there is no guarantee that they will land in a spot that is representative of either the polygon or of the associations included within the polygon's map unit. The point could easily land in a small gully or an inclusion that is too small to map, or an ecotone where trees are invading a shrubland, for instance. Because of this, it is important that the investigator pay attention not only to the vegetation within the ½ hectare sample area, but the larger area as well. For the primary plant association call, please rank the representativeness of this AA point for the polygon (Good, Fair, Poor or Unknown). Please note in the Classification Comments field if the AA point falls in an ecotone or inclusion, or in an anomalous situation such as a gully or rock outcrop. If the polygon is extremely large and the observer is unable to make an assessment, then please use the 'unknown' field.

Fit of plant association to description in the key:
The key being used does not provide a lot of descriptive information for each association, and is likely not to contain all the associations that may be encountered. Rank the representativeness of the AA point's primary association to the description in the key (Good, Fair, Poor). (If you created a new name for the association, rank the representativeness as poor) Please describe briefly any difficulty experienced in using the plant association key in the ***Field Key Log*** pages in the back of the field key. It would also be helpful to have specific suggestions on how to make the key work better. The field key log will ask you for a reference to the AA point number where the problem was encountered and a description of what didn't work and your suggestions. This is extremely important! It will provide information for improving the key for the final report.

ENVIRONMENTAL DESCRIPTION SECTION

Elevation
Elevation of the AA point. If a Trimble GeoXM is being used then use the GPS unit to record elevation in meters. If a different GPS unit is being used then estimate the elevation from the topographic map. Specify on the data sheet whether the measurement is in feet or meters, and whether it was obtained from a GPS unit or a map.

Slope
Measure the slope in degrees using a clinometer. The degree scale is the left-hand scale when looking through the clinometer. If the slope varies at the point then estimate an average. If the point is on rolling microtopography, enter "variable." Further information may be provided in the Environmental Comments section.

Aspect
Measure aspect in degrees using a compass (set for local magnetic declination, which is given in the lower left hand corner of every USGS topo map). If the slope is flat, enter "n/a" for aspect. If the point wraps around different aspects on a slope, enter "variable" and describe further in the Environmental Comments section.

Topographic Position
This is the position of the point on its related landform. Determining this requires the investigator to think of the landform in cross-section, which is roughly diagramed on the back of the cheat sheet. One of the terms listed below **must** be used:

Interfluve (crest, summit, ridge). Linear top of ridge, hill, or mountain; the elevated area between two drainages that sheds water to the drainages.
High slope (shoulder slope, upper slope, convex creep slope). The uppermost inclined surface at the top of a slope. Includes the transition zone from backslope to summit. Surface is dominantly convex in profile and erosional in origin.
High level (mesa, summit). Level top of a plateau.
Midslope (transportational midslope). Intermediate slope position.
Backslope (dipslope). Subset of midslopes that are steep, linear, and may include cliff segments.
Step in slope (ledge, terracette). Nearly level shelf interrupting a steep slope, rock wall, or cliff face.
Lowslope (lower slope, foot slope, colluvial footslope). Inner gently inclined surface at the base of a slope. Surface profile is generally concave and a transition between midslope or backslope, and toeslope.
Toeslope (alluvial toeslope). Outermost gently inclined surface at base of a slope. In profile, usually gentle, linear and characterized by alluvial deposition.
Low level (terrace). Valley floor or shoreline representing the former position of an alluvial plain, lake, or shore.

Landform
Enter the landforms that best describe the site where the AA point is located. Referring to the topo map for the landscape context may help the investigator determine what landform(s) to choose. Note that the landform choices may describe different scales, or that a landform feature can be described by more than one term. For example, the AA point may be on a ledge on the rim of a canyon. A suggested list of landforms and definitions is provided in Appendix A. *Note: The topographic position selected above should relate to the scale of the landform chosen here.*

Surficial Geology
List the primary geologic substrate where the AA point plant community occurs. A list of geologic types is provided on park specific cheatsheets at the end of this document. The geology map should help, but if one is unable to decipher the geology at all or a geology map is not available at the point, then provide a general description (e.g., coarse sandstone, green shale, aeolian sands or obscured by soils).

Environmental Comments
Enter any noteworthy comments on the environmental setting and its effect on the vegetation. Examples include: "stunted trees due to shallow soils", "vegetation only where pockets of soil occur", or "large colluvial boulders and small rocks litter surface of soil". This field can also be used to describe site history such as fire events. This is an extremely important field for crews to document so please take the time to do a good job. Information from this field is used to prepare local descriptions of the plant communities, and to help assign AA points to associations not previously recorded in the park.

Unvegetated Surface
This field is an ocular estimate of ground cover for the following: bedrock; litter/duff; wood (>1cm); large rocks (cobbles, boulders >10cm); small rocks (gravel 0.1-10 cm); sand (0.1-2mm); bare soil; other (please specify). For this estimation use the cover classes listed below. If an unvegetated surface category is not present in the observation point area, leave the corresponding line blank.

T	<1%	04	36-45%
P	1-5%	05	46-55%
1a	6-10%	06	56-65%
1b	11-15%	07	64-75%
02	16-25%	08	76-85%
03	26-35%	09	86-95%

VEGETATION DESCRIPTION SECTION

Leaf Phenology

Select the best description for the leaf phenology of the **dominant** stratum. The dominant stratum is the tallest stratum that contains at least 10% cover. Leave blank for non-vascular plant dominated AA points.

Evergreen. Greater than 75% of the total woody cover is never without green foliage. (Some tricky examples: most *Artemisia, Coleogyne, Ephedra* and all *Atriplex* except *A. canescens*, all *Chrysothamnus* except *C. nauseosus* var. *junceus*)
Cold deciduous. Greater than 75% of the total woody cover sheds its foliage in connection with an unfavorable season mainly characterized by winter frost (tricky ones: *Sarcobatus vermiculatus, Tamarix*).
Mixed evergreen - cold deciduous. Evergreen and deciduous species are mixed within the type and generally contribute 25-75% of the total woody cover.

Perennial. Herbaceous vegetation composed of more than 50% perennial species.
Annual. Herbaceous vegetation composed of more than 50% annual species.

Leaf Type

Select the best description for the leaf form of the dominant stratum. The dominant stratum is the uppermost stratum that contains at least 10% total coverage. Within that dominant stratum, the species that makes up greater than 50% of cover defines the leaf type.

Broad-leaved. Woody vegetation that is primarily broad-leaved (Sagebrush, oak, mountain mahogany).
Needle-leaved. Woody vegetation that is primarily needle-leaved (Juniper, pinyon, tamarisk).
Microphyllous. Woody cover that is primarily microphyllous (*Ephedra*).
Graminoid. Herbaceous vegetation composed of more than 50 percent graminoid species (grasses, sedges, rushes, etc).
Forb (broad-leaf-herbaceous). Herbaceous vegetation composed of more than 50% broad-leaf forb species (*Phlox, Astragalus, Erigeron*, etc).
Pteridophyte. Herbaceous vegetation composed of more than 50 percent ferns or fern allies (scouring rushes).
Non-vascular. Dominated by lichens or mosses.
Mixed. As with leaf phenology, the dominant stratum may be composed approximately equally of species with several different leaf types. Describe the mix briefly or circle leaf types that apply.

Physiognomic Class

This represents what is seen when looking across at the vegetation. The following definitions can be used as guidelines, but may not always apply in desert locales. For example, areas with scattered pinyon and juniper may not fit the cover classes below but they would best be described as a woodland.

Forest. Trees with their crowns overlapping (generally forming 60-100% cover).

Woodland. Open stands of trees with crowns not usually touching (generally forming 10-60% cover). Canopy tree cover may be less than 10% in cases where it exceeds shrub, dwarf-shrub, herb, and nonvascular cover, respectively.
Shrubland. Shrubs generally greater than 0.5 m tall with individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees generally less than 10% cover). Shrub cover may be less than 25% where it exceeds tree, dwarf-shrub, herb, and nonvascular cover, respectively. Vegetation composed of woody vines is included this class.
Dwarf-Shrubland. Low-growing shrubs usually under 0.5 m tall. Individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees and tall shrubs generally less than 10% cover). Dwarf-shrub cover may be less than 25% where it exceeds tree, shrub, herb, and nonvascular cover, respectively.
Shrub Herbaceous. Low or taller shrubs forming approximately equal cover with a grass or forb component. Individuals or clumps of shrubs generally not touching and usually forming more than 25% cover; trees less than 10% cover. Spaces between shrubs are generally mostly occupied by grasses and/or forbs.
Wooded Herbaceous. Trees forming approximately equal cover with a grass or forb component.
Herbaceous. Perennial or annual herbs (graminoids or forbs) dominant (generally forming at least 25% cover; trees, shrubs, and dwarf-shrubs generally with less than 10% cover). Herb cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and nonvascular cover, respectively.
Nonvascular. Nonvascular cover (bryophytes, lichens, and algae) dominant (generally forming at least 25% cover). Nonvascular perennial vegetation cover may be less than 25%, as long as it exceeds tree, shrub, dwarf-shrub, and herb cover.
Sparsely Vegetated. Abiotic substrate features dominant. Perennial vegetation is scattered to nearly absent and generally restricted to areas of concentrated resources. Total vegetation cover is typically less than 5-7% and greater than 2%. Badlands or sand dunes supporting communities of annual plants should be included in this category, regardless of cover.

DOMINANT PLANT SPECIES LIST

Record information on ***dominant species only***.
Strata: Species names will be recorded within the appropriate stratum. It is important that all crew members are consistent in assignment of species to strata throughout this project. Following are some guidelines to use in determining strata. The ‘working draft’ plant list for each park will be used as a guide for assigning species to the appropriate stratum. Field crew members are expected to help ‘improve’ this list and associated categorization as the field season progresses.

Begin by assessing the strata at the AA point . Trees are defined as single-stemmed woody plants, generally 5 m in height or greater at maturity and under optimal growing conditions. Shrubs are defined as multiple-stemmed woody plants generally less than 5 m in height at maturity and under optimal growing conditions. The exception is mature pinyon and juniper plants, which are considered trees regardless of their height.

T1 Emergent, T2 Canopy, T3 Subcanopy. A uniform stand of pine or cottonwood trees would be a good example of T2"canopy", but where they are absent then begin with the shrub stratum, or herbaceous stratum if no shrubs are present. If the tree crowns at the AA point are mostly touching and similar in height, but a given tree species is much taller that species would be a T1"emergent.” As another example, a sample area may be characterized by several tall scattered cottonwoods and then shorter scattered junipers. In this case, the cottonwoods would be the "canopy" and the junipers would be the

"subcanopy". There may also be cottonwoods listed in the “subcanopy” layer, if there are a number of short saplings in addition to mature tall trees.

The remaining vegetative strata are (remember to check with plant list for consistency):

S1 Tall Shrub. >2 meters tall. For example, *Fraxinus anomala* and *Purshia mexicana.*
S2 Short Shrub. <2 meters tall. For example, *Coleogyne ramosissima*, all *Atriplex* except *corrugata, gardneri* (which are dwarf).
S3 Dwarf Shrub. <0.5 meters tall. For example, *Opuntia polycantha.*
H Herbaceous. All herbaceous species including graminoids, forbs, ferns and fern allies.
H4 Tree Seedlings. Seedlings are trees with vertical stems < 1.5 m tall, but that may vary by species (e.g. does not always apply to pinyon – juniper).
N Nonvascular. This is mainly dark cyanobacteria, mosses and lichens.

Height can be used to define strata, but is not how species should be placed in strata. **Species characteristically belong to one stratum or another** (e.g., pinyon and juniper are canopy (T2), Utah serviceberry is a tall shrub (S1), blackbrush is a short shrub (S2), snakeweed is a dwarf shrub (S3), etc.), **EVEN when unusual environmental circumstances dictate that the plants have an unusually tall** (e.g., response of some plants to fire) **or unusually short growth form**. *So even if the junipers growing in cracks are only 1.5 m tall, as long as they are not seedlings, they get put in the T2 category*. About the only rule regarding height should be that the tree layer is (usually) higher than the tall shrub layer that is taller than the short shrub layer, etc.

The second thing is to avoid splitting species between strata. If a few mountain mahogany have been browsed to <1m tall, but most are 2m tall, they all get rolled into the tall shrub stratum. There are two exceptions: (1) each height class covers more than 10% of a point, or (2) there is a reproductive layer of baby shrubs or young trees.

The third issue is how to define some of the “borderline/confusing” species. What we want to avoid is having some crew members calling *Leptodactylon* a forb and some calling it a dwarf shrub. Same for snakeweed, *Eriogonum microthecum*, fringed sage, *Brickellia* and any number of other species. Consult the master plant species lists when in doubt. Crew members should keep the master plant list and strata assignments updated.

Completing the Species/Strata Table:

Dominant Species. List the dominant plant species using **full scientific name** by the strata listed below for each AA point. In some cases, due to severe drought conditions of recent years, a dominant species on the site may have experienced severe levels of mortality. In this case please record ‘DEAD’ in front of the scientific name and enter the cover value, independent of any live cover value for the same species. During data entry back in the office there will be a check field to use for ‘DEAD’. It is also important to document these relationships in the comments field.

T1	Emergent	S3	Dwarf Shrub
T2	Canopy	H	Herbaceous
T3	Sub-canopy	H4	Tree Seedlings
S1	Tall Shrub	N	Non-vascular
S2	Short Shrub		

Diagnostic Species. Mark species that characterize the stand with a ‘*’.

Height Class. Use the height class code from the list below that best describes the overall height of each plant species within a given stratum.

01	<0.5 m	06	10-15 m
02	0.5-1 m	07	15-20 m
03	1-2 m	08	20-35 m
04	2-5 m	09	35-50 m
05	5-10 m	10	>50 m

Cover Class. For each plant species use the cover class codes listed below to estimate overall canopy cover for each species listed on the form.

T	<1%	04	36-45%
P	1-5%	05	46-55%
1a	6-10%	06	56-65%
1b	11-15%	07	64-75%
02	16-25%	08	76-85%
03	26-35%	09	86-95%

Percent (%) Cover. Estimate the percent aerial cover (T-100%) for each plant species recorded in the far right hand column on the form.

If the point is on the border between two types… (and both types are at least MMU-size) Make two species lists, one for each type, on the back of the AA point form. These will both be entered into the database for that AA point.

ARCHES NATIONAL PARK – AA CHEAT SHEET

LANDFORMS

alluvial fan
alluvial flat
alluvial plain
remnant
alluvial terrace
alluvium
artificial levee
backslope
badlands
bajada
ballena
ballon
basin
basin floor
bench
blowout
bluff
bolson
borrow pit
bottomland
box canyon
braided stream
break
butte
canyon
channel
cliff
climbing dune
closed depression
colluvium
crest
cuesta
debris flow
deflation basin
depression
desert pavement
dip
ditch
divide
drainageway
draw
dune
dune field
earthflow
eolian deposit
eolian sands
ephemeral stream
escarpment
falling dune
finger ridge
flat
flood plain
foothills
gorge
gravel pit
gulch
gully
hanging valley
hill
hillslope
hogback
hummock
interdune
interfluve
intermittent stream
island
knob
knoll
lakebed
lakeshore
landslide
ledge
levee
meander belt
mesa
mountain
natural levee
overflow channel
pediment
perennial stream
plain
plateau
playa
point bar
pool
quarry
ravine
reef
ridge
rise
rim
rockfall
saddle
sand ramp
sand sheet
scarp
scree slope
shoulder
side slope
slope
slope wash
slot canyon
stream terrace
summit
swale
talus slope
tank
terrace
terracettes
toeslope
valley
valley floor
valley side
wash (dry wash)
zibar

TOPOGRAPHIC POSITION

SEE THE DIAGRAM ON OTHER SIDE

VEGETATIVE STRATA

T1 = emergent tree
T2 = tree canopy
T3 = tree sub-canopy.
S1 = tall shrub, > 2m
S2 = short shrub, < 2m
S3 = dwarf shrub. < 0.5m
H = herbaceous
H4 = Tree seedlings
N = nonvascular other than ferns

PARK SPECIALS (keep an eye out for)

Rare plants
Upland springs and seeps
Hanging Gardens
Invasive weeds (ignore cheatgrass, dandelions)

PHYSIOGNOMIC CLASS

Forest: Crowns touching
Woodland: Trees>10%, crowns not touching
Shrubland: Shrubs> grass, forbs or trees
Dwarf Shrubland: Shrubland <0.5 m tall
Shrub Herbaceous: Shrubs = Forbs/grasses
Herbaceous: Grass/forbs > trees or shrubs
Wooded Herbaceous: Trees= grass/forbs
Sparsely Vegetated: Total veg<5-7%

ASPECT

Flat
Azimuth (deg.)
Variable

GPS SETTINGS

NAD1983
WAAS on (Trimble Units)

Instructions for entering waypoint into Trimble GPS unit

1. Open a Point_generic (don't log points)
2. Go to Map screen
3. Change arrow in pulldown menu to "digitize" mode
4. Under options, select "enter coordinates", then enter UTMs, hit OK
5. Go back to data screen, enter name for the waypoint and close it.

SURFICIAL GEOLOGY

Obscured by soil
Aeolian sands
Alluvial deposits
Older Alluvium (pre Holocene)
Talus / Colluvium / Landslides
Cedar Mesa Sandstone
Chinle Formation
Cutler Group (undiff)
Dakota Sandstone
Dewey Bridge Member- Entrada
Elephant Canyon Formation
Entrada Sandstone
Halgaito Shale
Honaker Trail Formation
Kaibab Limestone
Kayenta Formation
Mancos Shale
Moab Tongue- Curtis Fm
Moenkopi Fm
Morrison Fm- Brushy Basin Member
Morrison Fm- Salt Wash Member
Morrison Fm- Tidwell Member
Navajo Sandstone
Organ Rock Shale- Cutler Group
Paradox Formation
Shinarump Conglomerate
White Rim Sandstone- Cutler Group
Wingate Sandstone

DISTURBANCE

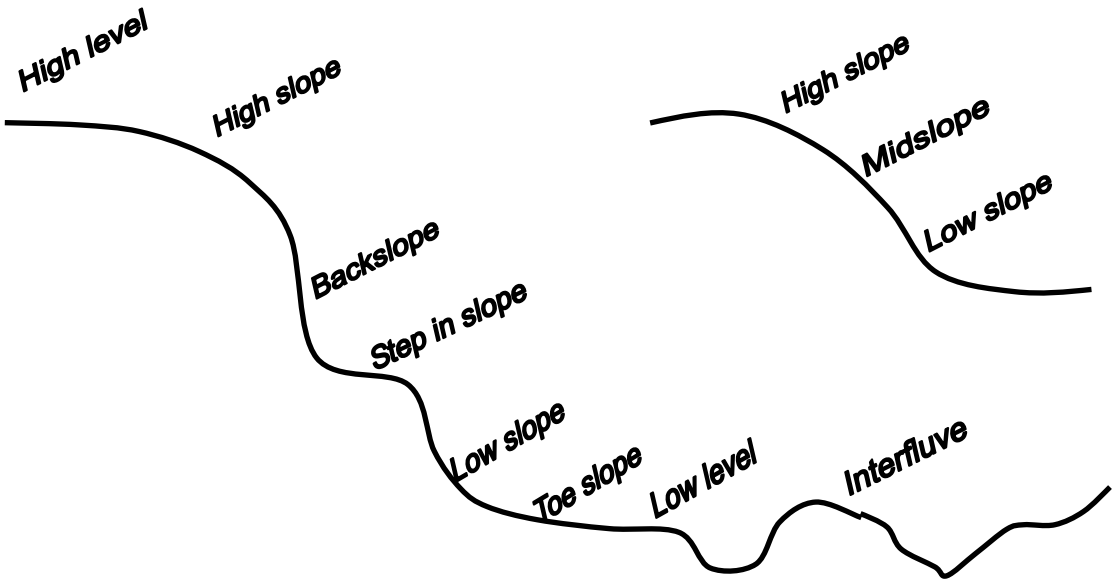
Water gullies
Mass wasting
Mountain pine beetle damage
Flash flooding
Grazing evidence
Development, historic structures
Agriculture
ORV use or Recreation
Wildlife concentration
Fire
Drought

To select a waypoint to navigate (Trimble):

1. From data screen, change "collect" in pulldown menu to "update"
2. Under Options, select "Set Nav Target"

Go to navigation screen to navigate to the selected point

TOPOGRAPHIC POSITION - CHEAT SHEET



EXTRA-CURRICULAR INSTRUCTIONS - 2005

The Northern Colorado Plateau Network Inventory and Monitoring Program is engaged is a wide suite of inventory activities designed to improve the information basis for developing a long-term natural resource monitoring program. Since field crews will be visiting most areas of each park and especially remote portions – we are requesting assistance with documenting information on the following features as they are encountered and as time allows.

Springs/Seeps/Hanging Gardens (Use Observation Point Form)

These areas are considered significant ecosystems across the Colorado Plateau and have been identified as a high priority vital sign for inclusion in the long-term monitoring program. Unfortunately very little information has been documented on the location and characteristics of these areas within the parks.

Use the 'Observation Point' (blue form) to record basic data on springs, seeps and hanging gardens and circle 'spring/hanging garden' in the Type of Observation field. It is important to take one or more photos to document the site and a GPS (or other) location reading. Please complete basic environmental and vegetation description fields as best possible. Completion of the comments field would be most appreciated.

If the spring community is sizeable enough please consider conducting a regular vegetation, as we need this information to characterize the full suite of vegetation types. Keep in mind that BPUs will typically overlook springs and seeps.

Invasive Plant Species (Use Invasive Plant Location Log or GeoXM GPS unit)

Invasions of aggressive non-native species are one of the largest threats to ecosystem integrity of terrestrial and aquatic systems. Field crews are requested to document 'noteworthy' populations of invasive plants on the 'Invasive Plant Log' Form (or in the data dictionary in the Trimble GeoXM GPS unit- "Weed" feature) and take photos as feasible and appropriate. We are not requesting a comprehensive inventory of all invasive plants, as that would be another full project. However, the park would appreciate having help documenting populations of invasive plants that are of especially high concern. Early detection of species populations that are small give the park a chance for control or eradication before the problem becomes too big. For example, a small population of diffuse knapweed was found last year near Upheaval Dome. This represented the first occurrence of this species in the park and control efforts were immediately implemented.

In addition to looking for established invasives in the park, field crews should take care to ensure that they are not contributing to the spread of weeds. If working in an infested area, please make sure that field crew members are not carrying seeds or other propagules to new locations. (Wear gaiters to minimize the spread of cheatgrass, for example.) Also for field workers coming from other areas, please make sure vehicles and clothing are free of weed seed.

General Floristic Inventory

An important part of the Northern Colorado Plateau Network Program is to assist parks with the documentation of all vascular plants and vertebrate species occurring within each park. As part of the vegetation mapping project, field crews are requested to assist in the collecting of vascular plant vouchers (herbarium specimens) for parks. The park-specific plant list provided to field crews indicates whether or not a voucher has been collected for a given species. If a voucher has not been collected, field crews are

to look for opportunities to make collections of these taxa. Field crews will receive training in how to collect, document and process vouchers. Specimens should contain appropriate flowering and/or fruiting material to assure correct identification. Additionally specimens should contain all appropriate plant parts (roots, leaves, stems, flowers etc.) and as possible show the habit of the plant. Enough material should be collected to fill a herbarium sheet.

DATA ENTRY

NCPN has developed a park-specific vegetation mapping database application for this project. This database application houses all associated data with the project including vegetation s, observation points, photographic documentation, and herbarium label information. Data will be entered at regular intervals as the field season progresses. Data will be entered both electronically (from the data dictionary's on the Trimble XM GPS Units) and manually from the field forms. Park Service crews will enter all data collected during the project.

NCPN staff are developing quality assessment and control procedures to help ensure that data collected are consistent, accurate and complete.

SPECIES LIST MANAGEMENT

As mentioned previously NCPN is working with each network park to compile vouchered vascular plant species lists. An important ancillary activity of the vegetation mapping project is to contribute to the collection of voucher specimens for currently undocumented species. To aid in this effort NCPN will provide field crews with a 'working copy' of the vascular plant species list for each park where work is being conducted. This list will include information on taxonomic number, family, genus, species, common name, life form, nativity and whether or not the taxon is documented with a specimen voucher. Field crews are requested to look for opportunities to collect vouchers where none exist.

HERBARIUM SPECIMENS

Field crews will be instructed on how to collect voucher specimens and associated label data. Specimens will be processed at regular intervals throughout the field season. Processing includes entering all appropriate information into the vegetation mapping database in order to generate herbarium labels, identification, mounting and labeling specimens. Each field crew member is required to record all specimen documentation in a field notebook.

CONSIDERATIONS FOR PLANNING

Planning for the day:

1. Safety and sustenance: Plenty of food, water, first-aid kit, raingear, sunscreen.
2. Field communications:
   c. Develop a plan with other team(s) for radio check-in time.
   d. Do you have a radio and are batteries charged? If you have a walkie talkie, do you have extra batteries for it? Does park staff know the area in which you will be working?
3. Make sure you have the right maps and photos.
4. Check your GPS (Datum set to NAD83? WAAS on? Needs new batteries?).
5. Plan the day's mission before departing using a) USGS quads, b) aerial photos, c) BLM maps.
6. Considerations for mission planning:
   d. Plan travel based on topography, best access routes, density and complexity of vegetation
   e. Communicate with the other team member(s) to make sure you aren't duplicating effort.

Planning for the Week (do this on the first day of the trip)

1. Do you have all appropriate maps, photos?
2. Develop a reasonable estimate of the number of points for each team broken up by day and based on an estimate of individual team's travel logistics for the week.
3. Develop plan of attack for the week to capture all AA points in the work area.
4. Balance points two and three above with the expected work schedule of the teams and ensure adequate time-off and reduce over-time concerns.
5. Do you have all necessary information and backups for the week's planning? E.g., blank field forms, film, plenty of batteries.

Wrapup (Do this on the last day of the trip, after you have returned to base)

1. Clean, recharge and repair equipment.
2. Hold brief meeting to discuss data collection issues, things that came up during the work week, and plan for next work hitch.
3. Edit field forms and file them systematically.
4. Re-file the aerial photos and maps.
5. Send exposed rolls of film to be developed.
6. Key unknown plants.
7. Enter edited data into database.

Communicate among teams / Topics for wrap-up meetings.

1. What were your questions about the points visited during the week?
2. Do you have any questions about the forms or fields?
3. What was accomplished, what was not accomplished?
4. Pass on developments and questions after every trip. Don't let them build up. For example, were there problems with interpreting the aerial photos, or are there personnel issues, problems in consistency in interpreting the forms, or with park-related logistics?

Accuracy Assessment Materials Checklist

- Park research permit
- Topo maps
- Park and BLM maps for general navigation
- DOQQ photos of AA point locations
- Geology map
- Compass with adjustable declination
- Clinometer
- GPS unit
- Extra AA batteries for walkie talkie
- Radio or walkie talkie and/or cell phone
- 35 mm camera & slide film (allow at least 2 exposures per AA point)
- Baggies for temporary storage of unknown plants, and masking tape for labeling
- Plant press & paper
- Plant Keys / Flora(s)
- Pencils / sharpies
- Forms: AA point and observation point
- Clipboard/forms holder
- Pens, pencils, pencil lead, slate board, chalk, and chalkboard eraser or supply of clean rags
- Key to the plant associations of the park
- Key to the map units of DINO (DINO only)
- All ancillary information (cheat sheet, species list, floras, sampling priority list for zone, main sampling protocol).
- First aid kit, personal gear (food, water, rain gear, etc.)

Landform Glossary

(excerpted from http://soils.usda.gov/technical/handbook/contents/part629glossary1.html**)**

alluvial cone - A semi-conical type of alluvial fan with very steep slopes; it is higher, narrower, and steeper (e.g., > 40% slopes) than a fan, and composed of coarser, and thicker layers of material deposited by a combination of alluvial episodes and to a much lesser degree, landslides (e.g., debris flow).

alluvial fan - A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes, shaped like an open fan or a segment of a cone, deposited by a stream (best expressed in semiarid regions) at the place where it issues from a narrow mountain or upland valley; or where a tributary stream is near or at its junction with the main stream. It is steepest near its apex which points upstream and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

alluvial flat (a) (colloquial: western US) A level, graded, alluvial surface in bolsons and semi-bolsons which commonly does not manifest traceable channels, terraces or floodplain levels. (b) (**not preferred**) A general term for a small flood plain bordering a river, on which alluvium is deposited during floods.

alluvial plain - (a) A large assemblage of fluvial landforms (braided streams, terraces, etc.,) that form low gradient, regional ramps along the flanks of mountains and extend great distances from their sources (e.g., High Plains of North America. SW (b) (not recommended, use flood plain.) An general, informal term for a broad flood plain or a low-gradient delta.

alluvial plain remnant - An erosional remnant of an alluvial plain which retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to a present-day stream or drainage network.

alluvial terrace - (not preferred) refer to stream terrace.

alluvium - Unconsolidated, clastic material subaerially deposited by running water, including gravel, sand, silt, clay, and various mixtures of these.

anticline - (a) A unit of folded strata that is convex upward and whose core contains the stratigraphically oldest rocks, and occurs at the earth's surface. In a single anticline, beds forming the opposing limbs of the fold dip away from its axial plane. (b) A fold, at any depth, generally convex upward whose core contains the stratigraphically older rocks.

arroyo - (colloquial: southwest A.) The channel of a flat-floored, ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material; sometimes called a wash. It is usually dry but can be transformed into a temporary watercourse or torrent after heavy rain within the watershed. Where arroyos intersect zones of ground-water discharge, they are better classed as intermittent stream channels.

artificial levee - An artificial embankment constructed along the bank of a watercourse or an arm of the sea, to protect land from inundation or to confine streamflow to its channel.

backslope - The hillslope profile position that forms the steepest and generally linear, middle portion of the slope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below. They may or may not include cliff segments (i.e. free faces). Backslopes are commonly erosional forms produced by mass movement, colluvial action, and running water.

badlands - A landscape which is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes with narrow interfluves. Badlands develop on surfaces with little or no vegetative cover, overlying unconsolidated or poorly cemented materials (clays, silts, or in some cases sandstones) sometimes with soluble minerals such as gypsum or halite.

bajada - (colloquial: southwestern US.) A broad, gently inclined, alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically it has a broadly undulating transverse profile, parallel to the mountain front, resulting from

the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins. Synonym - coalescent fan piedmont.

ballena - (colloquial: western US.) A fan remnant having a distinctively-rounded surface of fan alluvium. The ballena's broadly-rounded shoulders meet from either side to form a narrow summit and merge smoothly with concave sideslopes and then concave, short pediments which form smoothly-rounded drainageways between adjacent ballenas. A partial ballena is a fan remnant large enough to retain some relict fan surface on a remnant summit.

bar - A general term for a ridge-like accumulation of sand, gravel, or other alluvial material formed in the channel, along the banks, or at the mouth of a stream where a decrease in velocity induces deposition; e.g. a channel bar or a meander bar.

barchan dune - A crescent-shaped dune with tips extending leeward (downwind), making this side concave and the windward (upwind) side convex. Barchan dunes tend to be arranged in chains extending in the dominant wind direction.

base slope - A geomorphic component of hills consisting of the concave to linear slope (perpendicular to the contour) which, regardless of the lateral shape is an area that forms an apron or wedge at the bottom of a hillside dominated by colluvial and slope wash processes and sediments (e.g., colluvium and slope alluvium). Distal base slope sediments commonly grade to, or interfinger with, alluvial fills, or gradually thin to form pedisediment over residuum.

basin - (a) Drainage basin; (b) A low area in the Earth's crust, of tectonic origin, in which sediments have accumulated. (c) (colloquial: western US) A general term for the nearly level to gently sloping, bottom surface of an intermontane basin (bolson). Landforms include playas, broad alluvial flats containing ephemeral drainageways, and relict alluvial and lacustrine surfaces that rarely, if ever, are subject to flooding. Where through-drainage systems are well developed, flood plains are dominant and lake plains are absent or of limited extent. Basin floors grade mountainward to distal parts of piedmont slopes.

basin floor - A general term for the nearly level, lower-most part of intermontane basins (i.e. bolsons, semi-bolsons). The floor includes all alluvial, eolian, and erosional landforms below the piedmont slope.

basin-floor remnant - (colloquial: western US) A flat erosional remnant of any former landform of a basin floor that has been dissected following the incision of an axial stream.

bench - (not preferred) refer to structural bench.

beveled base - The lower portion of a canyon wall or escarpment marked by a sharp reduction in slope gradient from the precipitous cliff above, and characteristically composed of thinly mantled colluvium (e.g. < 1 m) and / or carapaced with a thin surficial mantle of large rock fragments from above, which overly residuum of less resistant rock (e.g., shale) whose thin strata intermittently outcrop at the surface; a zone of erosion and transport common in the canyonlands of the semi-arid, southwestern US.

blowout - A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand, loose soil, or where protective vegetation is disturbed or destroyed; the adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Commonly small, some blowouts may be kilometers in diameter.

bluff - (a) A high bank or bold headland, with a broad, precipitous, sometimes rounded cliff face overlooking a plain or body of water, especially on the outside of a stream meander; ex. a river bluff. (b) (not preferred) use cliff. Any cliff with a steep, broad face.

borrow pit - An excavated area from which earthy material has been removed typically for construction purposes offsite; also called barrow pit.

bottomland - (not recommended) use flood plain. An obsolete, informal term loosely applied to varying portions of a flood plain.

box canyon - a) A narrow gorge or canyon containing an intermittent stream following a zigzag course, characterized by high, steep rock walls and typically closed upstream by a similar wall, giving the impression, as viewed from its bottom, of being surrounded or "boxed in" by almost vertical walls. b) A steep-walled canyon heading against a cliff a dead-end canyon.

braided stream - A channel or stream with multiple channels that interweave as a result of repeated bifurcation and convergence of flow around inter-channel bars, resembling (in plan view) the strands of a complex braid. Braiding is generally confined to broad, shallow streams of low sinuosity, high bedload, non-cohesive bank material, and a steep gradient. At bank-full discharge, braided streams have steeper slopes and shallower, broader, and less stable channel cross sections than meandering streams.

breaks - (colloquial: western US) A landscape or large tract of steep, rough or broken land dissected by ravines and gullies and marks a sudden change in topography as from an elevated plain to lower hilly terrain, or a line of irregular cliffs at the edge of a mesa or a river (e.g., the Missouri River breaks).

butte - An isolated, generally flat-topped hill or mountain with steep slopes and talus or cliffs and characterized by summit width that is less than the height of bounding escarpments, commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks.

canyon - A long, deep, narrow, very steep-sided valley cut primarily in bedrock with high and precipitous walls in an area of high local relief (e.g., mountain or high plateau terrain), often with a perennial stream at the bottom; similar to but larger than a gorge. **canyon bench** - One of a series of relatively narrow, flat landforms occurring along a canyon wall and caused by differential erosion of alternating strong and weak horizontal strata; a type of structural bench.

canyonlands - A deeply and extensively dissected landscape composed predominantly of relatively narrow, steep-walled valleys with small flood plains or valley floors; commonly with considerable outcrops of hard bedrock on steep slopes, ledges, or cliffs, and with broader summits or interfluves than found in badlands. Sideslopes exhibit extensive erosion, active back-wearing, and sparse vegetation.

channel - (a) The hollow bed where a natural body of surface water flows or may flow. The deepest or central part of the bed of a stream, containing the main current and occupied more or less continuously by water. (b) (colloquial: western US.) The bed of a single or braided watercourse that commonly is barren of vegetation and is formed of modern alluvium. Channels may be enclosed by banks or splayed across and slightly mounded above a fan surface and include bars and mounds of cobbles and stones. (c) Small, trough-like, arcuate or sinuous channels separated by small bars or ridges, caused by fluvial processes; common to flood plains and young alluvial terraces; a constituent part of *bar and channel* topography.

cliff - Any high, very steep to perpendicular or overhanging face of rock or earth; a precipice.

climbing dune - A dune formed by the piling-up of sand by wind against a cliff or mountain slope; very common in arid regions with substantial local relief and strong winds.

closed depression - A generic name for an enclosed area that has no surface drainage outlet and from which water escapes only by evaporation or subsurface drainage; an area of low ground indicated on a topographic map by a hachured contour line forming a closed loop.

collapse sinkhole - A type of sinkhole that is formed by collapse of a cave within the underlying soluble bedrock (e.g., limestone, gypsum, salt).

colluvium - Unconsolidated, unsorted material being transported or deposited on sideslopes and/or at the base of slopes by mass movement (e.g. direct gravitational action) and by local, unconcentrated runoff.

complex landslide - A category of mass movement processes, associated sediments (complex landslide deposit) or resultant landforms characterized by a composite of several mass movement processes none of which dominates or leaves a prevailing landform. Numerous types of complex landslides can be specified by naming the constituent processes evident (e.g. a complex earth spread - earth flow landslide).

crest - (a) The commonly linear, narrow top of a ridge, hill, or mountain. It is appropriately applied to elevated areas where retreating backslopes are converging such that these high areas are almost exclusively composed of convex shoulders; (b) (not preferred) Sometimes used as an alternative for the hillslope component *summit*.

cuesta - An asymmetric, homoclinal ridge capped by resistant rock layers of slight to moderate dip (less than 15 percent); produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope), that roughly parallels the inclined beds, and on the other side has a relatively short and steep or cliff-like slope (scarp) that cuts through the tilted rocks.

cuesta valley - A low relief, low angle, asymmetrical depression which lies parallel to the strike of underlying strata; a type of strike valley. It's formed by the differential erosion of weaker strata interbedded with more resistant bedrock. It may or may not contain a local drainage network and commonly lies above and is not connected to the regional drainage system.

debris fall - The process, associated sediments (debris fall deposit) or resultant landform characterized by a rapid type of *fall* involving the relatively free, downslope movement or collapse of detached, unconsolidated material which falls freely through the air (lacks an underlying slip face); sediments have substantial proportions of both fine earth and coarse fragments; common along undercut stream banks.

debris flow - The process, associated sediments (debris flow deposit) or landform resulting from a very rapid type of *flow* dominated by a sudden downslope movement of a mass of rock, soil, and mud (more than 50% of the particles are > 2mm), and whether saturated or comparatively dry, behaves much as a viscous fluid when moving.

deflation basin - A topographic basin excavated and maintained by wind erosion which removes unconsolidated material and commonly leaves a rim of resistant material surrounding the depression. Unlike a blowout, a deflation basin does not include adjacent deposits derived from the basin.

depression - Any relatively sunken part of the Earth's surface; especially a low-lying area surrounded by higher ground. A closed depression has no natural outlet for surface drainage. An open depression has a natural outlet for surface drainage.

desert pavement - A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments, mantling a desert surface. It is formed where wind action and sheetwash have removed all smaller particles or where coarse fragments have migrated upward through sediments to the surface. It usually protects the underlying, finer-grained material from further deflation. The coarse fragments commonly are cemented by mineral matter.

dip - A geomorphic component (characteristic piece) of flat plains (e.g., lake plain, low coastal plain, low-relief till plain) consisting of a shallow and typically closed depression that tends to be an area of focused groundwater recharge but not a permanent water body and that lies slightly lower and is wetter than the adjacent talf, and favors the accumulation of fine sediments and organic materials.

ditch - An open and usually unlined channel or trench excavated to convey water for drainage or irrigation to or from a landscape; smaller than a canal; some ditches are modified natural waterways.

divide - (a) The line of separation; (b) The summit area, or narrow tract of higher ground that constitutes the watershed boundary between two adjacent drainage basins; it divides the surface waters that flow naturally in one direction from those that flow in the opposite direction.

drainageway - (a) A general term for a course or channel along which water moves in draining an area. (b) a term restricted to relatively small, roughly linear or arcuate depressions that move concentrated water at some time, and either lack a defined channel (e.g. head slope, swale) or have a small, defined channel (e.g. low order streams).

draw - A small, natural watercourse cut in unconsolidated materials, generally more open with a broader floor and more gently sloping sides than an arroyo, ravine or gulch, and whose present stream channel

may appear inadequate to have cut the drainageway that it occupies.

dune - A low mound, ridge, bank or hill of loose, windblown, subaerially deposited granular material (generally sand), either barren and capable of movement from place to place, or covered and stabilized with vegetation, but retaining its characteristic shape. (See barchan dune, parabolic dune, parna dune, shrub-coppice dune, seif dune, transverse dune).

dune field - An assemblage of moving and/or stabilized dunes, together with sand plains, interdune areas, and the ponds, lakes, or swamps produced by the blocking of steams by the sand. See dune lake.

earthflow - The process, sediments (earthflow deposit) or resultant landforms characterized by slow to rapid types of flow dominated by downslope movement of soil, rock, and mud (more than 50% of the particles are < 2 mm), and whether saturated or not, behaves as a viscous fluid when moving.

eolian deposit - Sand, silt or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess. Conventionally, primary volcanic deposits (e.g. tephra) are handled separately.

eolian sands - Sand-sized, clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sand sheet.

ephemeral stream - Generally a small stream, or upper reach of a stream, that flows only in direct response to precipitation. It receives no protracted water supply from melting snow or other sources and its channel is above the water table at all times.

eroded fan remnant - All, or a portion of an alluvial fan that is much more extensively eroded and dissected than a fan remnant; sometimes called an *erosional fan remnant*. It consists primarily of a) eroded and highly dissected sides (*eroded fan-remnant sideslopes*) dominated by hillslope positions (shoulder, backslope, etc.), and b) to a lesser extent an intact, relatively planar, relict alluvial fan "summit" area best described as a tread.

eroded fan-remnant sideslope - A rough margin of an *eroded fan remnant* highly dissected by ravines and gullies that can be just a fringe or make up a large part of an eroded alluvial fan; its bounding escarpments, originally formed by inset channels, have become highly dissected and irregular such that terrace components (tread and riser) have been consumed or modified and replaced by hillslope positions and components (shoulder, backslope, footslope, etc.); sometimes referred to as *fan remnant sideslopes*.

escarpment - A continuous, steep slope or cliff produced by erosion or faulting and that topographically interrupts or breaks the general continuity of more gently sloping land surfaces . The term is most commonly applied to cliffs produced by differential erosion. Synonym = scarp.

falling dune - An accumulation of sand that is formed as sand is blown off a mesa top or over a cliff face or steep slope, forming a solid wall, sloping at the angle of repose of dry sand, or a fan extending downward from a re-entrant in the mesa wall.

fan - (a) A gently sloping, fan-shaped mass of detritus forming a section of a low-angle cone commonly at a place where there is a notable decrease in gradient; specifically an alluvial fan.

fan apron - A sheet-like mantle of relatively young alluvium and soils covering part of an older fan piedmont (and occasionally alluvial fan) surface, commonly thicker and further down slope (e.g., mid-fan or mid-fan piedmont) than a fan collar. It somewhere buries an older soil that can be traced to the edge of the fan apron where the older soil emerges as the land surface, or relict soil. No buried soils should occur within a fan-apron mantle itself.

fan collar - A landform comprised of a thin, short, relatively young mantle of alluvium along the very upper margin (near the proximal end or apex) of a major alluvial fan. The young mantle somewhere buries an older soil that can be traced to the edge of the collar where the older soil emerges at the land surface as a relict soil.

fan remnant - A general term for landforms that are the remaining parts of older fan-landforms, such as alluvial fans, fan aprons, inset fans, and fan skirts, that either have been dissected (erosional fan-remnants) or partially buried (nonburied fan-remnants). An erosional fan remnant must have a relatively flat summit that is a relict fan-surface. A nonburied fan-remnant is a relict surface in its entirety.

fan skirt - The zone of smooth, laterally-coalescing, small alluvial fans that issue from gullies cut into the fan piedmont of a basin or that are coalescing extensions of the inset fans of the fan piedmont, and that merge with the basin floor at their toeslopes. These are generally younger fans which onlap older fan surfaces.

fault-line scarp - A steep slope or cliff formed by differential erosion along a fault line, as by the more rapid erosion of soft rock on one side of a fault as compared to more resistant rock on the other side; e.g. the east face of the Sierra Nevada in California.

finger ridge - One in a group of small, tertiary spur ridges that form crudely palmate extensions of erosional remnants along the flanks or nose of larger ridges.

flat - (a) (adjective) Said of an area characterized by a continuous surface or stretch of land that is smooth, even, or horizontal, or nearly so, and that lacks any significant curvature, slope, elevations, or depressions. (b) (noun) An informal, generic term for a level or nearly level surface or small area of land marked by little or no local relief. (c) (not recommended) A nearly level region that visibly displays less relief than its surroundings.

flood plain - The nearly level plain that borders a stream and is subject to inundation under flood-stage conditions unless protected artificially. It is usually a constructional landform built of sediment deposited during overflow and lateral migration of the streams.

foothills - A steeply sloping upland composed of hills with relief of 30 up to 300 meters and fringes a mountain range or high-plateau escarpment.

footslope - The hillslope profile position that forms the concave surface at the base of a hillslope. It is a transition zone between upslope sites of erosion and transport (shoulder, backslope) and downslope sites of deposition (toeslope).

free face - A geomorphic component of hills and mountains consisting of an outcrop of bare rock that sheds rock fragments and other sediments to, and commonly stands more steeply than the angle of repose of, the colluvial slope immediately below; most commonly found on shoulder and backslope positions, and can comprise part or all of a nose slope or side slope.

gorge - (a) A narrow, deep valley with nearly vertical, rocky walls, smaller than a canyon, and more steep-sided than a ravine; especially a restricted, steep-walled part of a canyon. (b) A narrow defile or passage between hills or mountains.

graben - An elongate trough or basin bounded on both sides by high-angle, normal faults that dip towards the interior of the trough. It is a structural form, it may be geomorphically expressed as a rift valley.

gravel pit - A depression, ditch or pit excavated to furnish gravel for roads or other construction purposes; a type of borrow pit.

ground soil - Any soil at the present-day land surface and actively undergoing pedogenesis,

gulch - (colloquial: western US.; not preferred - refer to ravine) A small stream channel, narrow and steep-sided in cross section, and larger than a gully, cut in unconsolidated materials. = Ravine.

gully - A small channel with steep sides caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water usually during and immediately following heavy rains or ice / snow melt. A gully generally is an obstacle to wheeled vehicles and too deep (e.g., > 0.5 m) to be obliterated by ordinary tillage; (a rill is of lesser depth and can be smoothed over by ordinary tillage).

hanging valley - A tributary valley whose floor at the lower end is notably higher than the floor of the

main valley in the area of junction.

head slope - A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway, resulting in converging overland water flow (e.g. sheet wash); head slopes are dominated by colluvium and slope wash sediments (e.g., slope alluvium); contour lines form concave curves. Slope complexity (downslope shape) can range from simple to complex. Headslopes are comparatively moister portions of hillslopes and tend to accumulate sediments (e.g., cummulic profiles) where they are not directly contributing materials to channel flow.

headwall - A steep slope at the head of a valley; e.g. the rock cliff at the back of a cirque.

hill - A generic term for an elevated area of the land surface, rising at least 30 m (100 ft.) to as much as 300 meters (approx. 1000 ft.) above surrounding lowlands, usually with a nominal summit area relative to bounding slopes, a well-defined, rounded outline and slopes that generally exceed 15 percent. A hill can occur as a single, isolated mass or in a group. A hill can be further specified based on the magnitude of local relief: *low hill* (30 - 90 m) or *high hill* (90 - 300 m). Informal distinctions between a hill and a mountain are often arbitrary and dependent on local convention.

hillock - A generic name for a small, low hill, generally between 3 - 30 m in height and slopes between 5 and 50% (e.g., bigger than a mound but smaller than a hill); commonly considered a microfeature.

hillslope - A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of the hill.

hogback - A sharp-crested, symmetric (homoclinal) ridge formed by highly tilted resistant rock layers; produced by differential erosion of interlayered resistant and weak rocks with dips greater than about 25 degrees (45 percent).

hoodoo - A column, pinnacle, or pillar of rock produced by differential weathering or erosion in a region of sporadically heavy rainfall. Formation is facilitated by joints and layers of varying hardness.

horst - An elongate block that is bounded on both sides by normal faults that dip away from the interior of the horst. It is a structural form and may or may not be expressed geomorphically.

hummock - (a) (not preferred - see hillock). An imprecise, general term for a rounded or conical mound or other small elevation. (b) (not preferred) A slight rise of ground above a level surface.

impact crater - a) A generally circular or elliptical depression formed by hypervelocity impact of an experimental projectile or ordinance into earthy or rock material. b) (not recommended - use meteorite crater) A generally circular crater formed by the impact of an interplanetary body (projectile) on a planetary surface.

inset fan - (colloquial; western US) The flood plain of an ephemeral stream that is confined between fan remnants, ballenas, basin-floor remnants, or closely-opposed fan toeslopes of a basin.

interdune - The relatively flat surface, whether sand-free or sand-covered, between dunes.

interfluve - A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways.

intermittent stream - A stream, or reach of a stream, that does not flow year-round (commonly dry for 3 or more months out of 12) and whose channel is generally below the local water table; it flows only when it receives a) base flow (i.e. solely during wet periods), or b) ground-water discharge or protracted contributions from melting snow or other erratic surface and shallow subsurface sources.

island - (a) Land completely surrounded by water; (b) An elevated area of land surrounded by swamp, or marsh, or isolated at high water or during floods.

knob - (a) A rounded eminence, a small hill or mountain; especially a prominent or isolated hill with

steep sides, commonly found in the Southern United States. (b) A peak or other projection from the top of a hill or mountain. Also, a boulder or group of boulders or an area of resistant rocks protruding from the side of a hill or mountain.

knoll - A small, low, rounded hill rising above adjacent landforms.

landslide - A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials, caused by gravitational forces and which may or may not involve saturated materials. Names of landslide types generally reflect the dominant process and/or the resultant landform. The main operational categories of mass movement are *fall* (rockfall, soil fall, topple), *slide* (rotational landslide, block glide, debris slide, lateral spread), *flow* [rock fragment flow (especially rockfall avalanche), debris avalanche, debris flow (e.g., lahar), earthflow, (creep, mudflow)], and *complex landslides*.

ledge - (a) A narrow shelf of rock, much longer than wide, formed on a rock wall or cliff face, as along a coast by differential wave action on softer rocks; erosion is by combined biological and chemical weathering. (b) A rocky outcrop; solid rock. (c) A shelf-like quarry exposure or natural rock outcrop.

levee - An artificial or natural embankment built along the margin of a watercourse or an arm of the sea, to protect land from inundation or to confine streamflow to its channel.

longitudinal dune - A long, narrow sand dune, usually symmetrical in cross profile, oriented parallel to the prevailing wind direction ; it is wider and steeper on the windward side but tapers to a point on the lee side. It commonly forms behind an obstacle in an area where sand is abundant and the wind is strong and constant. Such dunes can be a few meters high and up to 100 km long.

low hill - A generic name for an elevated, generally rounded land surface with low local relief, rising between 30 meters (100 ft.) to as much as 90 m (approx. 300 ft.) above surrounding lowlands.

lowland - (a) A generic, imprecise term for low-lying land or an extensive region of low-lying land, especially near a coast and including the extended plains or country lying not far above tide level. (b) (not preferred) A generic, imprecise term for a landscape of low, comparatively level ground of a region or local area, in contrast with the adjacent higher country. (c) (not recommended - use valley, bolson, etc.) A generic term for a large valley.

marsh - Periodically wet or continually flooded areas with the surface not deeply submerged. Covered dominantly with sedges, cattails, rushes, or other hydrophytic plants.

meander belt - The zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops. Landform components of the meander-belt surface are produced by a combination of gradual (lateral and down-valley) migration of meander loops and avulsive channel shifts causing abrupt cut-offs of loop segments. Landforms flanking the sinuous stream channel include: point bars, abandoned meanders, meander scrolls, oxbow lakes, natural levees, and flood-plain splays. Meander belts may not exhibit prominent natural levee or splay forms. Flood plains of broad valleys may contain one or more abandoned meander belts in addition to the zone flanking the active stream channel.

meander scar - (a) A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream which impinged upon and undercut the bluff; if it's no longer adjacent to the modern stream channel it indicates an abandoned route of the stream; (b) (not recommended - refer to oxbow) An abandoned meander, commonly filled in by deposition and vegetation, but still discernable.

meander scroll - (a) One of a series of long, parallel, close fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank. (b) (not recommended; refer to oxbow lake) - A small, elongate lake on a flood plain in a well-defined part of an abandoned stream channel.

mesa - A broad, nearly flat-topped, and usually isolated landmass bounded by steep slopes or precipitous cliff and capped by layers of resistant, nearly horizontal, rocky summit width greater than the height of bounding escarpments. (Colloquial: western US; not preferred) Also used to designate broad structural benches and alluvial terraces that occupy intermediate levels in stepped sequences of platforms bordering canyons and valleys.

monocline - (a) A unit of folded strata that dips from the horizontal in one direction only, is not part of an anticline or syncline, and occurs at the earth's surface.. This structure is typically present in plateau areas where nearly flat strata locally assume steep dips caused by differential vertical movements without faulting. (b) - A local steepening in an otherwise uniform gentle dip.

mountain - A generic term for an elevated area of the land surface, rising more than 300 meters above surrounding lowlands, usually with a nominal summit area relative to bounding slopes and generally with steep sides (greater than 25 percent slope) with or without considerable bare-rock exposed. A mountain can occur as a single, isolated mass or in a group forming a chain or range. Mountains are primarily formed by tectonic activity and/or volcanic action and secondarily by differential erosion.

natural levee - A long, broad low ridge or embankment of sand and coarse silt, built by a stream on its flood plain and along both sides of its channel, especially in time of flood when water overflowing the normal banks is forced to deposit the coarsest part of its load. It has a gentle slope away from the river and toward the surrounding floodplain, and its highest elevation is closest to the river bank.

open depression - A generic name for any enclosed or low area that has a surface drainage outlet whereby surface water can leave the enclosure; an area of lower ground indicated on a topographic map by contour lines forming an incomplete loop or basin indicating at least one surface exit.

overbank deposit - Fine-grained sediments (silt and clay) deposited from suspension on a flood plain by floodwaters that cannot be contained within the stream channel.

overflow stream channel - A watercourse that is generally dry but conducts flood waters that have overflowed the banks of a river, commonly from large storms or annual meltwater.

parabolic dune - A sand dune with a long, scoop-shaped form, convex in the downwind direction so that its horns point upwind, whose ground plan approximates the form of a parabola.

peak - Sharp or rugged upward extension of a ridge chain, usually at the junction of two or more ridges; the prominent highest point of a summit area.

pediment - A gently sloping erosional surface at the foot of a receding hill or mountain slope. The surface may be essentially bare, exposing earth material that extends beneath adjacent uplands; or it may be thinly mantled with alluvium and colluvium, ultimately in transit from upland front to basin or valley lowland. In hill-foot slope terrain the mantle is designated “pedisediment.” The term has been used in several geomorphic contexts: Pediments may be classed with respect to (a) landscape positions, for example, intermontane-basin piedmont or valley-border footslope surfaces (respectively, apron and terrace pediments); (b) type of material eroded, bedrock or regolith; or (c) combinations of the above.

perennial stream - A stream or reach of a stream that flows continuously throughout the year and whose surface is generally lower than the water table adjacent to the region adjoining the stream.

plain - A general term referring to any flat, lowland area, large or small, at a low elevation. Specifically, any extensive region of comparatively smooth and level gently undulating land. A plain has few or no prominent hills or valleys but sometimes has considerable slope, and usually occurs at low elevation relative to surrounding areas. Where dissected, remnants of a plain can form the local uplands. A plain may be forested or bare of trees and may be formed by deposition or erosion.

plateau - A comparatively flat area of great extent and elevation; specifically an extensive land region considerably elevated (more than 100 meters) above adjacent lower-lying terrain, and is commonly limited on at least one side by an abrupt descent, has a flat or nearly level surface. A comparatively large

part of a plateau surface is near summit level.

playa - The usually dry and nearly level lake plain occupying the lowest parts of closed depressions, such as those occurring on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation-runoff events. Playa deposits are fine grained and may or may not have high water table and saline conditions.

point bar - One of a series of low, arcuate ridges of sand and gravel developed on the inside of a growing meander by the migration of the channel toward the outer bank.

pond - (a) A natural body of standing fresh water occupying a small surface depression, usually smaller than a lake and larger than a pool. (b) A small artificial body of water, used as a source of water.

pool - A small, natural body of standing water, usually fresh; e.g. a stagnant body of water in a marsh, or a transient puddle in a depression following a rain.

quarry - Excavation areas, open to the sky, usually for the extraction of stone.

ravine - A small stream channel; narrow, steep-sided, commonly V-shaped in cross section and larger than a gully, cut in unconsolidated materials. General synonym (not preferred) - gulch.

reef - (a) A ridge-like or mound-like structure, layered or massive, built by sedentary calcareous organisms, especially corals, and consisting mostly of their remains; it is wave-resistant and stands above the surrounding contemporaneously deposited sediment. Also, such a structure built in the geologic past and now enclosed in rock, commonly of differing lithology.

ridge - A long, narrow elevation of the land, usually sharp crested with steep sides and forming an extended upland between valleys. The term is used in areas of both hill and mountain relief.

rill - A very small channel with steep sides caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water, usually during and immediately following moderate rains or after ice/snow melt. Generally, a rill is not an obstacle to wheeled vehicles and is shallow enough to be obliterated by ordinary tillage.

rim - The border, margin, edge, or face of a landform, such as the curved brim surrounding the top part of a crater or caldera; specifically the rimrock of a plateau or canyon.

rise - (refer to lake plain) (a) A general term for a slight increase in slope and elevation of the land surface, usually with a broad summit and gently sloping sides. (b) same as (a) but the term is restricted to microfeatures in areas of very low relief such as lake plains or coastal plains.

river - (a) A general term for a natural, freshwater surface stream of considerable volume and generally with a permanent base flow, moving in a defined channel toward a larger river, lake, or sea.

river valley - an elongate depression of the Earth's surface carved by a river during its development.

rockfall - The process, associated sediments (rockfall deposit) or resultant landform characterized by a very rapid type of *fall* dominated by downslope movement of detached rock bodies which fall freely through the air or by leaps and bounds (lacks an underlying slip face); also spelled rock fall.

rock pediment - An erosion surface of low relief, cut directly into and across bedrock and composed of either bare rock or thinly veneered pedisediment or residuum (e.g. < 1.5 m) over bedrock; it occurs along the flanks of mountain fronts, or at the base of mountains or high hills. Its surface grades to the backwearing mountain slopes or hillslopes above, and generally grades down to and merges with a lower-lying alluvial plain, piedmont slope or valley floor below.

rotational slide - The process, associated sediments (rotational landslide deposit) or resultant landforms characterized by an extremely slow to moderately rapid type of slide, composed of comparatively dry and largely soil-rock materials, portions of which remain largely intact and in which movement occurs along a well-defined, concave shear surface and resulting in a backward rotation of the displaced mass. The

landform may be single, successive (repeated up and down slope), or multiple (as the number of slide components increase).

rubble - An accumulation of loose angular rock fragments, commonly overlying outcropping rock; the unconsolidated equivalent of a breccia.

saddle - A low point on a ridge or interfluve, generally a divide (pass, col) between the heads of streams flowing in opposite directions.

sandhills - A region of semi-stabilized sand dunes or sandy hills, either covered with vegetation or bare, as in north-central Nebraska and the midlands of the Carolinas.

sand plain - (a) A sand-covered plain which may originate by deflation of sand dunes, and who's lower limit of erosion is governed by the ground-water level. Also spelled *sandplain*. (b) (not preferred - refer to *sandy* outwash plain) A small outwash plain composed chiefly of sand deposited by meltwater streams flowing from a glacier.

sand ramp - A sand sheet blown up onto the lower slopes of a bedrock hill or mountain and forming an inclined plane, sometimes filling small mountain-side valleys and even crossing low passes.

sand sheet - A large, irregularly shaped, commonly thin, surficial mantle of eolian sand, lacking the discernible slip faces that are common on dunes.

scarp - An escarpment, cliff, or steep slope of some extent along the margin of a plateau, mesa, terrace, or structural bench. A scarp may be of any height.

scarp slope - The relatively steeper face of a cuesta, facing in a direction opposite to the dip of the strata.

scree - A collective term for an accumulation of coarse rock debris mantling a slope. Scree is not a synonym of talus, as scree includes loose, coarse fragment material on slopes without cliffs.

scree slope - A portion of a hillside or mountain mantled by scree and lacking an upslope rockfall source.

seep - (noun) An area, generally small, where water or oil percolates slowly to the land surface. For water, it may be considered as a seepage spring, but it is used by some for flows too small to be considered as springs.

shoulder - The hillslope profile position that forms the convex, erosional surface near the top of a hillslope. If present, it comprises the transition zone from summit to backslope.

shrub-coppice dune - A small, streamlined dune that forms around brush and clump vegetation.

side slope - A laterally planar area of a hillside, resulting in predominantly parallel overland water flow (e.g., sheet wash); contour lines generally form straight lines. Side slopes are dominated by colluvium and slope wash sediments. Slope complexity (downslope shape) can range from simple to complex. The slope bounding a drainageway and lying between the drainageway and the adjacent interfluve. It is generally linear along the slope width.

slide - (a) Mass movement processes, associated sediments (slide deposit) or resultant landforms (e.g., rotational, translational, and snow slide) characterized by a failure of earth, snow, or rock under shear stress along one or several surfaces that are either visible or may reasonably be inferred. The moving mass may or may not be greatly deformed, and movement may be rotational (rotational slide) or planar (translational slide). A slide can result from lateral erosion, lateral pressure, weight of overlying material, accumulation of moisture, earthquakes, expansion owing to freeze-thaw of water in cracks, regional tilting, undermining, fire, and human agencies. (b) The track of bare rock or furrowed earth left by a slide. (c) The mass of material moved by or deposited by a slide.

slip face - The steeply sloping surface of a dune, standing at or near the angle of repose of loose sand, and advancing downwind by a succession of slides wherever that angle is exceeded.

slope - (also called slope gradient or gradient) The inclination of the land surface from the horizontal.

Percent slope is the vertical distance divided by the horizontal distance, then multiplied by 100.

slope alluvium - Sediment gradually transported down mountain or hill slopes primarily by non-channel alluvial processes (i.e., slope wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of coarse fragments and may be separated by stone lines. Sorting of pebbles or cobbles and burnished peds distinguish these materials from unsorted colluvial deposits.

slope wash - A collective term for non-fluvial, incipient alluvial *processes* (e.g. overland flow, minor rills) that detach, transport, and deposit sediments down hill and mountain slopes. Related sediments (*slope alluvium*) exhibit nominal sorting or rounding of particles, peds, etc., and lateral sorting downslope on long slopes; stratification is crude and intermittent and readily destroyed by pedoturbation and frost action. Also called *slope wash processes*.

slot canyon - A long, narrow, deep and tortuous channel or drainageway with sheer rock walls eroded into sandstone or other sedimentary rocks, especially in the semi-arid western US (e.g. Colorado Plateau); subject to flash flood events; depth to width ratios exceed 10:1 over most of its length and can approach 100:1; commonly containing unique ecological communities distinct from the adjacent, drier uplands.

strath terrace - A type of stream terrace, formed as an erosional surface cut on bedrock and thinly mantled with stream deposits (alluvium).

stream - (a) A body of running water that moves under gravity to progressively lower levels, in a relatively narrow but clearly defined channel on the ground surface, in a subterranean cavern, or beneath or in a glacier. It is a mixture of water and dissolved, suspended, or entrained matter. (b) A term used in quantitative geomorphology interchangeably with channel.

stream terrace - One or a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream, and representing the remnants of an abandoned flood plain, stream bed, or valley floor (i.e., currently very rarely or never floods; inactive cut and fill and/or scour and fill processes). Erosional surfaces cut into bedrock and thinly mantled with stream deposits (alluvium) are called “strath terraces.” Remnants of constructional valley floors thickly mantled with alluvium are called alluvial terraces.

strike valley - A subsequent valley eroded in, and developed parallel to the strike of, underlying weak strata; such as a cuesta; a valley that often, but not necessarily contains a strike valley.

structural bench - A platform-like, nearly level to gently inclined erosional surface developed on resistant strata in areas where valleys are cut in alternating strong and weak layers with an essentially horizontal attitude. Structural benches are bedrock controlled, and in contrast to stream terraces, have no geomorphic implication of former, partial erosion cycles and base-level controls, nor do they represent a stage of flood-plain development following an episode of valley trenching.

summit - (a) The topographically highest position of a hillslope profile with a nearly level (planar or only slightly convex) surface. (b) A general term for the top, or highest area of a landform such as a hill, mountain, or tableland. It usually refers to a high interfluve area of relatively gentle slope that is flanked by steeper slopes, e.g., mountain fronts or tableland escarpments.

swale - (a) A shallow, open depression in unconsolidated materials which lacks a defined channel but can funnel overland or subsurface flow into a drainageway. Soils in swales tend to be more moist and thicker (cummulic) compared to surrounding soils. (b) A small, shallow, typically closed depression in an undulating ground moraine formed by uneven glacial deposition; (c) (not preferred; refer to interdune) A long, narrow, generally shallow, trough-like depression between two beach ridges, and aligned roughly parallel to the coastline.

syncline - (a) A unit of folded strata that is concave upward whose core contains the stratigraphically younger rocks, and occurs at the earth's surface. In a single syncline, beds forming the opposing limbs of

the fold dip toward its axial plane. (b) A fold, at any depth, generally concave upward whose core contains the stratigraphically younger rocks.

tableland - A term for a broad upland with an extensive, nearly level or undulating summit area and steep side slopes descending to surrounding lowlands.

talus - Rock fragments of any size or shape (usually coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of loose broken rock formed chiefly by falling, rolling, or sliding.

talus cone - A small, steep, cone-shaped landform at the base of a cliff or escarpment, that heads in a relatively small declivity or ravine, and composed of poorly sorted rock and soil debris that has accumulated primarily by episodic rockfall or, to a lesser degree, by slope wash. Not to be confused with an *alluvial cone*; a similar feature but of fluvial origin, composed of better stratified and more sorted material, and that tapers up into a more extensive drainageway.

talus slope - a portion of a hillslope or mountainslope mantled by talus and lying below a rock source.

tank - (colloquial: southwestern US) A natural depression or cavity in impervious rocks in which water collects and remains for the greater part of the year.

terrace - A step-like surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, or lake or sea shore. The term is usually applied to both the relatively flat summit surface (tread), cut or built by stream or wave action, and the steeper slope (scarp, riser), descending to a lower level. Practically, terraces are considered to be generally flat alluvial areas above the 100 yr. flood stage.

terracettes - Small, irregular step-like forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock such as sheep or cattle. Synonyms (not preferred) - catstep, sheep or cattle track.

toeslope - The hillslope position that forms the gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear, and are constructional surfaces forming the lower part of a hill-slope continuum that grades to valley or closed-depression floors.

translational slide - A category of mass movement processes, associated sediments (translational slide deposit) or resultant landforms characterized by the extremely slow to moderately rapid downslope displacement of comparatively dry soil-rock material on a surface (slip face) that is roughly parallel to the general ground surface, in contrast to falls, topples, and rotational slides. The term includes such diverse *slide* types as translational debris slides, translational earth slide, translational rock slide, block glides, and slab or flake slides.

valley - An elongate, relatively large, externally drained depression of the Earth's surface that is primarily developed by stream erosion or glacial activity.

valley floor - A general term for the nearly level to gently sloping, lowest surface of a valley. Landforms include axial stream channels, the flood plain, flood-plain steps, and, in some areas, low terrace surfaces.

valley side - The sloping to very steep surfaces between the valley floor and summits of adjacent uplands. Well-defined, steep valley sides have been termed valley walls (not recommended). Note: Scale, relief, and perspective may require use of closely related terms such as hill slope or mountain slope.

wash (dry wash) - (colloquial: western US.) The broad, flat- floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in alluvium. Note: When channels reach intersect zones of ground-water discharge they are more properly classed as “intermittent stream” channels.

zibar - A small, low-relief sand dune that lacks discernible slip faces and commonly occurs on sand sheets, in interdune areas, or in corridors between larger dunes. Zibar spacing can range from 50-400 m with local relief < 10 m. Unlike coppice dunes, zibars are unrelated to deposition around vegetation. Generally dominated by coarser sands.

B.3. Example of a Vegetation Plot Data Form

NATIONAL PARK VEGETATION MAPPING PROGRAM: PLOT SURVEY FORM

Park

IDENTIFIERS/LOCATORS

Plot Code ARCH/CANY/NABR 305 BPU Code 23311

Provisional Community Name MIXED CANYON WALL SHRUBLAND

State UT Park Name ARCH/CANY/NABR Park Site Name SALT VALLEY

Quad Name MOLLIE HOGAN'S Quad Code _____ Aerial Photo # 902-46

GPS file name AP305 Field UTM X 622313 m E Field UTM Y 4291074 m N
DATUM 83 UTM Zone: 12 S Error +/- 6.0 m 3D Differential? (Y)/ N
Comments/GPS device used:

Survey Date 6 5 03 Surveyors B. CONDIE S. TOPP

Directions to Plot FROM THE JUNCTION OF THE MAIN PARK ROAD AND THE SALT VALLEY ROAD, GO 986 METERS BEARING 200°.

Plot length(m)_____ Azimuth _____ Plot width(m)_____ Diameter if circle 22.6 Plot Photos (y/n) __ Roll # BS 3 Frame #s 11, 12
Plot Permanent: NO Photo comments: Biological crust frame # NO

Plot representativeness (discuss plot placement and explain non-representativeness)
a. Representativeness of association compared with occurrences outside park (if known):
b. Representativeness of plot in stand: VEG IS PRETTY CONSISTENT ON THIS SLOPE AND ASPECT EXCEPT AS THE SLOPE CONTINUES NORTH, THE SCATTERED PIÑON AND JUNIPER DISAPPEAR.

ENVIRONMENTAL DESCRIPTION

Elevation: 4870 (ft)/ m (circle one) Slope: 33° deg. Aspect: 306 deg.
Topographic Position (see cheat sheet) MIDSLOPE
Landform (see cheat sheet) RAVINE
Surficial Geology (see cheat sheet/map) WINGATE SANDSTONE ? SEE NOTES

Cowardin System		Hydrology		
X Upland	___ Palustrine	___ Permanently Flooded	___ Unknown	___ Temporarily Flooded
___ Riverine	___ Lacustrine	___ Semipermanently Flooded	___ Seasonally Flooded ___ Saturated	___ Intermittently Flooded

Environmental Comments (factors controlling community/plant distribution, seral stage, fire history etc): STEEP, RUBBLY SLOPE IS A WORK IN PROGRESS. SOME VEG SEEMS TO BE HANGING ON UPHILL. SOME SHRUBS HAVE DEAD LIMBS, MAYBE FROM THE DROUGHT - BUT PLANTS LOOKING GOOD NOW. LOTS OF NEW GROWTH.

Ground Cover: *(please estimate to the nearest percentage. Sum = 100%)*

30 Bare soil	26 Large rocks (>10 cm)
5 Bedrock	0 Lichen (ground)
0 Sand (0.1-2 mm)	1 Lichen (on rocks)
1 Wood (>1 cm)	0 Moss
25 Small rocks (0.2-10 cm)	___ Other (describe):
0 Water	5 Litter / duff
1 Dark cyanobacteria	1 Live veg - wood
5 Live veg - litter	

Soil Texture (see cheat sheet):
___ sand X loamy sand ___ sandy loam ___ loam
___ silt loam ___ silt ___ clay loam ___ silty clay
___ sandy clay ___ clay ___ peat ___ muck

Soil Drainage:
X Rapidly drained ___ Well drained
___ Moderately well drained ___ Somewhat poorly drained
___ Poorly drained ___ Very poorly drained

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic Class	Height Scale for Strata	Cover Scale for Strata
Trees and Shrubs __Evergreen X Cold-deciduous __Mixed evergreen-cold-deciduous Herbs __Annual __Perennial	X Broad-leaved __Needle-leaved __Microphyllous __Graminoid __Forb __Pteridophyte __Non-vascular __Mixed (describe)	__Forest __Woodland __Shrubland __Dwarf Shrubland X Shrub Herbaceous __Herbaceous __Nonvascular __Sparsely Vegetated	01 <0.5 m 02 0.5-1m 03 1-2 m 04 2-5 m 05 5-10 m 06 10-15 m 07 15-20 m 08 20-35 m 09 35 – 50 m 10 >50 m	T 0-1% P >1-5% 1 >5-15% 2 >15-25% 3 >25-35% 4 >35-45% 5 >45-55% 6 >55-65% 7 >65-75% 8 >75-85% 9 >85-95% 10 > 95%

	Height Class	Cover Class	Dominant Species (mark Diagnostic species with *)
T1 Emergent			
T2 Canopy	04	P	JUN OST, PIN EDU
T3 Sub-canopy			
S1 Tall shrub			
S2 Short Shrub	02	1	ART BIG, CHR VIS
S3 Dwarf-shrub	01	T	ERIO MIC
Ht Herbaceous		P	
H1 Graminoids	01	P	ORY HYM
H2 Forbs	01	T	DRIED MUSTARD (ANNUAL)
H3 Ferns			
H4 Tree seedlings	02	T	JUN OST
N Non-vascular	01	P	CYANOBACTERIA
V Vine/liana			
E Epiphyte			

Animal Use Evidence (including scat, browse, burrows, bedding sites, etc) NONE OBVIOUS

Natural and Anthropogenic Disturbance Comments (see cheat sheet for examples; describe intensity and effect on the vegetation, also whether disturbance is current, chronic, episodic or historic) LOOSE SLOPE IS PROBABLY DISTURBED OFTEN BY MOVING RUBBLE AND BOULDERS. PLANTS DON'T SEEM CONCERNED BY THIS PERIL.

Other Comments/Continuation from previous sections. **Describe surrounding communities and how they relate to the plot.** Describe distribution of biological crust components in the community. AS FAR AS I CAN TELL, THE GEOLOGY MAPS SAYS WINGATE SANDSTONE, BUT IT DOESN'T LOOK LIKE THE BIG WINGATE CLIFFS ELSEWHERE IN THE PARK. MAYBE THE MANY NEARBY FAULTS HAVE BROKEN IT UP AND MADE IT LOOK MORE LEDGEY. THIS SLOPE IS QUITE DIFFERENT THAN THE ONE ACCROSS THE RAVINE. OVER THERE IT LOOKS LIKE MOSTLY BLACK BRUSH AND SCATTERED PIÑON-JUNIPER.

Plot Code: ARCH/CANYNABR. 305

Species/percent cover: Starting with the uppermost stratum, list all species with % cover for each species in the stratum. For each tree species estimate seedling, sapling, total cover indicating stratum. **List species outside the plot at the end of the table and designate with a 0 in Cover Class column.**

Stratum	Species Name	Cover Class	Stratum	Species Name	Cover Class	Stratum	Species Name	Cover Class	TOTALS
T2	JUNOST	T	H1	ORYHYM	T				
	PIN EDU	T		BRO TEC	T				
				FES OCT	T				
				HIC JAM	T				T1=
				ARI PUR	T				T2=
S2	ERA ANO	T		STI ARI	T				T3=
	ART BIG	P		STI COM	T				S1=
	EPH TOR	T							S2=
	EPH VIR	T							S3=
	CHR VIS	P							H1=
	CHR NAU JUN	T							H1=
	COL RAM	T							H2=
									H3=
									H4=
									N=
S3	GUTSAR	T							V=
	ERIO MIC	T							E=
H2	Cryptantha sp.	T	N	Cyano	P				
	DES PIN	T		PSORA	T				
	STR LON	T		Fulgensia	T				
	LEPidium MON	T		Collema	T				
	Gilia INC	T							
	EUPH FEN	T							
	CRYPT FLAVA	T							
	ERIGERON SP.	T							
	PENSTA SPP.	T							
			H4	JUNOST	T				

Cover Class Scale:	Strata:
T = >0-1%	T1 = Emergent
P = >1-5%	T2 = Canopy
1 = >5-15%	T3 = Subcanopy
2 = >15-25%	S1 = Tall Shrub
3 = >25-35%	S2 = Short Shrub
4 = >35-45%	S3 = Dwarf Shrub
5 = >45-55%	H1 = Graminoid
6 = >55-65%	H2 = Forb
7 = >65-75%	H3 = Fern
8 = >75-85%	H4 = Tree seedling
9 = >85-95%	N = Nonvascular
10 = >95%	V = Vine/liana
	E = Epiphyte

Tree DBH Form

Plot Code (Please circle one): CANY ARCH NABR 305 Units in cm or inches (circle one) Subplot? (Y/N) N

Record tree diameter over 5 cm at 4.5 feet (1.37 m) height for species that contribute to the tree canopy.

Separate measurements of multi-stemmed trees with commas.

Species	~~DBH~~ DRC(s) for multi-stemmed trees
JUOS	17
JUOS	16
PIED	9

Species	DBH(s) for multi-stemmed trees

Pinyon-juniper age classes (check one)

- X Not PJ
- ___ Old-growth (>500 years old)
- ___ Mature (350-500 years old, shrub layer absent)
- ___ Young (100-350 years old)
- ___ Invasive (<80 years old)

B.4. Example of an Observation Point Data Form

PARK

NATIONAL PARK VEGETATION MAPPING PROGRAM: OBSERVATION POINT FORM

IDENTIFIERS/LOCATORS

Plot Code (Please Circle One): CANY-ARCH-NABR 689 **Polygon Code:** N/A

Provisional Community Name: Hanging Garden

State: UT **Park Name (Pleae Circle One):** Canyonlands, Arches, Natural Bridges **Park Site Name:** Updraft Arch

Quad Name: Moab **Quad Code:** A. Photo 902-85

GPS File Name: A0689 **Field UTM X:** 625568 **mE Field UTM Y:** 4274993 **mN** +/-20.1m

Please do not complete the following information when in the field:

Corrected UTM X: **mE** **Corrected UTM Y:** **mN** **Zone:** 12S

Observers: Williams & Hahn **Date:** 19-Aug-03 **Photos:** PJ 18 #24, 20 GPS 25

ENVIRONMENTAL DESCRIPTION

Elevation: 4000ft **Slope:** 40 deg. **Aspect:** 154° deg.

Topographic Position: Steep slope

Landform: Cliff Base **Geology:** Navajo SS

Cowardin Wetland Classification System	Hydrologic Regime - Non Tidal
X Upland	___ Permanently Flooded
___ Estuarine	___ Semi-permanently Flooded
___ Riverine	___ Seasonally/Temporarily Flooded
___ Palustrine	___ Saturated
___ Lacustrine	___ Seasonally Flooded/Saturated
	___ Intermittently Flooded

Environmental Comments: This is a small, narrow hanging garden, which extends SW for approx 40meters, and there are few other spots along this Navajo wall with small seeps. This was the easiest accessible spot. The plants are patchy in places, but most of the usual species of hanging gardens occur here.

Unvegetated Surface (*please use cover scale below*)

02 Bedrock	02 Bare Soil
01 Rocks >10 cm	03 Litter/Duff
01 Rocks 0.2-10 cm	01 Wood
___ Sand	
___ Other (describe)_____	

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic Class	Cover Scale for Strata and Unvegetated Surface
Trees and Shrubs	___ Broad-leaved	___ Forest	01 = 0 - 10%
___ Evergreen	___ Needle-leaved	___ Woodland	02 = 10 - 25%
___ Cold-deciduous	___ Microphyllous	___ Shrubland	03 = 25 - 60%
___ Drought-deciduous	X Graminoid	___ Dwarf shrubland	04 = 60 - 100%
___ Mixed evergreen/ cold-deciduous	___ Forb	___ Shrub Herbaceous	
	___ Pteridophyte	X Herbaceous	
Herbs	___ Mixed (describe)	___ Nonvascular	
___ Annual		___ Sparsely vegetated	
X Perennial			

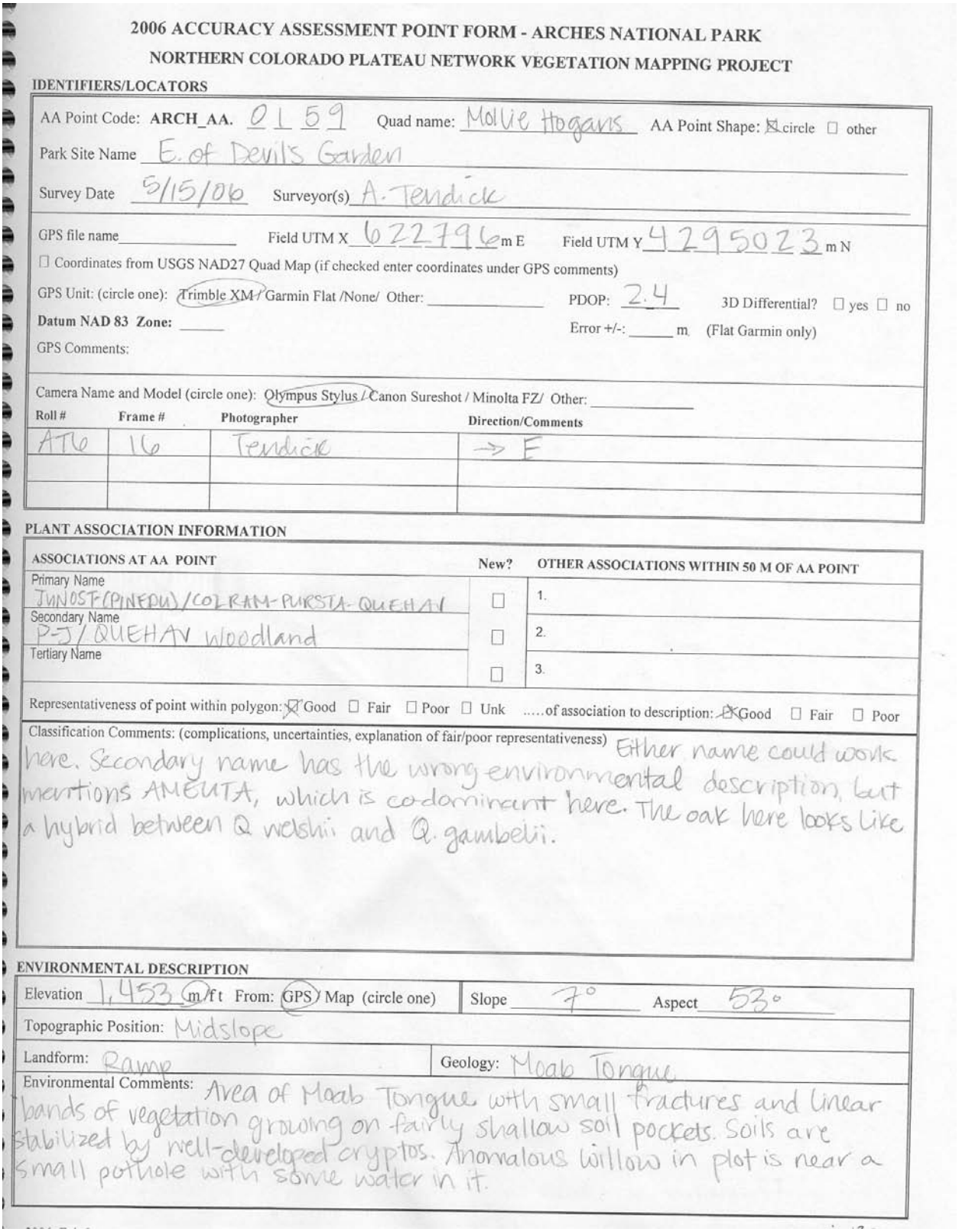
NATIONAL PARK VEGETATION MAPPING PROGRAM: OBSERVATION POINT FORM

Stratum	Height	Cover Class	Dominant species (mark diagnostic spp with a *)	% cover
T1: Emergent				
T2: Canopy				
T3: Sub-canopy				
S1: Tall shrub	03	01	MAHFRE FRAANO	01 01
S2: Short shrub	02	01	EPHVIR QUEHAV	01 01
H: Herbaceous	01	03	CALSCO AGUMIC ZIGVAG PRImula specuicola DICLAN MIMEAS CASLIN	03 01
N: Non-vascular				
V: Vine/liana				
E: Epiphyte				

EPIGIG 01
HETVIL 01
BROTEC 01
Asclepias cry 01
SCHIZach. scop. 01

Height Scale for strata:		Cover scale for strata and Unvegetated Surface:
01 = <0.5 m	06 = 10-15m	
02 = 0.5-1m	07 = 15-20m	01 = 0 - 10%
03 = 1-2m	08 = 20-35m	02 = 10 - 25%
04 = 2-5m	09 = 35-50m	03 = 25 - 60%
05 = 5-10m	10 = >50m	04 = 60 - 100%

B.5. Example of an Accuracy Assessment Data Form



2006 ACCURACY ASSESSMENT POINT FORM - ARCHES NATIONAL PARK

NORTHERN COLORADO PLATEAU NETWORK VEGETATION MAPPING PROJECT

IDENTIFIERS/LOCATORS

AA Point Code: ARCH_AA. 0159 Quad name: Mollie Hogans AA Point Shape: ☒ circle ☐ other

Park Site Name E. of Devil's Garden

Survey Date 5/15/06 Surveyor(s) A. Tendick

GPS file name _____ Field UTM X 622796 m E Field UTM Y 4295023 m N

☐ Coordinates from USGS NAD27 Quad Map (if checked enter coordinates under GPS comments)

GPS Unit: (circle one): Trimble XM / Garmin Flat /None/ Other: _____ PDOP: 2.4 3D Differential? ☐ yes ☐ no

Datum NAD 83 Zone: _____ Error +/-: _____ m (Flat Garmin only)

GPS Comments:

Camera Name and Model (circle one): Olympus Stylus / Canon Sureshot / Minolta FZ/ Other: _____

Roll #	Frame #	Photographer	Direction/Comments
AT6	16	Tendick	→ E

PLANT ASSOCIATION INFORMATION

ASSOCIATIONS AT AA POINT	New?	OTHER ASSOCIATIONS WITHIN 50 M OF AA POINT
Primary Name JUNOST(PINEDU)/COLRAM-PURSTA-QUEHAV	☐	1.
Secondary Name PJ/QUEHAV woodland	☐	2.
Tertiary Name	☐	3.

Representativeness of point within polygon: ☒ Good ☐ Fair ☐ Poor ☐ Unk .....of association to description: ☒ Good ☐ Fair ☐ Poor

Classification Comments: (complications, uncertainties, explanation of fair/poor representativeness) Either name could work here. Secondary name has the wrong environmental description, but mentions AMEUTA, which is codominant here. The oak here looks like a hybrid between Q. wislizenii and Q. gambelii.

ENVIRONMENTAL DESCRIPTION

Elevation 1,453 (m)/ft From: (GPS) / Map (circle one) Slope 7° Aspect 53°

Topographic Position: Midslope

Landform: Ramp Geology: Moab Tongue

Environmental Comments: Area of Moab Tongue with small fractures and linear bands of vegetation growing on fairly shallow soil pockets. Soils are stabilized by well-developed cryptos. Anomalous willow in plot is near a small pothole with some water in it.

2006 ACCURACY ASSESSMENT POINT FORM - ARCHES NATIONAL PARK

NORTHERN COLORADO PLATEAU NETWORK VEGETATION MAPPING PROJECT

Unvegetated Surface Cover+: *(please use the cover scale below)*

—	Bedrock	—	Large rocks (cobbles, boulders > 10 cm)	—	Sand (0.1-2 mm)
10	Litter, duff	T	Small rocks (gravel, 0.2-10 cm)	09	Bare soil
—	Wood (> 1 cm)			____	Other:____

VEGETATION DESCRIPTION

Leaf phenology (dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic Class	Height Class (m)	Cover Scale
Trees and Shrubs	____ Broad-leaved	____ Forest	01 - <0.5	T - <1%
____ Evergreen	____ Needle-leaved	____ Woodland	02 - 0.5-1	P - 1-5%
____ Cold-deciduous	____ Microphyllous	____ Shrubland	03 - 1-2	1a - 6-10%
____ Mixed evergreen - cold-deciduous	X Graminoid	____ Dwarf- shrubland	04 - 2-5	1b- 11-15%
Herbs	____ Forb	____ Shrub herbaceous	05 - 5-10	02 - 16-25%
____ Perennial	____ Pteridophyte	____ Wooded herbaceous	06 - 10-15	03 - 26-35%
X Annual	____ Non Vascular	____ Wooded Shrubland	07 - 15-20	04 - 36-45%
	____ Mixed	X Herbaceous	08 - 20-35	05 - 46-55%
		____ Nonvascular	09 - 35-50	06 - 56-65%
		____ Sparsely vegetated	10 - >50	07 - 66-75%
				08 - 76-85%
				09 - 86-95%

Strata	Height Class	Cover Class	Dominant species (mark any known diagnostic species with a *)	% Cover
T1 Emergent	____	____	____	____
T2 Canopy	____	____	____	____
			____	____
			____	____
T3 Sub-canopy	____	____	____	____
			____	____
S1 Tall shrub	____	____	____	____
			____	____
			____	____
			____	____
S2 Short Shrub	____	____	____	____
			____	____
			____	____
			____	____
			____	____
			____	____
S3 Dwarf-shrub	____	____	____	____
			____	____
			____	____
H Herbaceous	01	02	Halogeton glomeratus	3
			Bromus tectorum	8
			Dead halogeton	5
			Descurainia ~~pinnata~~ sophia	5
H4 Tree Seedlings	____	H	salsola tragus	3
		H	Lappula occidentalis	T
N Non-vascular	____	____	____	____

☐ Please check this box if AA point has more than one plant association (e.g. two or more species list at a point recorded on form)

2006: Feb 9

Appendix C

Database Documentation

C.1. Plots Database Documentation

Background

This database, designed for data resulting from fieldwork related to vegetation mapping projects, was developed by the Northern Colorado Plateau Network (NCPN). The Plots Database System, developed by The Nature Conservancy, was the starting point for this database. From this starting point, NCPN normalized the data structure, added fields and lookup tables, and developed an extensive user interface. Similar versions of this database, subsequently referred to as the ARCH VegMapDB, have been used for all vegetation mapping projects conducted by NCPN. ARCH VegMapDB contains plot, observation point, and accuracy assessment data collected during project field work.

Two database files are required to use ARCH VegMapDB:

- *ARCH_PlotsAA_XP.mdb.* This "frontend" file contains all queries, forms, reports, associated modules and Visual Basic code.
- *ARCH_PlotsAA_XP_be.mdb*. This "backend" file contains the database tables.

The frontend/backend file structure allows multiple users to enter data in a network environment, and allows for easy backup and transfer of the data tables. Users typically launch the frontend file, and a utility will prompt them to establish a link to the backend file. The contents of the backend file, however, can be used independently of the frontend.

Entity Relationship Diagram

The primary tables and relationships from the backend file (ARCH_PlotsAA_XP_be.mdb) are illustrated below. The database follows the design structure of the National Park Service Natural Resource Database Template, which is based on a location record, one or more related event records, and observation data elements linked to each event.

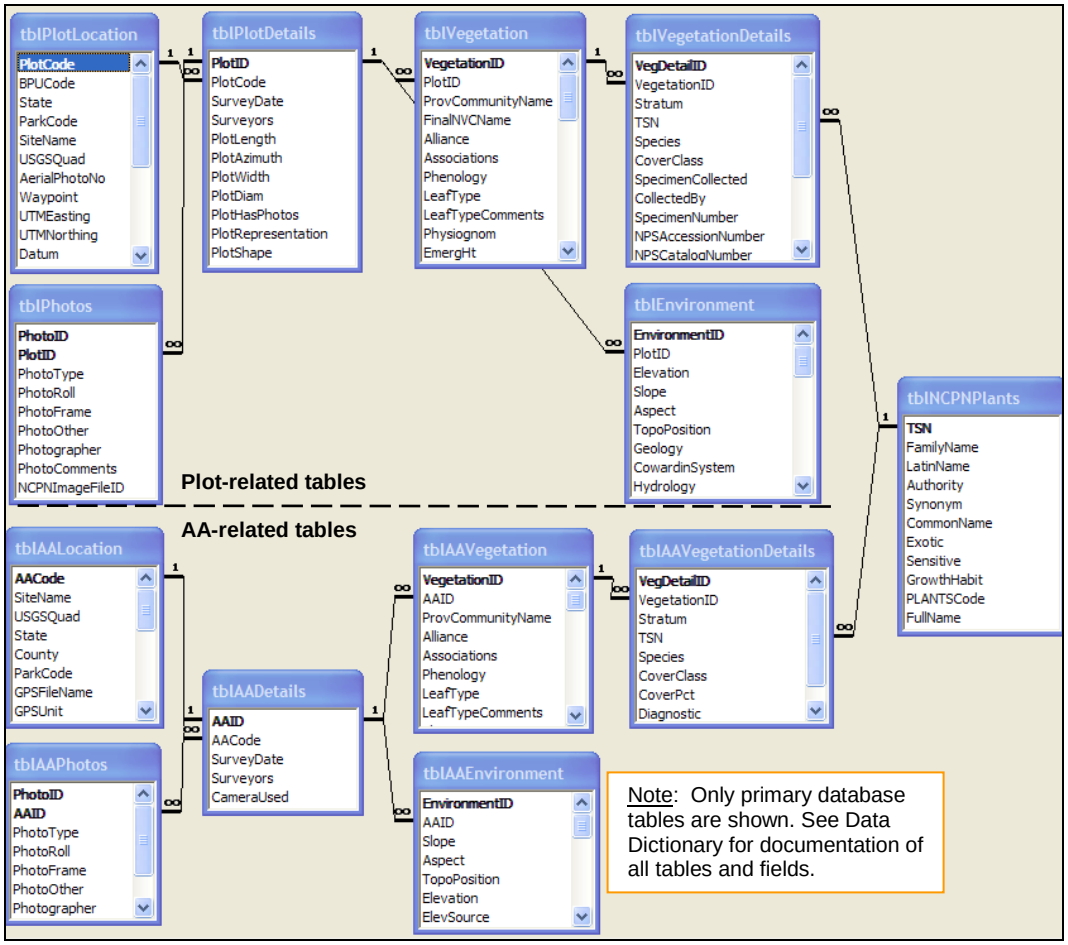


Figure 1. Entity Relationship Diagram for ARCH VegMapDB

Data Dictionary

The database consists of three types of tables: plot data, accuracy assessment data, and lookup tables that provide a standardized list of values to be used for certain data fields. Tables appear in alphabetical order within each of these three categories.

Plot-related tables

Table Name: tblDataMgmtLog
Description: Table containing a log of data set manipulations or database object alterations.

Field Name	Field Description	Field Type	Field Width
ActionDate	The date on which the data set was changed or manipulated.	dbDate	8
ActionMonth	If ActionDate known to month only, use this field and the ActionYear field.	dbText	50
ActionYear	If ActionDate known to year only, use this field.	dbText	50
Action	What was done with the data set. How was it altered, manipulated, etc. Include changes to data and changes to database objects or structures, and decisions that are made on data entry procedures or standards	dbMemo	0

Field Name	Field Description	Field Type	Field Width
Who	The name of the person who performed the action with the data set.	dbText	50

Table Name: tblEnvironment
Description: Table containing values on environmental features and conditions of plot or observation point

Field Name	Field Description	Field Type	Field Width
EnvironmentID	Unique record identifier	dbLong	4
PlotID	Foreign key; links record to tblPlotDetails	dbLong	4
Elevation	Elevation of plot in meters	dbLong	4
Slope	Slope of plot measured in degrees	dbText	50
Aspect	Aspect of plot	dbText	50
TopoPosition	Topographic position of plot; value selected from tlkpTopography	dbText	50
Geology	Geologic substrate influencing the plant community; value selected from tlkpGeology	dbText	75
CowardinSystem	If the plot is in a wetland system, select term that best describes its hydrology; value selected from tlkpCowardin	dbText	12
Hydrology	Select value that best describes hydrology of plot from tlkpHydrology	dbText	50
EnvironmentalComments	Comments on environmental setting and its effect on the vegetation; also comments on any disturbance or reproduction factors	dbMemo	0
BareSoil	Estimate to the nearest percentage of bare soil ground cover	dbText	3
Bedrock	Estimate to the nearest percentage of bedrock ground cover	dbText	3
Sand	Estimate to the nearest percentage of sand ground cover	dbText	3
Moss	Estimate to the nearest percentage of moss ground cover	dbText	3
Other	Estimate to the nearest percentage of other ground cover	dbText	3
OtherPctDesc	Description of "other" used in Other category (above)	dbText	255
Litter	Estimate to the nearest percentage of litter ground cover	dbText	3
Rocks	Estimate to the nearest percentage of rocks ground cover	dbText	3
Lichen	Estimate to the nearest percentage of lichen ground cover	dbText	3
Wood	Estimate to the nearest percentage of wood ground cover	dbText	3
Gravel	Estimate to the nearest percentage of gravel ground cover	dbText	3
Water	Estimate to the nearest percentage of water ground cover	dbText	3
Cryptogam	Estimate to the nearest percentage of cryptogam ground cover	dbText	3
SoilTexture	Assessment of average soil texture from sample taken a few inches below the surface; values selected from	dbText	50

Field Name	Field Description	Field Type	Field Width
	tlkpSoilTexture		
SoilDrainage	Soil drainage class based on actual moisture content and extent period; values selected from tlkpSoilDrainage	dbText	30
AnimalUseComments	Comments on evidence of use by non-domestic animals in plot area	dbMemo	0
DisturbanceComments	Comments on evidence of natural or anthropogenic disturbance in plot area, severity and effects on vegetation	dbMemo	0
OtherComments	Other general comments	dbMemo	0
LandscapeComments	Description of landscape context of plot, including any important landscape features influencing the community	dbMemo	0
SoilTaxonDesc	Field used for either identifying soils keyed, or to describe if large rocks or outcrops are present on the surface	dbText	255
LiveVegLitter	Estimate to the nearest percentage of live veg litter ground cover	dbText	3
LiveVegWood	Estimate to the nearest percentage of live veg wood ground cover	dbText	3
LichenRocks	Estimate to the nearest percentage of lichen rocks ground cover	dbText	3
LichenGround	Estimate to the nearest percentage of lichen ground cover	dbText	3
DarkCyanobacteria	Estimate to the nearest percentage of dark cyanobacteria ground cover	dbText	3
TotalPct	Total ground cover percentage for data validation.	dbInteger	2

Table Name: tblEnvironmentDetails
Description: Table containing one or more landform values associated with tblEnvironment. Values selected from tlkpLandform.

Field Name	Field Description	Field Type	Field Width
EnvDetailID	Unique record identifier	dbLong	4
EnvironmentID	Foreign key; links to tblEnvironment	dbLong	4
Landform	One or more landform values corresponding to plot location; values selected from tlkpLandform	dbText	50

Table Name: tblFinalAssociationNamesPlots
Description: Table containing final Association Names (plots) assigned by NatureServe.

Field Name	Field Description	Field Type	Field Width
PlotCode	Identifier assigned to plot by survey crew	dbText	255
ELC_Code	Unique ID assigned by NatureServe	dbText	255
Association_Name	Association Name assigned by NatureServe	dbText	255

Table Name: tblFuels
Description: Table containing details on fuels characteristics of plot

Field Name	Field Description	Field Type	Field Width
FuelsID	Unique record ID	dbLong	4
PlotID	Foreign key; links to tblPlotDetails	dbLong	4

Field Name	Field Description	Field Type	Field Width
PPDFPhotoGuide	Photo Series Guide: the page number of the PPDF photo that most closely resemble the plot in terms of vegetation structure and fuel on the ground	dbText	3
PJPhotoGuide	Photo Series Guide: the page number of the PJ photo that most closely resemble the plot in terms of vegetation structure and fuel on the ground	dbText	3
SBPhotoGuide	Photo Series Guide: the page number of the SB photo that most closely resemble the plot in terms of vegetation structure and fuel on the ground	dbText	3
PJAgeClass	If plot contains pinyon and/or juniper, enter value that best describes the age class of the stand; values stored in tlkpPJAge	dbText	15
LitterOrigin	Measurement of litter at plot center (origin)	dbText	3
LitterNorth	Measurement of litter at 20m north of plot origin	dbText	3
LitterEast	Measurement of litter at 20m east of plot origin	dbText	3
LitterSouth	Measurement of litter at 20m south of plot origin	dbText	3
LitterWest	Measurement of litter at 20m west of plot origin	dbText	3
DuffOrigin	Measurement of duff at plot center (origin)	dbText	3
DuffNorth	Measurement of duff at 20m north of plot origin	dbText	3
DuffEast	Measurement of duff at 20m east of plot origin	dbText	3
DuffSouth	Measurement of duff at 20m south of plot origin	dbText	3
DuffWest	Measurement of duff at 20m west of plot origin	dbText	3
IsSubplot	indicate if measurements are for subplot (if plot has >25 trees, one quadrant (subplot) of plot can be measured for fuels	dbBoolean	1

Table Name: tblFuelsDetails
Description: Details on stems, height, crown width, and other attributes of trees within plot

Field Name	Field Description	Field Type	Field Width
FuelsDetailID	Unique identifier for record	dbLong	4
FuelsID	Foreign key, links to tblFuels	dbLong	4
StemCount	Number of stems measured. Value will be 1 if forest species; >=1 if woodland species.	dbInteger	2
StemDiameter	diameter in cm of stem(s). If stem count =1 for a forest species, diameter represents dbh. If stem count is >1 for a woodland species, diameter represents the average diameter of all stems measured at crown base.	dbDouble	8
TSN	Taxonomic Serial Number - unique taxon identifier assigned by ITIS	dbDouble	8
WoodlandCrownWidth	Width, in meters, of woodland tree crown	dbDouble	8
WoodlandCrownHeight	Height, in meters, of woodland tree	dbDouble	8
ForestCrownBaseHeight	Height, in meters, of crown base of forest tree	dbDouble	8
ForestCrownHeight	Height, in meters, of forest tree (PP or DF)	dbDouble	8
CrownRatio	[not used]	dbText	12
StructureStage	Stage of tree; values selected from tlkpStructureStages	dbText	12
Comments	Brief comments (e.g., dead top, twinned, ladder fuels, diseased)	dbText	255

Table Name: tblGeneralPhotos
Description: Information pertaining to photos not associated with plots.

Field Name	Field Description	Field Type	Field Width
GenPhotoID	Unique record identifier	dbLong	4
GenPhotoParkCode	Four-letter abbreviation of park where photo was taken (if applicable)	dbText	50
GenPhotoDate	Date photo taken	dbDate	8
GenPhotographer	Name of photographer	dbText	75
GenPhotoDesc	General description of photo contents	dbText	250
GenPhotoUTME	UTME of photo	dbLong	4
GenPhotoUTMN	UTMN of photo	dbLong	4
GenUTMZone	UTMZone of photo UTM coordinates	dbLong	4
GenPhotoRoll10	Roll number of photo	dbText	50
GenPhotoFrame	Frame number of photo	dbText	10
GenPhotoDigFile	Digital file name of photo	dbText	50
GenPhotoComments	General comments	dbText	250

Table Name: tblGeneralSpecimens
Description: Table used to enter data on specimens collected outside of plots or observation points but within the park

Field Name	Field Description	Field Type	Field Width
GenSpecimenID	Unique record ID	dbLong	4
GenSpecFamily	Family name of species collected	dbText	50
GenSpecLatinName	Latin name of species collected	dbText	120
GenSpecCollector	Name of person collecting specimen	dbText	50
GenSpecCollectNum	Reference of specimen assigned by collector	dbText	50
GenSpecAccNumber	NPS Accession Number of specimen	dbText	15
GenSpecCatNumber	NPS Catalog Number of specimen	dbText	15
GenSpecDate	Date collection made	dbDate	8
GenSpecUTMN	Northing of collection location	dbLong	4
GenSpecUTME	Easting of collection location	dbLong	4
GenSpecCounty	County of collection location	dbText	50
GenSpecElev	Elevation (ft) of collection location	dbLong	4
GenSpecLocality	Description of locality where specimen was collected	dbText	250
GenSpecHabitat	Description of habitat where specimen was collected	dbText	250
GenSpecAssocSpec	Associated species where specimen was collected	dbText	250
GenSpecComments	Comments about specimen	dbText	250

Table Name: tblPhotos
Description: Details on individual photos taken of plot or observation point

Field Name	Field Description	Field Type	Field Width
PhotoID	Unique record identifer	dbLong	4
PlotID	Foreign key, links to tblPlotDetails	dbLong	4
PhotoType	Type of photo being referenced; value selected from tlkpPhotoTypes.	dbText	16
PhotoRoll	Reference number for film roll of photo.	dbText	12
PhotoFrame	Frame number of photo within roll.	dbText	50
PhotoOther	Other unique identifier or reference number for digital photo or name of movie file.	dbText	25
Photographer	Name of photographer (first initial, last name).	dbText	50
PhotoComments	Brief description of photo (e.g., "plot, S to N across plot", "Landscape, community", "Biocrust, with 6" scale".	dbText	255
NCPNImageFileID	Cross-reference for NCPN photo database 'ImageFileID' with	dbText	50

Field Name	Field Description	Field Type	Field Width
	'PhotoOther'		

Table Name: tblPlotDetails
Description: Information on a plot that is specific to a visit

Field Name	Field Description	Field Type	Field Width
PlotID	Unique identifier for record	dbLong	4
PlotCode	Foreign key, links to tblPlotLocation	dbText	10
SurveyDate	Date plot was visited and data collected	dbDate	8
Surveyors	Names of persons collecting data at plot (first initial, last name)	dbText	75
PlotLength	Length of plot, in meters	dbText	5
PlotAzimuth	Azimuth of plot; synonymous with aspect. One or the other, or both, can be used	dbText	5
PlotWidth	Width of plot, in meters	dbText	5
PlotDiam	Diameter of plot, in meters, if plot is circular	dbText	5
PlotHasPhotos	Yes if photos are taken of plot	dbBoolean	1
PlotRepresentation	Description or discussion of representativeness of plot in stand, and in comparison to associations outside the park (if known)	dbMemo	0
PlotShape	Shape of plot	dbText	15

Table Name: tblPlotLocation
Description: Basic and unchanging information on plot or observation point location

Field Name	Field Description	Field Type	Field Width
PlotCode	Identifier assigned to plot by survey crew	dbText	10
BPUCode	Biophysical unit code where plot is located.	dbText	10
State	State where plot is located	dbText	2
ParkCode	Park unit where plot is located	dbText	4
SiteName	Short, descriptive name of site where plot is located	dbText	100
USGSQuad	USGS quadrangle (1:24K) where plot is located	dbText	50
AerialPhotoNo	Aerial photo number corresponding to plot location	dbText	10
Waypoint	GPS location ID assigned to plot	dbText	7
UTMEasting	UTM easting of plot	dbDouble	8
UTMNorthing	UTM northing of plot	dbDouble	8
Datum	Datum of UTM coordinates	dbText	10
UTMZone	UTM zone of coordinates	dbText	4
UTM Error	Estimated Position Error (EPE) indicated on GPS unit	dbText	5
DiffCorrected	Indicate if coordinates have been differentially corrected	dbText	3
DirectionsToPlot	Precise directions to plot	dbMemo	0
County	County where plot is located.	dbText	50
GPSUnit	Manufacturer and model of GPS unit (e.g., Trimble GeoExplorer 3)	dbText	25
GPSComments	Any brief comments on GPS data collection at plot.	dbText	255
InPark	Select Yes if plot is within park boundaries.	dbBoolean	1
IsObservationPt	Yes if observation point.	dbBoolean	1

Table Name: tblVegetation
Description: Overall vegetation characteristics of a plot or observation point

Field Name	Field Description	Field Type	Field Width
VegetationID	Unique record ID	dbLong	4
PlotID	Foreign key, links to tblPlotDetails	dbLong	4
ProvCommunityName	Community name (provisional) assigned by field crews from list of potential alliances and associations	dbText	120
FinalNVCName	Final community name assigned by NatureServe.	dbText	240
Alliance	Alliance corresponding to provisional community name	dbText	100
Associations	Association corresponding to provisional community name	dbText	150
Phenology	Leaf phenology of the dominant stratum. Field is blank for non-vascular plots	dbText	35
LeafType	Leaf form of the dominant stratum.	dbText	35
LeafTypeComments	Comments on leaf type selected or observed	dbText	255
Physiognom	Physiognomic class of plot	dbText	20
EmergHt	Height class of emergent stratum (classes are in tlkpHeightClass)	dbText	2
EmergCovTot	Cover class of emergent stratum (classes are in tlkpCover)	dbText	2
CanHt	Height class of canopy	dbText	2
CanCovTot	Cover class of canopy	dbText	50
SubHt	Height class of sub-canopy	dbText	2
SubCovTot	Cover class of sub-canopy	dbText	2
TallShHt	Height class of tall shrub	dbText	2
TallShCovTot	Cover class of tall shrub	dbText	2
ShrubHt	Height class of short shrub	dbText	2
ShrubCovTot	Cover class of short shrub	dbText	2
DwarfHt	Height class of dwarf shrub	dbText	2
DwarfCovTot	Cover class of dwarf shrub	dbText	2
HerbHt	Height class of herbaceous	dbText	2
HerbCovTot	Cover class of herbaceous	dbText	2
GramHt	Height class of graminoids	dbText	2
GramCovTot	Cover class of graminoids	dbText	2
ForbHt	Height class of forbs	dbText	2
ForbCovTot	Cover class of forbs	dbText	2
FernHt	Height class of ferns	dbText	2
FernCovTot	Cover class of ferns	dbText	2
SeedlHt	Height class of tree seedlings	dbText	2
SeedlCovTot	Cover class of tree seedlings	dbText	2
NonvasHt	Height class of non-vascular	dbText	2
NonvasCovTot	Cover class of non-vascular	dbText	2
VineHt	Height class of vines	dbText	2
VineTotCov	Cover class of vines	dbText	2
EpiHt	Height class of epiphytes	dbText	2
EpiTotCov	Cover class of epiphytes	dbText	2

Table Name: tblVegetationDetails
Description: Species and strata-specific data related to a plot or observation point

Field Name	Field Description	Field Type	Field Width
VegDetailID	Unique record ID	dbLong	4
VegetationID	Foreign key, links to tblVegetation	dbLong	4
Stratum	Strata class from tlkpStrata	dbText	2

Field Name	Field Description	Field Type	Field Width
TSN	Taxonomic Serial Number - unique taxon identifier assigned by ITIS	dbDouble	8
Species	Latin names of species, from tblNCPNPlants	dbText	100
CoverClass	Cover class to describe species and strata (from tlkpCover)	dbText	2
SpecimenCollected	Check yes if a specimen of the species was collected.	dbBoolean	1
CollectedBy	Name of person collecting specimen	dbText	50
SpecimenNumber	Enter the collector's reference number for the specimen collected.	dbText	50
NPSAccessionNumber	Accession number for collection provided by park curator	dbText	50
NPSCatalogNumber	Unique catalog number for collection provided by park curator	dbText	50
Diagnostic	Check yes if the species is known to be diagnostic of the vegetation type.	dbBoolean	1
SpecimenLocality	Brief description of collection location, suitable for specimen label	dbText	250
SpecimenHabitat	Brief description of collection habitat, suitable for specimen label	dbText	240
SpecimenAssocSpecies	Brief description of associated species in collection area, suitable for specimen label	dbText	240
SpecimenComments	Comments on specimen collected	dbText	240

Accuracy assessment-related tables

Table Name: tblAADetails
Description: Information on an AA point that is specific to a visit.

Field Name	Field Description	Field Type	Field Width
AAID	Unique identifier for record	dbLong	4
AACode	Identifier of AA record; assigned by field crew	dbText	13
SurveyDate	Date AA point was visited and data was collected	dbDate	8
Surveyors	Name(s) of persons who collected data at an AA point (Last name and first initial)	dbText	75
CameraUsed	Make and model of camera used to photograph plot	dbText	50

Table Name: tblAAEnvironment
Description: Table containing values on environmental features and conditions of an AA point.

Field Name	Field Description	Field Type	Field Width
EnvironmentID	Unique record identifier	dbLong	4
AAID	Foreign key; links to tblAADetails	dbLong	4
Slope	Slope of AA point measured in degrees	dbText	50
Aspect	Aspect of AA point	dbText	50
TopoPosition	Topographic position of AA point; value selected from tlkpTopography	dbText	50
Elevation	Elevation of AA point in meters as estimated from either map or GPS unit	dbLong	4
ElevSource	How elevation was derived in the field (GPS or Quad Map)	dbText	50

Field Name	Field Description	Field Type	Field Width
EnvironmentalComments	Comments on environmental setting and its effect on the vegetation; also comments on any disturbance or reproduction factors	dbMemo	0
Geology	Geologic substrate influencing the plant community; value selected from tlkpGeology	dbText	75
BareSoil	Estimate to the nearest percentage of bare soil ground cover	dbText	3
Bedrock	Estimate to the nearest percentage of bedrock ground cover	dbText	3
Sand	Estimate to the nearest percentage of sand (particle size 0.1-2mm) ground cover	dbText	3
Moss	Estimate to the nearest percentage of moss ground cover	dbText	3
Other	Estimate to the nearest percentage of other type of ground cover	dbText	3
OtherPctDesc	Description of other type of ground cover if "Other" percentage field contains a value	dbText	255
Litter	Estimate to the nearest percentage of litter ground cover	dbText	3
Rocks	Estimate to the nearest percentage of rocks >10cm wide ground cover	dbText	3
Lichen	Estimate to the nearest percentage of lichen ground cover	dbText	3
Gravel	Estimate to the nearest percentage of gravel <10cm wide ground cover	dbText	3
LiveVegLitter	Estimate to the nearest percentage of live veg litter ground cover	dbText	3
LiveVegWood	Estimate to the nearest percentage of live veg wood ground cover	dbText	3
Wood	Estimate to the nearest percentage of wood >1cm ground cover	dbText	3
LichenRocks	Estimate to the nearest percentage of lichen covering rocks	dbText	3
LichenGround	Estimate to the nearest percentage of lichen covering ground	dbText	3
DarkCyanobacteria	Estimate to the nearest percentage of dark cyanobacteria ground cover	dbText	3
Water	Estimate to the nearest percentage of water ground cover	dbText	3

Table Name: tblAAEnvironmentDetails
Description: Table containing values on environmental features and conditions of an AA point.

Field Name	Field Description	Field Type	Field Width
EnvDetailID	Unique record identifier	dbLong	4
EnvironmentID	Foreign key; provides link to tblEnvironment	dbLong	4
Landform	One or more landform values corresponding to AA point location; any value may be entered by crew	dbText	50

Table Name: tblAALocation
Description: Basic and unchanging information on AA point location.

Field Name	Field Description	Field Type	Field Width
AACode	Identifier assigned to AA point by survey crew	dbText	13
SiteName	Short, descriptive name of site where point is located	dbText	100
USGSQuad	USGS quadrangle (1:24K) where point is located	dbText	50
State	State where point is located	dbText	2
County	County where plot is located.	dbText	50
ParkCode	Park unit where point is located	dbText	4
GPSFileName	Name of corresponding GPS file	dbText	50
GPSUnit	Manufacturer and model of GPS unit (e.g., Trimble GeoExplorer 3)	dbText	25
UTMEasting	UTM easting of point	dbText	9
UTMNorthing	UTM northing of point	dbText	10
UTMZone	UTM zone of coordinates	dbText	4
DiffCorrected	Indicate if coordinates have been differentially corrected	dbText	3
Datum	Datum of UTM coordinates	dbText	10
PDOP	Satellite Precision Dilution of Position (based on reading from Trimble GPS unit)	dbText	50
UTM Error	Error, in meters, of location data (based on reading from Garmin GPS unit)	dbText	5
InPark	Select Yes if plot is within park boundaries	dbBoolean	1
GPSComments	Any brief comments on GPS data collection	dbText	255
RepresentPWP	Representativeness of point within polygon: Good, Fair, or Poor (on association page)	dbText	8
RepresentATD	Representativeness of association to ***description:*** Good, Fair, or Poor (on association page)	dbText	4
ClassificationComments	Classification comments (on association page)	dbMemo	0
PlotShape	Plot shape: Circular, Other	dbText	10

Table Name: tblAAPhotos
Description: Details on individual photos taken of an AA point.

Field Name	Field Description	Field Type	Field Width
PhotoID	Unique record identifier	dbLong	4
AAID	Foreign key; provides link to tblAADetails	dbLong	4
PhotoType	Type of photo being referenced	dbText	16
PhotoRoll	Reference number for film roll of photo	dbText	12
PhotoFrame	Frame number of photo within roll	dbText	50
PhotoOther	Other unique identifier or reference number for digital photo or name of movie file	dbText	20
Photographer	Name of photographer	dbText	50
PhotoComments	Brief description of photo	dbText	255
NCPNImageFileID	NCPN Photo Database Image File ID	dbText	50

Table Name: tblAAVegAssociation
Description: Vegetation association at AA location.

Field Name	Field Description	Field Type	Field Width
VegAssocID	Unique record identifier	dbLong	4
AAID	Foreign key; provides link to tblAADetails	dbLong	4
VegAssocCode	Identification code of vegetation association; provided by NatureServe	dbText	50

Field Name	Field Description	Field Type	Field Width
FieldKey	Was name obtained from field key?	dbBoolean	1
NewName	Is it a new classification name?	dbBoolean	1
Post_Field_Name	Post-field name?	dbBoolean	1
VegAssocRank	Rank of vegetation association (primary, secondary, tertiary)	dbText	15
OtherAssocCode	Other associations within 50 meters	dbText	255

Table Name: tblAAVegetation
Description: Overall vegetation characteristics of an AA point.

Field Name	Field Description	Field Type	Field Width
VegetationID	Unique record identifier	dbLong	4
AAID	Foreign key; provides link to tblAADetails	dbLong	4
ProvCommunityName	Community name (provisional) assigned by field crews by following naming protocols as described in field manual and training 04/04	dbText	120
Alliance	Alliance corresponding to provisional community name	dbText	100
Associations	Association corresponding to provisional community name	dbText	100
Phenology	Leaf phenology of the dominant stratum	dbText	35
LeafType	Leaf form of the dominant stratum	dbText	35
LeafTypeComments	If Leaf Type is "mixed," this field describes the multiple leaf types found in the dominant stratum	dbText	255
Physiognom	Physiognomic class of plot (from tlkpPhysiogClass)	dbText	20
EmergHt	Height class of emergent stratum (from tlkpHeightClass)	dbText	2
EmergCovTot	Cover class of emergent stratum (from tlkpCoverAA)	dbText	15
EmergCovPercent	[not used]	dbText	50
CanHt	Height class of canopy stratum	dbText	2
CanCovTot	Cover class of canopy stratum	dbText	15
CanCovPercent	[not used]	dbText	50
SubHt	Height class of subcanopy stratum	dbText	2
SubCovTot	Cover class of subcanopy stratum	dbText	15
SubCovPercent	[not used]	dbText	50
TallShHt	Height class of tall shrub stratum	dbText	2
TallShCovTot	Cover class of tall shrub stratum	dbText	15
TallShCovPercent	[not used]	dbText	50
ShrubHt	Height class of shrub stratum	dbText	2
ShrubCovTot	Cover class of shrub stratum	dbText	15
ShrubCovPercent	[not used]	dbText	50
DwarfHt	Height class of dwarf shrub stratum	dbText	2
DwarfCovTot	Cover class of dwarf shrub stratum	dbText	15
DwarfCovPercent	[not used]	dbText	50
HTotalHt	Height class of total herbaceous stratum	dbText	2
HTotalCover	Cover class of total herbaceous stratum	dbText	15
HTotalCoverPercent	[not used]	dbText	50
H4Ht	Height class of tree seedling stratum	dbText	2
H4Cover	Cover class of tree seedling stratum	dbText	15
H4CoverPercent	[not used]	dbText	50
NonvasHt	Height class of nonvascular stratum	dbText	2
NonvasCovTot	Cover class of nonvascular stratum	dbText	15

Field Name	Field Description	Field Type	Field Width
NonvasCovPercent	[not used]	dbText	50
VineHt	Height class of vine stratum	dbText	2
VineTotCov	Cover class of vine stratum	dbText	15
VineTotPercent	[not used]	dbText	50
EpiHt	Height class of epiphyte stratum	dbText	2
EpiTotCov	Cover class of epiphyte stratum	dbText	15
EpiTotPercent	[not used]	dbText	50
PlantSpeciesComments	Comments on plant species list	dbMemo	0
MultipleAssoc	Does list represent more than one association?	dbBoolean	1

Table Name: tblAAVegetationDetails
Description: Species and strata-specific data related to an AA point.

Field Name	Field Description	Field Type	Field Width
VegDetailID	Unique record ID	dbLong	4
VegetationID	Foreign key; links to tblAAVegetation	dbLong	4
Stratum	Strata class from tlkpStrataAA	dbText	2
TSN	Taxonomic Serial Number - unique taxon identifier assigned by ITIS	dbDouble	8
Species	Latin names of species, from tblNCPNPlants	dbText	100
CoverClass	Cover class to describe species and strata (from tlkpCoverAA)	dbText	5
CoverPct	[not used]	dbText	5
Diagnostic	Check if species is known to be diagnostic of the vegetation type.	dbBoolean	1
Dead	Check if the species is dead	dbBoolean	1

Table Name: tblFinalAssociationNamesAA
Description: Table containing final Association Names (AA points) assigned by NatureServe.

Field Name	Field Description	Field Type	Field Width
AACode	Identifier of AA record; assigned by field crew	dbText	255
ELC_Code	Unique ID assigned by NatureServe	dbText	255
VegAssocName	Association Name assigned by NatureServe	dbText	255
VegAssocRank	Rank of vegetation association (primary, secondary, tertiary)	dbText	255

Lookup tables

Table Name: tblNCPNPlants
Description: Master look-up table for plant species names and taxonomic information. Derived from ITIS (Integrated Taxonomic Information System)

Field Name	Field Description	Field Type	Field Width
TSN	Taxonomic Serial Number - unique taxon identifier assigned by ITIS	dbDouble	8
FamilyName	Family name of taxon	dbText	255
LatinName	Latin name of taxon	dbText	255
Authority	Authority of Latin name	dbText	255
Synonym	Accepted synonyms of taxon	dbText	255
CommonName	Locally accepted common name for taxon	dbText	255
Exotic	Check yes if species is exotic	dbBoolean	1
Sensitive	check yes if species is threatened, endangered, or sensitive	dbBoolean	1

Field Name	Field Description	Field Type	Field Width
GrowthHabit	Select GrowthHabit for species -- habit can vary based on region; edit as needed to reflect habit in park	dbText	255
PLANTSCode	Code for taxonomic unit assigned by USDA PLANTS	dbText	255
FullName	temporary field; concatenation of Latin name and authority	dbText	255

Table Name: tlkpAAVegAssociation
Description: Lookup of vegetation association codes (CEGL codes from NatureServe) and vegetation association name.

Field Name	Field Description	Field Type	Field Width
VegAssocCode	Vegetation association code (CEGL code); assigned by NatureServe	dbText	255
VegAssocName	Final vegetation association name; assigned by NatureServe	dbText	255

Table Name: tlkpAAVegAssocRanks
Description: Rank of vegetation association (primary, secondary, tertiary).

Field Name	Field Description	Field Type	Field Width
VegAssocRank	Indicates whether the vegetation association represents a primary, secondary, or tertiary collection by field crews	dbText	255

Table Name: tlkpAlliances
Description: Look-up of provisional community names

Field Name	Field Description	Field Type	Field Width
Alliance	Alliance name from NatureServe classification	dbText	100

Table Name: tlkpAssociations
Description: Look-up of association names

Field Name	Field Description	Field Type	Field Width
Associations	Association names from NatureServe classification	dbText	100

Table Name: tlkpCamera
Description: Lookup of Camera make/models used for plot photos.

Field Name	Field Description	Field Type	Field Width
CameraType	Model and make of camera used for photographs of plot	dbText	50
CameraComments	Additional comments on camera, including default focal length	dbText	50

Table Name: tlkpCover
Description: Look-up of cover classes assigned to species and strata in VegetationDetails.

Field Name	Field Description	Field Type	Field Width
CoverClass	Numeric code for cover class; for Plots: 01, 02, 03, 04, 05, 06, 07, 08, 09, T, P; for Observation points: 01, 02, 03, 04.	dbText	50
CoverClassPercent	Percent value of each class; for Plots: T =0-1%, P >1-5%, 01=5-15%, 02=15-25%, 03=25-35%, 04=35-45%, 05=45-55%, 06=55-65%, 07=65-75%, 08=75-85%, 09=85-95%, 10=>95%; for Observation points: 01 = T-10%, 02 = 10-25%, 03 = 25-60%, 04 = 60%.	dbText	50

Table Name: tlkpCoverAA

Description: Look-up of cover classes assigned to species and strata in AAVegetationDetails.

Field Name	Field Description	Field Type	Field Width
CoverClass	T =0-1%, P >1-5%, 1a >5-10%, 1b=10-15%, 02=15-25%, 03=25-35%, 04=35-45%, 05a=45-50%, 05b=50-55%, 06=55-65%, 07=65-75%, 08=75-85%, 09=85-95%, 10=>95%.	dbText	50

Table Name: tlkpCowardin
Description: Look-up table of Cowardin system categories for Environment descriptions.

Field Name	Field Description	Field Type	Field Width
CowardinSystem	Cowardin system descriptors for environmental description of plot.	dbText	50

Table Name: tlkpGeology
Description: Look-up of geology types to describe substrate of plot.

Field Name	Field Description	Field Type	Field Width
Geology	Geology types used to describe substrate of plot or observation point	dbText	75

Table Name: tlkpHeightClass
Description: Look-up of height classes assigned to strata in VegetationDetails.

Field Name	Field Description	Field Type	Field Width
HeightClass	01<.5m 02=.5-1m 03=1-2m 04=2-5m 05=5-10m 06=10-15m 07=15-20m 08=20-35m 09=35-50m 10=>50m	dbText	2
HeightClassRange	Range of each height class	dbText	20

Table Name: tlkpHydrology
Description: Look-up of hydrology types from Cowardin et al. 1979

Field Name	Field Description	Field Type	Field Width
Hydrology	Hydrology descriptors for plots that are in a wetland or upland with intermittent flooding (dry wash).	dbText	50

Table Name: tlkpLandform
Description: Lookup of landforms in Veg Mapping Manual (from http://soils.usda.gov/technical/handbook/contents/part629glossary1.html)

Field Name	Field Description	Field Type	Field Width
Landform	Landforms from appendix 1 of field manual	dbText	50

Table Name: tlkpLeafPhen
Description: Look-up of phenology types to describe dominant stratum (from VegMapping Manual 04/04.)

Field Name	Field Description	Field Type	Field Width
Phenology	Leaf phenology descriptors to describe dominant stratum	dbText	40

Table Name: tlkpLeafType
Description: Look-up of leaf form of dominant stratum (from VegMapping Manual 04/04)

Field Name	Field Description	Field Type	Field Width
LeafType	Leaf form description of the dominant stratum	dbText	35

Table Name: tlkpParks

Description: Look-up table of parks in the Northern Colorado Plateau Network

Field Name	Field Description	Field Type	Field Width
ParkCode	Four-letter abbreviation for park code	dbText	4
ParkName	Full name of park where data were collected	dbText	50

Table Name: tlkpPhotoComments
Description: Lookup table of photo comments

Field Name	Field Description	Field Type	Field Width
PhotoComments	Photograph comments.	dbText	50

Table Name: tlkpPhotographer
Description: Lookup table of photographer names

Field Name	Field Description	Field Type	Field Width
Photographer	Photographer name.	dbText	50

Table Name: tlkpPhotoTypes
Description: Look-up of types of photos taken during data collection.

Field Name	Field Description	Field Type	Field Width
PhotoType	Type of photo taken, associated with plot	dbText	50

Table Name: tlkpPhysiogClass
Description: Look-up of physiognomic types to describe each plot or observation point.

Field Name	Field Description	Field Type	Field Width
Physiognom	Physiognomic class used to describe plot	dbText	50

Table Name: tlkpPJAge
Description: Look-up of Pinyon-Juniper age classes.

Field Name	Field Description	Field Type	Field Width
PJAgeClass	Unique identifier for record	dbText	15
PJAgeDescription	Description of PJ age class	dbText	240

Table Name: tlkpPlotShapes
Description: Look-up of shapes of plots.

Field Name	Field Description	Field Type	Field Width
PlotShape	shapes of plots	dbText	15

Table Name: tlkpSoilDrainage
Description: Look-up of soil drainage classes to describe plot or observation point.

Field Name	Field Description	Field Type	Field Width
SoilDrainage	Soil drainage classes used to describe soil where plot is located	dbText	30

Table Name: tlkpSoilTexture
Description: Look-up of soil textures based on Bowker 2003 field key for CANY, ARCH, and NABR.

Field Name	Field Description	Field Type	Field Width
SoilTexture	Look-up of soil textures based on Bowker 2003 field key for CANY, ARCH, and NABR.	dbText	15

Table Name: tlkpStates
Description: Look-up of all states in the USA

Field Name	Field Description	Field Type	Field Width

Field Name	Field Description	Field Type	Field Width
StateCode	Two-letter abbreviation for each state	dbText	2
StateName	Full name of each state in the USA	dbText	50

Table Name: tlkpStrata
Description: Look-up of strata classes in VegetationDetails (from VegMapping Manual 04/04).

Field Name	Field Description	Field Type	Field Width
Stratum	Stratum code: T1, T2, T3, S1, S2, S3, H1, H2, H3, H4, N, V, E	dbText	3
StratumDefinition	Stratum code definition: T1=Emergent T2=Canopy T3=Subcanopy S1=Tall Shrub S2=Short Shrub S3=Dwarf Shrub H1=Graminoid H2=Forb H3=Fern H4=Tree Seedl N=Nonvasc V=Vine E=Epiphyte	dbText	20

Table Name: tlkpStructureStages
Description: Look-up of vegetation structure stages.

Field Name	Field Description	Field Type	Field Width
StructureStage	Standard fuel model classes for forest and woodland trees indicating their position in the canopy	dbText	12

Table Name: tlkpSurveyors
Description: Look-up of teams for ARCH field data collection.

Field Name	Field Description	Field Type	Field Width
SurveyorName	Last names of crew members on each ARCH data collection team.	dbText	75

Table Name: tlkpTopography
Description: Look-up of topographic positions to describe where plot or observation point is located on its related landform.

Field Name	Field Description	Field Type	Field Width
TopoPosition	Topographic positions used to describe where plot or observation point is located on its related landform.	dbText	50

Table Name: tlkpUSGS_Quad
Description: Look-up of all 7.5 minute USGS quads for ARCH.

Field Name	Field Description	Field Type	Field Width
USGSQuad	Names of all 7.5 minute USGS quads for ARCH	dbText	50
USGSQuadCode	n/a for ARCH	dbText	7

Table Name: tlkpUTMZone
Description: Look-up for UTM zones of ARCH

Field Name	Field Description	Field Type	Field Width
UTMZone	UTM zone where ARCH plots were collected	dbText	5

C.2. Geodatabase Documentation

Background

The geodatabase was designed to consolidate all spatial and non-spatial (i.e., tabular) data from the ARCH vegetation mapping project. In the geodatabase, feature classes were created for the spatial datasets, including plots, observation points, AA points, and polygons. These feature classes were then linked to the tables in the Plots database via relationship classes.

Entity Relationship Diagram

The primary tables and relationships for the geodatabase are illustrated below.

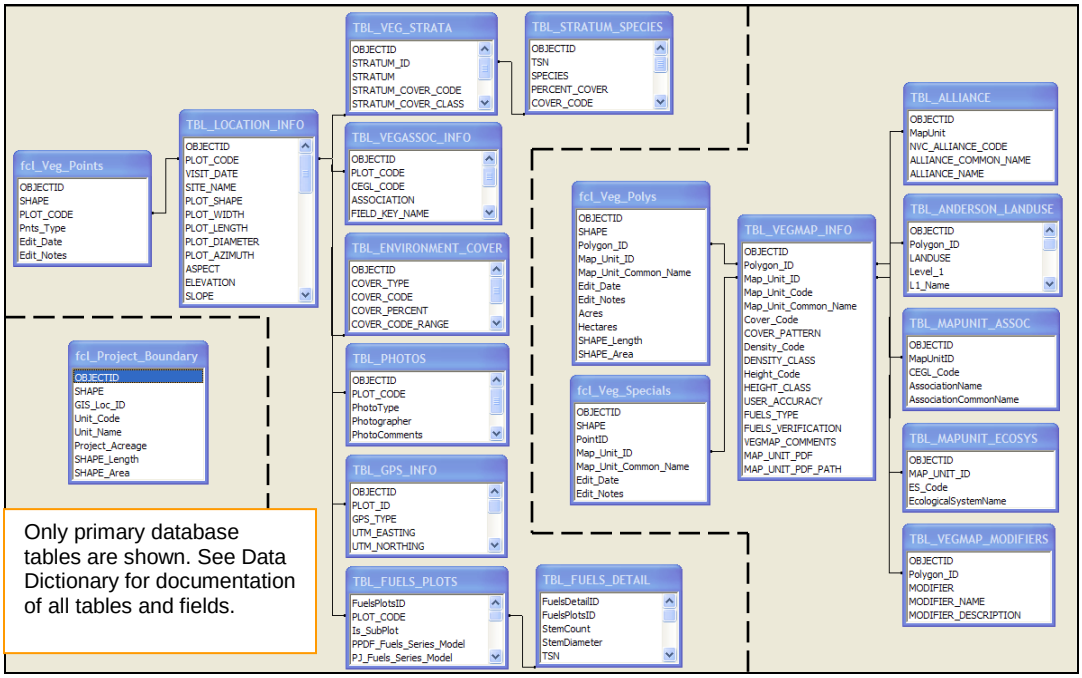


Figure 2. Entity Relationship Diagram for ARCH Geodatabase

Data Dictionary

The geodatabase consists of two types of tables: spatial (i.e., feature classes), and non-spatial tables. Tables appear in alphabetical order within these two categories.

Spatial tables

Table Name: fcl_Project_Boundary
Description: The feature class of the boundary of the vegetation mapping project area.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
SHAPE	ESRI generated	dbLongBinary	0
GIS_Loc_ID	unique ID	dbText	128
Unit_Code	Four-letter park code (ARCH)	dbText	10

Field Name	Field Description	Field Type	Field Width
Unit_Name	Full name of national park (Arches National Park)	dbText	255
Project_Acreage	Acreage of project area	dbLong	4
SHAPE_Length	ESRI generated	dbDouble	8
SHAPE_Area	ESRI generated	dbDouble	8

Table Name: fcl_Veg_Points
Description: The feature class containing all point data associated with the vegetation project (Plots, Observations, Fuels, AA).

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
SHAPE	ESRI generated	dbLongBinary	0
PLOT_CODE	Unique Plot code, used for relating tables and feature class (TBL_LOCATION_INFO)	dbText	20
Pnts_Type	Type of point (fuels, plot, observation, aa, misc)	dbLong	4
Edit_Date	Date of any edits to the point or data	dbText	10
Edit_Notes	Notes regarding any edits	dbText	255

Table Name: fcl_Veg_Polys
Description: The feature class displaying the vegetation mapping units for the park.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
SHAPE	ESRI generated	dbLongBinary	0
Polygon_ID	Unique polygon code, used for relating tables (TBL_VEGMAP_INFO)	dbText	128
Map_Unit_ID	The map unit identifier, used by the mappers (aka: grid_code or map class code)	dbText	10
Map_Unit_Common_Name	The name of the map unit (or map class)	dbText	250
Edit_Date	Date of any edits to the polygon or its attributes	dbDate	8
Edit_Notes	Notes regarding any edits to the polygon or its attributes	dbText	250
Acres	Acres per polygon, generated using ArcMap	dbDouble	8
Hectares	Hectares per polygon, generated using ArcMap	dbDouble	8
SHAPE_Length	ESRI generated	dbDouble	8
SHAPE_Area	ESRI generated	dbDouble	8

Table Name: fcl_Veg_Specials
Description: The feature class containing point data for vegetation types of special interest to the park too small to delineate with a polygon.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
SHAPE	ESRI generated	dbLongBinary	0
PointID	Unique Plot code, used for relating tables (TBL_VEGMAP_INFO)	dbText	15
Map_Unit_ID	The map unit identifier, used by the mappers (aka: grid_code or map class code)	dbText	15
Map_Unit_Common_Name	The name of the map unit (or map class)	dbText	250
Edit_Date	Date of any edits to the point or its attributes	dbText	20
Edit_Notes	Notes regarding any edits to the point or its attributes	dbText	150

Non-spatial tables

Table Name: TBL_ALLIANCE
Description: Contains the alliances for the vegetation polygons by map unit ID.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
MapUnit	The map unit identifier, used by the mappers (aka: grid_code or map class code, usually a number)	dbText	12
NVC_ALLIANCE_CODE	The NVC alliance code	dbText	20
ALLIANCE_COMMON_NAME	NVC alliance common name	dbText	250
ALLIANCE_NAME	NVC alliance latin name	dbText	250

Table Name: TBL_ANDERSON_LANDUSE
Description: Contains the Anderson Landuse classes for the vegetation polygons.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
Polygon_ID	Unique polygon code, used for relating tables (TBL_VEGMAP_INFO)	dbText	20
LANDUSE	The Anderson landuse classes of the polygon (version 1.5, January 2002)	dbDouble	8
Level_1	Anderson landuse code for level one	dbText	255
L1_Name	Anderson landuse name for level one	dbText	255
Level_2	Anderson landuse code for level two	dbText	50
L2_Name	Anderson landuse name for level two	dbText	255
Level_3	Anderson landuse code for level three	dbText	255
L3_Name	Anderson landuse name for level three	dbText	255
Level_4	Anderson landuse code for level four	dbText	255
L4_Name	Anderson landuse name for level four	dbText	255
Level_5	Anderson landuse code for level five	dbText	255
L5_Name	Anderson landuse name for level five	dbText	255
Level_6	Anderson landuse code for level six	dbText	255
L6_Name	Anderson landuse name for level six	dbText	255

Table Name: TBL_ENVIRONMENT_COVER
Description: Contains ground cover data for the veg points feature class.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
COVER_TYPE	Ground cover type	dbText	30
COVER_CODE	Cover code from field sheet - AA only	dbText	5
COVER_PERCENT	Field estimate to the nearest percentage of ground cover type (plots only).	dbDouble	8
COVER_CODE_RANGE	Cover code range - for plots with non-integer percentages.	dbText	50
COVER_PERCENT_DESC	Description of cover, if "other"	dbText	255
PLOT_CODE	Unique Plot code, used for relating tables	dbText	20

Table Name: TBL_ENVIRONMENT_LANDFORM
Description: Contains landform data for the veg points feature class.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
LANDFORM	Landform on which plot is located, any landform could be entered by crew.	dbText	100
PLOT_CODE	Unique Plot code, used for relating tables (TBL_LOCATION_INFO)	dbText	20

Table Name: TBL_FORMATION
Description: Contains NVC formation level data for the vegetation polygons.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
MAP_UNIT_ID	The map unit identifier, used by the mappers (aka: grid_code or map class code)	dbText	10
Formation_Code	NVC formation level code	dbText	30
Formation_Name	NVC formation level name	dbText	255

Table Name: TBL_FUELS_DETAIL
Description: Details on stems, height, crown width, and other attributes of trees within plot for the veg points feature class.

Field Name	Field Description	Field Type	Field Width
FuelsDetailID	Unique identifier for record	dbLong	4
FuelsPlotsID	Foreign key to TBL_FUELS_PLOTS	dbLong	4
StemCount	Number of stems measured. Value will be 1 if forest species; >=1 if woodland species.	dbInteger	2
StemDiameter	Diameter in cm of stem(s). If stem count =1 for a forest species, diameter represents dbh. If stem count is >1 for a woodland species, diameter represents the average diameter of all stems measured at crown base.	dbDouble	8
TSN	Taxonomic Serial Number - unique taxon identifier assigned by ITIS	dbDouble	8
Species	Species name	dbText	250
WoodlandCrownWidth	In PJ woodlands, the width of the tree crown at its widest point, in meters to the nearest half-meter	dbDouble	8
WoodlandCrownHeight	In PJ woodlands, distance from the ground to the top of the living tree crown, in meters to the nearest half-meter	dbDouble	8
ForestCrownBaseHeight	In Douglas-fir, ponderosa pine, or other tall tree woodlands, the distance from the ground to the base of the living tree crown, exclusive of dead or single branches, in meters to the nearest half-meter	dbDouble	8
ForestCrownHeight	Same as for woodlands, but for real trees	dbDouble	8
CrownRatio	The ratio of crown height to total tree height.	dbText	12
StructureStage	Describes the place of the tree in the canopy - emergent above the canopy, main canopy, sub canopy, sapling, seedling	dbText	12
Comments	General comments regarding the fuels at a specific plot.	dbText	255
PLOT_CODE	Unique Plot code, used for relating tables (TBL_LOCATION_INFO)	dbText	20

Table Name: TBL_FUELS_PLOTS
Description: Details on stems, height, crown width, and other attributes of trees within plot for the veg points feature class.

Field Name	Field Description	Field Type	Field Width
FuelsPlotsID	Unique identifier for record	dbLong	4
PLOT_CODE	Unique Plot code, used for relating tables (TBL_LOCATION_INFO)	dbText	20
Is_SubPlot	Indicate if measurements are for subplot (if plot has >25 trees, one quadrant (subplot) of plot can be measured for fuels	dbText	4
PPDF_Fuels_Series_Model	PPDF Fuels series ID	dbText	6
PJ_Fuels_Series_Model	Pinyon/Juniper Fuels series ID	dbText	6
SB_Fuels_Series_Model	Sagebrush Fuels series ID	dbText	6
PJ_Age_Class	If plot contains pinyon and/or juniper, enter value that best describes the age class of the stand	dbText	50
LitterOrigin	Litter measured in cm at origin of plot	dbText	3
LitterNorth	Litter measured in cm at 10 m north of plot center	dbText	3
LitterSouth	Litter measured in cm at 10 m south of plot center	dbText	3
LitterEast	Litter measured in cm at 10 m east of plot center	dbText	3
LitterWest	Litter measured in cm at 10 m west of plot center	dbText	3
DuffOrigin	Duff measured in cm at origin of plot	dbText	3
DuffNorth	Duff measured in cm at 10 m north of plot center	dbText	3
DuffSouth	Duff measured in cm at 10 m south of plot center	dbText	3
DuffEast	Duff measured in cm at 10 m east of plot center	dbText	3
DuffWest	Duff measured in cm at 10 m west of plot center	dbText	3

Table Name: TBL_GPS_INFO
Description: Contains information about the GPS unit and accuracies of data collected for the veg points feature class.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
PLOT_ID	Unique Plot code, used for relating tables (TBL_LOCATION_INFO)	dbText	20
GPS_TYPE	Manufacturer / model of GPS unit (e.g., Garmin Etrex or Trimble XM)	dbText	30
UTM_EASTING	UTM easting of plot	dbDouble	8
UTM_NORTHING	UTM northing of plot	dbDouble	8
UTM_ZONE	UTM zone of coordinates	dbText	3
DATUM	Datum of UTM coordinates (NAD83)	dbText	10
GPS_ERROR	Error, in meters, of location data (based on reading from Garmin GPS unit)	dbText	5
DIFF_CORRECTED	Indicates if coordinates have been differentially corrected (from Garmin screen)	dbText	3
GPS_COMMENTS	Any brief comments on GPS data collection at plot.	dbText	255
GPS_QUALITY	Indicates the quality of the GPS unit used (recreational, mapping grade)	dbText	35
PDOP	Positional Dilution Of Precision reading (from Garmin screen)	dbText	30
ERROR_RANGE	General error range, in meters, of the type of GPS unit used.	dbText	20

Table Name: TBL_LOCATION_INFO
Description: Contains data about the location of the point and general observations about the area for the veg points feature class.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
PLOT_CODE	Unique Plot code, used for relating tables and feature class (fcl_Veg_Points)	dbText	20
VISIT_DATE	Date the location was visited	dbText	10
SITE_NAME	General Site name given by field crew	dbText	180
PLOT_SHAPE	The shape of the area observed as a point	dbText	20
PLOT_WIDTH	The width of the point (plot and obs only)	dbText	3
PLOT_LENGTH	The length of the point (plot and obs only)	dbText	3
PLOT_DIAMETER	The diameter of the point (plot and obs only)	dbText	5
PLOT_AZIMUTH	The azimuth of the point (plot and obs only)	dbText	5
ASPECT	Aspect of plot	dbText	10
ELEVATION	Elevation of plot in meters, generated by GPS unit	dbDouble	8
SLOPE	Slope of plot measured in degrees	dbText	15
TOPO_POSITION	Topographic position of plot	dbText	50
DIRECTIONS_PLOT	Directions to the location of the plot (plot and obs only)	dbText	255
REPRESENTATIVENESS	The representativeness of the vegetation (at plots and obs only)	dbText	255
OBSERVER	The names of the field crew member(s) observing the site.	dbText	50
IN_PARK	Indicates if the point was inside or outside the park boundary (only applicable to Plots and Observation points, all AA pts inside park)	dbBoolean	1
UNIT_CODE	4 letter park code (ARCH)	dbText	10
AERIAL_PHOTO_NO	9X9 photo name on which the point most directly falls (2001 flight, plots & obs only)	dbText	30
STATE_CODE	State (UT)	dbText	2
USGS_NAME	USGS 1:24k Topo Name	dbText	75
COUNTY_NAME	County where plot is located (Grand County)	dbText	80
PHENOLOGY	Leaf phenology of the dominant stratum. Field is blank for non-vascular plots	dbText	50
PHYSIOGNOMIC_NAME	Physiognomic class of plot	dbText	80
LEAF_TYPE	Leaf form of the dominant stratum.	dbText	80
LEAF_TYPE_COMMENTS	If Leaf Type is "mixed," this field describes the multiple leaf types found in the dominant stratum.	dbText	250
PROVISIONAL_COMM_NAME	Community name (provisional) assigned by field crews by following naming protocols as described in field manual and training (plot and obs only).	dbText	220
ALLIANCE	Alliance corresponding to provisional community name (plots and obs only)	dbText	150
PLANT_SPECIES_COMMENTS	Comments about the plant species observed.	dbText	200
COWARDIN_SYSTEM	If the plot is in a wetland system, select term that best describes its hydrology (Upland, Palustrine, Riverine, Lacustrine). plot and obs only	dbText	40
HYDROLOGY	Describes hydrology of plot (plot and obs only)	dbText	40
GEOLOGY	Geologic substrate influencing the plant community (plot and obs only); Surficial	dbText	60

Field Name	Field Description	Field Type	Field Width
	geology (AA points)		
ENV_COMMENTS	Comments on environmental setting and its effect on the vegetation; also comments on any disturbance or reproduction factors	dbText	255
LANDSCAPE_COMMENTS	Description of landscape context of plot, including any important landscape features influencing the community (plot and obs only)	dbText	255
ANIMAL_USE_COMMENTS	Comments on evidence of use by non-domestic animals in plot area (plot and obs only)	dbText	255
DISTURBANCE_COMMENTS	Comments on evidence of natural or anthropogenic disturbance in plot area, severity and effects on vegetation (plot and obs only)	dbText	255
OTHER_COMMENTS	Other general comments (plot and obs only)	dbText	255
SOIL_TEXTURE	Assessment of average soil texture from sample taken a few inches below the surface (plot and obs only)	dbText	50
SOIL_DRAINAGE	Soil drainage class based on actual moisture content and extent period (plot and obs only)	dbText	30
SOIL_TAXON_DESC	Field used for either identifying soils keyed, or to describe if large rocks or outcrops are present on the surface (plot and obs only)	dbText	255

Table Name: TBL_MAPUNIT_ASSOC
Description: Contains association data for the vegetation polygons by map unit ID.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
MapUnitID	The map unit identifier, used by the mappers (aka: grid_code or map class code)	dbText	20
CEGL_Code	NVC association code	dbText	18
AssociationName	The NVC Association name (scientific)	dbText	250
AssociationCommonName	The NVC Association Common name	dbText	250

Table Name: TBL_MAPUNIT_ECOSYS
Description: Contains ecological system data for the vegetation polygons by map unit ID.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
MAP_UNIT_ID	The map unit identifier, used by the mappers (aka: grid_code or map class code)	dbText	10
ES_Code	Ecological System code	dbText	30
EcologicalSystemName	Ecological system name (mid-scale classification, larger than associations or alliances, smaller than ecoregions).	dbText	255

Table Name: TBL_PHOTOS
Description: Details on individual photos taken of a point.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
PLOT_CODE	Unique Plot code, used for relating tables (TBL_LOCATION_INFO)	dbText	50

Field Name	Field Description	Field Type	Field Width
PhotoType	Type of photo being referenced.	dbText	16
Photographer	Name of photographer.	dbText	50
PhotoComments	Brief description of photo.	dbText	255
IMAGE_ID	NCPN Photo Database (unique) file name.	dbText	50
PHOTO_PATH	Hard-coded path name to photos (update this field)	dbText	200

Table Name: TBL_STRATUM_SPECIES
Description: Contains species level data by stratum.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
TSN	Taxonomic Serial Number - unique taxon identifier assigned by ITIS	dbDouble	8
SPECIES	Latin names of species	dbText	255
PERCENT_COVER	Applicable to AA data only, percent cover by species	dbText	4
COVER_CODE	Cover class code to describe species and strata	dbText	5
COVER_CLASS	Cover class to describe species and strata	dbText	50
DIAGNOSTIC	Check yes if the species is known to be diagnostic of the vegetation type.	dbInteger	2
SPECIMEN_COLLECTED	"yes" (-1) if a specimen of the species was collected.	dbInteger	2
SPECIMEN_NO	The collector's reference number for the specimen collected.	dbText	10
DEAD	Percent cover of dead species seen at plot. Not completed of every species, but always done if diagnostic species.	dbInteger	2
STRATUM_ID	Unique ID, relates to TBL_VEG_STRATA	dbLong	4

Table Name: TBL_VEG_STRATA
Description: Contains stratum data for the veg points feature class.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
STRATUM_ID	Links to strata	dbLong	4
STRATUM	Stratum name/type	dbText	20
STRATUM_COVER_CODE	stratum cover code	dbText	5
STRATUM_COVER_CLASS	stratum percentage cover class	dbText	50
STRATUM_HEIGHT_CODE	stratum height code	dbText	5
STRATUM_HEIGHT_CLASS	stratum height class in meters	dbText	50
PLOT_CODE	Unique Plot code, used for relating tables (TBL_STRATUM_SPECIES)	dbText	15

Table Name: TBL_VEGASSOC_INFO
Description: Contains association data for all points (plots, obs, and AA points) in the veg points feature class.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
PLOT_CODE	Unique Plot code, used for relating tables	dbText	35
CEGL_CODE	CEGL (association) code	dbText	10
ASSOCIATION	Association corresponding to provisional community name	dbText	180

Field Name	Field Description	Field Type	Field Width
FIELD_KEY_NAME	Yes if association name was chosen from field key	dbText	10
CREATED_NAME	Yes if no name really fits from the field key, the surveyor will create a new name.	dbText	10
POST_AA_FIELD_NAME	Yes if association name was assigned after AA field work, based on species lists and comments fields -- during AA meetings.	dbText	10
ASSOC_RANK	Rank of vegetation association (primary, secondary, tertiary)	dbText	50
OTHER_ASSOC_50M	Other associations noted in a 50meter area beyond plot	dbText	200

Table Name: TBL_VEGMAP_INFO
Description: Contains map unit level data for each vegetation map unit polygon.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
Polygon_ID	Unique polygon code, used for relating tables and feature classes (fcl_Veg_polys)	dbText	30
Map_Unit_ID	The map unit identifier, used by the mappers (aka: grid_code or map class code)	dbText	10
Map_Unit_Code	NCPN code (e.g., s_blac)	dbText	10
Map_Unit_Common_Name	The name of the map unit (or map class)	dbText	250
Cover_Code	Cover pattern value class code	dbText	1
COVER_PATTERN	Characterizes the pattern of vegetation on the landscape (Clumped/Bunched, Linear, Gadational/Transitional, Regularly alternating, Homogenous (default)) per polygon.	dbText	100
Density_Code	Density value code	dbText	1
DENSITY_CLASS	Density of Forest/Woodland vegetation, and density for sagebrush communities per polygon.	dbText	100
Height_Code	Height class value code	dbText	1
HEIGHT_CLASS	Vegetation height classes assigned to each polygon of forest/woodland and/or shrubland types	dbText	100
USER_ACCURACY	User accuracy of the map unit (determined during AA meetings). N/A means the class was not accuracy assessed.	dbText	3
FUELS_TYPE	Fuels vegetation types (if applicable)	dbText	50
FUELS_VERIFICATION	Fuels verification (if applicable)	dbText	255
VEGMAP_COMMENTS	Any comments about the particular polygon or map class.	dbText	255
MAP_UNIT_PDF	File name of pdf describing map unit (class)	dbText	50
MAP_UNIT_PDF_PATH	Hard-coded link to Map Unit description PDF document - path name (e.g. C:/ARCH/Vegetation/MapClassDescriptions/s_blac_mu10.pdf)	dbText	250

Table Name: TBL_VEGMAP_MODIFIERS
Description: Contains modifiers for the vegetation map unit polygons.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
Polygon_ID	Unique polygon code, used for relating tables (TBL_VEGMAP_INFO)	dbText	20
MODIFIER	Modifier code (one lower case letter)	dbText	12
MODIFIER_NAME	Name/type of modifier	dbText	50
MODIFIER_DESCRIPTION	Description of modifier	dbText	255

Appendix D

Plant Species List and Crosswalk

Three hundred eighty-eight vascular plant species representing 59 families were noted during plot, observation point and accuracy assessment point data collection at Arches National Park (ARCH). The Northern Colorado Plateau Network uses three taxonomic authorities for vascular plants: Welsh et al. 2003 as the nomenclatural authority for Utah parks, Weber and Wittmann 2001 for Colorado parks, and Dorn and Lichvar 1984 for the single park in Wyoming; the ARCH vegetation mapping project database reflects scientific names as assigned by Welsh. These names are crosswalked to Kartesz 1999, which is the nomenclatural authority used by NatureServe for the National Vegetation Classification. Scientific and common names used by NatureServe are presented in this crosswalk; these names are used throughout the ARCH vegetation mapping report and in the individual association descriptions in Appendix F. The taxonomic serial number (TSN) assigned by the Integrated Taxonomic Information System (ITIS) is provided for each species.

VASCULAR PLANTS

Family	Scientific Name (Welsh et al. 2003)	Scientific Name (Kartesz 1999)	Common Name (NatureServe)	TSN
Aceraceae	*Acer negundo* L.	*Acer negundo*	boxelder	28749
Agavaceae	*Yucca angustissima* Engelm. ex Trel.	*Yucca angustissima*	narrowleaf yucca	43131
	Yucca harrimaniae Trel.	*Yucca harrimaniae*	Spanish bayonet	43144
	Yucca L.	*Yucca*	yucca	43116
Anacardiaceae	*Rhus aromatica* Ait.	*Rhus aromatica*	fragrant sumac	28779
	Rhus aromatica var. *simplicifolia* (Greene) Cronq.	*Rhus trilobata* var. *simplicifolia*	skunkbush sumac	530013
	Rhus aromatica var. *trilobata* (Nutt.) Gray ex. S. Wats.	*Rhus trilobata* var. *trilobata*	skunkbush sumac	530014
	Rhus glabra L.	*Rhus glabra*	smooth sumac	28782
	Toxicodendron rydbergii (Small ex Rydb.) Greene	*Toxicodendron rydbergii*	western poison ivy	28822
Apiaceae	*Cymopterus newberryi* (S. Wats.) M.E. Jones	*Cymopterus newberryi*	sweetroot springparsley	29649
	Cymopterus purpurascens (Gray) M.E. Jones	*Cymopterus purpurascens*	widewing springparsley	29653
	Cymopterus purpureus S. Wats.	*Cymopterus purpureus*	purple springparsley	29654
	Cymopterus Raf.	*Cymopterus*	springparsley	29625
	Lomatium latilobum (Rydb.) Mathias	*Lomatium latilobum*	Canyonlands biscuitroot	29717
	Lomatium parryi (S. Wats.) J.F. Macbr.	*Lomatium parryi*	Utah desertparsley	29735
	Lomatium Raf.	*Lomatium*	desertparsley	29677
Apocynaceae	*Amsonia tomentosa* var. *stenophylla* Kearney & Peebles	*Amsonia tomentosa* var. *stenophylla*	woolly bluestar	182210
	Apocynum cannabinum L.	*Apocynum cannabinum*	Indianhemp	30157
Asclepiadaceae	*Asclepias asperula* (Dcne.) Woods.	*Asclepias asperula*	spider milkweed	30247
	Asclepias cryptoceras S. Wats.	*Asclepias cryptoceras*	pallid milkweed	30257
	Asclepias involucrata Engelm. ex Torr.	*Asclepias involucrata*	dwarf milkweed	30275
	Asclepias L.	*Asclepias*	milkweed	30240
	Asclepias macrosperma Eastw.	*Asclepias involucrata*	dwarf milkweed	30275
Asteraceae	*Ambrosia acanthicarpa* Hook.	*Ambrosia acanthicarpa*	flatspine burr ragweed	36497
	Ambrosia L.	*Ambrosia*	ragweed	36495
	Artemisia bigelovii Gray	*Artemisia bigelovii*	Bigelow sage	35452
	Artemisia campestris L.	*Artemisia campestris*	field sagewort	183748
	Artemisia dracunculus L.	*Artemisia dracunculus*	tarragon	35462
	Artemisia filifolia Torr.	*Artemisia filifolia*	sand sagebrush	35463
	Artemisia L.	*Artemisia*	sagebrush	35431
	Artemisia ludoviciana Nutt.	*Artemisia ludoviciana*	white sagebrush	35474

Family	Scientific Name (Welsh et al. 2003)	Scientific Name (Kartesz 1999)	Common Name (NatureServe)	TSN
Asteraceae	*Artemisia ludoviciana* ssp. *mexicana* (Willd. ex Spreng.) Keck	*Artemisia ludoviciana ssp. mexicana*	white sagebrush	183738
	Artemisia ludoviciana var. *latiloba* Nutt.	*Artemisia ludoviciana ssp. candicans*	white sagebrush	183735
	Artemisia spinescens D.C. Eat.	*Picrothamnus desertorum*	bud sagebrush	519062
	Artemisia tridentata Nutt.	*Artemisia tridentata*	big sagebrush	35498
	Artemisia tridentata ssp. *tridentata* Nutt.	*Artemisia tridentata ssp. tridentata*	basin big sagebrush	35499
	Artemisia tridentata ssp. *wyomingensis* Beetle & Young	*Artemisia tridentata ssp. wyomingensis*	Wyoming big sagebrush	183741
	Aster chilensis ssp. *adscendens* (Lindl.) Cronq.	*Symphyotrichum ascendens*	western aster	193306
	Aster L.	*Aster*	aster	35510
	Baccharis salicina Torr. & Gray	*Baccharis salicina*	Great Plains false willow	35698
	Brickellia longifolia S. Wats.	*Brickellia longifolia*	longleaf brickellbush	36885
	Brickellia microphylla (Nutt.) Gray	*Brickellia microphylla*	littleleaf brickellbush	36886
	Brickellia oblongifolia Nutt.	*Brickellia oblongifolia*	Mojave brickellbush	36891
	Centaurea maculosa auct. non Lam.	*Centaurea biebersteinii*	spotted knapweed	501347
	Chaenactis douglasii (Hook.) Hook. & Arn.	*Chaenactis douglasii*	Douglas' dustymaiden	36987
	Chaenactis stevioides Hook. & Arn.	*Chaenactis stevioides*	Steve's dustymaiden	36998
	Chaetopappa ericoides (Torr.) Nesom	*Chaetopappa ericoides*	rose heath	501376
	Chrysopsis villosa (Pursh) Nutt. ex DC	*Heterotheca villosa*	hairy false goldenaster	37689
	Chrysothamnus linifolius Greene	*Chrysothamnus linifolius*	spearleaf rabbitbrush	37054
	Chrysothamnus nauseosus (Pallas ex Pursh) Britt.	*Ericameria nauseosa*	rubber rabbitbrush	507594
	Chrysothamnus nauseosus var. *glabratus* (Gray) Cronq.	*Ericameria nauseosa ssp. nauseosa* var. *glabrata*	rubber rabbitbrush	566639
	Chrysothamnus nauseosus var. *junceus* (Greene) Hall	*Ericameria nauseosa ssp. consimilis* var. *juncea*	rubber rabbitbrush	566631
	Chrysothamnus nauseosus var. *leiospermus* (Gray) Hall	*Ericameria nauseosa ssp. consimilis* var. *leiosperma*	rubber rabbitbrush	566632
	Chrysothamnus viscidiflorus (Hook.) Nutt.	*Chrysothamnus viscidiflorus*	yellow rabbitbrush	37090
	Chrysothamnus viscidiflorus var. *lanceolatus* (Nutt.) Greene	*Chrysothamnus viscidiflorus ssp. lanceolatus*	yellow rabbitbrush	37094
	Chrysothamnus viscidiflorus var. *stenophyllus* (Gray) Hall	*Chrysothamnus viscidiflorus ssp. viscidiflorus* var. *stenophyllus*	yellow rabbitbrush	566624
	Cirsium P. Mill.	*Cirsium*	thistle	36334
	Cirsium rydbergii Petrak	*Cirsium rydbergii*	Rydberg's thistle	36411
	Cirsium undulatum (Nutt.) Spreng.	*Cirsium undulatum*	wavyleaf thistle	36423
	Conyza canadensis (L.) Cronq.	*Conyza canadensis*	Canadian horseweed	37113

Family	Scientific Name (Welsh et al. 2003)	Scientific Name (Kartesz 1999)	Common Name (NatureServe)	TSN
Asteraceae	*Encelia frutescens* (Gray) Gray	*Encelia frutescens*	button brittlebush	37309
	Enceliopsis nudicaulis (Gray) A. Nels.	*Enceliopsis nudicaulis*	nakedstem sunray	37314
	Enceliopsis nutans (Eastw.) A. Nels.	*Encelia nutans*	nodding sunray	37315
	Erigeron bellidiastrum Nutt.	*Erigeron bellidiastrum*	western daisy fleabane	35827
	Erigeron L.	*Erigeron*	fleabane	35803
	Erigeron pulcherrimus Heller	*Erigeron pulcherrimus*	basin fleabane	35933
	Erigeron utahensis Gray	*Erigeron utahensis*	Utah fleabane	35967
	Gaillardia aristata Pursh	*Gaillardia aristata*	common gaillardia	37398
	Gaillardia pinnatifida Torr.	*Gaillardia pinnatifida*	red dome blanketflower	37409
	Grindelia aphanactis Rydb.	*Grindelia nuda* var. *aphanactis*	curlytop gumweed	528284
	Grindelia squarrosa (Pursh) Dunal	*Grindelia squarrosa*	curlycup gumweed	37472
	Grindelia Willd.	*Grindelia*	gumweed	37439
	Gutierrezia Lag.	*Gutierrezia*	snakeweed	37478
	Gutierrezia microcephala (DC.) Gray	*Gutierrezia microcephala*	threadleaf snakeweed	37482
	Gutierrezia sarothrae (Pursh) Britt. & Rusby	*Gutierrezia sarothrae*	broom snakeweed	37483
	Haplopappus acaulis (Nutt.) Gray	*Stenotus acaulis*	stemless mock goldenweed	505369
	Haplopappus armerioides (Nutt.) Gray	*Stenotus armerioides*	thrift mock goldenweed	505370
	Helianthus annuus L.	*Helianthus annuus*	common sunflower	36616
	Helianthus L.	*Helianthus*	sunflower	36611
	Helianthus petiolaris Nutt.	*Helianthus petiolaris*	prairie sunflower	36671
	Hymenopappus filifolius Hook.	*Hymenopappus filifolius*	fineleaf hymenopappus	37766
	Hymenoxys acaulis (Pursh) Parker	*Tetraneuris acaulis*	stemless four-nerve daisy	38508
	Hymenoxys acaulis var. *ivesiana* (Greene) Parker	*Tetraneuris ivesiana*	Ives' fournerved daisy	38512
	Iva axillaris Pursh	*Iva axillaris*	povertyweed	36033
	Lactuca serriola L.	*Lactuca serriola*	prickly lettuce	36608
	Lygodesmia grandiflora (Nutt.) Torr. & Gray	*Lygodesmia grandiflora*	largeflower skeletonplant	503622
	Machaeranthera Nees	*Machaeranthera*	tansyaster	37970
	Machaeranthera canescens (Pursh) Gray	*Machaeranthera canescens*	hoary tansyaster	37984
	Machaeranthera canescens var. *aristata* (Eastw.) B.L. Turner	*Machaeranthera canescens ssp. glabra* var. *aristata*	hoary tansyaster	566727
	Machaeranthera grindelioides (Nutt.) Shinners	*Machaeranthera grindelioides*	rayless tansyaster	37992
	Machaeranthera tanacetifolia (Kunth) Nees	*Machaeranthera tanacetifolia*	tanseyleaf tansyaster	38013
	Malacothrix sonchoides (Nutt.) Torr. & Gray	*Malacothrix sonchoides*	sowthistle desertdandelion	38055

Family	Scientific Name (Welsh et al. 2003)	Scientific Name (Kartesz 1999)	Common Name (NatureServe)	TSN
Asteraceae	*Oxytenia acerosa* Nutt.	*Iva acerosa*	copperweed	36026
	Petradoria pumila (Nutt.) Greene	*Petradoria pumila*	grassy rockgoldenrod	38233
	Platyschkuhria integrifolia (Gray) Rydb.	*Platyschkuhria integrifolia*	basindaisy	38253
	Platyschkuhria integrifolia var. *desertorum* (M.E. Jones) W. Ellison	*Platyschkuhria integrifolia* var. *desertorum*	desert basindaisy	529721
	Senecio L.	*Senecio*	ragwort	36084
	Senecio multilobatus Torr. & Gray ex Gray	*Packera multilobata*	lobeleaf groundsel	518150
	Senecio spartioides var. *multicapitatus* (Greenm. ex Rydb.) Welsh	*Senecio spartioides* var. *multicapitatus*	broomlike ragwort	531525
	Solidago L.	*Solidago*	goldenrod	36223
	Solidago canadensis L.	*Solidago canadensis*	Canada goldenrod	36224
	Solidago occidentalis (Nutt.) Torr. & Gray	*Euthamia occidentalis*	western goldentop	37356
	Stephanomeria exigua Nutt.	*Stephanomeria exigua*	small wirelettuce	38445
	Tetradymia canescens DC.	*Tetradymia canescens*	spineless horsebrush	38494
	Tetradymia DC.	*Tetradymia*	horsebrush	38491
	Tetradymia spinosa Hook. & Arn.	*Tetradymia spinosa*	shortspine horsebrush	38499
	Townsendia annua Beaman	*Townsendia annua*	annual Townsend daisy	38538
	Townsendia incana Nutt.	*Townsendia incana*	hoary Townsend daisy	38549
	Tragopogon dubius Scop.	*Tragopogon dubius*	yellow salsify	38564
	Vanclevea stylosa (Eastw.) Greene	*Vanclevea stylosa*	pillar false gumweed	38587
	Wyethia scabra Hook.	*Wyethia scabra*	badlands mule-ears	38687
	Xanthium strumarium L.	*Xanthium strumarium*	rough cockleburr	38692
	Xanthium strumarium var. *canadense* (P. Mill.) Torr. & Gray	*Xanthium strumarium* var. *canadense*	Canada cockleburr	530872
	Xylorhiza glabriuscula var. *linearifolia* T.J. Wats.	*Xylorhiza glabriuscula* var. *linearifolia*	smooth woodyaster	530876
	Xylorhiza Nutt.	*Xylorhiza*	woodyaster	38695
	Xylorhiza tortifolia (Torr. & Gray) Greene	*Xylorhiza tortifolia*	Mojave woodyaster	38700
	Xylorhiza venusta (M.E. Jones) Heller	*Xylorhiza venusta*	charming woodyaster	38701
Berberidaceae	*Mahonia fremontii* (Torr.) Fedde	*Mahonia fremontii*	Fremont's mahonia	195033
	Mahonia repens (Lindl.) G. Don	*Mahonia repens*	creeping barberry	195045
Boraginaceae	*Cryptantha crassisepala* var. *elachantha* I.M. Johnston	*Cryptantha crassisepala* var. *elachantha*	thicksepal cryptantha	527560
	Cryptantha flava (A. Nels.) Payson	*Cryptantha flava*	Brenda's yellow cryptantha	31770
	Cryptantha flavoculata (A. Nels.) Payson	*Cryptantha flavoculata*	roughseed cryptantha	31809

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Boraginaceae	*Cryptantha* Lehm. ex G. Don	*Cryptantha*	cryptantha	31765
	Lappula occidentalis (S. Wats.) Greene	*Lappula occidentalis*	flatspine stickseed	503329
	Lappula occidentalis var. *cupulata* (Gray) Higgins	*Lappula occidentalis* var. *cupulata*	flatspine stickseed	528677
	Tiquilia latior (I.M. Johnston) A. Richards.	*Tiquilia latior*	matted crinklemat	505519
Brassicaceae	*Alyssum alyssoides* (L.) L.	*Alyssum alyssoides*	pale madwort	23030
	Arabis divaricarpa	*Arabis* X *divaricarpa*	spreadingpod rockcress	22688
	Chorispora tenella (Pallas) DC.	*Chorispora tenella*	crossflower	23099
	Descurainia Webb & Berth.	*Descurainia*	tansymustard	22819
	Descurainia californica (Gray) O.E. Schulz	*Descurainia californica*	Sierra tansymustard	22821
	Descurainia incana (Bernh. ex Fisch. & C.A. Mey.) Dorn	*Descurainia incana*	mountain tansymustard	502003
	Descurainia pinnata (Walt.) Britt.	*Descurainia pinnata*	western tansymustard	22826
	Descurainia sophia (L.) Webb ex Prantl	*Descurainia sophia*	herb sophia	22843
	Dithyrea wislizeni Engelm.	*Dimorphocarpa wislizeni*	touristplant	502067
	Draba L.	*Draba*	draba	22844
	Draba cuneifolia Nutt. ex Torr. & Gray	*Draba cuneifolia*	wedgeleaf draba	22874
	Lepidium alyssoides var. *eastwoodiae* (Woot.) C.L. Hitchc.	*Lepidium alyssoides* var. *eastwoodiae*	mesa pepperwort	531291
	Lepidium L.	*Lepidium*	pepperweed	22953
	Lepidium lasiocarpum Nutt.	*Lepidium lasiocarpum*	shaggyfruit pepperweed	22967
	Lepidium montanum Nutt.	*Lepidium montanum*	mountain pepperweed	503381
	Lepidium montanum var. *jonesii* (Rydb.) C.L. Hitchc.	*Lepidium montanum* var. *jonesii*	Jones' pepperweed	528731
	Malcolmia africana (L.) Ait. f.	*Malcolmia africana*	African mustard	23243
	Physaria (Nutt. ex Torr. & Gray) Gray	*Physaria*	twinpod	23269
	Physaria acutifolia Rydb.	*Physaria acutifolia*	sharpleaf twinpod	23270
	Physaria newberryi Gray	*Physaria newberryi*	Newberry's twinpod	23281
	Sisymbrium altissimum L.	*Sisymbrium altissimum*	tall tumblemustard	23312
	Stanleya pinnata (Pursh) Britt.	*Stanleya pinnata*	desert princesplume	23329
	Streptanthella longirostris (S. Wats.) Rydb.	*Streptanthella longirostris*	longbeak streptanthella	23333
	Thelypodiopsis elegans (M.E. Jones) Rydb.	*Thelypodiopsis elegans*	Westwater tumblemustard	23387
	Thelypodium integrifolium (Nutt.) Endl. ex Walp.	*Thelypodium integrifolium*	entireleaved thelypody	23398
	Thelypodium integrifolium var. *gracilipes* B.L. Robins.	*Thelypodium integrifolium ssp. gracilipes*	entireleaved thelypody	524752
Cactaceae	*Echinocereus triglochidiatus* Engelm.	*Echinocereus triglochidiatus*	kingcup cactus	19815
	Opuntia erinacea Engelm. & Bigelow ex Engelm.	*Opuntia erinacea*	grizzlybear pricklypear	19705

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Cactaceae	*Opuntia erinacea* var. *utahensis* (Engelm.) L. Benson	*Opuntia erinacea* var. *utahensis*	Utah grizzlybear pricklypear	195276
	Opuntia P. Mill.	*Opuntia*	pricklypear	19686
	Opuntia phaeacantha Engelm.	*Opuntia phaeacantha*	tulip pricklypear	19724
	Opuntia polyacantha Haw.	*Opuntia polyacantha*	plains pricklypear	19726
	Sclerocactus whipplei (Engelm. & Bigelow) Britt. & Rose	*Sclerocactus whipplei*	Whipple's fishhook cactus	19765
Capparaceae	*Cleome lutea* Hook.	*Cleome lutea*	yellow spiderflower	22620
Caprifoliaceae	*Symphoricarpos longiflorus* Gray	*Symphoricarpos longiflorus*	desert snowberry	35334
Caryophyllaceae	*Arenaria fendleri* Gray	*Arenaria fendleri*	Fendler's sandwort	20245
	Silene antirrhina L.	*Silene antirrhina*	sleepy silene	20045
	Stellaria longifolia Muhl. ex Willd.	*Stellaria longifolia*	longleaf starwort	20185
Chenopodiaceae	*Allenrolfea occidentalis* (S. Wats.) Kuntze	*Allenrolfea occidentalis*	iodinebush	20677
	Atriplex canescens (Pursh) Nutt.	*Atriplex canescens*	fourwing saltbush	20518
	Atriplex confertifolia (Torr. & Frém.) S. Wats.	*Atriplex confertifolia*	shadscale saltbush	20519
	Atriplex corrugata S. Wats.	*Atriplex corrugata*	mat saltbush	20522
	Atriplex gardneri (Moq.) D. Dietr.	*Atriplex gardneri*	Gardner's saltbush	20531
	Atriplex gardneri var. *cuneata* (A. Nels.) Welsh	*Atriplex cuneata ssp. cuneata*	valley saltbush	192237
	Bassia americana Welsh et al.	*Kochia americana*	green molly	20694
	Chenopodium L.	*Chenopodium*	goosefoot	20589
	Chenopodium album L.	*Chenopodium album*	lateflowering goosefoot	20592
	Cycloloma atriplicifolium (Spreng.) Coult.	*Cycloloma atriplicifolium*	winged pigweed	20685
	Grayia spinosa (Hook.) Moq.	*Grayia spinosa*	spiny hopsage	20690
	Halogeton glomeratus (Bieb.) C.A. Mey.	*Halogeton glomeratus*	saltlover	20692
	Krascheninnikovia lanata (Pursh) A.D.J. Meeuse & Smit	*Krascheninnikovia lanata*	winterfat	503290
	Salsola tragus L.	*Salsola tragus*	prickly Russian thistle	520950
	Sarcobatus vermiculatus (Hook.) Torr.	*Sarcobatus vermiculatus*	greasewood	20707
	Suaeda torreyana S. Wats.	*Suaeda moquinii*	Mojave seablite	505404
	Zuckia brandegeei (Gray) Welsh & Stutz ex Welsh	*Zuckia brandegeei*	siltbush	505810
Cornaceae	*Cornus sericea* L.	*Cornus sericea*	redosier dogwood	523904
Cupressaceae	*Juniperus osteosperma* (Torr.) Little	*Juniperus osteosperma*	Utah juniper	194859
	Juniperus scopulorum Sarg.	*Juniperus scopulorum*	Rocky Mountain juniper	194872
Cyperaceae	*Carex* L.	*Carex*	sedge	39369
	Carex aurea Nutt.	*Carex aurea*	golden sedge	39445

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Cyperaceae	*Carex nebrascensis* Dewey	*Carex nebrascensis*	Nebraska sedge	39711
	Carex praegracilis W. Boott	*Carex praegracilis*	clustered field sedge	39767
	Cyperus L.	*Cyperus*	flatsedge	39882
	Cyperus erythrorhizos Muhl.	*Cyperus erythrorhizos*	redroot flatsedge	39887
	Eleocharis palustris (L.) Roemer & J.A. Schultes	*Eleocharis palustris*	common spikerush	40019
	Scirpus L.	*Scirpus*	bulrush	40225
	Scirpus pungens Vahl	*Schoenoplectus pungens*	common threesquare	508146
	Scirpus validus Vahl	*Schoenoplectus tabernaemontani*	softstem bulrush	507797
Elaeagnaceae	*Elaeagnus angustifolia* L.	*Elaeagnus angustifolia*	Russian olive	27770
Ephedraceae	*Ephedra torreyana* S. Wats.	*Ephedra torreyana*	Torrey's jointfir	502318
	Ephedra viridis Coville	*Ephedra viridis*	Mormon-tea	502319
	Ephedra viridis var. *viscida* (Cutler) L. Benson	*Ephedra cutleri*	Cutler's jointfir	508106
Equisetaceae	*Equisetum* L.	*Equisetum*	horsetail	17148
	Equisetum arvense L.	*Equisetum arvense*	field horsetail	17152
	Equisetum laevigatum A. Braun	*Equisetum laevigatum*	smooth horsetail	17156
Euphorbiaceae	*Chamaesyce fendleri* (Torr. & Gray) Small	*Chamaesyce fendleri*	Fendler's sandmat	501419
	Chamaesyce glyptosperma (Engelm.) Small	*Chamaesyce glyptosperma*	ribseed sandmat	501422
	Chamaesyce parryi (Engelm.) Rydb.	*Chamaesyce parryi*	Parry's sandmat	501448
	Euphorbia brachycera Engelm.	*Euphorbia brachycera*	horned spurge	28049
	Euphorbia L.	*Euphorbia*	spurge	28032
Fabaceae	*Astragalus* L.	*Astragalus*	milkvetch	25392
	Astragalus cymboides M.E. Jones	*Astragalus cymboides*	canoe milkvetch	25488
	Astragalus desperatus M.E. Jones	*Astragalus desperatus*	rimrock milkvetch	25491
	Astragalus lentiginosus Dougl. ex Hook.	*Astragalus lentiginosus*	freckled milkvetch	25559
	Astragalus mollissimus Torr.	*Astragalus mollissimus*	woolly locoweed	25589
	Astragalus praelongus Sheldon	*Astragalus praelongus*	stinking milkvetch	25639
	Dalea L.	*Dalea*	prairie clover	26597
	Dalea flavescens var. *flavescens*	*Dalea flavescens*	Canyonlands prairie clover	26614
	Dalea oligophylla (Torr.) Shinners	*Dalea candida* var. *oligophylla*	white prairie clover	192889
	Glycyrrhiza lepidota Pursh	*Glycyrrhiza lepidota*	American licorice	26719
	Hedysarum boreale Nutt.	*Hedysarum boreale*	boreal sweetvetch	26724
	Medicago sativa L.	*Medicago sativa*	alfalfa	183623
	Melilotus P. Mill.	*Melilotus*	sweetclover	26148

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Fabaceae	*Melilotus alba* Medikus	*Melilotus officinalis*	yellow sweetclover	26149
	Melilotus officinalis (L.) Lam.	*Melilotus officinalis*	yellow sweetclover	26150
	Pediomelum megalanthum (Woot. & Standl.) Rydb.	*Pediomelum megalanthum*	Intermountain Indian breadroot	504181
	Psoralea juncea Eastw.	*Psoralidium junceum*	rush lemonweed	504644
	Psoralea lanceolata Pursh	*Psoralidium lanceolatum*	lemon scurfpea	504645
	Psoralidium lanceolatum (Pursh) Rydb.	*Psoralidium lanceolatum*	lemon scurfpea	504645
Fagaceae	*Quercus gambelii* Nutt.	*Quercus gambelii*	Gambel oak	19337
	Quercus havardii X *gambellii*	*Quercus havardii X gambelii*	hybrid oak	
	Quercus turbinella Greene	*Quercus turbinella*	Sonoran scrub oak	19440
	Quercus welshii Welsh et al.	*Quercus havardii* var. *tuckeri*	Tucker oak	529960
Fumariaceae	*Corydalis aurea* Willd.	*Corydalis aurea*	scrambled eggs	18999
Geraniaceae	*Erodium cicutarium* (L.) L'Hér. ex Ait.	*Erodium cicutarium*	redstem stork's bill	29147
Hydrangeaceae	*Fendlera rupicola* Gray	*Fendlera rupicola*	cliff fendlerbush	24331
	Philadelphus microphyllus Gray	*Philadelphus microphyllus*	littleleaf mock orange	24437
Hydrophyllaceae	*Phacelia crenulata* Torr. ex S. Wats.	*Phacelia crenulata*	cleftleaf wildheliotrope	31478
	Phacelia crenulata var. *corrugata* (A. Nels.) Brand	*Phacelia crenulata* var. *corrugata*	cleftleaf wildheiotrope	529549
Juncaceae	*Juncus arcticus* Willd.	*Juncus arcticus*	arctic rush	39222
	Juncus ensifolius Wikstr.	*Juncus ensifolius*	swordleaf rush	39269
	Juncus torreyi Coville	*Juncus torreyi*	Torrey's rush	39320
Lamiaceae	*Poliomintha incana* (Torr.) Gray	*Poliomintha incana*	frosted mint	504488
Liliaceae	*Allium* L.	*Allium*	onion	42634
	Allium macropetalum Rydb.	*Allium macropetalum*	largeflower onion	42682
	Calochortus flexuosus S. Wats.	*Calochortus flexuosus*	winding mariposa lily	42848
	Calochortus nuttallii Torr. & Gray	*Calochortus nuttallii*	sego lily	42863
	Zigadenus vaginatus (Rydb.) J.F. Macbr.	*Zigadenus vaginatus*	sheathed deathcamas	505802
Linaceae	*Linum perenne* var. *lewisii* (Pursh) Eat. & J. Wright	*Linum lewisii* var. *lewisii*	prairie flax	528819
Loasaceae	*Mentzelia albicaulis* (Dougl. ex Hook.) Dougl. ex Torr. & Gray	*Mentzelia albicaulis*	whitestem blazingstar	503757
	Mentzelia L.	*Mentzelia*	blazingstar	202469
	Mentzelia multiflora (Nutt.) Gray	*Mentzelia multiflora*	Adonis blazingstar	503788
Malvaceae	*Sphaeralcea coccinea* (Nutt.) Rydb.	*Sphaeralcea coccinea*	scarlet globemallow	21920
Malvaceae	*Sphaeralcea leptophylla* (Gray) Rydb.	*Sphaeralcea leptophylla*	scaly globemallow	21947

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	Sphaeralcea parvifolia A. Nels.	*Sphaeralcea parvifolia*	smallflower globemallow	21953
	Sphaeralcea St.-Hil.	*Sphaeralcea*	globemallow	21909
Moraceae	*Morus alba* L.	*Morus alba*	white mulberry	19066
Nyctaginaceae	*Abronia fragrans* Nutt. ex Hook.	*Abronia fragrans*	snowball sand verbena	19557
	Mirabilis linearis (Pursh) Heimerl	*Mirabilis linearis*	narrowleaf four o'clock	19651
Oleaceae	*Forestiera pubescens* Nutt.	*Forestiera pubescens*	stretchberry	32957
	Fraxinus anomala Torr. ex S. Wats.	*Fraxinus anomala*	singleleaf ash	32937
Onagraceae	*Camissonia* Link	*Camissonia*	suncup	27462
	Camissonia scapoidea var. *scapoidea* Raven	*Camissonia scapoidea ssp. scapoidea*	Paiute suncup	27544
	Epilobium angustifolium L.	*Chamerion angustifolium*	fireweed	510756
	Oenothera L.	*Oenothera*	evening-primrose	27367
	Oenothera caespitosa Nutt.	*Oenothera caespitosa*	tufted evening-primrose	565328
	Oenothera longissima Rydb.	*Oenothera longissima*	longstem evening-primrose	27428
	Oenothera pallida Lindl.	*Oenothera pallida*	pale evening-primrose	27436
Orchidaceae	*Epipactis gigantea* Dougl. ex Hook.	*Epipactis gigantea*	stream orchid	43481
Orobanchaceae	*Orobanche fasciculata* Nutt.	*Orobanche fasciculata*	clustered broomrape	34290
Pinaceae	*Pinus edulis* Engelm.	*Pinus edulis*	twoneedle pinyon	183336
Plantaginaceae	*Plantago patagonica* Jacq.	*Plantago patagonica*	woolly plantain	32907
Poaceae	*Agropyron dasystachyum* (Hook.) Scribn. & J.G. Sm.	*Elymus lanceolatus*	streambank wheatgrass	502267
	Agrostis stolonifera L.	*Agrostis stolonifera*	creeping bentgrass	40400
	Aristida L.	*Aristida*	threeawn	41400
	Aristida purpurea Nutt.	*Aristida purpurea*	purple threeawn	41429
	Bouteloua curtipendula (Michx.) Torr.	*Bouteloua curtipendula*	sideoats grama	41500
	Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths	*Bouteloua gracilis*	blue grama	41493
	Bromus japonicus Thunb. ex Murr.	*Bromus japonicus*	Japanese brome	40479
	Bromus tectorum L.	*Bromus tectorum*	cheatgrass	40524
	Calamagrostis scopulorum M.E. Jones	*Calamagrostis scopulorum*	ditch reedgrass	40566
	Distichlis spicata (L.) Greene	*Distichlis spicata*	inland saltgrass	40662
	Elymus L.	*Elymus*	wildrye	40677
	Elymus canadensis L.	*Elymus canadensis*	Canada wildrye	40683
	Elymus cinereus Scribn. & Merr.	*Leymus cinereus*	basin wildrye	503433
	Elymus elymoides (Raf.) Swezey	*Elymus elymoides*	squirreltail	502264
	Elymus salinus M.E. Jones	*Leymus salinus*	saline wildrye	503441

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Poaceae	*Elymus smithii* (Rydb.) Gould	*Pascopyrum smithii*	western wheatgrass	504124
	Elymus trachycaulus (Link) Gould ex Shinners	*Elymus trachycaulus*	slender wheatgrass	502282
	Eragrostis hypnoides (Lam.) B.S.P.	*Eragrostis hypnoides*	teal lovegrass	40721
	Eremopyrum (Ledeb.) Jaubert & Spach	*Eremopyrum*	false wheatgrass	41716
	Eremopyrum triticeum (Gaertn.) Nevski	*Eremopyrum triticeum*	annual wheatgrass	41717
	Erioneuron pilosum (Buckl.) Nash	*Erioneuron pilosum*	hairy woollygrass	41731
	Erioneuron pulchellum (Kunth) Tateoka	*Dasyochloa pulchella*	low woollygrass	512087
	Festuca octoflora Walt.	*Vulpia octoflora*	sixweeks fescue	42264
	Festuca ovina L.	*Festuca ovina*	sheep fescue	40804
	Hilaria jamesii (Torr.) Benth.	*Pleuraphis jamesii*	James' galleta	507993
	Hordeum jubatum L.	*Hordeum jubatum*	foxtail barley	40871
	Muhlenbergia Schreb.	*Muhlenbergia*	muhly	41883
	Muhlenbergia asperifolia (Nees & Meyen ex Trin.) Parodi	*Muhlenbergia asperifolia*	scratchgrass	41899
	Muhlenbergia pungens Thurb.	*Muhlenbergia pungens*	sandhill muhly	41934
	Panicum acuminatum Sw.	*Dichanthelium acuminatum*	tapered rosette grass	41646
	Phragmites australis (Cav.) Trin. ex Steud.	*Phragmites australis*	common reed	41072
	Poa L.	*Poa*	bluegrass	41074
	Poa fendleriana (Steud.) Vasey	*Poa fendleriana*	muttongrass	504467
	Poa pratensis L.	*Poa pratensis*	Kentucky bluegrass	41088
	Poa secunda J. Presl	*Poa secunda*	Sandberg bluegrass	41103
	Polypogon monspeliensis (L.) Desf.	*Polypogon monspeliensis*	annual rabbitsfoot grass	41171
	Schizachyrium scoparium (Michx.) Nash	*Schizachyrium scoparium*	little bluestem	42076
	Spartina pectinata Bosc ex Link	*Spartina pectinata*	prairie cordgrass	41272
	Sphenopholis obtusata (Michx.) Scribn.	*Sphenopholis obtusata*	prairie wedgescale	41279
	Sporobolus R. Br.	*Sporobolus*	dropseed	42115
	Sporobolus airoides (Torr.) Torr.	*Sporobolus airoides*	alkali sacaton	42128
	Sporobolus contractus A.S. Hitchc.	*Sporobolus contractus*	spike dropseed	42131
	Sporobolus cryptandrus (Torr.) Gray	*Sporobolus cryptandrus*	sand dropseed	42132
	Sporobolus flexuosus (Thurb. ex Vasey) Rydb.	*Sporobolus flexuosus*	mesa dropseed	42137
	Sporobolus giganteus Nash	*Sporobolus giganteus*	giant dropseed	42138
	Stipa L.	obsolete	needlegrass	42158
	Stipa arida M.E. Jones	*Achnatherum aridum*	Mormon needlegrass	507932

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Poaceae	*Stipa comata* Trin. & Rupr.	*Hesperostipa comata*	needle and thread	507974
	Stipa hymenoides Roemer & J.A. Schultes	*Achnatherum hymenoides*	Indian ricegrass	507943
	Stipa neomexicana (Thurb. ex Coult.) Scribn.	*Hesperostipa neomexicana*	New Mexico feathergrass	507976
	Stipa speciosa Trin. & Rupr.	*Achnatherum speciosum*	desert needlegrass	507958
Polemoniaceae	*Gilia* Ruiz & Pavón	*Gilia*	gilia	31075
	Gilia inconspicua (Sm.) Sweet	*Gilia inconspicua*	shy gilia	31127
	Gilia leptomeria Gray	*Gilia leptomeria*	sand gilia	31150
	Ipomopsis aggregata (Pursh) V. Grant	*Ipomopsis aggregata*	scarlet gilia	31192
	Ipomopsis gunnisonii (Torr. & Gray) V. Grant	*Ipomopsis gunnisonii*	sanddune ipomopsis	31210
	Ipomopsis longiflora (Torr.) V. Grant	*Ipomopsis longiflora*	flaxflowered ipomopsis	31198
	Ipomopsis polycladon (Torr.) V. Grant	*Ipomopsis polycladon*	manybranched ipomopsis	31216
	Ipomopsis roseata (Rydb.) V. Grant	*Ipomopsis roseata*	rosy ipomopsis	31218
	Leptodactylon pungens (Torr.) Torr. ex Nutt.	*Leptodactylon pungens*	granite prickly phlox	31233
Polygonaceae	*Eriogonum* Michx.	*Eriogonum*	buckwheat	21054
	Eriogonum alatum Torr.	*Eriogonum alatum*	winged buckwheat	21057
	Eriogonum bicolor M.E. Jones	*Eriogonum bicolor*	pretty buckwheat	21078
	Eriogonum cernuum Nutt.	*Eriogonum cernuum*	nodding buckwheat	21090
	Eriogonum corymbosum Benth.	*Eriogonum corymbosum*	crispleaf buckwheat	21103
	Eriogonum corymbosum var. *orbiculatum* (S. Stokes) Reveal & Brotherson	*Eriogonum corymbosum* var. *orbiculatum*	crispleaf buckwheat	195447
	Eriogonum gordonii Benth.	*Eriogonum gordonii*	Gordon's buckwheat	21138
	Eriogonum inflatum Torr. & Frém.	*Eriogonum inflatum*	desert trumpet	21163
	Eriogonum leptocladon Torr. & Gray	*Eriogonum leptocladon*	sand buckwheat	21179
	Eriogonum microthecum Nutt.	*Eriogonum microthecum*	slender buckwheat	21192
	Eriogonum ovalifolium Nutt.	*Eriogonum ovalifolium*	cushion buckwheat	21212
	Eriogonum salsuginosum (Nutt.) Hook.	*Stenogonum salsuginosum*	salty buckwheat	21322
	Eriogonum wetherillii Eastw.	*Eriogonum wetherillii*	Wetherill's buckwheat	21278
	Polygonum lapathifolium L.	*Polygonum lapathifolium*	curlytop knotweed	20860
	Rumex L.	*Rumex*	dock	20933
	Rumex hymenosepalus Torr.	*Rumex hymenosepalus*	canaigre dock	20962
	Rumex venosus Pursh	*Rumex venosus*	veiny dock	20980
Primulaceae	*Primula specuicola* Rydb.	*Primula specuicola*	cavedwelling primrose	24032
Pteridaceae	*Adiantum capillus-veneris* L.	*Adiantum capillus-veneris*	common maidenhair	17308

Family	Scientific Name (Welsh et al. 2003)	Scientific Name (Kartesz 1999)	Common Name (NatureServe)	TSN
Pteridaceae	*Cryptogramma acrostichoides* R. Br.	*Cryptogramma acrostichoides*	American rockbrake	17461
Ranunculaceae	*Aquilegia micrantha* Eastw.	*Aquilegia micrantha*	Mancos columbine	18743
	Clematis ligusticifolia Nutt.	*Clematis ligusticifolia*	western white clematis	18702
	Delphinium L.	*Delphinium*	larkspur	18457
	Delphinium andersonii Gray	*Delphinium andersonii*	Anderson's larkspur	501976
	Delphinium andersonii var. *scaposum* (Greene) Welsh	*Delphinium scaposum*	tall mountain larkspur	18507
	Delphinium nuttallianum Pritz. ex Walp.	*Delphinium nuttallianum*	twolobe larkspur	18483
	Ranunculus cymbalaria Pursh	*Ranunculus cymbalaria*	alkali buttercup	18600
	Ranunculus testiculatus Crantz	*Ceratocephala testiculata*	curveseed butterwort	501365
Rhamnaceae	*Rhamnus betulifolia* Greene	*Frangula betulifolia*	beechleaf frangula	506984
Rosaceae	*Amelanchier utahensis* Koehne	*Amelanchier utahensis*	Utah serviceberry	25121
	Cercocarpus intricatus S. Wats.	*Cercocarpus intricatus*	littleleaf mountain mahogany	25133
	Cercocarpus montanus Raf.	*Cercocarpus montanus*	alderleaf mountain mahogany	25136
	Coleogyne ramosissima Torr.	*Coleogyne ramosissima*	blackbrush	25150
	Purshia mexicana (D. Don) Henrickson	*Purshia mexicana*	Mexican cliffrose	195899
	Purshia mexicana var. *stansburiana* (Torr.) Welsh	*Purshia stansburiana*	Stansbury cliffrose	195901
	Purshia tridentata (Pursh) DC.	*Purshia tridentata*	antelope bitterbrush	25290
	Rosa woodsii Lindl.	*Rosa woodsii*	Woods' rose	24847
Rubiaceae	*Galium multiflorum* Kellogg	*Galium multiflorum*	shrubby bedstraw	34892
Salicaceae	*Populus fremontii* S. Wats.	*Populus fremontii*	Fremont cottonwood	22459
	Salix amygdaloides Anderss.	*Salix amygdaloides*	peachleaf willow	22499
	Salix eriocephala (Michx.)	*Salix eriocephala*	Missouri River willow	22528
	Salix exigua Nutt.	*Salix exigua*	narrowleaf willow	22529
	Salix gooddingii Ball	*Salix gooddingii*	Goodding's willow	22539
Santalaceae	*Comandra umbellata* (L.) Nutt.	*Comandra umbellata*	bastard toadflax	501614
Scrophulariaceae	*Castilleja* Mutis ex L. f.	*Castilleja*	Indian paintbrush	33049
	Castilleja chromosa A. Nels.	*Castilleja applegatei ssp. martinii*	wavyleaf Indian paintbrush	525154
	Castilleja exilis A. Nels.	*Castilleja minor ssp. minor*	lesser Indian paintbrush	525162
	Castilleja linariifolia Benth.	*Castilleja linariifolia*	Wyoming Indian paintbrush	33138
	Castilleja scabrida Eastw.	*Castilleja scabrida*	rough Indian paintbrush	33165
	Cordylanthus Nutt. ex Benth.	*Cordylanthus*	bird's-beak	33537
	Cordylanthus wrightii Gray	*Cordylanthus wrightii*	Wright's bird's beak	33577
Scrophulariaceae	*Mimulus eastwoodiae* Rydb.	*Mimulus eastwoodiae*	Eastwood's monkeyflower	33309

Family	Scientific Name (Welsh et al. 2003)	Scientific Name (Kartesz 1999)	Common Name (NatureServe)	TSN
Scrophulariaceae	*Penstemon* Schmidel	*Penstemon*	beardtongue	33665
	Penstemon cyanocaulis Payson	*Penstemon cyanocaulis*	bluestem beardtongue	33868
	Penstemon eatonii Gray	*Penstemon eatonii*	Eaton's penstemon	33686
Tamaricaceae	*Tamarix chinensis* Lour.	*Tamarix chinensis*	tamarisk, salt-cedar	22308
Typhaceae	*Typha* L.	*Typha*	cattail	42324
	Typha domingensis Pers.	*Typha domingensis*	southern cattail	42327
	Typha latifolia L.	*Typha latifolia*	broadleaf cattail	42326
Ulmaceae	*Celtis reticulata* Torr.	*Celtis laevigata* var. *reticulata*	netleaf hackberry	527226

NON-VASCULAR PLANTS

Family	Scientific Name	Scientific Name	Common Name (NatureServe)	TSN
Bacidiaceae	*Squamarina* Poelt	*Squamarina*	rim lichen	190068
Catillariaceae	*Toninia* A. Massal.	*Toninia*	bruised lichen	190205
Collemataceae	*Collema* Wigg.	*Collema*	jelly lichen	191331
Hymeneliaceae	*Aspicilia* Massal.	*Aspicilia*	rimmed lichen	189695
Psoraceae	*Psora* Hoffm.	*Psora*	fishscale lichen	190026
Teloschistaceae	*Fulgensia* Massal. and De Not.	*Fulgensia*	sulphur lichen	191759
Verrucariaceae	*Catapyrenium* Flotow	*Catapyrenium*	earth lichen	N/A
Verrucariaceae	*Endocarpon* Hedwig	*Endocarpon*	chalice lichen	N/A

Appendix E

Field Plot Crosswalk to NVC Associations

Plots, observation points, and accuracy assessment (AA) points are assigned to National Vegetation Classification associations based on their composition and structure as they were recorded in the field. Five associations in the table below were documented only during accuracy assessment (Plot codes in the rightmost column contain the letters “AA”). Accuracy assessment points assigned to associations already described from plots or observation points are not included in this table unless the comprise the majority of plots sampled in the type. Element codes are used by NatureServe and state Natural Heritage Programs to track nomenclature and status of rare plants, rare animals, and communities (“elements”). Nomenclature used by the NVC follows Kartesz (1999).

Plant Association Scientific Name	Element Code	No. of Samples	Supporting Plot, Observation Point, and AA Point Assignments
Achnatherum hymenoides Colorado Plateau Herbaceous Vegetation	CEGL002343	5	ARCH.0377, ARCH.9646, ARCH_AA.0039, ARCH_AA.0190, ARCH_AA.0050
Allenrolfea occidentalis Shrubland	CEGL000988	3	ARCH.9044, ARCH_AA.0625, ARCH_AA.0605
Aquilegia micrantha - Mimulus eastwoodiae Herbaceous Vegetation	CEGL002729	3	ARCH.0669, ARCH.9693, ARCH.9689
Artemisia bigelovii - Ephedra (viridis, torreyana) Talus Shrubland	CEGL003755	5	ARCH.0348, ARCH.0666, ARCH.9325, ARCH.9042, ARCH.9651
Artemisia filifolia Colorado Plateau Shrubland	CEGL002697	26	ARCH.0011, ARCH.0086, ARCH.0112, ARCH.0116, ARCH.0126, ARCH.0327, ARCH.0328, ARCH.0362, ARCH.0373, ARCH.0374, ARCH.0678, ARCH.0686, ARCH.0697, ARCH.9637, ARCH.9640, ARCH.9659, ARCH.9022, ARCH.9021, ARCH.9352, ARCH.9306, ARCH.9323, ARCH.9321, ARCH.9320, ARCH.9004, ARCH.9358, ARCH.9355
Artemisia tridentata - (Ericameria nauseosa) / Bromus tectorum Semi-natural Shrubland	CEGL002699	4	ARCH_AA.0097, ARCH_AA.0131, ARCH_AA.0322, ARCH_AA.0468
Atriplex canescens / Sporobolus airoides Shrubland	CEGL001291	1	ARCH.0330
Atriplex canescens Shrubland	CEGL001281	7	ARCH.0076, ARCH.0384, ARCH.0646, ARCH.0652, ARCH.9346, ARCH.9620, ARCH.9641
Atriplex confertifolia - Picrothamnus desertorum Shrubland	CEGL001295	2	ARCH.0613, ARCH.0633
Atriplex confertifolia - Sarcobatus vermiculatus Shrubland	CEGL001313	9	ARCH.9040, ARCH.9314, ARCH.9359, ARCH.9368, ARCH.9605, ARCH_AA.0407, ARCH_AA.0553, ARCH_AA.0727, ARCH_AA.0728
Atriplex confertifolia / Pleuraphis jamesii Shrubland	CEGL001304	19	ARCH.0008, ARCH.0013, ARCH.0036, ARCH.0040, ARCH.0055, ARCH.0095, ARCH.0099, ARCH.0100, ARCH.0107, ARCH.0111, ARCH.0352, ARCH.0359, ARCH.0360, ARCH.0614, ARCH.0631, ARCH.0635, ARCH.0643, ARCH.0668, ARCH.0670
Atriplex confertifolia / Sporobolus cryptandrus Shrubland	CEGL003762	2	ARCH.0714, ARCH.0718

Plant Association Scientific Name	Element Code	No. of Samples	Supporting Plot, Observation Point, and AA Point Assignments
Atriplex corrugata Dwarf-shrubland	CEGL001437	3	ARCH.0096, ARCH.0102, ARCH.0103, ARCH_AA.0584
Atriplex gardneri / Pleuraphis jamesii Dwarf-shrubland	CEGL001441	4	ARCH.0610, ARCH.0611, ARCH_AA.0538, ARCH_AA.0550
Atriplex gardneri Dwarf-shrubland	CEGL001438	8	ARCH.0101, ARCH.0104, ARCH.0105, ARCH.0110, ARCH.0310, ARCH.0325, ARCH.0676, ARCH.0677
Atriplex spp. Desert Pavement Sparse Vegetation	CEGL003767	5	ARCH.0038, ARCH.0602, ARCH.0608, ARCH.0615, ARCH.0618
Bromus tectorum Semi-natural Herbaceous Vegetation	CEGL003019	10	ARCH.0044, ARCH.0049, ARCH.0053, ARCH.9692, ARCH.9003, ARCH.9009, ARCH.9658, ARCH.9619, ARCH.9038, ARCH.9010
Chrysothamnus viscidiflorus Shrubland Alliance	A.2651	1	ARCH.0089
Coleogyne ramosissima - Purshia stansburiana - Quercus havardii var. tuckeri Shrubland	CEGL002348	13	ARCH.0020, ARCH.0039, ARCH.0046, ARCH.0070, ARCH.0075, ARCH.0094, ARCH.0127, ARCH.0312, ARCH.0337, ARCH.0685, ARCH.0699, ARCH.0702, ARCH.0708
Coleogyne ramosissima Shrubland	CEGL001332	68	ARCH.0002, ARCH.0006, ARCH.0010, ARCH.0016, ARCH.0023, ARCH.0024, ARCH.0025, ARCH.0027, ARCH.0028, ARCH.0029, ARCH.0030, ARCH.0033, ARCH.0035, ARCH.0043, ARCH.0045, ARCH.0051, ARCH.0052, ARCH.0054, ARCH.0062, ARCH.0064, ARCH.0066, ARCH.0080, ARCH.0091, ARCH.0092, ARCH.0118, ARCH.0120, ARCH.0121, ARCH.0306, ARCH.0307, ARCH.0308, ARCH.0309, ARCH.0311, ARCH.0314, ARCH.0318, ARCH.0319, ARCH.0320, ARCH.0323, ARCH.0342, ARCH.0343, ARCH.0347, ARCH.0354, ARCH.0361, ARCH.0366, ARCH.0371, ARCH.0603, ARCH.0605, ARCH.0623, ARCH.0624, ARCH.0625, ARCH.0627, ARCH.0634, ARCH.0639, ARCH.0641, ARCH.0648, ARCH.0650, ARCH.0655, ARCH.0658, ARCH.0661, ARCH.0673, ARCH.0674, ARCH.0679, ARCH.0681, ARCH.0684, ARCH.0701, ARCH.0707, ARCH.0715, ARCH.0716, ARCH.0717

Plant Association Scientific Name	Element Code	No. of Samples	Supporting Plot, Observation Point, and AA Point Assignments
Elaeagnus angustifolia Semi-natural Woodland	CEGL005269	4	ARCH.0375, ARCH_AA.0989, ARCH_AA.0981, ARCH_AA.0952
Ephedra torreyana - (Atriplex spp.) / Nonvascular Gypsum Sparse Vegetation	CEGL002349	8	ARCH.0058, ARCH.0302, ARCH.0332, ARCH.0659, ARCH.0660, ARCH.0662, ARCH.0663, ARCH.0664
Ephedra torreyana / Achnatherum hymenoides - Pleuraphis jamesii Shrubland	CEGL002352	1	ARCH.0713
Ephedra torreyana / Pleuraphis jamesii Shrubland	CEGL003772	5	ARCH.0326, ARCH.0712, ARCH.0719, ARCH.9307, ARCH.9636
Ephedra torreyana Sparse Vegetation	CEGL002353	9	ARCH.0119, ARCH.9329, ARCH.9338, ARCH.9350, ARCH.9370, ARCH.9373, ARCH.9375, ARCH.9685, ARCH.9686
Ephedra viridis / (Achnatherum hymenoides, Hesperostipa comata) Shrubland	CEGL002354	9	ARCH.0019, ARCH.0042, ARCH.0367, ARCH.0626, ARCH.0630, ARCH.0654, ARCH.9337, ARCH.9378, ARCH.9379
Ephedra viridis / Pleuraphis jamesii Shrubland	CEGL002356	8	ARCH.0022, ARCH.0037, ARCH.0117, ARCH.0303, ARCH.0315, ARCH.0642, ARCH.0656, ARCH.0657
Ericameria nauseosa Desert Wash Shrubland	CEGL002261	8	ARCH.0078, ARCH_AA.0259, ARCH_AA.0383, ARCH_AA.0437, ARCH_AA.0470, ARCH_AA.0546, ARCH_AA.0993, ARCH_AA.1006
Eriogonum corymbosum Badlands Sparse Vegetation	CEGL002979	2	ARCH.0106, ARCH.0680
Fendlera rupicola Talus Shrubland	CEGL002765	1	ARCH.0711
Grayia spinosa Shrubland	CEGL002358	2	ARCH.0021, ARCH_AA.0014
Hesperostipa comata Great Basin Herbaceous Vegetation	CEGL001705	3	ARCH.0123, ARCH.0688, ARCH.9006

Plant Association Scientific Name	Element Code	No. of Samples	Supporting Plot, Observation Point, and AA Point Assignments
Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii var. tuckeri Wooded Shrubland	CEGL003774	47	ARCH.0003, ARCH.0009, ARCH.0015, ARCH.0026, ARCH.0041, ARCH.0047, ARCH.0048, ARCH.0065, ARCH.0072, ARCH.0073, ARCH.0077, ARCH.0079, ARCH.0082, ARCH.0115, ARCH.0122, ARCH.0125, ARCH.0128, ARCH.0317, ARCH.0324, ARCH.0336, ARCH.0339, ARCH.0344, ARCH.0345, ARCH.0346, ARCH.0350, ARCH.0351, ARCH.0369, ARCH.0370, ARCH.0372, ARCH.0380, ARCH.0604, ARCH.0612, ARCH.0619, ARCH.0622, ARCH.0628, ARCH.0629, ARCH.0638, ARCH.0640, ARCH.0647, ARCH.0651, ARCH.0665, ARCH.0672, ARCH.0682, ARCH.0691, ARCH.0692, ARCH.0695, ARCH.0696
Juniperus osteosperma / Artemisia tridentata ssp. tridentata Woodland	CEGL002360	9	ARCH_AA.0184, ARCH_AA.0188, ARCH_AA.0218, ARCH_AA.0237, ARCH_AA.0303, ARCH_AA.0411, ARCH_AA.0904, ARCH_AA.0911, ARCH_AA.0919
Juniperus osteosperma / Cercocarpus intricatus Woodland	CEGL000733	5	ARCH.0683, ARCH.9340, ARCH.9611, ARCH.9665, ARCH_AA.0705
Juniperus osteosperma / Coleogyne ramosissima Woodland	CEGL002909	6	ARCH.9016, ARCH.9341, ARCH.9353, ARCH.9626, ARCH_AA.0001, ARCH_AA.0874
Juniperus osteosperma / Mixed Shrubs Talus Woodland	CEGL002266	5	ARCH.0061, ARCH.0349, ARCH.0644, ARCH.9046, ARCH.9050
Juniperus osteosperma / Purshia stansburiana Woodland	Park Special	14	ARCH.9047, ARCH.9049, ARCH.9054, ARCH.9055, ARCH.9066, ARCH.9079, ARCH.9080, ARCH.9081, ARCH.9342, ARCH.9347, ARCH.9349, ARCH.9624, ARCH.9682, ARCH.9683
Juniperus osteosperma / Sparse Understory Woodland	CEGL000732	8	ARCH.0617, ARCH.9068, ARCH.9310, ARCH.9312, ARCH.9343, ARCH.9618, ARCH.9666, ARCH.9667
Krascheninnikovia lanata / Pleuraphis jamesii Dwarf-shrubland	CEGL001322	8	ARCH.0667, ARCH_AA.0037, ARCH_AA.0109, ARCH_AA.0254, ARCH_AA.0284, ARCH_AA.0301, ARCH_AA.0486, ARCH_AA.0533

Plant Association Scientific Name	Element Code	No. of Samples	Supporting Plot, Observation Point, and AA Point Assignments
Krascheninnikovia lanata Dwarf-shrubland	CEGL001320	7	ARCH.0382, ARCH.0653, ARCH.9691, ARCH_AA.0134, ARCH_AA.0224, ARCH_AA.0316, ARCH_AA.0365
Leymus salinus Shale Sparse Vegetation	CEGL002745	10	ARCH.0012, ARCH.0031, ARCH.0059, ARCH.0114, ARCH.0322, ARCH.0353, ARCH.0607, ARCH.0616, ARCH.0632, ARCH.0671
Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus Woodland	CEGL000779	3	ARCH.0365, ARCH.9650
Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima Woodland	CEGL000781	7	ARCH.0063, ARCH.0071, ARCH.0074, ARCH.0090, ARCH.0645, ARCH.9621, ARCH.9644
Pinus edulis - Juniperus osteosperma / Mixed Shrubs Talus Woodland	CEGL002328	3	ARCH.0305, ARCH.9005, ARCH.9037
Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland	CEGL000782	8	ARCH.0060, ARCH.0301, ARCH.0381, ARCH.9013, ARCH.9014, ARCH.9024, ARCH.9033, ARCH.9604
Pinus edulis - Juniperus osteosperma / Quercus havardii var. tuckeri Woodland	CEGL002497	5	ARCH.0014, ARCH.0067, ARCH.0316, ARCH.0687, ARCH.9002
Pinus edulis - Juniperus spp. / Cercocarpus montanus - Mixed Shrubs Woodland	CEGL000780	4	ARCH.9018, ARCH.9073, ARCH.9648, ARCH.9661
Pinus edulis - Juniperus spp. / Quercus gambelii Woodland	CEGL000791	2	ARCH.9690, ARCH_AA.0690
Pleuraphis jamesii - Sporobolus airoides Herbaceous Vegetation	CEGL001778	2	ARCH.0032, ARCH.0069
Pleuraphis jamesii Herbaceous Vegetation	CEGL001777	13	ARCH.0005, ARCH.0034, ARCH.0050, ARCH.0056, ARCH.0057, ARCH.0304, ARCH.0329, ARCH.0333, ARCH.0363, ARCH.0606, ARCH.0636, ARCH.0649, ARCH.0709

Plant Association Scientific Name	Element Code	No. of Samples	Supporting Plot, Observation Point, and AA Point Assignments
Poliomintha incana - Artemisia filifolia - Vanclevea stylosa Shrubland	CEGL002418	15	ARCH.0001, ARCH.0004, ARCH.0081, ARCH.0083, ARCH.0084, ARCH.0093, ARCH.0321, ARCH.0331, ARCH.0334, ARCH.0335, ARCH.0379, ARCH.0601, ARCH.0693, ARCH.0694, ARCH.0698
Populus fremontii / Artemisia tridentata Woodland	CEGL005365	9	ARCH_AA.0155, ARCH_AA.0161, ARCH_AA.0178, ARCH_AA.0781, ARCH_AA.0782, ARCH_AA.0783, ARCH_AA.0785, ARCH_AA.0822, ARCH_AA.0794
Populus fremontii / Equisetum spp. Woodland	CEGL003775	5	ARCH.0068, ARCH_AA.0154, ARCH_AA.0256, ARCH_AA.0257, ARCH_AA.0258
Populus fremontii / Ericameria nauseosa Woodland	CEGL002465	16	ARCH.0378, ARCH.0720, ARCH_AA.0155, ARCH_AA.0161, ARCH_AA.0163, ARCH_AA.0170, ARCH_AA.0178, ARCH_AA.0187, ARCH_AA.0476, ARCH_AA.0779, ARCH_AA.0785, ARCH_AA.0867, ARCH_AA.0875, ARCH_AA.0887, ARCH_AA.0911, ARCH_AA.0921
Populus fremontii / Salix exigua Forest	CEGL000666	27	ARCH.0620, ARCH_AA.0114, ARCH_AA.0153, ARCH_AA.0332, ARCH_AA.0359, ARCH_AA.0422, ARCH_AA.0738, ARCH_AA.0747, ARCH_AA.0756, ARCH_AA.0768, ARCH_AA.0776, ARCH_AA.0787, ARCH_AA.0793, ARCH_AA.0794, ARCH_AA.0798, ARCH_AA.0803, ARCH_AA.0816, ARCH_AA.0817, ARCH_AA.0821, ARCH_AA.0839, ARCH_AA.0847, ARCH_AA.0852, ARCH_AA.0864, ARCH_AA.0869, ARCH_AA.0880, ARCH_AA.0902, ARCH_AA.0939
Quercus gambelii / Sparse Understory Shrubland	CEGL002337	4	ARCH.0710, ARCH_AA.0120, ARCH_AA.0413, ARCH_AA.0842
Quercus havardii var. tuckeri Shrubland	CEGL002486	9	ARCH.0085, ARCH.0313, ARCH.0340, ARCH.0341, ARCH.0358, ARCH.0368, ARCH.0675, ARCH.0689, ARCH.0700
Rhus trilobata - Ephedra (viridis, torreyana) Talus Shrubland	CEGL003776	4	ARCH.0098, ARCH.9043, ARCH.9045, ARCH.9048
Rhus trilobata Intermittently Flooded Shrubland	CEGL001121	1	ARCH.0690

Plant Association Scientific Name	Element Code	No. of Samples	Supporting Plot, Observation Point, and AA Point Assignments
Salix exigua / Barren Shrubland	CEGL001200	4	ARCH.0088, ARCH.0703, ARCH.0721, ARCH.9684
Salix gooddingii / Salix exigua Woodland	CEGL003778	1	ARCH.0704
Salix ligulifolia Shrubland	CEGL001218	1	ARCH.9015
Sarcobatus vermiculatus / Artemisia tridentata Shrubland	CEGL001359	6	ARCH.0007, ARCH.0108, ARCH.0355, ARCH.0357, ARCH.0609, ARCH.0621
Sarcobatus vermiculatus / Sporobolus airoides Shrubland	CEGL001368	1	ARCH.0124
Sarcobatus vermiculatus Disturbed Shrubland	CEGL001357	6	ARCH.0017, ARCH.0087, ARCH.0364, ARCH.0376, ARCH.0637, ARCH.0706
Schoenoplectus pungens Herbaceous Vegetation	CEGL001587	1	ARCH.0705
Slickrock Fin Pocket [Park Special]	Park Special	12	ARCH.0338, ARCH.9008, ARCH.9655, ARCH_AA.0286, ARCH_AA.0656, ARCH_AA.0683, ARCH_AA.0763, ARCH_AA.0980, ARCH_AA.1018, ARCH_AA.1040, ARCH_AA.1041, ARCH_AA.1042
Sphaeralcea (coccinea, parvifolia) Herbaceous Vegetation	CEGL005366	3	ARCH_AA.0128, ARCH_AA.0135, ARCH_AA.0251
Sporobolus airoides Southern Plains Herbaceous Vegetation	CEGL001685	1	ARCH.0097
Sporobolus cryptandrus Great Basin Herbaceous Vegetation	CEGL002691	1	ARCH.0383
Suaeda moquinii Shrubland	CEGL001991	1	ARCH.9311
Tamarix spp. Temporarily Flooded Semi-natural Shrubland	CEGL003114	7	ARCH.0113, ARCH.0356, ARCH.9026, ARCH.9333, ARCH.9374, ARCH.9670, ARCH.9687
Typha (latifolia, angustifolia) Western Herbaceous Vegetation	CEGL002010	1	ARCH_AA.0417
Zuckia brandegeei Sparse Vegetation	CEGL002493	1	ARCH.0109

Appendix F

Plant Association Descriptions for Arches National Park

The Arches National Park (ARCH) vegetation mapping project identified 75 National Vegetation Classification (NVC) plant associations or alliances and park special vegetation types. Detailed vegetation descriptions are essential for recognizing floristic vegetation types (association and alliance levels of the NVC) in the field. Local and global descriptions "*provide specific information on the geographical distribution, level of acceptable physiognomic and compositional variation, and the key ecological process and environmental / abiotic factors that are associated with a type*" (Grossman et al. 1998). The two levels of vegetation descriptions are valuable for comparing each association as it appears in the park with the global range of variation for that association.

The following report was prepared by NatureServe to provide local and global descriptions for each plant association found at ARCH. These descriptions reflect NatureServe's accumulated data and analysis. Global descriptions of NVC associations are available on NatureServe's Explorer Web site (http://www.natureserve.org/explorer); local descriptions are not. Only local descriptions are available for provisional and park special vegetation types.

In this appendix, NVC plant associations are arranged by physiognomic class (e.g., Forest, Shrubland), with upland types listed before riparian and wetland types. Within each physiognomic class, associations are sorted into formations (e.g., Conical-crowned temperate), and alliances (e.g., *Juniperus osteosperma* Woodland Alliance).

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Populus fremontii / Salix exigua Forest
Fremont Cottonwood / Coyote Willow Forest

CODE	CEGL000666
PHYSIOGNOMIC CLASS	Forest (I)
PHYSIOGNOMIC SUBCLASS	Deciduous forest (I.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous forest (I.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous forest (I.B.2.N.)
FORMATION	Temporarily flooded cold-deciduous forest (I.B.2.N.d.)
ALLIANCE	*POPULUS FREMONTII* TEMPORARILY FLOODED FOREST ALLIANCE (A.313) Fremont Cottonwood Temporarily Flooded Forest Alliance

ECOLOGICAL SYSTEM(S): Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland (CES304.045)
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY

Globally

This association is documented from along large rivers in Utah, southwestern New Mexico, and Arizona. Stands are found on stable bars at mid elevations of the floodplain. Substrates are typically relatively recently deposited alluvium. Periodic flooding is required for the growth, maintenance and reproduction of this forest. Characteristic of this deciduous forest is the dominance of *Populus fremontii* in the moderately dense to dense tree canopy and *Salix exigua* in the tall-shrub layer. *Salix gooddingii* or *Baccharis salicifolia* are not abundant or are absent. Other associated species include *Castilleja linariifolia, Distichlis spicata, Leymus cinereus, Muhlenbergia asperifolia, Phragmites australis*, and species of *Equisetum, Juncus*, and *Carex*. Introduced species such as *Elaeagnus angustifolia, Tamarix* spp., *Poa pratensis, Melilotus* spp., and other exotic forage species are often present in disturbed stands.

DISTRIBUTION

Arches National Park

This association is common in the larger canyons in the park . It was sampled in Cottonwood Wash, throughout Courthouse Wash, in Salt Wash, and in Cordova and Sevenmile canyons.

Globally

This riparian forest is known from southwestern New Mexico along the Gila River, the East Fork of the Virgin River in southwestern Utah, the Fremont River in southeastern Utah, and in canyons in north-central Arizona. It likely occurs elsewhere in Utah and Arizona.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This deciduous forest association occurs adjacent to the active channel in washes with perennial flow or at least a high water table during the growing season. The one sampled site is flat and occurs at 1351 m elevation. The unvegetated surface has high cover of litter and moderate cover of water. Soils are rapidly drained silty clays derived from alluvium.

Globally

This riparian forest association is documented from along large rivers in southwestern Utah, southwestern New Mexico, and Arizona. Elevation ranges from 1220-1950 m (4000-6400 feet). Stands are found on stable bars in floodplains and along streambanks in canyons, where the water table is still high but flooding occurs only occasionally. Substrates are typically relatively recently deposited alluvium. Stream gradient is typically gentle, and soils are rapidly drained, sandy or silty clays derived from alluvium (Szaro 1989, Muldavin et al. 2000a).

VEGETATION DESCRIPTION

Arches National Park

This Fremont cottonwood association is rare within the park. Total vegetation cover approaches 100%. The vegetation is characterized by an open canopy, typically 5-10 m tall, of *Populus fremontii* with up to 45% cover and

an understory dominated by *Salix exigua* that range in cover from 35 to 45%. There may be a subcanopy layer of *Populus fremontii* saplings. Few other shrubs are present. The herbaceous layer provides moderate to high cover. Common graminoids include *Juncus balticus, Leymus cinereus,* and the exotic *Poa pratensis*. Common forbs include *Castilleja linariifolia* and the exotic *Melilotus officinalis*.

Globally
This association is characterized by an open to dense, deciduous tree canopy (10 to 75% cover) that is dominated by *Populus fremontii* with *Salix exigua* dominating the tall-shrub layer. *Acer negundo* may be present in the tree canopy, but *Salix gooddingii* is typically not present. *Baccharis salicifolia* is also typically not abundant in the shrub layer, but a variety of other riparian and upland shrub species may be present, including *Betula occidentalis, Amelanchier* spp., *Ericameria nauseosa, Artemisia tridentata,* or *Quercus gambelii*. The herbaceous layer is generally sparse, depending on the density of the shrub and tree layers. *Castilleja linariifolia, Distichlis spicata, Leymus cinereus, Muhlenbergia asperifolia, Phragmites australis,* and species of *Equisetum, Juncus,* and *Carex* are commonly present (Szaro 1989, Muldavin et al. 2000a). Introduced species such as *Elaeagnus angustifolia, Tamarix* spp., *Alhagi maurorum, Melilotus officinalis, Bromus* spp., and *Poa pratensis* are often present in disturbed stands.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree (canopy & subcanopy)	*Populus fremontii*
Tall shrub/sapling	*Salix exigua*
Herb (field)	*Castilleja linariifolia, Melilotus officinalis*
Herb (field)	*Juncus balticus, Leymus cinereus, Poa pratensis*

Globally

Stratum	Species
Tree canopy	*Populus fremontii*
Tall shrub/sapling	*Salix exigua*
Herb (field)	*Phragmites australis*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum

Globally
Bromus tectorum, Elaeagnus angustifolia

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (20-Sep-2001). Few intact examples of this association remain in the southwestern U.S. It is documented from the Gila, middle Rio Grande and, possibly the lower Pecos rivers of southern New Mexico, as well as several tributary drainages in southern Utah. It may also occur in southern Arizona. This association is found on stable bars at mid-elevations of the floodplain; it develops on recently deposited alluvium. Flood flows are required for the growth, maintenance and reproduction of this community type. The association continues to be in decline, primarily as a function of major hydrological alterations (dams and diversions), grazing, off-road vehicles and agricultural conversion. The remaining functional stands are restricted to wild rivers such as the Gila and San Francisco rivers, and possibly along the Mimbres River in New Mexico, or the San Pedro River in Arizona. A significant association with respect to biodiversity, particularly birds in the Southwest. Stands are rare that have not been invaded by exotic trees, shrubs and herbs. Even protected examples are threatened by continued declines in upland watershed conditions.

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
This association was not reported in the Handbook of Wetland Vegetation Communities of New Mexico (Muldavin et al. 2000a) and needs further review to distinguish it from similar associations such as *Populus fremontii - Salix*

gooddingii / Salix exigua Forest (CEGL002684). Part of the confusion is related to a taxonomic change in Rio Grande cottonwood from *Populus fremontii* var. *wislizeni* S. Wats. to *Populus deltoides ssp. wislizeni* (S. Wats.) Eckenwalder. This change resulted in part of this association (central NM along the Rio Grande) being moved into *Populus deltoides (ssp. wislizeni, ssp. monilifera) / Salix exigua* Woodland (CEGL002685). More work is needed to determine the range and possible areas of overlap between these two cottonwood species, and vegetation types in which they are important.

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Arches National Park Inventory Notes: This association distributes in a narrow zone along small, mesic drainages. The stream occasionally flash floods. There has been historic grazing. A larger stand of this type occurs upstream in Cottonwood Wash.
Arches National Park Field Data: The description is based on 2003 and 2006 field data (1 plot*:* ARCH.0620, and 26 accuracy assessment points: ARCH_AA.0114, ARCH_AA.0153, ARCH_AA.0332, ARCH_AA.0359, ARCH_AA.0422, ARCH_AA.0738, ARCH_AA.0747, ARCH_AA.0756, ARCH_AA.0768, ARCH_AA.0776, ARCH_AA.0787, ARCH_AA.0793, ARCH_AA.0794, ARCH_AA.0798, ARCH_AA.0803, ARCH_AA.0816, ARCH_AA.0817, ARCH_AA.0821, ARCH_AA.0839, ARCH_AA.0847, ARCH_AA.0852, ARCH_AA.0864, ARCH_AA.0869, ARCH_AA.0880, ARCH_AA.0902, ARCH_AA.0939).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: E. Milford, E. Muldavin, mod. K. Schulz and J. Coles

REFERENCES: Bourgeron and Engelking 1994, Cogan et al. 2004, Driscoll et al. 1984, Hansen et al. 2004b, Muldavin et al. 1993b, Muldavin et al. 2000a, NMNHP unpub. data, Szaro 1989, Western Ecology Working Gp n.d.

Juniperus osteosperma / Artemisia tridentata ssp. tridentata Woodland
Utah Juniper / Basin Big Sagebrush Woodland

CODE	CEGL002360
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a.)
ALLIANCE	*JUNIPERUS OSTEOSPERMA* WOODLAND ALLIANCE (A.536) Utah Juniper Woodland Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This woodland association occurs locally on benches, alluvial terraces, plateaus and draws in northwestern Colorado and eastern Utah. Elevations range from 1255-1860 m. Sites are located on gentle to moderate slopes, and tend to occupy relatively cool microsites, either on north aspects or cold-air drainages. Stands of this association tend to develop in *Artemisia tridentata ssp. tridentata* shrublands that have escaped disturbance for a long enough time to allow *Juniperus osteosperma* trees from nearby woodlands to invade. Soils are deep and generally are derived from alluvium. The best-developed stands occur on canyon floors where terraces are protected from flooding. The tree canopy is generally open, with between 10 and 50% cover by *Juniperus osteosperma*. *Artemisia tridentata ssp. tridentata* often has equal or greater cover than the tree layer, and shrubs may be 2 m high. If other shrubs are present, it is with low cover; species reported include *Amelanchier utahensis, Ericameria nauseosa, Atriplex canescens, Opuntia* spp., and *Gutierrezia sarothrae*. The herbaceous layer is diverse and well-developed in stands that have been protected from grazing, and may be dominated by grasses such as *Bouteloua gracilis, Hesperostipa comata*, or *Distichlis spicata*. However, most stands have experienced a long history of grazing, and in these cases, the herbaceous layer is generally dominated by exotic *Bromus tectorum*.

DISTRIBUTION
Arches National Park

This association is found in Upper Salt Wash, Lost Spring Canyon, and Upper Courthouse Wash on alluvial flats, valley floors, canyon bottoms, and plateaus often along drainages; one stand is in an alcove and one in a box canyon.

Globally
This association has been sampled in eastern Utah and northwestern Colorado. It is likely to be widespread throughout the Colorado Plateau.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This woodland association occurs in alluvial flats, valley floors, canyon bottoms, and plateaus often along drainages; one stand is in an alcove. Sites are flat to gently sloping (<4 degrees) with aspects ranging from north and east to southwest at 1255-1353 m elevation. Soils are sandy loams derived from alluvium. Soil surface has moderate to high cover of litter (20-90%) and often has significant biological soil crust cover (10-80%).

Globally
This woodland association occurs locally in small patches occupying benches, alluvial terraces, plateaus and draws in the Colorado Plateau of western Colorado and eastern Utah. Elevations range from 1255 to 1860 m. Sites are located on gentle to moderate (1-46%) slopes and tend to occupy relatively cool microsites, either on north aspects or cold-air drainages. Soils are deep and generally are derived from alluvium.

VEGETATION DESCRIPTION
Arches National Park
This association is characterized by sparse to moderately dense cover of *Juniperus osteosperma* (4-25% cover) with an open to moderately dense shrub layer characterized by *Artemisia tridentata ssp. tridentata* (4-11% cover). Stands with <5% tree cover also had low shrub cover and represent sparse examples of this type. Associated shrubs that are frequently present include *Atriplex canescens, Fraxinus anomala, Mahonia fremontii, Quercus havardii* var. *tuckeri (= Quercus welshii), Rhus trilobata*, and *Sarcobatus vermiculatus*. The herbaceous layer is sparse, except when occasionally dominated by the exotic annual grass *Bromus tectorum*. Associated species include *Achnatherum hymenoides, Pleuraphis jamesii*, and *Sporobolus cryptandrus*.

Globally
This woodland association is best developed on canyon floors on terraces that are protected from flooding. The tree canopy is generally open, with between 10 and 50% cover by *Juniperus osteosperma*. *Artemisia tridentata ssp. tridentata* often has equal or greater cover than the tree layer, and shrubs may be 2 m high. If other shrubs are present, it is with low cover; species reported include *Amelanchier utahensis, Atriplex canescens, Ericameria nauseosa, Fraxinus anomala, Gutierrezia sarothrae, Mahonia fremontii, Opuntia* spp., *Rhus trilobata*, and *Sarcobatus vermiculatus*. The herbaceous layer is diverse and well-developed in stands that have been protected from grazing, and may be dominated by grasses such as *Bouteloua gracilis, Hesperostipa comata*, or *Distichlis spicata*. However, most stands have a long history of grazing; in these cases, the herbaceous layer is generally dominated by exotic *Bromus tectorum*.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Artemisia tridentata* ssp. *tridentata, Atriplex canescens*

Globally

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Artemisia tridentata* ssp. *tridentata*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum

Globally

Bromus tectorum

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (22-Mar-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Data are not available.
Arches National Park Field Data: The description is based on 2006 field data (9 accuracy assessment points: ARCH_AA.0184, ARCH_AA.0188, ARCH_AA.0218, ARCH_AA.0237, ARCH_AA.0303, ARCH_AA.0411, ARCH_AA.904, ARCH_AA.911, ARCH_AA.919).
Local Description Authors: K.A. Schulz
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Juniperus osteosperma / Cercocarpus intricatus Woodland
Utah Juniper / Littleleaf Mountain-mahogany Woodland

CODE	CEGL000733
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a)
ALLIANCE	*JUNIPERUS OSTEOSPERMA* WOODLAND ALLIANCE (A.536) Utah Juniper Woodland Alliance
ECOLOGICAL SYSTEM(S):	Great Basin Pinyon-Juniper Woodland (CES304.773) Inter-Mountain Basins Cliff and Canyon (CES304.779) Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765) Colorado Plateau Pinyon-Juniper Shrubland (CES304.766) Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This woodland association occurs on steep, rocky ridges in the Great Basin of Nevada, whereas in the Colorado Plateau of Utah and Colorado it occupies gentle to moderate slopes on mesas, benches and canyon floors where bedrock is partially covered by sandy soils. Stands are located between 1500 and 1980 m (4920-6500 feet) elevation. Aspect may influence the distribution of stands locally, but across the full range, stands may occur on any aspect. At least half the unvegetated surface is bare ground or sandstone slickrock, with the remainder divided primarily between litter and biological soil crusts. Soils are shallow or skeletal and are rapidly drained sands or sandy loams. Total vegetation cover rarely exceeds 35% because the high exposure of rock limits where plants can grow. The canopy is open, with *Juniperus osteosperma* trees providing between 5 and 25% cover; the trees are often stunted. There is a well-developed shrub layer in which *Cercocarpus intricatus* is dominant or codominant. Total shrub cover ranges from 5 to 15%. Associated shrubs include *Amelanchier utahensis, Fraxinus anomala, Artemisia bigelovii, Glossopetalon spinescens* var. *meionandrum, Atriplex confertifolia, Cercocarpus montanus, Chrysothamnus greenei, Philadelphus microphyllus, Symphoricarpos longiflorus*, and *Ephedra viridis*. The herbaceous layer is diverse in terms of species composition and provides sparse to low cover. Graminoids

commonly include *Aristida purpurea, Achnatherum hymenoides, Hesperostipa* and/or *Achnatherum* spp., and *Muhlenbergia pungens*. Forbs are diverse but provide sparse cover; *Stenotus acaulis* occurs throughout the range.

DISTRIBUTION

Arches National Park

Occurrences of this uncommon association are scattered throughout the park in areas where massive sandstone substrates outcrop in shaded situations or at higher elevations, such as near the Windows and the Highlands.

Globally

This association is known from southeastern Utah, western Colorado and northern Nevada. It may also occur in eastern California and is likely to occur in scattered stands throughout the Great Basin and Colorado Plateau.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This woodland association occupies sheltered and mesic situations in areas of massive slickrock where fracturing and weathering have allowed small pockets of soil to develop. Most stands are on ridges, rims, or plateaus, on gentle slopes or level sites. One stand was in a drainage cut into the slickrock. Elevations range between 1300 and 1525 m elevation. Exposed sandstone and bare soil comprise most of the unvegetated surface. Parent materials include Navajo and Moab Tongue sandstone. Soils are rapidly drained sandy loams.

Globally

This woodland association occurs on steep, rocky ridges in the Great Basin of Nevada, whereas in the Colorado Plateau of Utah and Colorado it occupies gentle to moderate slopes on mesas, benches and canyon floors where bedrock is partially covered by sandy soils. Stands are located between 1500 and 1980 m (4920-6500 feet) elevation. Aspect may influence the distribution of stands locally, but range-wide stands may occur on any aspect. At least half the unvegetated surface is bare ground or sandstone slickrock, with the remainder divided primarily between litter and biological soil crusts. Soils are shallow or skeletal and are rapidly drained sands or sandy loams.

VEGETATION DESCRIPTION

Arches National Park

This woodland association is uncommon within the park, being restricted to sheltered sites at higher elevations. The vegetation is characterized by an open canopy of *Juniperus osteosperma* trees and a mixed shrub understory in which *Cercocarpus intricatus* is dominant or co-dominant. Because the soils are often extremely shallow, the trees may be dwarfed to little more than 1m tall and the density of vegetation is limited by the availability of soil. Associated shrubs include *Amelanchier utahensis, Brickellia microphylla, Ephedra* spp., *Fraxinus anomala*. Herbaceous species rarely contribute more than a trace cover, but include many different species. The most consistent species are perennial bunchgrasses such as *Achnatherum hymenoides* and *Pleuraphis jamesii*, tall forbs such as *Lepidium montanum,* and cushion forbs such as *Petradoria pumila*.

Globally

Total vegetation cover rarely exceeds 35% because the high exposure of slickrock limits where plants can grow. The canopy is open, with *Juniperus osteosperma* trees providing between 5 and 25% cover. There is a well-developed shrub layer in which *Cercocarpus intricatus* is dominant or codominant. Total shrub cover ranges from 5 to 15%. Associated shrubs include *Amelanchier utahensis, Artemisia bigelovii, Atriplex confertifolia, Cercocarpus montanus, Chrysothamnus greenei, Echinocereus triglochidiatus, Ephedra viridis, Fraxinus anomala, Glossopetalon spinescens* var. *meionandrum, Opuntia erinacea, Philadelphus microphyllus, Quercus havardii* var. *tuckeri, Rhus trilobata, Symphoricarpos longiflorus*, and *Yucca angustissima*. The herbaceous layer is diverse in terms of species composition and provides sparse to low cover. Graminoids commonly include *Aristida purpurea, Achnatherum hymenoides, Hesperostipa* and/or *Achnatherum* spp., and *Muhlenbergia pungens*. Forbs are diverse but provide sparse cover; *Stenotus acaulis* occurs throughout the range. *Tetraneuris acaulis, Lepidium montanum*, and *Cryptantha flavoculata* are also reported from plots.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Tall shrub/sapling	*Fraxinus anomala*

Short shrub/sapling	*Cercocarpus intricatus, Ephedra viridis, Yucca angustissima*
Herb (field)	*Achnatherum hymenoides, Festuca octoflora, Pleuraphis jamesii*

Globally

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Cercocarpus intricatus*

OTHER NOTEWORTHY SPECIES
Arches National Park
N/A

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (23-Feb-1994).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
It is unusual for sites as rocky as those occupied by this association not to have *Pinus edulis* in the understory. It is not clear why *Pinus* is absent from these stands, but the sites may be too warm or may be isolated from other woodlands containing *Pinus*.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Top of lumpy slickrock tilted table. The very edge of the rim here is a miniature garden in the slickrock fractures. Trees are les than 1 meter tall but old. Vegetated crevices are less than 3 feet wide; 95 percent of the area is slickrock or chunks of chert. Runoff and the sheltering aspects of the slickrock slopes above community contribute to the mix of species. This is a variably sloped slickrock ridge, erosional remnants of petrified sand dunes. Very sparsely vegetated with diverse but sparse lichens on the slickrock. Sparse vegetation in soil pockets - very shallow pockets - dwarfed juniper.
Arches National Park Data: The description is based on 2003 and 2006 field data (1 plot: ARCH.0683, three observation points: ARCH.9340, ARCH.9611, ARCH.9665, and one accuracy assessment point: ARCH_AA.0705).
Local Description Authors: J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Blackburn et al. 1968c, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Driscoll et al. 1984, NVNHP 2003, Western Ecology Working Group n.d.

Juniperus osteosperma / Coleogyne ramosissima Woodland [Provisional]
Utah Juniper / Blackbrush Shrubland

CODE	CEGL002909
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a)
ALLIANCE	*JUNIPERUS OSTEOSPERMA* WOODLAND ALLIANCE (A.536) Utah Juniper Woodland Alliance
ECOLOGICAL SYSTEM(S):	Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765) Colorado Plateau Pinyon-Juniper Shrubland (CES304.766) Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally

This association occurs on sites with shallow to moderately deep sandy soils overlying hills, benches, plateaus and slopes of sandstone. Sites are generally on gentle to moderate slopes (up to 15 degrees), occur between 1200 and 1850 m elevation, and are oriented to all aspects. Bare soil, gravel, and bedrock typically cover most of the unvegetated surface; litter provides sparse to low cover. Biological soil crust cover is typically significant and can be as high as 70%. Soils are rapidly drained sands, sandy loams, or loamy sands derived from eolian deposits or alluvium, or from sandstone bedrock. Parent materials include most of the sandstones found within the range of the association, including Kayenta, Entrada, and Navajo formations. This association can take the form of a sparse woodland with a scattered shrub understory, but more often appears as a wooded shrubland. Total vegetation cover is generally low; most stands have between 10 and 20% cover. *Coleogyne* is dominant in a mixed shrub layer that may have higher cover than the tree layer. Common shrub associates include *Artemisia bigelovii, Atriplex canescens, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Fraxinus anomala, Gutierrezia sarothrae,* and *Opuntia polyacantha. Purshia stansburiana* is absent or has very low relative cover. Grass cover is usually sparse, rarely exceeding a few percent by species such as *Achnatherum hymenoides, Aristida purpurea, Bouteloua gracilis,* and *Pleuraphis jamesii.* Forbs vary greatly across the range of this association and never contribute significant cover; the species present usually are indicative of the sandy soils. The substrate also favors the development of extensive biological soil crusts.

DISTRIBUTION
Arches National Park
This association occurs in scattered locations throughout the park. It was sampled in Cordova Canyon, Eagle Park, Upper Courthouse Wash, Petrified Dunes, near Willow Springs, and on the Salt Valley anticline.

Globally
This plant association is currently described only from national park units in southern Utah. It is likely to occur in similar habitats in adjacent Arizona and possibly Nevada within the range of *Coleogyne ramosissima*. It is unlikely to occur with any regularity in New Mexico or Colorado.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This sparse woodland or wooded shrubland association occurs on sandy sites underlain by slickrock. Stands occur between 1250 and 1550 m elevation, on gentle to moderate slopes oriented to northerly aspects. The unvegetated surface is mostly bare ground, gravel, or bedrock. Soils are shallow to moderately deep sands, loamy sands and sandy loams derived from local sandstone outcrops or eolian deposits. Parent materials include the Salt Wash member of the Morrison Formation as well as Entrada and Kayenta sandstones.

Globally
This woodland or wooded shrubland association occurs where a layer of sand of variable thickness overlies a slickrock surface. Landforms include plateaus, benches, ridges, hogbacks, valley slopes, and sandsheets. Sites are generally on gentle to moderate slopes (up to 15 degrees), occur between 1200 and 1850 m elevation, and are oriented to all aspects. Bare soil, gravel, and bedrock typically cover most of the unvegetated surface; litter provides sparse to low cover. Biological soil crust cover is typically significant and can be as high as 70%. Soils are rapidly drained sands, sandy loams, or loamy sands derived from eolian deposits or alluvium, or from sandstone bedrock. Parent materials include sandstones of the Cedar Mesa, Kayenta, Entrada, White Rim and Navajo formations, Moab Tongue of the Curtis Formation, and the Salt Wash Member of the Morrison Formation.

VEGETATION DESCRIPTION
Arches National Park
This woodland or wooded shrubland association is scattered across widespread areas of the park, usually in a mosaic with related woodland types. The vegetation is characterized by a sparse to open canopy of *Juniperus osteosperma* with between 3 and 15% cover. Stands with tree cover at the lower end of the range tend to have sparse cover overall. The shrub understory generally has several times the cover of the tree stratum and is clearly dominated by *Coleogyne ramosissima.* Other shrubs present with low cover include *Ephedra viridis* and *Gutierrezia sarothrae.* The herbaceous layer only provides sparse cover and is inconsistent from stand to stand. Reported species include

the grasses *Achnatherum hymenoides* and *Pleuraphis jamesii* and the forbs *Lepidium montanum* and *Petradoria pumila.* The cover of biological soil crust varies from stand to stand; some stands have only a little moss, whereas others have more than 30% cover by dark cyanobacteria and ground lichens..

Globally
This association can take the form of a sparse woodland with a scattered shrub understory, but more often appears as a wooded shrubland, with the cover of *Coleogyne ramosissima* is often far greater than that of *Juniperus osteosperma*. Total vegetation cover is generally low; few stands exceed 25% cover by vascular species, and most stands have between 10 and 20% cover. *Pinus edulis* is absent of has only a small fraction of the cover of *Juniperus osteosperma*. *Coleogyne* is always clearly the dominant shrub; common associates include *Artemisia bigelovii, Atriplex canescens, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Fraxinus anomala, Gutierrezia sarothrae,* and *Opuntia polyacantha. Purshia stansburiana* is absent or has very low relative cover. Grass cover is usually sparse, rarely exceeding a few percent by species such as *Achnatherum hymenoides, Aristida purpurea, Bouteloua gracilis,* and *Pleuraphis jamesii.* Forbs vary greatly across the range of this association and never contribute significant cover. The locally common species tend to reflect the sandy substrate: *Lepidium montanum, Oenothera pallida, Sphaeralcea parvifolia*, and *Streptanthella longirostris*. The sandy substrate favors the development of biological soil crusts; these dominate the ground cover in many stands.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Coleogyne ramosissima, Ephedra viridis, Chrysothamnus nauseosus*

Globally

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Tall shrub/sapling	*Fraxinus anomala, Mahonia repens*
Short shrub/sapling	*Coleogyne ramosissima, Ephedra viridis*
Herb (field)	*Achnatherum hymenoides, Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus rubens, Bromus tectorum, Salsola kali

Globally
Bromus tectorum, Cryptantha crassisepala var. *elachantha, Descurainia pinnata*

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR

CLASSIFICATION COMMENTS
Arches National Park
This type grades into the *Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii* Wooded Shrubland association and can be difficult to distinguish in areas with patchy *Purshia* or *Quercus.*

Globally
This plant association is distinguished from other juniper woodlands on shallow soils over slickrock by the overwhelming dominance of *Coleogyne ramosissima* and by the absence of other diagnostic trees and shrubs.

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Arches National Park Inventory Notes: Soil seems moderately well stabilized. Bedrock showing in strips. Rocky red dirt does not encourage lush plant growth. Deep clay soils of the Morrison (blue-grey and tan) are interrupted by small exposures of the Salt Wash in sort of a badland topography. Exposed bedrock with soil pockets in fissures/depressions in bedrock.

Arches National Park Data: The description is based on 2003 and 2006 field data (4 observation points: ARCH.9016, ARCH.9341, ARCH.9353, ARCH.9626, and two accuracy assessment points: ARCH_AA.0001, ARCH_AA.0874).
Local Description Authors: J. Coles
Global Description Authors: J. Coles

REFERENCES: Western Ecology Working Group n.d.

Juniperus osteosperma / Mixed Shrubs Talus Woodland
Utah Juniper / Mixed Shrubs Talus Woodland

CODE	CEGL002266
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a.)
ALLIANCE	*JUNIPERUS OSTEOSPERMA* WOODLAND ALLIANCE (A.536) Utah Juniper Woodland Alliance
ECOLOGICAL SYSTEM(S):	Colorado Plateau Pinyon-Juniper Woodland (CES304.767) Colorado Plateau Pinyon-Juniper Shrubland (CES304.766)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This association is known from Arches National Park and Colorado National Monument but likely is widespread in the canyons of the Colorado Plateau. Stands occur on midslopes, ledges, benches, bottoms and especially talus or rockfall slopes of canyons and midslopes of ridges. Elevations range between 1376 and 1585 m. Sites are moderately steep to very steep (16-84% slopes) and include all aspects. Soils are shallow, poorly developed, rapidly drained sandy clays, clay loams and sandy loams. The unvegetated surface has low to moderate cover of litter and bare soil and high cover of bedrock and large and small rocks. Parent materials are sandstones, shale, and Precambrian gneiss. This woodland is characterized by an open tree canopy of stunted *Juniperus osteosperma* that ranges in cover from 5 to 40%, but may be less if juniper cover is still significant relative to total vegetation and stand appears wooded. *Pinus edulis* and *Fraxinus anomala* may occasionally be present. The shrub layer is highly variable in cover and composition among stands and can include *Amelanchier utahensis, Artemisia bigelovii, Artemisia tridentata ssp. tridentata, Atriplex canescens, Brickellia microphylla, Cercocarpus montanus, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Eriogonum corymbosum, Eriogonum microthecum, Fendlera rupicola, Fraxinus anomala, Gutierrezia sarothrae, Rhus trilobata,* and a number of succulents. The herbaceous layer is typically sparse to low in terms of cover but high in species diversity. Common graminoids provide sparse to low cover and include *Achnatherum hymenoides, Aristida purpurea, Bouteloua curtipendula, Bromus tectorum, Elymus elymoides, Vulpia octoflora, Hesperostipa comata, Leymus salinus, Pleuraphis jamesii, Poa fendleriana,* and *Pseudoroegneria spicata*. *Pleuraphis jamesii* consistently provides the highest cover of the graminoid species. Common forbs include scattered *Eriogonum inflatum* and *Chamaesyce fendleri*.

DISTRIBUTION
Arches National Park
This association occurs around the margins of the Salt Valley, the lower slopes of Courthouse Wash, Park Avenue, and upper Salt Wash, as well as on the slopes around the old highway right-of-way.

Globally
This association is known from Arches National Park and Colorado National Monument but likely is widespread in the canyonlands of the Colorado Plateau in western Colorado and eastern Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park
This sparse woodland association occurs on steep (45%) slopes, ledges and benches of Morrison or Chinle shales overlain by Wingate or Salt Wash sandstone colluvium. Elevations range between 1402 and 1585 m, and stands may be oriented to any aspect. Rocks, gravel and bare ground occupy most of the unvegetated surface. Soils are shallow, poorly developed, rapidly drained sandy clays, clay loams and sandy loams.

Globally
This association is known from Arches National Park and Colorado National Monument but likely is widespread in the canyons of the Colorado Plateau. Stands occur on midslopes, ledges, benches, bottoms and especially talus or rockfall slopes of canyons and midslopes of ridges. Elevations range between 1376 and 1585 m. Sites are moderately steep to very steep (16-84% slopes) and include all aspects. Soils are shallow, poorly developed, rapidly drained sandy clays, clay loams and sandy loams. The unvegetated surface has low to moderate cover of litter and bare soil and high cover of bedrock and large and small rocks. Parent materials are sandstones, shale, and Precambrian gneiss. Typical sites at Arches National Park are Morrison or Chinle shales overlain by Wingate or Salt Wash sandstone colluvium. Other parent materials include Moenkopi Formation, Navajo sandstone, and Elephant Canyon Formation at Canyonlands National Park, and Tidwell Member of the Morrison Formation and Kayenta Formation at Black Canyon National Park.

VEGETATION DESCRIPTION
Arches National Park
Total vegetation cover in this open woodland association is around 25%. The vegetation is characterized by a sparse canopy of scattered *Juniperus osteosperma* with between 5 and 10% cover. Juniper has significant cover relative to the total vegetation, enough so that to the eye the community appears to be wooded, no matter how sparse. Pinyon is absent or is a minor element. The shrub component is conspicuous and mixed, and every stand may have a different dominant species. Common shrubs include *Ephedra torreyana, Ephedra viridis, Artemisia bigelovii, Coleogyne ramosissima, Amelanchier utahensis, Ericameria nauseosa, Rhus trilobata*, and *Eriogonum corymbosum*. Herbaceous species are a minor part of the community; common elements include scattered *Eriogonum inflatum, Chamaesyce fendleri, Achnatherum hymenoides, Aristida purpurea*, and *Pleuraphis jamesii*.

Globally
This woodland is characterized by an open tree canopy of stunted *Juniperus osteosperma* that ranges in cover from 5 to 40%, but may be less if juniper cover is still significant relative to total vegetation and stand appears wooded. *Pinus edulis* and *Fraxinus anomala* may occasionally be present. The shrub layer is highly variable in cover and composition among stands and can include *Amelanchier utahensis, Artemisia bigelovii, Artemisia tridentata ssp. tridentata, Atriplex canescens, Brickellia microphylla, Cercocarpus montanus, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Eriogonum corymbosum, Eriogonum microthecum, Fendlera rupicola, Fraxinus anomala, Gutierrezia sarothrae, Rhus trilobata*, and a number of succulents. The herbaceous layer is typically sparse to low in terms of cover but high in species diversity. Common graminoids provide sparse to low cover and include *Achnatherum hymenoides, Aristida purpurea, Bouteloua curtipendula, Bromus tectorum, Elymus elymoides, Vulpia octoflora, Hesperostipa comata, Leymus salinus, Pleuraphis jamesii, Poa fendleriana*, and *Pseudoroegneria spicata*. *Pleuraphis jamesii* consistently provides the highest cover of the graminoid species. Common forbs include scattered *Eriogonum inflatum* and *Chamaesyce fendleri*.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Ericameria nauseosa*, *Eriogonum corymbosum*, *Rhus trilobata*
Short shrub/sapling	*Artemisia bigelovii*, *Ephedra torreyana*, *Ephedra viridis*
Herb (field)	*Pleuraphis jamesii*

Globally

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Ericameria nauseosa*

Herb (field) *Gutierrezia sarothrae*

OTHER NOTEWORTHY SPECIES
Arches National Park
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (10-Jan-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
This association is closely related to a number of other colluvial slope types with sparse, variable vegetation described for the northern Colorado Plateau network of national parks. These include *Fendlera rupicola* Talus Shrubland (CEGL002765) (ARCH, COLM), *Atriplex canescens - Ephedra viridis* Talus Shrubland (CEGL001287) (CANY, CARE, COLM), and *Chrysothamnus viscidiflorus* Talus Shrubland (CEGL002347) (CANY, CARE, DINO). At some point the plots assigned to the various types should be re-analyzed to see if patterns are apparent and particular names can be assigned to groups of plots, or if a generic name such as this should be retained.

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Arches National Park Inventory Notes: Stands contain many dead plants as a legacy of the 2002 drought. Sheet and rill erosion keep soils moving and biological soil crust development minimal.
Arches National Park Field Data: The description is based on 2003 field data (3 plots: ARCH.0061, ARCH.0349, ARCH.0644, and 2 observation points: ARCH.9046, ARCH.9050).
Local Description Authors: J. Coles
Global Description Authors: M.S. Reid and J. Coles, mod. K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Juniperus osteosperma / Purshia stansburiana Woodland [Park Special]
Utah Juniper / Stansbury's Cliffrose Woodland

CODE	Park Special
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a)
ALLIANCE	*JUNIPERUS OSTEOSPERMA* WOODLAND ALLIANCE (A.536) Utah Juniper Woodland Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
Data are not available

DISTRIBUTION
Arches National Park
Examples of this association are concentrated in the northwestern part of the mapping area, which is where exposures of the Salt Wash Member also occur. Most are in the environs.

Globally
Data are not available

ENVIRONMENTAL DESCRIPTION
Arches National Park
Most stands of this type occur on rims, slopes, and benches supported by Salt Wash Member of the Morrison Formation or less often The Kayenta Formation. Sites slope gently to moderately (3° to 21°), occur between 1345 and 1540 m elevation, and tend to be oriented to western and northwestern aspects. The unvegetated ground surface is mostly exposed bedrock, followed by gravel, rock, and bare ground. Litter and biological soil crusts have low cover. Soils are shallow, rapidly drained, coarse, and sandy or gravelly.

Globally
Data are not available

VEGETATION DESCRIPTION
Arches National Park
This woodland association is uncommon within the park; most stands are in the environs. The vegetation is characterized by a sparse to open canopy of *Juniperus osteosperma* trees and an open, shrub understory of mixed species. The density of woody vegetation is limited by the degree of fracturing of the underlying sandstone; no species has more than 10% cover and many have only a few percent cover. *Purshia stansburiana* has the highest cover of any shrub present and *Fraxinus anomala* is usually present to co-dominant. Other shrubs may include *Artemisia bigelovii, Brickellia microphylla, Ephedra* spp., *Eriogonum microthecum, Gutierrezia sarothrae,* and *Rhus trilobata.* The herbaceous layer is diverse but sparse; common species include *Aristida purpurea, Petradoria pumila, Haplopappus armerioides, Hymenopappus filifolius, Cryptantha flava,* and *Pleuraphis jamesii.*

Globally
Data are not available

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Tall shrub/sapling	*Purshia stansburiana, Fraxinus anomala*
Short shrub/sapling	*Artemisia bigelovii, Brickellia microphylla, Ephedra torreyana, Eriogonum microthecum*
Herb (field)	*Aristida purpurea, Gutierrezia sarothrae*

Globally
Data are not available

OTHER NOTEWORTHY SPECIES
Arches National Park
N/A

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: N/A

CLASSIFICATION COMMENTS
Arches National Park
This type is at the dry end of the spectrum of *Juniperus osteosperma* woodlands on bedrock-dominated sites at ARCH. The mesic end of this spectrum contains *Cercocarpus intricatus* and *Amelanchier utahensis* in addition to *Purshia stansburiana* and *Coleogyne ramosissima*. Across the Colorado Plateau, it may be difficult or impossible to recognize this park special community consistently as distinct from others in the spectrum, but at ARCH appears to be possible.

Globally
Data are not available

CLASSIFICATION CONFIDENCE: N/A

ELEMENT SOURCES
Arches National Park Inventory Notes:
Arches National Park Data: The description is based on 2003 field data (14 observation points: ARCH.9047, ARCH.9049, ARCH.9054, ARCH.9055, ARCH.9066, ARCH.9079, ARCH.9080, ARCH.9081, ARCH.9342, ARCH.9347, ARCH.9349, ARCH.9624, ARCH.9682, ARCH.9683).
Local Description Authors: J. Coles
Global Description Authors: N/A

REFERENCES: N/A

Juniperus osteosperma / Sparse Understory Woodland
Utah Juniper / Sparse Understory Woodland

CODE	CEGL000732
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a.)
ALLIANCE	*JUNIPERUS OSTEOSPERMA* WOODLAND ALLIANCE (A.536) Utah Juniper Woodland Alliance
ECOLOGICAL SYSTEM(S):	Great Basin Pinyon-Juniper Woodland (CES304.773) Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This widespread woodland association occurs in the Great Basin, Colorado Plateau and western Rocky Mountain regions where it occupies sites in which junipers have become established but that are too dry to support a developed understory of shrubs, forbs and grasses. Lack of soil moisture-holding capacity, southern or western aspects, old-growth conditions, or high cover by rocks or bedrock may all contribute to the development of these stands. Elevations range between 1400 and 2200 m, and stands occur on may types of soils, geology, slope, aspect and landform. Total vegetation cover ranges from 10 to 70% and consists almost entirely of the *Juniperus osteosperma* canopy. Shrub cover and herbaceous cover each total less than 5%, and usually total 1% or less. Because of the sparseness of the understory vegetation, there are few species that can be expected throughout the range of this association. Common species include *Ephedra viridis, Gutierrezia sarothrae*, and *Elymus elymoides*. Cryptobiotic crust cover may be high.

DISTRIBUTION
Arches National Park
This association is rare in the park; most reported occurrences were in the environs, including Little Valley South Dalton Wells, Yellow Cat Flat, and the Bar M loop road. Locations in the park include Park Avenue, Salt Wash, and Courthouse Wash.

Globally
This association occurs widely in the Great Basin of Nevada and western Utah, as well as the Colorado Plateau and western Rocky Mountains of eastern Utah and western Colorado, and extends north to the Uinta Mountains.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This woodland association was sampled once on a gently sloping (7%), southwest-facing valley side at 1460 m

elevation. The unvegetated surface has high cover of small rocks and biological soil crusts and low cover of litter, large rocks, and exposure of bare soil. The soil is a rapidly drained sandy loam derived from the Brushy Basin Member of the Morrison Formation.

Globally
This widespread woodland association occurs on slopes, ridges, benches and mesas at elevations ranging between 1400 and 2200 m (4600-7220 feet). Slopes range from gentle to moderately steep, with a few examples on very steep slopes. Sites may be oriented to any aspect. In Colorado Plateau and Great Basin stands, substrates and soils tend to have poor water-holding capacity (hydrothermically altered volcanic tuff, clay or coarse sands) and are on warm south or west exposures. In some Colorado Plateau stands, the substrate is so rocky as to afford few places for shrubs or herbaceous species to grow, or the woodland is in an old-growth condition and juniper trees are using all of the available light and moisture. The unvegetated ground surface may have high cover of cryptobiotic crusts on sandy sites; shale sites usually have high cover of bare ground, and other sites may have high cover by rock, bedrock and gravel.

VEGETATION DESCRIPTION
Arches National Park
This woodland association is rare within the park; most wooded types at Arches NP have an understory with at least as much cover as the tree canopy. Total vegetation cover ranges from 6 to 20%. The canopy of this woodland association consists of dwarfed mature *Juniperus osteosperma* trees providing approximately 10% cover. Scattered shrubs are present but provide between a trace and 5% cover; *Artemisia bigelovii, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Gutierrezia sarothrae*, and *Purshia stansburiana* are among the recorded species. The herbaceous layer is also sparse and includes *Pleuraphis jamesii, Chamaesyce glyptosperma*, and *Phacelia crenulata*. Biological soil crust cover ranges from 30 to 50%.

Globally
This common woodland association is characterized by a canopy of *Juniperus osteosperma* with between 10 and 70% cover, sometimes less in very open stands. In many stands the total vegetation cover does not exceed 20%. *Pinus edulis* is generally absent from the canopy. Trees may be barely 2 m high on shale sites, or in old-growth stands the trees may approach 5 m in height. Scattered shrubs are usually present, but do not exceed 5% cover, and usually the total is 1% or less. Common species include *Ephedra viridis, Cercocarpus montanus, Artemisia tridentata ssp. wyomingensis, Gutierrezia sarothrae,* and *Opuntia* spp. Forbs and grasses also total less than 5% (usually 1% or less) and may include *Pleuraphis jamesii, Achnatherum hymenoides, Petradoria pumila*, or *Elymus elymoides*. Cryptobiotic crusts may cover as much as 25% of the unvegetated area in stands with sandy substrates.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Purshia stansburiana*

Globally

Stratum	Species
Tree canopy	*Juniperus osteosperma*

OTHER NOTEWORTHY SPECIES
Arches National Park
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: GNRQ (23-Feb-1994).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Milton and Purdy (1983) describe a pinyon-juniper / sparse understory woodland type at two sites in the Great Basin of Nevada and western Utah. The soils at these sites are derived from hydrothermically altered rocks. Juniper (*Juniperus osteosperma*) is the dominant tree; however, the scattered pinyon pine in these sites is *Pinus monophylla*, not *Pinus edulis* as occurs in the Colorado Plateau.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Arches National Park Inventory Notes: The sampled site occupies a conglomerate outcrop where soils have weathered in place. Trees root in bedrock cracks.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0617 and 7 observation points: ARCH.9068, ARCH.9310, ARCH.9312, ARCH.9343, ARCH.9618, ARCH.9666, ARCH.9667).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles

REFERENCES: Bourgeron and Engelking 1994, Driscoll et al. 1984, Milton and Purdy 1983

Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus Woodland
Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland

CODE	CEGL000779
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a.)
ALLIANCE	*PINUS EDULIS - (JUNIPERUS* SPP.) WOODLAND ALLIANCE (A.516) Two-needle Pinyon - (Juniper species) Woodland Alliance
ECOLOGICAL SYSTEM(S):	Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765) Colorado Plateau Pinyon-Juniper Shrubland (CES304.766) Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This woodland association occurs on dry sandstone ridgetops, mesa edges, outcrops, colluvial slopes, slickrock hills, benches and knolls at moderate elevations of 1484 to 2470 m (4870-8100 feet) on the Colorado Plateau and in extreme northwestern Colorado, adjacent Utah, and possibly Wyoming. South and southwest aspects are common, and slopes can be variable in steepness. Exposed bedrock and large rock may cover over 50% of the stand, with vegetation growing in the cracks. These sandstone-derived soils are generally poorly developed, coarse-textured and skeletal. Bare soil is common. The vegetation is characterized by a short (2-10 m), open tree canopy (10-25% cover) codominated by *Pinus edulis* and *Juniperus osteosperma*, and by the dominance of *Cercocarpus intricatus* in the relatively sparse short-shrub layer (5-25% cover). *Pinus edulis* and *Juniperus osteosperma* vary in cover between 1 and 15%, though higher covers are possible. The shrubs *Amelanchier utahensis, Arctostaphylos patula, Gutierrezia sarothrae, Mahonia fremontii, Quercus gambelii*, or *Yucca* spp. are often present in many stands. Herbaceous cover is sparse (<5% cover) and is composed of scattered forbs and grasses such as species of *Cryptantha, Penstemon*, and *Opuntia, Achnatherum hymenoides, Bouteloua gracilis, Elymus elymoides, Pleuraphis jamesii*, and *Poa fendleriana*.

DISTRIBUTION
Arches National Park
This association is uncommon and occurs in scattered sheltered sites throughout the park. It was sampled south of The Windows and near Klondike Bluffs within the park.

Globally
This plant association is found on the Colorado Plateau and in extreme northwestern Colorado, adjacent Utah, and

possibly Wyoming.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This woodland association occurs on slickrock hills, benches and knolls. Sites are moderately steep (12 to 25%), occur between 1524 and 1610 m elevation and tend to be oriented to southeast aspects. Bedrock and bare soil cover most of the unvegetated surface. Soils are rapidly drained sandy loams and loamy sands derived from local sandstones. This association occurs on all slickrock types except Salt Wash sandstone.

Globally

This woodland association occurs on dry, sandstone ridgetops, mesa edges, outcrops, colluvial slopes, slickrock hills, benches and knolls at moderate elevations (1484 -2470 m) on the Colorado Plateau and in extreme northwestern Colorado, adjacent Utah, and possibly Wyoming. South and southwest aspects are common, and slopes can vary from gentle to steep. Exposed bedrock and large rock may cover over 50% of the stand, with vegetation growing in soil that has collected in joints and cracks. These sandstone-derived soils are generally poorly developed, coarse-textured and skeletal. Soils are rapidly drained sandy loams, sands, or silt loams derived from colluvium derived from a variety of parent materials, including Carmel Formation, Cedar Mesa sandstone, Chinle Formation, Dakota Formation, Kayenta Formation, Morrison Formation, Navajo Formation, or Wingate Formation. Bare soil is common.

VEGETATION DESCRIPTION

Arches National Park

This woodland type represents an endpoint in the continuum of pinyon-juniper / mixed shrub communities in the park. It is locally common in mesic sites within the boundary. Total vegetation cover ranges from 5 to 45%, depending on the degree of bedrock fracturing. The association is characterized by an open canopy of *Juniperus osteosperma* and an understory of mixed shrubs dominated by the short shrub *Cercocarpus intricatus*. *Pinus edulis* may also be present in some stands. Commonly associated shrubs include *Amelanchier utahensis, Fraxinus anomala, Artemisia bigelovii, Brickellia microphylla, Ephedra viridis, Gutierrezia sarothrae,* and *Opuntia polyacantha*. *Coleogyne ramosissima* is absent, but *Celtis laevigata* var. *reticulata* may be present on the north side of Salt Valley. The herbaceous layer provides sparse cover; grasses include *Achnatherum hymenoides* and *Vulpia octoflora*. Commonly associated forbs include *Cryptantha* sp., *Chamaesyce fendleri, Lepidium montanum,* and *Streptanthella longirostris*. Biological soil crusts provide less than 10% cover.

Globally

The association is characterized by an open tree canopy (10-25% cover) codominated by *Pinus edulis* and *Juniperus osteosperma*, and by the dominance of *Cercocarpus intricatus* in the relatively sparse short-shrub layer (5-25% cover). The tree canopy may be between 2 and 10 m tall; *Pinus edulis* and *Juniperus osteosperma* vary in cover between 1 and 15%, with some stands having up to 25% cover of *Pinus edulis*. Some stands may have an occasional emergent *Pinus ponderosa, Pseudotsuga menziesii*, or *Juniperus scopulorum* tree. Additionally, some sparse (<10% total cover), tree-dominated stands from extremely dry, rocky sites in the Colorado Plateau are included in this woodland association as a best fit. The shrub layer represents the mesic end of the pinyon-juniper / mixed shrub understory communities found on slickrock exposures. *Amelanchier utahensis, Arctostaphylos patula, Gutierrezia sarothrae, Mahonia fremontii, Quercus gambelii* (low cover), or *Yucca* spp. are often present in many stands. A variety of other shrubs and dwarf-shrubs may be present depending on location, including *Artemisia bigelovii, Brickellia microphylla, Cercocarpus montanus, Chrysothamnus viscidiflorus, Echinocereus triglochidiatus, Ephedra viridis, Eriogonum corymbosum, Fendlerella utahensis, Fraxinus anomala, Glossopetalon spinescens* var. *meionandrum, Holodiscus dumosus, Philadelphus microphyllus, Purshia stansburiana, Quercus turbinella*, or *Shepherdia rotundifolia*. *Coleogyne ramosissima* is typically absent. Herbaceous cover is sparse (<5% cover) and is composed of scattered forbs and grasses, such as species of *Cryptantha, Penstemon*, and *Opuntia, Achnatherum hymenoides, Bouteloua gracilis, Elymus elymoides, Pleuraphis jamesii*, and *Poa fendleriana*.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species	
Tree (canopy & subcanopy)	*Juniperus osteosperma*	
Tall shrub/sapling	*Fraxinus anomala*	
Short shrub/sapling	*Coleogyne ramosissima,*	*Cercocarpus intricatus, Ephedra viridis*

Herb (field)	*Streptanthella longirostris*
Herb (field)	*Achnatherum speciosum*

Globally

Stratum	Species
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Amelanchier utahensis, Cercocarpus intricatus*
Herb (field)	*Achnatherum hymenoides, Elymus elymoides, Poa fendleriana*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum

Globally
Hymenoxys lapidicola, Yucca elata var. *utahensis*

CONSERVATION STATUS RANK
Global Rank & Reasons: G3 (30-Dec-2000). The plant association is limited to a small geographic area and is documented from a narrow elevational band on sandstone substrates in extreme northwestern Colorado and possibly adjacent Utah. There are 11 documented stands in Colorado with size ranging from 4-450 acres. Although most occurrences are considered in good to excellent condition, those in excellent condition tend to be small. Grazing and woodcutting are the primary threats where stands are accessible.

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Compare this association with *Juniperus osteosperma / Cercocarpus intricatus* Woodland (CEGL000733) which is very similar, but lacks *Pinus edulis*. On dry, rocky or slickrock sites on the Colorado Plateau, this pinyon-juniper woodland association may include stands with very open tree canopies (5-10% cover) in cases where the total vegetation cover is less than 15%. These stands may be similar to open *Cercocarpus intricatus* shrublands with scattered pinyon and juniper trees but is considered to be a variation of the woodland type because of the ecological values of the trees.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Stands occupy slickrock habitats and vegetation is rooted in slickrock cracks. Drainages across stands are common.
Arches National Park Field Data: The description is based on 2003 field data (1 plot: ARCH.0365 and 1 observation point: ARCH.9650).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: A.E. Black, mod. K.A. Schulz, J. Drake, J. Coles

REFERENCES: Baker 1983b, Baker 1983c, Baker 1984a, Baker and Kennedy 1985, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Cogan et al. 2004, Driscoll et al. 1984, Zimmerman 1978

Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima Woodland
Two-needle Pinyon - Utah Juniper / Blackbrush Woodland

CODE	CEGL000781
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a.)
ALLIANCE	*PINUS EDULIS - (JUNIPERUS* SPP.) WOODLAND ALLIANCE (A.516)

Two-needle Pinyon - (Juniper species) Woodland Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Pinyon-Juniper Shrubland (CES304.766)
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This woodland association has been described from valley bottoms, terraces, benches, slopes, mesa rims, elevated plains and rolling terrain sometimes interrupted by bedrock. It occurs extensively across the Colorado Plateau from southwestern Colorado through southern Utah into Arizona and probably also Nevada. Sites are on flat to moderate slopes (0-20%) between 1070 and 1890 m (3500-6200 feet) elevation on all aspects. Bare soil covers most of the unvegetated surface, although cryptogam cover can be as high as 45%. Soils are typically shallow, rocky sandy loams derived from sandstone, eolian sands, alluvium or limestone. A few stands occur on deep or clay-textured soils derived from shale. Stands of this association can vary greatly in appearance, ranging from sparsely vegetated (<10% total cover) to relatively dense (80% cover). Sparsely vegetated stands also tend to have dwarfed trees not exceeding 2 m in height. Typically, stands have an open (5-25% cover) tree canopy 3-6 m tall that contains both *Pinus edulis* and *Juniperus osteosperma*, although one or the other tree may dominate. The shrub layer has 5 to 55% cover and is dominated by *Coleogyne ramosissima*. In Arizona, *Mortonia sempervirens* may be codominant. Other common shrub species may include *Agave utahensis, Cercocarpus montanus, Ephedra viridis, Glossopetalon spinescens* var. *aridum, Glossopetalon spinescens, Gutierrezia sarothrae, Opuntia polyacantha, Purshia stansburiana, Quercus turbinella, Yucca baccata, Yucca harrimaniae,* and *Yucca elata* var. *utahensis*. The sparse herbaceous layer is composed of graminoids such as *Achnatherum hymenoides, Achnatherum speciosum, Elymus elymoides, Poa fendleriana, Bouteloua curtipendula,* and *Aristida* species. *Bromus rubens, Bromus tectorum,* and *Vulpia octoflora* may be present to abundant in disturbed sites. Forbs are typically variable and scattered, contributing little cover. *Lappula occidentalis, Lepidium montanum, Chaenactis stevioides, Psilostrophe sparsiflora,* and *Streptanthella longirostris* are among the many species that have been recorded. Scattered cacti are often present, including *Opuntia erinacea, Opuntia phaeacantha, Opuntia polyacantha, Echinocereus triglochidiatus,* and *Echinocereus engelmannii*.

DISTRIBUTION

Arches National Park

This association is scattered widely through the park. It was sampled in Salt Valley, near The Windows, in Herdina Park, near the Dark Angel, and along Klondike Bluffs Road within the park.

Globally

This woodland association occurs across the Colorado Plateau from southwestern Colorado through southern Utah into Arizona. It is likely to occur in California and Nevada. More survey work is needed to assess the range.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This woodland association occurs on valley bottoms and benches, mesa rims, and slopes. Stands of this association tend to be on more alkaline substrates such as the Salt Wash sandstone and Tidwell shale members of the Morrison Formation. Sites slope gently to moderately (9 to 18%), occur between 1470 and 1646 m elevation and tend to be oriented to the west. Most of the unvegetated surface consists of bare soil or sand. Biological soil crust cover can be as high as 40%. Soils are rapidly drained sandy loams and sandy clays derived from mixed alluvium and eolian deposits.

Globally

This woodland association has been described from valley bottoms, terraces, benches, slopes, mesa rims, elevated plains and rolling terrain sometimes interrupted by bedrock. It likely occurs extensively across the Colorado Plateau from southwestern Colorado through southern Utah into Nevada. Sites are on flat to moderate slopes (0-20%) between 1070 and 1890 m (3500-6200 feet) elevation on all aspects. Bare soil covers most of the unvegetated surface, although cryptogam cover can be as high as 45%. Soils are typically shallow, rocky sandy loams derived from sandstone, eolian sands, alluvium or limestone. A few stands occur on deep or clay-textured soils derived from shale. Parent materials are variable and include eolian deposits derived from Cedar Mesa, Dakota or Navajo sandstones and the Morrison Formation (Salt Wash Member), Kayenta Formation, and Moenkopi Formation.

VEGETATION DESCRIPTION

Arches National Park

This woodland association occurs scattered throughout the park, mostly on ledgy sites in Salt Wash or Kayenta sandstones. Total vegetation cover ranges from 12 to 80% depending on the depth of soil and the degree of fracturing in the bedrock, as woody plants root in the fractures. This woodland is characterized by an open canopy of often stunted *Pinus edulis* and *Juniperus osteosperma* trees that have up to 25% cover. The canopy may also consist solely of *Juniperus osteosperma* in some stands. *Coleogyne ramosissima* dominates a shrub understory that ranges in cover from 5 to 55%. The associated shrub layer is mixed and generally includes *Ephedra viridis, Gutierrezia sarothrae, Opuntia polyacantha*, and *Yucca harrimaniae*. If *Purshia stansburiana* is present, it is with no more than trace cover, and *Cercocarpus montanus, Cercocarpus intricatus*, and *Amelanchier utahensis* are absent. The herbaceous layer is a minor element of this community. Common grasses include *Achnatherum hymenoides, Bromus tectorum*, and *Vulpia octoflora*. Forbs present include *Chaenactis stevioides, Lepidium montanum*, and *Streptanthella longirostris*.

Globally

Stands of this association can vary greatly in appearance, ranging from sparsely vegetated (<10% total cover) to relatively dense (80% cover). Sparsely vegetated stands also tend to have dwarfed trees not exceeding 2 m in height. Typically, stands have an open (5-25% cover) tree canopy 3-6 m tall that contains both *Pinus edulis* and *Juniperus osteosperma*, although one or the other tree may dominate. The shrub layer has 5 to 55% cover and is dominated by *Coleogyne ramosissima*. In some parts of the range, *Mortonia sempervirens* may be codominant. Other shrub species present may include *Agave utahensis, Cercocarpus montanus, Ephedra viridis, Glossopetalon spinescens* var. *aridum, Glossopetalon spinescens, Gutierrezia sarothrae, Opuntia polyacantha, Purshia stansburiana, Quercus turbinella, Yucca baccata, Yucca harrimaniae*, and *Yucca elata* var. *utahensis*. The sparse herbaceous layer is composed of graminoids such as *Achnatherum hymenoides, Achnatherum speciosum, Elymus elymoides, Poa fendleriana, Bouteloua curtipendula*, and *Aristida* species. *Bromus rubens, Bromus tectorum*, and *Vulpia octoflora* may be present to abundant in disturbed sites. Forbs are typically variable and scattered, contributing little cover. *Lappula occidentalis, Lepidium montanum, Chaenactis stevioides, Psilostrophe sparsiflora*, and *Streptanthella longirostris* are among the many species that have been recorded. Scattered cacti are often present, including *Opuntia erinacea, Opuntia phaeacantha, Opuntia polyacantha, Echinocereus triglochidiatus*, and *Echinocereus engelmannii*.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Fraxinus anomala*
Short shrub/sapling	*Coleogyne ramosissima, Quercus havardii* var. *tuckeri, Ephedra viridis, Purshia stansburiana*
Herb (field)	*Gutierrezia sarothrae, Opuntia polyacantha, Yucca harrimaniae*
Herb (field)	*Cryptantha crassisepala, Vulpia octoflora*

Globally

Stratum	Species
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Short shrub/sapling	*Coleogyne ramosissima*
Short shrub/sapling	*Mortonia sempervirens*

OTHER NOTEWORTHY SPECIES

Arches National Park

Descurainia pinnata

Globally

Bromus rubens, Bromus tectorum

CONSERVATION STATUS RANK

Global Rank & Reasons: G3 (19-Sep-2000). This late-seral woodland association occurs extensively across the Colorado Plateau in southwestern Colorado and southern Utah into Arizona and probably also Nevada. Introduced

annual grasses such as *Bromus rubens* may threaten this woodland because the dry annual grasses provide fine fuels that allow fire to spread. *Coleogyne ramosissima* is very sensitive to fire. A hot fire will completely remove this shrub from a site for decades. More survey work is needed to assess the entire range of this type.

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Arches National Park Inventory Notes: Stands occur on bedrock with sand-filled fissures and pockets, deep soils of eolian dunes, and shallow soils over bedrock ledges. Soil depth controls plant distribution. Biological soil crusts are common on some stands on dunes. Some stands are grazed.
Arches National Park Field Data: The description is based on 2003 field data (5 plots: ARCH.0063, ARCH.0071, ARCH.0074, ARCH.0090, ARCH.0645, and 2 observation points: ARCH.9621, ARCH.9644).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Driscoll et al. 1984, FEIS 1996, Larson and Moir 1987, Stuever and Hayden 1997a, Warren et al. 1982, Western Ecology Working Group n.d.

Pinus edulis - Juniperus osteosperma / Mixed Shrubs Talus Woodland
Two-needle Pinyon - Utah Juniper / Mixed Shrubs Talus Woodland

CODE	CEGL002328
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a.)
ALLIANCE	*PINUS EDULIS - (JUNIPERUS* SPP.) WOODLAND ALLIANCE (A.516) Two-needle Pinyon - (Juniper species) Woodland Alliance
ECOLOGICAL SYSTEM(S):	Colorado Plateau Pinyon-Juniper Woodland (CES304.767) Colorado Plateau Pinyon-Juniper Shrubland (CES304.766)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This open woodland association is found in western Colorado and eastern Utah, generally on lower slopes where talus and rockfalls accumulate. Sites can be between 1330 and 2290 m (4365-7500 feet) elevation. Slopes can be gentle to steep and of any aspect. The unvegetated ground surface is mostly bedrock and large and small rocks. Soils are rapidly drained. The parent material is talus rockfall. This woodland association can have sparse to moderate vegetation cover (4-61%) but is most often relatively sparse (<15% cover). The sparse to open tree canopy is 2-10 m tall. *Pinus edulis* and *Juniperus osteosperma* are the dominant canopy trees; either species can range from extremely low to moderate cover. The composition of the shrub stratum can be diverse, but cover is sparse to low. Common species are *Amelanchier utahensis, Artemisia bigelovii, Artemisia tridentata ssp. vaseyana, Cercocarpus montanus, Chrysothamnus viscidiflorus, Echinocereus triglochidiatus, Ephedra viridis, Eriogonum corymbosum, Fendlera rupicola, Gutierrezia sarothrae, Opuntia* spp., and *Rhus trilobata*. The herbaceous layer also provides sparse to low cover. Common graminoid species are *Achnatherum hymenoides, Aristida purpurea, Bromus tectorum, Elymus elymoides, Pleuraphis jamesii,* and *Poa fendleriana*. Common forbs are *Chamaesyce fendleri, Descurainia pinnata, Heterotheca villosa, Lepidium montanum,* and *Streptanthus cordatus.* Cryptogams are rare or absent on these active slopes.

DISTRIBUTION

Arches National Park

This association is uncommon and was sampled in Salt Valley, Spring Canyon, and Cache Valley within the park.

Globally

This association is found on the eastern edge of the Colorado Plateau and western slope of the southern Rocky Mountains in western Colorado.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This sparse woodland association occurs on dry colluvial slopes on valley sides and in canyons. The underlying geology is Chinle shale overlain by Wingate sandstone rubble. Sites are on steep, north-facing slopes (65 to 78%) between 1427 and 1485 m elevation. Soils are shallow, poorly developed loamy sands.

Globally

This association is found on midslopes of ridges on dry colluvial slopes and in ravines and canyons on talus and rockfalls in the Colorado Plateau. Sites are found between 1330 and 2290 m elevation. Slopes can be gentle to steep (up to 78%) and of any aspect. The unvegetated ground surface is mostly bedrock and large and small rocks. Bare soil and litter are also found. Soils are variable and are generally rapidly drained clay loam, loam, sandy loam, loamy sand and, less commonly, silty clay soils. The parent material is talus rockfall and older landslide deposits from the Tidwell Member of the Morrison Formation, Chinle Formation, Kayenta and Wingate sandstones, Moenkopi Formation and Cutler Group (including Cedar Mesa sandstone).

VEGETATION DESCRIPTION

Arches National Park

Total vegetation cover in this pinyon-juniper woodland association may be as low as 10% or as high as 25%, depending on how much of the surface is covered by boulders. The vegetation is characterized by an open canopy of *Pinus edulis* and *Juniperus osteosperma*, which may be as low as 3%, but this has the appearance of a woodland. The shrub understory is mixed and variable, with different dominant species in each stand and with cover rarely exceeding 10%. Common shrub species include *Artemisia bigelovii, Chrysothamnus viscidiflorus*, and *Ephedra viridis*. Herbaceous cover is more diverse and conspicuous than in most colluvial vegetation types but still rarely exceeds 3% cover. Typical herbaceous species include *Achnatherum hymenoides, Vulpia octoflora*, and *Lepidium montanum*.

Globally

This woodland association can have very sparse to moderate total vegetation cover (4-61%) but is most often relatively sparse (<15%). The sparse to open tree canopy is 2-10 m tall. *Pinus edulis* and *Juniperus osteosperma* are the dominant canopy trees. Either species can have extremely low cover. *Juniperus osteosperma* has been observed with up to 45% cover, and *Pinus edulis* with up to 15% cover. A few *Fraxinus anomala* may be found in some stands. The composition of the shrub stratum can be diverse, but cover is sparse to low. Common species are *Amelanchier utahensis, Artemisia bigelovii, Artemisia tridentata ssp. vaseyana, Brickellia microphylla, Cercocarpus montanus, Chrysothamnus viscidiflorus, Echinocereus triglochidiatus, Ephedra viridis, Ephedra torreyana, Eriogonum corymbosum, Fendlera rupicola, Gutierrezia sarothrae, Opuntia* spp., and *Rhus trilobata*. The herbaceous layer also provides sparse to low cover, usually less than 5%. Common graminoid species are *Achnatherum hymenoides, Aristida purpurea, Bromus tectorum, Elymus elymoides, Pleuraphis jamesii*, and *Poa fendleriana*. Common forbs are *Chamaesyce fendleri, Descurainia pinnata, Heterotheca villosa, Lepidium montanum,* and *Streptanthus cordatus*. Cryptogams are rare or absent on these active slopes.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Short shrub/sapling	*Chrysothamnus viscidiflorus, Fraxinus anomala, Artemisia bigelovii, Ephedra viridis*
Herb (field)	*Lepidium montanum*
Herb (field)	*Achnatherum hymenoides*

Globally

Stratum	Species
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Amelanchier utahensis*
Short shrub/sapling	*Artemisia bigelovii, Ephedra viridis*
Herb (field)	*Opuntia fragilis*
Herb (field)	*Achnatherum hymenoides, Elymus elymoides, Poa fendleriana*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum

Globally
Bromus tectorum

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (11-Jan-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Arches National Park Inventory Notes: Some shrubs have dead limbs (maybe from the drought), but plants are looking good now with lots of new growth.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0305 and 2 observation points: ARCH.9005, ARCH.9037).
Local Description Authors: J. Coles
Global Description Authors: J. Drake, mod. K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland
Two-needle Pinyon - Utah Juniper / Stansbury's Cliffrose Woodland

CODE	CEGL000782
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a.)
ALLIANCE	*PINUS EDULIS - (JUNIPERUS* SPP.) WOODLAND ALLIANCE (A.516) Two-needle Pinyon - (Juniper species) Woodland Alliance
ECOLOGICAL SYSTEM(S):	Colorado Plateau Pinyon-Juniper Shrubland (CES304.766) Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This woodland association is known from the Colorado Plateau of southern Utah and Colorado south to central Arizona. It occurs on dry sites on canyon rims, ridges and slopes. Elevations range from 1400 to 2165 m. Stands typically occur on gentle to moderately steep slopes on all aspects. The soils are generally shallow and rocky, ranging from sand to clay loam in texture. Rock outcrop and bare soil are common. Parent materials include sandstone and shale. The vegetation is characterized by an open to moderately dense tree canopy (10-60% cover)

codominated by *Pinus edulis* and *Juniperus osteosperma*. *Purshia stansburiana* dominates or codominates the sparse to moderately dense short-shrub layer, often with *Artemisia tridentata* in the northern part of its range. *Cercocarpus montanus* and *Purshia tridentata* are scarce or absent. Other shrubs may be present, including *Amelanchier utahensis, Arctostaphylos patula, Chamaebatiaria millefolium, Ephedra viridis, Gutierrezia sarothrae, Quercus gambelii* (<5% cover), or species of *Yucca* and *Opuntia*. Herbaceous cover is variable, ranging from sparse to moderately dense, but generally dominated by graminoids (<5% cover) with scattered perennial forbs.

DISTRIBUTION

Arches National Park

This association is uncommon in the park and was sampled near Devil's Garden, near Klondike Bluffs, near Sand Dune Arch, and in Cache Valley. It was also reported near Dalton Wells in the environs.

Globally

This woodland association occurs in the Colorado Plateau region of central Arizona, western New Mexico, southwestern Colorado, and southern Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This woodland association occurs on knolls and canyon rims. Sites slope gently (average 9°) and occur between 1421 and 1604 m elevation. Bedrock or litter may cover most of the unvegetated surface. Downed wood can have as much as 10% cover. Parent materials are variable and include sandstones of the Moab Tongue of the Curtis Formation and shale of the Salt Wash Member of the Morrison Formation. Soils are rapidly drained sandy loams, loamy sands, and sandy clays derived from local sandstones.

Globally

This woodland occurs on the Colorado Plateau of southern Utah and Colorado south to central Arizona, on dry canyon rims, ridges, hills, benches, mesas and occasionally in intermittent drainages. Elevations range from 1400 to 2165 m (4600-7100 feet). Stands typically occur on gentle to moderately steep slopes on all aspects, but range from flat to steep slopes (0-30%). Soils are generally shallow and rocky, ranging in texture from sand in most stands to clay loam or sandy clay. Exposed sandstone or limestone bedrock and bare soil have high cover, and woody plants are generally rooted in cracks and joints in bedrock. A minority of stands may also occur on shale slopes covered by sandstone colluvium. Parent materials are variable and include sandstones and shale of the Moab Tongue of the Curtis Formation, Kayenta Formation, Moenkopi Formation, Morrison Formation, Cedar Mesa sandstone and eolian silt deposits.

VEGETATION DESCRIPTION

Arches National Park

This woodland association represents an endpoint of the continuum of pinyon-juniper woodland / mixed shrub communities that cover much of the park. It is locally common within the park. Total vegetation cover ranges from 12 to 65% depending on the depth of soil and the degree of fracturing of the underlying bedrock. The woodland canopy is characterized by an open canopy of *Pinus edulis* and *Juniperus osteosperma* (sometimes dwarfed) that have up to 35% cover and a scattered shrub layer dominated by *Purshia stansburiana*. *Coleogyne ramosissima* and *Quercus havardii* var. *tuckeri* are absent from the understory. Associated shrubs include *Amelanchier utahensis, Fraxinus anomala, Ephedra viridis,* and *Eriogonum corymbosum*. The herbaceous layer is diverse and variable but typically provides only sparse cover. Common graminoids include *Achnatherum hymenoides, Aristida purpurea, Bromus tectorum,* and *Vulpia octoflora*. Common forbs include *Cryptantha* sp., *Descurainia pinnata,* and *Lappula occidentalis.*

Globally

This woodland association is characterized by an open to moderately dense tree canopy (10-60% cover) codominated by *Pinus edulis* and *Juniperus osteosperma*. *Purshia stansburiana* dominates or codominates the sparse to moderately dense short-shrub layer, often with *Artemisia tridentata* in the northern part of its range. Total vegetation cover can vary from 12% to more than 65%, with tree canopy sometimes falling below 10% cover in very open stands. *Cercocarpus montanus* and *Purshia tridentata* are scarce or absent. Other shrubs may be present, including *Amelanchier utahensis, Arctostaphylos patula, Artemisia bigelovii, Artemisia nova, Artemisia tridentata, Chamaebatiaria millefolium, Ephedra viridis, Ericameria nauseosa, Eriogonum corymbosum, Eriogonum microthecum, Fraxinus anomala, Gutierrezia sarothrae, Quercus gambelii* (<5% cover), *Rhus trilobata, Shepherdia*

rotundifolia, Symphoricarpos longiflorus, or species of *Yucca* and *Opuntia*. Herbaceous cover is variable, ranging from sparse to moderately dense, but generally dominated by graminoids (>5% cover) with scattered forbs. Associated graminoids include *Achnatherum hymenoides, Aristida purpurea, Bouteloua curtipendula, Bouteloua gracilis, Bouteloua hirsuta, Elymus elymoides, Hesperostipa comata, Hesperostipa neomexicana, Koeleria macrantha, Poa fendleriana, Pleuraphis jamesii,* and *Schizachyrium scoparium*. Forbs may include *Artemisia ludoviciana, Artemisia frigida, Calliandra humilis, Descurainia pinnata, Eriogonum ovalifolium, Lappula occidentalis, Oenothera pallida,* and *Penstemon linarioides*.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree (canopy & subcanopy)	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Amelanchier utahensis, Fraxinus anomala*
Short shrub/sapling	*Ephedra viridis, Eriogonum corymbosum, Quercus gambelii, Rhus trilobata* var. *trilobata*
Herb (field)	*Eriogonum corymbosum, Opuntia phaeacantha,Petradoria pumila*

Globally

Stratum	Species
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Amelanchier utahensis, Purshia stansburiana*

OTHER NOTEWORTHY SPECIES

Arches National Park
Erodium cicutarium

Globally
Bromus tectorum, Descurainia pinnata, Erodium cicutarium

CONSERVATION STATUS RANK

Global Rank & Reasons: G4? (1-Feb-1996).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
The global name of this association was changed on 2001-09-04 because of a taxonomic change of the nominal species. *Purshia mexicana* var. *stansburiana* (Torr.) Welsh is now recognized as *Purshia stansburiana* (Torr.) Henrickson (Kartesz 1999). *Purshia mexicana* (D. Don) Henrickson, a closely related species, occurs in Chihuahua, Durango and Zacateca, Mexico, and possibly extreme southern Arizona, and is not known to be present within the range of this association (Cronquist et al. 1997).

This association appears to be part of a continuum of Colorado Plateau woodland communities growing on fractured sandstone. Stands where *Purshia stansburiana* is the dominant understory shrub are less common than those in which it is a component of a mixed shrub understory that includes *Cercocarpus montanus, Amelanchier utahensis,* and *Cercocarpus intricatus* in mesic stands, or *Coleogyne ramosissima* and *Yucca* spp. in xeric stands. An analysis of the woodland data from four parks (Colorado, Arches, Natural Bridges, Canyonlands) confirmed that *Pinus edulis - Juniperus osteosperma / Purshia stansburiana* Woodland (CEGL000782) is a valid association but not always easy to distinguish from more mixed-shrub woodlands in the field.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES

Arches National Park Inventory Notes: Fissured slickrock controls the vegetation. Soil collects in pockets and fissures. There is concentrated runoff from bedrock surfaces.
Arches National Park Field Data: The description is based on 2003 field data (3 plots: ARCH.0060, ARCH.0301, ARCH.0381, and 5 observation points: ARCH.9013, ARCH.9014, ARCH.9024, ARCH.9033, ARCH.9604).

Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: BIA 1979, Baker 1980a, Baker 1984a, Bourgeron and Engelking 1994, Britton and Wright 1983, CONHP unpubl. data 2003, Cogan et al. 2004, Cronquist et al. 1997, Driscoll et al. 1984, Isaacson 1967, Kartesz 1999, Larson and Moir 1987, Moir and Carleton 1987, Northcutt 1978, Stuever and Hayden 1997a, USFS 1982, USFS 1985c

Pinus edulis - Juniperus osteosperma / Quercus havardii var. *tuckeri* Woodland
Two-needle Pinyon - Utah Juniper / Tucker Sand Shinnery Oak Woodland

CODE	CEGL002497
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a.)
ALLIANCE	*PINUS EDULIS - (JUNIPERUS* SPP.) WOODLAND ALLIANCE (A.516) Two-needle Pinyon - (Juniper species) Woodland Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This woodland association occurs on deep accumulations of eolian and alluvial sands on canyon and valley floors, in intermittent washes, and on dunes and sandsheets on plateaus and benches in southeastern Utah. It is located on level to gently sloping (0-11%) sites between 1445 and 1868 m (4740-6130 feet) elevation. Aspect apparently does not influence the distribution of this association, although it does influence the vegetative composition somewhat. Bare soil and sand cover most of the unvegetated surface, although there is sometimes low cover of bedrock or gravel, and biological soil crusts can provide up to 30% cover. Geologic substrates include various sandstones, which for the most part have eroded and been redeposited as eolian sands. Soils are rapidly drained, moderately deep loamy sands, sandy loams, and sands. Total vegetation cover ranges from 21% to more than 100%. The open tree canopy of *Pinus edulis* and *Juniperus osteosperma* is typically 2-5 m tall and ranges in cover from 10 to 50%. *Fraxinus anomala* may occasionally occur as a canopy tree with sparse cover. The understory is dominated by clumps of *Quercus havardii* var. *tuckeri* that range in cover from 5 to 65%. Associated shrubs vary depending on the aspect and the amount of soil moisture available; cooler, more mesic stands include *Amelanchier utahensis, Cercocarpus intricatus, Cercocarpus montanus, Mahonia fremontii*, and *Shepherdia rotundifolia*. In more exposed, drier stands these shrubs are mostly replaced by *Artemisia bigelovii, Ephedra viridis, Eriogonum microthecum, Gutierrezia sarothrae, Opuntia polyacantha*, and *Yucca harrimaniae*. The herbaceous layer is more consistent in species composition yet provides only sparse cover. Common graminoids include *Achnatherum hymenoides, Bouteloua gracilis, Muhlenbergia pungens*, and *Pleuraphis jamesii*. Forbs often present include species typical of sandy sites: *Cryptantha flava, Tetraneuris acaulis, Lepidium montanum*, and *Streptanthella longirostris*.

DISTRIBUTION

Arches National Park

This association is uncommon and was observed and sampled in Herdina Park, near the Eye of the Whale, near Broken Arch, and near Klondike Bluffs within the park.

Globally

This association is apparently restricted to southeastern Utah. It may also occur in some parts of southern Colorado.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This woodland association occurs on canyon floors, adjacent to washes, and on dunes and sandsheets. Sites slope gently (2 to 11%) and occur between 1445 and 1537 m elevation. Litter and bare sand cover most of the unvegetated surface. A few sites have some gravel cover and exposed bedrock. Biological soil crusts are generally present and

can provide as much as 30% cover. Stands occur on sandstones of the Entrada Formation and Moab Tongue as well as shale of the Tidwell Member. This material can become wind-transported to form eolian deposits. Soils are rapidly drained loamy sand, sandy loam, or sand.

Globally
This woodland association occurs on canyon and valley floors, in intermittent washes, on dunes and sandsheets on plateaus and benches in southeastern Utah. It is located on level to gently sloping (0-11%) sites between 1445 and 1868 m (4740-6130 feet) elevation. Aspect apparently does not influence the distribution of this association. Bare soil and sand cover most of the unvegetated surface, although there is sometimes low cover of bedrock or gravel, and biological soil crusts can provide up to 30% cover. Geologic substrates include Navajo, Moab Tongue, Cedar Mesa or Entrada sandstones, which for the most part have eroded and been redeposited as eolian sands as well as shale of the Tidwell Member and Carmel Formation. Soils are rapidly drained, moderately deep loamy sands, sandy loams, and sands.

VEGETATION DESCRIPTION
Arches National Park
This pinyon-juniper woodland association is rare in the park. Total vegetation cover ranges from 21 to 90%. This canopy is characterized by *Pinus edulis* and *Juniperus osteosperma* trees 2-5 m tall that range in cover between 10 and 35%. *Quercus havardii* var. *tuckeri* is the most conspicuous shrub in the understory, often forming coppices in the sand. Other shrubs present may include *Fraxinus anomala, Amelanchier utahensis, Artemisia bigelovii, Cercocarpus intricatus, Ephedra viridis, Gutierrezia sarothrae, Mahonia fremontii*, and *Opuntia polyacantha*. *Coleogyne ramosissima* and *Purshia stansburiana* are absent from the community. The herbaceous layer has sparse cover. Common graminoids include *Achnatherum hymenoides, Bromus tectorum*, and *Vulpia octoflora*. Forbs often present include *Cryptantha crassisepala, Tetraneuris acaulis, Lappula occidentalis, Lepidium montanum*, and *Streptanthella longirostris*. Biological soil crusts are typically present providing low to moderate cover, up to 35%.

Globally
This woodland association is limited to sites with deep, loose sands. Total vegetation cover ranges from 21% to more than 100%. The open tree canopy of *Pinus edulis* and *Juniperus osteosperma* is typically 2-5 m tall and ranges in cover from 10 to 50%. *Fraxinus anomala* may occasionally occur as a canopy tree with sparse cover. The understory is dominated by large clumps of *Quercus havardii* var. *tuckeri* that range in cover from 2 to 65% in sand mounds between tree canopies. Associated shrubs vary depending on the aspect and the amount of soil moisture available; cooler, more mesic stands include *Amelanchier utahensis, Cercocarpus intricatus, Cercocarpus montanus, Mahonia fremontii*, and *Shepherdia rotundifolia*. In more exposed, drier stands these shrubs are mostly replaced by *Artemisia bigelovii, Ephedra viridis, Eriogonum microthecum, Gutierrezia sarothrae, Opuntia polyacantha*, and *Yucca harrimaniae*. The herbaceous layer is more consistent in species composition yet provides only sparse cover. Common graminoids include *Achnatherum hymenoides, Bouteloua gracilis, Muhlenbergia pungens*, and *Pleuraphis jamesii*. Forbs often present include species typical of sandy sites: *Cryptantha crassisepala, Cryptantha flava, Lappula occidentalis, Lepidium montanum, Streptanthella longirostris*, and *Tetraneuris acaulis*.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Amelanchier utahensis, Fraxinus anomala, Cercocarpus intricatus, Cercocarpus montanus*
Short shrub/sapling	*Quercus havardii* var. *tuckeri, Vanclevea stylosa, Ephedra viridis*
Herb (field)	*Opuntia polyacantha, Yucca harrimaniae*
Herb (field)	*Artemisia ludoviciana*
Herb (field)	*Achnatherum hymenoides, Bromus tectorum*

Globally

Stratum	Species
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Fraxinus anomala*

Short shrub/sapling *Quercus havardii* var. *tuckeri*

OTHER NOTEWORTHY SPECIES
Arches National Park
Descurainia pinnata

Globally
Bromus tectorum

CONSERVATION STATUS RANK
Global Rank & Reasons: G3? (10-Jan-2006). Because *Quercus havardii* var. *tuckeri* is restricted to southeastern Utah, this association is likely to have equally limited distribution in the Colorado Plateau. It may occur in some parts of southern Colorado. Between Arches, Canyonlands and Capitol Reef, the three national parks in which this association has been documented, there are nine small occurrences. Total number of occurrences on the Colorado Plateau is unlikely to exceed 100, and most occurrences will not exceed 5 hectares in size.

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Plant distribution is dependent on soil deposition in one wash and in slickrock fissures in a second. One site occurs on a dune and another in the bottom of a narrow slickrock canyon.
Arches National Park Field Data: The description is based on 2003 field data (4 plots: ARCH.0014, ARCH.0067, ARCH.0316, ARCH.0687, and 1 observation point: ARCH.9002).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Pinus edulis - Juniperus spp. / *Cercocarpus montanus* - Mixed Shrubs Woodland
Two-needle Pinyon - Juniper species / True Mountain-mahogany - Mixed Shrubs Woodland

CODE	CEGL000780
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a.)
ALLIANCE	*PINUS EDULIS - (JUNIPERUS* SPP.) WOODLAND ALLIANCE (A.516) Two-needle Pinyon - (Juniper species) Woodland Alliance
ECOLOGICAL SYSTEM(S):	Colorado Plateau Pinyon-Juniper Shrubland (CES304.766) Colorado Plateau Pinyon-Juniper Woodland (CES304.767) Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This broadly defined woodland association is common on the Colorado Plateau, occurring on sheltered colluvial slopes, sandstone hogbacks, dry foothills and mesas from north-central New Mexico and southern Colorado west to the Mogollon Rim of Arizona, and in western Colorado and adjacent Utah. It can be found on any slope position,

though lower slopes are less common. Elevations range from 1472 to 2480 m (4830-8135 feet). Stands occur on gentle to steep slopes on all aspects. The soils are variable but generally shallow, poorly developed and skeletal, ranging from clayey marl to loamy sands. The unvegetated surface is characterized by bedrock, large and small rocks, and/or bare soil with little litter. Sandstone or shale are the most common parent materials. This association is characterized by an open to moderately dense tree canopy (10-60% cover) dominated by a combination of *Pinus edulis* and *Juniperus* spp. with a shrub layer dominated by *Cercocarpus montanus*. The tree canopy averages 2-5 m tall, but some stands may be as tall as 10 m. *Pinus edulis* and *Juniperus* spp. codominate in most stands, but sometimes one may be more prevalent than the other. The species of *Juniperus* varies with geography and elevation and includes *Juniperus deppeana, Juniperus monosperma, Juniperus osteosperma*, and *Juniperus scopulorum*. The total shrub cover may range from sparse to moderate. *Cercocarpus montanus* is the dominant shrub with up to 35% cover. It typically occurs as a short shrub but can be a tall shrub on some sites. Other shrubs may be present, including *Amelanchier* spp., *Artemisia bigelovii, Artemisia tridentata, Ephedra viridis, Chrysothamnus viscidiflorus, Gutierrezia sarothrae, Fendlera rupicola, Garrya ovata, Mahonia* spp., *Nolina microcarpa, Quercus gambelii, Quercus grisea, Rhus trilobata*, or species of *Yucca* and *Opuntia*. Herbaceous cover is variable, ranging from sparse to moderately dense, and generally dominated by graminoids (>5% cover) with scattered forbs. Extremely open stands of this association, usually occurring on fractured slickrock exposures, may have as little as 5% total vegetation cover and an upper canopy only 2 m tall.

DISTRIBUTION

Arches National Park

This association is rare and was sampled near Klondike Bluffs, near Devil's Garden Campground, and in Winter Camp Wash within the park as well as on the Bar M loop road in the environs.

Globally

This widespread woodland association is found from southern Colorado and north-central New Mexico to the Mogollon Rim of Arizona, north across the Colorado Plateau into western Colorado and adjacent Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This woodland association occurs on sheltered colluvial slopes and sandstone hogbacks of Salt Wash or Dakota sandstone. Sites are moderately steep (up to 36% slope), lie at 1585 m elevation and are oriented to the north or northeast. The unvegetated surface has high cover of large rocks and bedrock. Litter provides low cover. Soils are rapidly drained sandy loam.

Globally

This broadly defined woodland association is common on the Colorado Plateau, occurring on sheltered colluvial slopes, sandstone hogbacks, dry foothills and mesas. It can be found on any slope position (upper, middle, or lower), though lower slopes are the least common. Elevations range from 1472 to 2480 m (4830-8135 feet). Stands occur on gentle to steep (3- to 36-degree) slopes on all aspects. The soils are variable but generally shallow, poorly developed and skeletal, ranging from clayey marl to loamy sands. The unvegetated surface is characterized by bedrock, large and small rocks, and/or bare soil. Litter has low cover. Parent materials are often sandstone or shale, but others are possible.

VEGETATION DESCRIPTION

Arches National Park

This pinyon-juniper woodland association is rare within the park. Total vegetation cover ranges from 5 to 25%. The vegetation is characterized by an open canopy of dwarfed *Pinus edulis* and *Juniperus osteosperma* trees with around 10% cover. *Cercocarpus montanus* dominates the shrub layer. Associated shrub species include *Amelanchier utahensis, Artemisia bigelovii, Ephedra viridis, Gutierrezia sarothrae*, and *Rhus trilobata* var. *trilobata*. The herbaceous layer is sparse and includes the tall bunchgrass *Leymus salinus* and the forb *Petradoria pumila*. Biological soil crusts provide sparse cover.

Globally

This association is characterized by an open to moderately dense tree canopy (10-60% cover) dominated by a combination of *Pinus edulis* and *Juniperus* spp. The canopy averages 2-5 m tall, but some stands may be as tall as 10 m. *Pinus edulis* and *Juniperus* spp. codominate in most stands, but sometimes one may be more prevalent than the other. *Pinus edulis* and *Juniperus* spp. are also present as smaller individuals in the shrub and field strata. The

species of *Juniperus* varies with geography and elevation. *Juniperus monosperma* is common in north-central New Mexico and southern Colorado. *Juniperus deppeana* is common in southern New Mexico, and *Juniperus osteosperma* is common from northwestern New Mexico west into Arizona and north into western Colorado and Utah. *Juniperus scopulorum* is more common in higher elevation stands. The total shrub cover may range from sparse to moderate. *Cercocarpus montanus* is the dominant shrub with 1-35% cover. It typically occurs as a short shrub <2 m tall but can be a tall shrub (2-5 m) on some sites. Other shrubs may be present, including *Amelanchier* spp., *Artemisia bigelovii, Artemisia tridentata, Ephedra viridis, Chrysothamnus viscidiflorus, Gutierrezia sarothrae, Fendlera rupicola, Fraxinus anomala, Garrya ovata, Mahonia* spp., *Nolina microcarpa, Purshia stansburiana, Quercus gambelii* (<5% cover), *Quercus grisea, Rhus trilobata, Symphoricarpos oreophilus*, or species of *Yucca* and *Opuntia*. Herbaceous cover is variable, ranging from sparse to moderately dense, and generally dominated by graminoids (>5% cover) with scattered forbs. Associated graminoids include *Achnatherum hymenoides, Andropogon gerardii, Aristida purpurea, Bouteloua curtipendula, Bouteloua gracilis, Bouteloua hirsuta, Carex rossii, Hesperostipa comata, Koeleria macrantha, Leymus salinus, Muhlenbergia pauciflora, Pascopyrum smithii, Pleuraphis jamesii, Poa fendleriana, Pseudoroegneria spicata*, and *Schizachyrium scoparium*. Common forbs include species of *Chamaesyce, Cryptantha, Eriogonum, Machaeranthera, Packera, Penstemon, Petradoria, Phlox*, and *Tetraneuris*. Extremely open stands of this association occurring on exposed and fractured slickrock may have as little as 5% total vegetation cover and an upper canopy only 2 m tall. Biological soil crusts are patchy but may contribute up to 27% cover and are generally well-developed.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Tall shrub/sapling	*Cercocarpus montanus*

Globally

Stratum	Species
Tree canopy	*Juniperus monosperma, Juniperus osteosperma, Pinus edulis*
Short shrub/sapling	*Cercocarpus montanus*

OTHER NOTEWORTHY SPECIES

Arches National Park
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
This is a widely distributed and variable association, found throughout much of the Colorado Plateau, edges of the Colorado Rockies and south into New Mexico. On dry, rocky or slickrock sites on the Colorado Plateau, this pinyon-juniper woodland may include stands with very open tree canopies (5-10% cover) where the total vegetation cover is less than 15%. These stands may be similar to open *Cercocarpus montanus* shrublands with scattered pinyon and juniper trees but is considered to be a variation of the woodland type because of the ecological values of the trees.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Arches National Park Inventory Notes: Site has an interesting combination of shale and slickrock elements. North-facing sandstone slabs tilt in toward the valley and support this community.
Arches National Park Field Data: The description is based on 2003 field data (4 observation points: ARCH.9018,

ARCH.9073, ARCH.9648, ARCH.9661).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Drake and J. Coles

REFERENCES: Baker 1983b, Baker 1984a, Baker and Kennedy 1985, Bourgeron and Engelking 1994, Bradley et al. 1992, CONHP unpubl. data 2003, Cogan et al. 2004, Driscoll et al. 1984, Erdman 1969, Hess and Wasser 1982, Isaacson 1967, Johnston 1987, Kennedy 1983a, Larson and Moir 1987, Marr et al. 1979, Medina 1986, Moir 1963, Moir and Carleton 1987, Moir and Ludwig 1979, Pase and Lindenmuth 1971, Stuever and Hayden 1997a, USFS 1981a, USFS 1981b, USFS 1983a, USFS 1985d, USFS 1985e, USFS 1985g, Vories 1974, Wright et al. 1979

Pinus edulis - Juniperus spp. / *Quercus gambelii* Woodland
Two-needle Pinyon - Juniper species / Gambel Oak Woodland

CODE	CEGL000791
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Evergreen woodland (II.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N)
FORMATION	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a)
ALLIANCE	*PINUS EDULIS - (JUNIPERUS* SPP.) WOODLAND ALLIANCE (A.516) Two-needle Pinyon - (Juniper species) Woodland Alliance
ECOLOGICAL SYSTEM(S):	Colorado Plateau Pinyon-Juniper Woodland (CES304.767) Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This widespread woodland association is known from the Colorado Plateau and southern Rocky Mountains, from southern Colorado to south-central New Mexico, west along the Mogollon Rim of Arizona, and north into Utah. Elevations normally range from 1509-2665 m but may be higher in stands in southern New Mexico. Sites are variable but generally are relatively mesic. Stands occur on flat to moderate slopes along drainages and on mesa tops, and on moderate to steep, rocky slopes of foothills, mountains and canyons, especially in draws where soil moisture is concentrated, or on northern aspects or where shaded by upper canyon walls. The soils are variable and range from deep to shallow, silty clay to sandy loam, and often gravelly. Litter from *Quercus gambelii* and other shrubs is often extensive (over 50% cover). The vegetation is characterized by an open to moderately dense tree canopy (10-60% cover) codominated by *Pinus edulis* and *Juniperus* spp. The species of *Juniperus* varies with geography and elevation. *Juniperus monosperma* is common in north-central New Mexico and southern Colorado. *Juniperus deppeana* is common in southern New Mexico, and *Juniperus osteosperma* is common in northwestern New Mexico, northern Arizona and in Utah. *Juniperus scopulorum* is more common in higher elevation stands. An occasional *Pinus ponderosa* tree may be present in some stands. *Quercus gambelii* dominates the often patchy, moderately dense tall-shrub layer with at least 5% cover, but often over 25% cover. *Amelanchier utahensis, Cercocarpus montanus, Symphoricarpos oreophilus*, or species of *Yucca* and *Opuntia* are common shrub associates. Herbaceous cover is variable, ranging from sparse to moderately dense, but generally dominated by graminoids (>5% cover) with scattered forbs. Associated graminoids include *Achnatherum hymenoides, Bouteloua gracilis, Carex geyeri, Carex rossii, Elymus elymoides, Festuca arizonica, Koeleria macrantha, Muhlenbergia montana, Poa fendleriana*, and *Schizachyrium scoparium*.

DISTRIBUTION
Arches National Park
This uncommon association was sampled in a tributary of Courthouse Wash and in an alcove near The Windows.

Globally
This woodland association occurs in foothills and mesas from southern Colorado to south-central New Mexico, west along the Mogollon Rim of Arizona, and north into Utah and western Colorado.

ENVIRONMENTAL DESCRIPTION

Arches National Park
This woodland association occupies mesic sites in canyon bottoms and below seeps emerging from sandstone layers. Sites tend to slope gently (<5 degrees. Elevation and aspect are not as important as landform in determining the distribution of this association; sources of water to support this mesic community are usually associated with sandstone layers such as the Entrada or Kayenta formations. Litter or bare sand covers most of the unvegetated surface. Soils are deep, moderately well drained, and sandy.

Globally
This widespread woodland association is known from the Colorado Plateau and southern Rocky Mountains, occurring from south-central Colorado to south-central New Mexico, west along the Mogollon Rim of Arizona, and north into Utah and western Colorado. Elevations normally range from 1509-2665 m but may be higher in stands in southern New Mexico. Sites are variable but generally are relatively mesic. Stands occur on flat to moderate slopes along drainages and on mesa tops, and on moderate to steep, sometimes rocky slopes of foothills, mountains and canyons, especially in draws where soil moisture is concentrated, or on northern aspects or where shaded by upper canyon walls. Stands are less common on hot south-facing slopes, unless they are located in a moisture-concentrating gully. Soils are variable and range from deep to shallow, silty clay to sandy loam, and are often gravelly or rocky. Litter from *Quercus gambelii* and other shrubs is often extensive (over 50% cover). Parent materials include alluvial, colluvial or eolian deposits derived from sandstone, shale, limestone and rhyolite.

VEGETATION DESCRIPTION
Arches National Park
Stands of this association tend to take the form of oak shrublands with scattered pinyon and juniper trees. Total vegetation cover is generally around 25%. This woodland association is characterized by an open canopy, typically 5 m tall, of scattered, large crowned *Juniperus osteosperma* with between 5 and 10% cover. *Quercus gambelii* (sometimes also the hybrid with *Quercus havardii* var. *tuckeri*) is the dominant of a mixed shrub layer that can be up to 5m tall. The shrub layer generally has higher cover than the tree layer. Other conspicuous shrubs in this community include *Amelanchier utahensis* and *Rhus trilobata*. The herbaceous layer is variable, depending on the situation, and may include upland as well as mesic species.

Globally
This widespread association is characterized by an open to moderately dense tree canopy (10-70% cover) codominated by *Pinus edulis* and *Juniperus* spp. The species of *Juniperus* varies with geography and elevation. *Juniperus monosperma* is common in north-central New Mexico and southern Colorado. *Juniperus deppeana* is common in southern New Mexico, and *Juniperus osteosperma* is common in northwestern New Mexico, northern Arizona and in Utah. *Juniperus scopulorum* is more common in higher elevation stands. An occasional *Pinus ponderosa* tree may be present is some stands. *Quercus gambelii* dominates the often patchy, moderately dense tall-shrub layer with at least 5% cover, but often with more than 25% cover. *Amelanchier utahensis, Cercocarpus montanus, Symphoricarpos oreophilus*, or species of *Yucca* and *Opuntia* are common shrub associates. Other shrubs, depending on geography, may include *Artemisia tridentata, Artemisia nova, Arctostaphylos patula, Cercocarpus ledifolius, Ephedra viridis, Fendlera rupicola, Gutierrezia sarothrae, Garrya* spp., *Mahonia fremontii, Ptelea trifoliata, Prunus* spp., *Quercus X pauciloba, Robinia neomexicana*, or *Rosa* spp. Herbaceous cover is variable, ranging from sparse to moderately dense, but generally dominated by graminoids (>5% cover) with scattered forbs. Associated graminoids include *Achnatherum hymenoides, Bouteloua gracilis, Carex geyeri, Carex rossii, Elymus elymoides, Festuca arizonica, Koeleria macrantha, Muhlenbergia montana, Poa fendleriana*, and *Schizachyrium scoparium*. Common forbs may include *Artemisia frigida, Balsamorhiza sagittata, Geranium caespitosum, Lepidium montanum, Machaeranthera grindelioides, Packera neomexicana, Thalictrum fendleri, Tetraneuris acaulis*, or *Vicia americana*.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Tall shrub/sapling	*Amelanchier utahensis*, *Quercus gambelii*, *Quercus gambelii* X *havardii*, *Rhus trilobata*
Short shrub/sapling	*Symphoricarpos longiflorus*
Herb (field)	*Apocynum cannabinum*

Herb (field)	*Poa fendleriana*

Globally

Stratum	Species
Tree canopy	*Juniperus monosperma, Juniperus osteosperma, Juniperus scopulorum, Pinus edulis*
Tall shrub/sapling	*Amelanchier utahensis, Cercocarpus montanus, Quercus gambelii*
Short shrub/sapling	*Symphoricarpos oreophilus*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Arches National Park Inventory Notes: Patchy crust on bank that is not regularly flooded. The alcove plot has moisture seeping out at points along the rocky wash bottom. Grass grows on the drier slopes above the wash.
Arches National Park Data: The description is based on 2003 and 2006 field data (1 plot: ARCH.9690 and 1 accuracy assessment point: ARCH_AA.0690).
Local Description Authors: J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: Bassett 1987, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Cogan et al. 2004, Driscoll et al. 1984, Harmon 1980, Hess and Wasser 1982, Holm 1927, Isaacson 1967, Johnston 1987, Kallender 1959, Larson and Moir 1987, Marr et al. 1973b, Muldavin et al. 1994a, Muldavin et al. 2000b, Steinhoff 1978, Stuever and Hayden 1997a, Vories 1974, Warren et al. 1982, Wright 1972, Wright et al. 1979

Elaeagnus angustifolia Semi-natural Woodland
Russian-olive Semi-natural Woodland

CODE	CEGL005269
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Deciduous woodland (II.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous woodland (II.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous woodland (II.B.2.N.)
FORMATION	Cold-deciduous woodland (II.B.2.N.a.)
ALLIANCE	*ELAEAGNUS ANGUSTIFOLIA* SEMI-NATURAL WOODLAND ALLIANCE (A.3566) Russian-olive Semi-natural Woodland Alliance
ECOLOGICAL SYSTEM(S):	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821) Western Great Plains Floodplain (CES303.678) North American Warm Desert Lower Montane Riparian Woodland and Shrubland (CES302.748) North American Warm Desert Riparian Woodland and Shrubland (CES302.753)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY

Globally

This widespread Russian-olive woodland type is found in the northern Great Plains, Colorado Plateau, and probably throughout much of the western United States and adjacent Canada. It is a naturalized species that has been widely planted in hedgerows for windbreaks. It has since spread to a variety of native habitats, particularly more mesic ones, such as near streams and rivers, although small upland stands are also known. The vegetation is dominated by *Elaeagnus angustifolia*, sometimes accompanied by *Tamarix* spp. Remnant *Populus fremontii* trees may remain as canopy emergents. Stands may be small and linear. The vegetation is dominated by the tree *Elaeagnus angustifolia* with a variety of native and introduced species in the shrub and herbaceous layers. Associated species have not been characterized. Canopy closure is between 40 and 50%., Shrub cover is provided by *Salix exigua* and *Amorpha fruticosa*. *Pascopyrum smithii, Sporobolus airoides, Distichlis spicata*, and *Hordeum jubatum* comprise the herbaceous layer in some stands; in others the understory is dominated by introduced species, such as *Lepidium latifolium, Descurainia sophia*, and *Bassia scoparia*.

DISTRIBUTION

Arches National Park

This association was found in both the upper and lower reaches of Courthouse Wash within the park.

Globally

This widespread Russian-olive woodland type is reported from the northern Great Plains, Colorado Plateau, and probably occurs throughout much of the western United States and adjacent Canada along rivers and streams, where it replaces native *Populus* spp.- and *Acer negundo*-dominated forests and woodlands.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This woodland association is restricted in its distribution, occurring on the lowest terrace in the upper reaches of Courthouse Wash. The site is flat and at 1265 m elevation. The unvegetated surface has high cover of litter and moderate exposure of bare soil. The soil is a well-drained loamy sand derived from alluvium.

Globally

This woodland type is naturalized throughout the interior West and Great Plains, probably spreading as a result of *Elaeagnus angustifolia* being widely planted in hedgerows for windbreaks. It has spread to a variety of native habitats, particularly more mesic ones, such as riverbanks, stream terraces and shorelines. Stands also occur in upland basins and drainages. Stands may be small and linear, but many extend for great distances along streams. Adjacent vegetation includes other riparian shrublands and wetlands dominated by *Salix exigua* or *Scirpus* and/or *Schoenoplectus* spp. Upland vegetation is variable.

VEGETATION DESCRIPTION

Arches National Park

woodland association is known from a single occurrence within the park. Total vegetation cover is approximately 60% in this stand. Scattered mature *Populus fremontii* trees form a very open canopy, but the vegetation is dominated by a subcanopy of *Elaeagnus angustifolia* trees with up to 25% cover. The shrub layer is poorly developed but includes a few clumps of *Salix exigua, Tamarix chinensis*, and *Chrysothamnus linifolius*. Graminoids dominate the herbaceous layer, especially *Distichlis spicata, Muhlenbergia asperifolia*, and *Pascopyrum smithii*. Forbs present include *Grindelia* sp. and *Euthamia occidentalis*.

Globally

The vegetation is dominated by the tree *Elaeagnus angustifolia* with a variety of native and introduced species in the shrub and herbaceous layers. Canopy closure is open to moderately dense (25-50% cover). In the Colorado Plateau, *Tamarix ramosissima* may be present in the tree canopy with less cover than *Elaeagnus angustifolia*, or relict *Populus deltoides* or *Populus fremontii* trees may remain as canopy emergents. Shrubs in the understory include *Salix exigua, Rhus trilobata, Artemisia tridentata ssp. tridentata, Chrysothamnus linifolius*, and *Amorpha fruticosa*. The herbaceous understory is variable in composition and abundance depending on location. Some species known to occur include *Atriplex patula, Distichlis spicata, Eleocharis palustris, Euthamia occidentalis, Glycyrrhiza lepidota, Grindelia* sp., *Hordeum jubatum, Muhlenbergia asperifolia, Pascopyrum smithii, Spartina pectinata*, and

Sporobolus airoides. Exotic herbaceous species may be common to abundant, including *Bassia scoparia, Bromus tectorum, Descurainia Sophia, Lepidium latifolium,* and *Xanthium strumarium*.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Populus fremontii*
Tree subcanopy	*Elaeagnus angustifolia*
Tall shrub/sapling	*Chrysothamnus linifolius, Salix exigua, Tamarix chinensis*
Herb (field)	*Euthamia occidentalis*
Herb (field)	*Distichlis spicata, Muhlenbergia asperifolia, Pascopyrum smithii*

Globally

Stratum	Species
Tree canopy	*Elaeagnus angustifolia*
Shrub/sapling (tall & short)	*Amorpha fruticosa, Salix exigua, Tamarix ramosissima*
Herb (field)	*Distichlis spicata, Pascopyrum smithii, Sporobolus airoides*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Polypogon monspeliensis

Globally
Lepidium latifolium

CONSERVATION STATUS RANK
Global Rank & Reasons: GNA (invasive) (5-Nov-1999).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Populus deltoides- and *Populus fremontii*-dominated associations may have significant cover of *Elaeagnus angustifolia* in the tree canopy but are generally considered native woodlands until *Elaeagnus angustifolia* comprises more than 80-90% of the tree cover. Some stands have a nearly closed tree canopy (80% cover) or may have significant gaps in the tree canopy.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Site is a narrow strip of vegetation on a terrace next to Courthouse Wash. The wash is incised approximately 1 m. The terrace occasionally floods.
Arches National Park Field Data: The description is based on 2003 and 2006 field data (1 plot*:* ARCH.0375 and 3 accuracy assessment points: ARCH_AA.0989, ARCH_AA.0981, ARCH_AA.0952).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: D. Faber-Langendoen, mod. J. Coles and K.A. Schulz

REFERENCES: Great Plains Flora Association 1986, Midwestern Ecology Working Group n.d., NDNHI n.d., Von Loh et al. 1999

Populus fremontii / Artemisia tridentata Woodland
Fremont Cottonwood / Basin Big Sagebrush Woodland

CODE	CEGL005365
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Deciduous woodland (II.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous woodland (II.B.2.)

PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous woodland (II.B.2.N.)
FORMATION	Temporarily flooded cold-deciduous woodland (II.B.2.N.b.)
ALLIANCE (A.644)	*POPULUS FREMONTII* TEMPORARILY FLOODED WOODLAND ALLIANCE Fremont Cottonwood Temporarily Flooded Woodland Alliance

ECOLOGICAL SYSTEM(S): Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This deciduous woodland association occurs on upper stream terraces and the banks of dry washes in valleys and canyon bottoms between 1220 and 1355 m elevation. These sites may flood occasionally but are located high above the water table during the growing season. Sites are generally flat with one known stand occurring on a sloping terrace. Litter covers most of the unvegetated surface with bare ground and downed wood covering the rest. Soils are rapidly drained to well-drained sandy loams derived from alluvium. The vegetation is characterized by an open to relatively closed canopy, typically 10-15 m tall, of mature to decadent *Populus fremontii* trees with up to 30% cover. The subcanopy layer, if present, includes smaller *Populus fremontii* and *Salix gooddingii* trees, and occasional *Juniperus osteosperma* may be present. *Artemisia tridentata ssp. tridentata* dominates or codominates the understory, although cover may be as low as 4%. Low cover of associated shrub species may be diverse and include *Ericameria nauseosa, Purshia stansburiana, Rhus trilobata, Rosa woodsii, Salix exigua, Sarcobatus vermiculatus*, and the vine *Clematis ligusticifolia*. Exotic shrub *Tamarix chinensis* is present in some stands. The herbaceous layer is generally diverse in terms of species composition, includes a number of exotic species, and provides sparse to moderate cover.

DISTRIBUTION

Arches National Park

This riparian association was sampled in Lower Courthouse Wash, North Fork Side Canyon of Courthouse Wash, Confluence of Courthouse Wash and Sevenmile Canyon, Salt Wash, Sevenmile Wash, Sevenmile Canyon, Cordova Canyon and Lost Spring Canyon.

Globally

This association has been described from Arches National Park in southeastern Utah. It is likely to be widespread throughout the Colorado Plateau.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This deciduous woodland association occurs on upper stream terraces and the banks of dry washes in valleys and canyon bottoms between 1220 and 1355 m elevation. These sites may flood occasionally but are located high above the water table during the growing season. Sites are generally flat with one stand occurring on a sloping terrace. Aspects are variable and range from north to east to southwest. Litter covers most of the unvegetated surface with bare ground and downed wood covering the rest. Soils are rapidly drained to well-drained sandy loams derived from alluvium.

Globally

This deciduous woodland association occurs on upper stream terraces and the banks of dry washes in valleys and canyon bottoms between 1220 and 1355 m elevation. These sites may flood occasionally but are located high above the water table during the growing season. Sites are generally flat with one known stand occurring on a sloping terrace. Litter covers most of the unvegetated surface with bare ground and downed wood covering the rest. Soils are rapidly drained to well-drained sandy loams derived from alluvium.

VEGETATION DESCRIPTION

Arches National Park

This woodland association is restricted to stream terraces or the banks of dry washes. The height of the community above the water table means that most of the understory species are upland, not riparian. Total vegetation cover is generally less than 100% in these stands. The vegetation is characterized by an open to relatively closed canopy, typically 10-15 m tall, of mature to decadent *Populus fremontii* trees with up to 30% cover. The subcanopy layer, if

present, includes smaller *Populus fremontii* and *Salix gooddingii* trees, and occasional *Juniperus osteosperma* may be present. *Artemisia tridentata ssp. tridentata* dominates or codominates the understory, although cover may be as low as 4%. Low cover of associated shrub species may be diverse and include *Ericameria nauseosa, Purshia stansburiana, Rhus trilobata, Rosa woodsii, Salix exigua, Sarcobatus vermiculatus*, and the vine *Clematis ligusticifolia*. Exotic shrub *Tamarix chinensis* is present in some stands. The herbaceous layer is generally diverse in terms of species composition, includes a number of exotic species, and provides sparse to moderate cover. Common graminoids include *Bromus tectorum, Distichlis spicata, Juncus balticus, Phragmites australis, Sporobolus airoides*, and *Sporobolus cryptandrus*. Forbs commonly present include *Conyza canadensis, Equisetum hyemale, Heterotheca villosa*, and *Melilotus officinalis*.

Globally
The vegetation is characterized by an open to relatively closed canopy, typically 10-15 m tall, of mature to decadent *Populus fremontii* trees with up to 30% cover. The subcanopy layer, if present, includes smaller *Populus fremontii* and *Salix gooddingii* trees, and occasional *Juniperus osteosperma* may be present. *Artemisia tridentata ssp. tridentata* dominates or codominates the understory, although cover may be as low as 4%. Low cover of associated shrub species may be diverse and include *Ericameria nauseosa, Purshia stansburiana, Rhus trilobata, Rosa woodsii, Salix exigua, Sarcobatus vermiculatus*, and the vine *Clematis ligusticifolia*. Exotic shrub *Tamarix chinensis* is present in some stands. The herbaceous layer is generally diverse in terms of species composition, includes a number of exotic species, and provides sparse to moderate cover.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree (canopy & subcanopy)	*Populus fremontii*
Tall shrub/sapling	*Artemisia tridentata* ssp. *tridentata*
Herb (field)	*Juncus balticus*

Globally

Stratum	Species
Tree (canopy & subcanopy)	*Populus fremontii*
Tall shrub/sapling	*Artemisia tridentata* ssp. *tridentata*
Herb (field)	*Juncus balticus*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Melilotus officinalis, Tamarix chinensis

Globally
Bromus tectorum, Melilotus officinalis, Tamarix chinensis

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (6-May-2008).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
This *Populus fremontii* woodland is very similar ecologically to *Populus deltoides (ssp. wislizeni, ssp. monilifera) / Artemisia tridentata* Woodland (CEGL005966). With upcoming taxonomic changes to *Populus fremontii* and *Populus deltoides*, these will likely be merged (Mary Ellen Ford, Colorado Native Plant Society, pers. comm. 2008).

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Arches National Park Inventory Notes: Data are not available.
Arches National Park Field Data: The description is based on 2006 field data (9 accuracy assessment points: ARCH_AA.0155, ARCH_AA.0161, ARCH_AA.0178, ARCH_AA.0781, ARCH_AA.0782, ARCH_AA.0783,

ARCH_AA.0785, ARCH_AA.0822, ARCH_AA.794).
Local Description Authors: K.A. Schulz
Global Description Authors: K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Populus fremontii / Equisetum spp. Woodland [Provisional]
Fremont Cottonwood / Horsetail species Woodland

CODE	CEGL003775
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Deciduous woodland (II.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous woodland (II.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous woodland (II.B.2.N.)
FORMATION	Temporarily flooded cold-deciduous woodland (II.B.2.N.b.)
ALLIANCE (A.644)	*POPULUS FREMONTII* TEMPORARILY FLOODED WOODLAND ALLIANCE Fremont Cottonwood Temporarily Flooded Woodland Alliance

ECOLOGICAL SYSTEM(S): Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY
Globally
This deciduous riparian woodland is found in the Colorado Plateau in southeastern Utah, where it occurs along narrow streams, on low alluvial terraces in canyon bottoms and intermittently flooded wash bottoms with a high water table. These sites flood periodically and generally have a high water table or flowing water during the growing season. Sampled sites slope gently (not exceeding 3%) at 1421-1536 m elevation. The unvegetated surface has high cover of litter. Soils are rapidly drained sandy loams derived from alluvium. The vegetation is characterized by an open tree canopy, typically 15-20 m tall, of *Populus fremontii* trees with up to 45% cover, with the understory dominated by the fern ally *Equisetum hyemale* (up to 35% cover). Flood scouring removes most vegetation except for *Equisetum* sp. Scattered shrubs and other trees species may be present, including *Juniperus osteosperma*, *Forestiera pubescens*, *Rhus trilobata*, *Salix exigua*, and *Salix lutea*, but do make a distinct shrub layer. The sparse to moderately dense herbaceous layer is moderately diverse in species composition. Other herbaceous species include relatively mesic species such as *Juncus balticus*, *Maianthemum stellatum*, *Artemisia ludoviciana* and exotic forage species *Medicago sativa*, *Melilotus officinalis*, and *Poa pratensis*.

DISTRIBUTION
Arches National Park
This association is rare in the park and most samples were located in Clover Canyon within the park. One sample was in Salt Wash.

Globally
This association is known only from Arches and Canyonlands national parks in southeastern Utah but likely occurs elsewhere in the southwestern U.S. along rivers and streams with periodic flooding.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This deciduous woodland association occurs along narrow streams and on low alluvial terraces in canyon bottoms. These sites flood periodically and generally have a high water table or flowing water during the growing season. The one sampled site slopes gently (not exceeding 3%) at 1421 m elevation. The unvegetated surface has high cover of litter. Soils are rapidly drained sandy loams derived from alluvium.

Globally
This deciduous riparian woodland is known from drainages in the Colorado Plateau in southeastern Utah. Stands occur in intermittently flooded wash bottoms with a high water table, along narrow streams and on low alluvial

terraces in canyon bottoms. These sites flood periodically and generally have a high water table or flowing water during the growing season. Sampled sites are gently sloping (not exceeding 3%) and range from 1421-1536 m elevation. The unvegetated surface has high cover of litter. Soils are rapidly drained sandy loams derived from alluvium.

VEGETATION DESCRIPTION

Arches National Park

This riparian woodland association is rare within the park. Flood scouring removes most vegetation except for *Equisetum*. Total vegetation cover can exceed 100% in this community. The vegetation is characterized by an open canopy, typically 15-20 m tall, of *Populus fremontii* trees with up to 45% cover and the fern ally *Equisetum hyemale* with up to 35% cover. Scattered individuals of other woody species may be present, including *Juniperus osteosperma, Rhus trilobata* var. *trilobata*, and *Salix lutea*. The associated herbaceous layer is moderately diverse in terms of species composition but provides only sparse to moderate cover. The forb layer includes the exotic hay species *Medicago sativa* and the native *Glycyrrhiza lepidota*. Graminoids commonly present include *Juncus balticus* and the exotic perennial *Poa pratensis*. The vine *Clematis ligusticifolia* provides sparse cover.

Globally

This riparian woodland is characterized by an open to moderate tree canopy (30-45% cover), typically 10-20 m tall, of *Populus fremontii* trees. The understory is dominated by the fern ally *Equisetum hyemale* (20-35% cover). Flood scouring removes most vegetation except for *Equisetum* sp. Scattered shrubs and other trees species may be present, including *Juniperus osteosperma, Forestiera pubescens, Rhus trilobata* var. *trilobata, Salix exigua*, and *Salix lutea*, but do make a distinct shrub layer. The vine *Clematis ligusticifolia* is usually present and may provide up to 10% cover. The sparse to moderately dense herbaceous layer is moderately diverse in species composition. Other herbaceous species include *Juncus balticus, Maianthemum stellatum, Artemisia ludoviciana, Comandra umbellata, Cirsium calcareum, Glycyrrhiza lepidota*, and exotic forage species *Medicago sativa, Melilotus officinalis*, and *Poa pratensis*.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree canopy	*Populus fremontii*
Tall shrub/sapling	*Rhus trilobata* var. *trilobata, Salix lutea*
Herb (field)	*Juncus balticus*
Herb (field)	*Equisetum hyemale*

Globally

Stratum	Species
Tree canopy	*Populus fremontii*
Herb (field)	*Equisetum hyemale*

OTHER NOTEWORTHY SPECIES

Arches National Park

Medicago sativa, Melilotus officinalis, Poa pratensis, Tragopogon dubius

Globally

Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (16-Mar-2006).

CLASSIFICATION COMMENTS

Arches National Park

Data are not available.

Globally

Populus fremontii / Scour Forest (CEGL005978) is very similar to this type. More sampling is needed to clarify differences.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Arches National Park Inventory Notes: Plot represents the most common association found on the relatively flat, lowest stream terrace levels under Fremont cottonwood canopies. The site contains a narrow (1 m), shallow, dry stream channel. Species composition varies up and down the section of this drainage.
Arches National Park Field Data: The description is based on 2003 and 2006 field data (1 plot*:* ARCH.0068, and 4 accuracy assessment points: ARCH_AA.0154, ARCH_AA.0256, ARCH_AA.0257, ARCH_AA.0258).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Populus fremontii / Ericameria nauseosa Woodland
Fremont Cottonwood / Rubber Rabbitbrush Woodland

CODE	CEGL002465
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Deciduous woodland (II.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous woodland (II.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous woodland (II.B.2.N.)
FORMATION	Temporarily flooded cold-deciduous woodland (II.B.2.N.b.)
ALLIANCE (A.644)	*POPULUS FREMONTII* TEMPORARILY FLOODED WOODLAND ALLIANCE Fremont Cottonwood Temporarily Flooded Woodland Alliance

ECOLOGICAL SYSTEM(S): Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)
North American Warm Desert Riparian Woodland and Shrubland (CES302.753)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This common woodland association occurs on the high terraces of perennial streams and on the banks of intermittent washes throughout the Colorado Plateau on sites that are rarely subject to flooding. Sites are level to gently sloping and are located between 1165 and 2165 m (3825-7100 feet) elevation. Soils are poorly developed, well-drained sands and loamy sands derived from alluvium. Total vegetation cover ranges from 34 to 170%. The 10- to 15-m tall canopy is dominated by mature *Populus fremontii* trees that range in cover from 5 to 50%. Other trees, both riparian and upland, may be present with low cover in the canopy and subcanopy, including *Populus angustifolia, Salix gooddingii*, and *Juniperus osteosperma*. Young *Populus* and *Salix* are rare, because these stands are often at least 2 m above the water table. The shrub layer is low to moderate in terms of species composition and cover. *Ericameria nauseosa* dominates or codominates the stratum, often with *Artemisia tridentata ssp. tridentata*. Other shrubs may be scattered through the stand, including *Rhus trilobata, Sarcobatus vermiculatus, Opuntia* spp., *Forestiera pubescens, Atriplex canescens,* and *Fraxinus anomala*. The exotic *Tamarix chinensis* may also be present. The herbaceous layer is diverse in terms of species composition, although many species are exotic and most reflect upland conditions. Common graminoids include *Achnatherum hymenoides, Agrostis stolonifera, Bromus tectorum, Bromus japonicus, Elymus canadensis, Sporobolus* spp., and *Juncus balticus*. Forbs commonly present include *Ambrosia acanthicarpa, Artemisia campestris, Castilleja linariifolia, Equisetum hyemale, Lepidium montanum, Sphaeralcea* spp., and *Heterotheca villosa*.

DISTRIBUTION
Arches National Park
This association locally common within the park. It was sampled in several sections of Courthouse Wash as well as in some of the larger tributaries (Sevenmile Wash), Lost Spring Canyon, Winter Camp Wash, and upper Salt Wash.

Globally
This association is described from southeastern Utah. It is likely to be widespread throughout the Colorado Plateau.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This deciduous woodland association occurs on upper stream terraces and the banks of dry washes. These sites may flood occasionally but are located high above the water table during the growing season. Sites are flat and occur between 1250 and 1256 m elevation. Litter covers most of the unvegetated surface, with bare ground and down wood covering the rest. Soils are rapidly drained to well-drained sandy loams derived from alluvium.

Globally

This common woodland association occurs on the high terraces of perennial streams and on the banks of intermittent washes throughout the Colorado Plateau. These habitats are rarely subject to flooding. Sites are level to gently sloping and are located between 1165 and 2165 m (3825-7100 feet) elevation. Aspect is not important in determining the distribution of this association. Bare soil and litter cover most of the unvegetated surface. Soils are poorly developed, well-drained sands and loamy sands derived from alluvium.

VEGETATION DESCRIPTION

Arches National Park

This woodland association is uncommon within the park. It is restricted to high terraces or the banks of dry washes. The height of the community above the water table means that most of the understory species are upland, not riparian. Total vegetation cover is generally less than 100% in these stands. The vegetation is characterized by an open to relatively closed canopy, typically 10-15 m tall, of mature to decadent *Populus fremontii* trees with up to 25% cover. The subcanopy layer, if present, includes smaller *Populus fremontii* and *Salix gooddingii* trees, and seedling *Juniperus osteosperma* may be present. *Ericameria nauseosa* short shrubs are always present in the understory, although cover may be as low as 1%. Other minor shrubs that may occur in this association include *Artemisia tridentata ssp. tridentata* and the exotic *Tamarix chinensis*, as well as *Gutierrezia sarothrae*. The herbaceous layer is diverse in terms of species composition, includes a number of exotic species, and provides sparse to moderate cover. Common graminoids include *Agrostis stolonifera, Bromus tectorum, Bromus japonicus, Elymus canadensis*, and *Juncus balticus*. Forbs commonly present include *Castilleja linariifolia, Equisetum hyemale*, and *Heterotheca villosa*. The vine *Clematis ligusticifolia* provides sparse cover in one stand.

Globally

This woodland association is common throughout the Colorado Plateau, where it occupies dry terraces along intermittent and perennial stream courses. Total vegetation cover ranges from 27 to 170%. The 10- to 15-m tall canopy is dominated by mature *Populus fremontii* trees that range in cover from 5 to 50%. Other trees, both riparian and upland, may be present with low cover in the canopy and subcanopy, including *Populus angustifolia, Salix gooddingii*, and *Juniperus osteosperma*. Young *Populus* and *Salix* are rare, because these stands are often at least 2 m above the water table. The shrub layer is low to moderate in terms of species composition and cover. *Ericameria nauseosa* dominates or codominates the stratum, often with *Artemisia tridentata ssp. tridentata*. Other shrubs may be scattered through the stand, including *Rhus trilobata, Sarcobatus vermiculatus, Opuntia* spp., *Forestiera pubescens, Atriplex canescens, Fraxinus anomala*, and in the southern extent *Parryella filifolia* and *Isocoma drummondii*. The exotic *Tamarix chinensis* may also be present. The herbaceous layer is diverse in terms of species composition, although many species are exotic, and most reflect upland conditions. Common graminoids include *Achnatherum hymenoides, Agrostis stolonifera, Bromus tectorum, Bromus japonicus, Elymus canadensis, Sporobolus airoides*, and *Juncus balticus*. Forbs commonly present include *Ambrosia acanthicarpa, Artemisia campestris, Castilleja linariifolia, Equisetum hyemale, Lepidium montanum, Sphaeralcea* spp., and *Heterotheca villosa*.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree (canopy & subcanopy)	*Populus fremontii*
Tall shrub/sapling	*Tamarix chinensis*
Short shrub/sapling	*Artemisia tridentata* ssp. *tridentata*
Herb (field)	*Clematis ligusticifolia, Artemisia campestris*
Herb (field)	*Agrostis stolonifera, Bromus japonicus, Distichlis spicata, Elymus canadensis, Juncus balticus, Vulpia octoflora*
Herb (field)	*Equisetum hyemale*

Globally

Stratum	Species
Tree canopy	*Populus fremontii*
Short shrub/sapling	*Artemisia tridentata* ssp. *tridentata, Atriplex canescens, Ericameria nauseosa*
Herb (field)	*Artemisia campestris*
Herb (field)	*Achnatherum hymenoides*

OTHER NOTEWORTHY SPECIES
Arches National Park
Melilotus officinalis, Polypogon monspeliensis, Tragopogon dubius

Globally
Bromus tectorum, Tamarix chinensis

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (24-Mar-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: One stand on a wide, flat area has heavy cover by tamarisk. This stand occasionally floods. High water tables are evident.
Arches National Park Field Data: The description is based on 2003 and 2006 field data (2 plots: ARCH.0378, ARCH.0720, and 14 accuracy assessment points: ARCH_AA.0155, ARCH_AA.0161, ARCH_AA.0163, ARCH_AA.0170, ARCH_AA.0178, ARCH_AA.0187, ARCH_AA.0476, ARCH_AA.0779, ARCH_AA.0785, ARCH_AA.0867, ARCH_AA.0875, ARCH_AA.0887, ARCH_AA.0911, ARCH_AA.0921).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles

REFERENCES: Western Ecology Working Group n.d.

Salix gooddingii / Salix exigua Woodland [Provisional]
Goodding's Willow / Coyote Willow Woodland

CODE	CEGL003778
PHYSIOGNOMIC CLASS	Woodland (II)
PHYSIOGNOMIC SUBCLASS	Deciduous woodland (II.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous woodland (II.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous woodland (II.B.2.N.)
FORMATION	Temporarily flooded cold-deciduous woodland (II.B.2.N.b.)
ALLIANCE	*SALIX GOODDINGII* TEMPORARILY FLOODED WOODLAND ALLIANCE (A.640) Goodding's Willow Temporarily Flooded Woodland Alliance

ECOLOGICAL SYSTEM(S): Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY
Globally
This riparian woodland is known from the Colorado Plateau in southeastern Utah and occurs on sandy wash bottoms in narrow slickrock canyons and intermittently flooded terraces of the Colorado River. Water tables remain at or

near the surface throughout the growing season. Sampled sites are gently sloping and occur at 1293-1738 m elevation. The unvegetated surface has high cover of litter and generally sparse cover of bare soil and large rocks. Soils are intermittently moist to saturated loamy sands to poorly drained sandy clay derived from alluvium. The vegetation is characterized by an open to moderately dense tree canopy (up to 85% cover) that is dominated by 10- to 35-m tall *Salix gooddingii* trees. Scattered *Celtis laevigata* var. *reticulata* and emergent *Populus fremontii* trees may be present in or above the tree canopy. The tall-shrub understory is dominated by *Salix exigua* usually with 35 to 45% cover, but *Forestiera pubescens* and exotic *Tamarix chinensis* can contribute significant cover. The herbaceous layer consists largely of weedy forbs but natives include *Schoenoplectus pungens* and *Typha* sp.

DISTRIBUTION

Arches National Park

This association is rare in the park and was sampled in Courthouse Wash. It may also occur in upper Salt Wash or in slickrock potholes.

Globally

This association is known only from Arches and Canyonlands national parks in southeastern Utah but likely occurs elsewhere in the southwestern U.S. along rivers and stream with periodic flooding.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This woodland association occurs on sandy wash bottoms in narrow slickrock canyons. Water tables remain at or near the surface throughout the growing season. The one sampled site is nearly flat and occurs at 1293 m elevation. The unvegetated surface has high cover of litter and moderate exposure of sand. Soils are intermittently moist to saturated loamy sands derived from alluvium.

Globally

This riparian woodland occurs on sandy wash bottoms in narrow slickrock canyons and intermittently flooded terraces of the Colorado River in the Colorado Plateau. Water tables remain at or near the surface throughout the growing season. Sampled sites are gently sloping and occur at 1293-1738 m elevation. The unvegetated surface has high cover of litter, sparse to moderate cover of sand or bare soil, and sparse cover of large rocks. Soils are intermittently moist to saturated loamy sands to poorly drained sandy clay derived from alluvium.

VEGETATION DESCRIPTION

Arches National Park

This willow woodland is rare within the park. Total vegetation cover generally exceeds 100%. The vegetation is characterized by a *Salix gooddingii* canopy up to 10 m tall with up to 85% cover and an understory dominated by *Salix exigua* with 35 to 45% cover. A sparse emergent layer of *Populus fremontii* trees from 15-20 m tall and seedling *Populus fremontii* may be present. The only associated shrub species is the exotic *Tamarix chinensis*. The herbaceous layer consists largely of weedy or exotic forbs such as *Ambrosia acanthicarpa, Salsola tragus,* and *Xanthium strumarium,* but natives include *Schoenoplectus pungens* and *Typha* sp.

Globally

This riparian woodland is characterized by an open to moderately dense tree canopy (up to 85% cover) that is dominated by 10- to 35-m tall *Salix gooddingii* trees. Scattered *Celtis laevigata* var. *reticulata* and emergent *Populus fremontii* trees may be present in or above the tree canopy. The tall-shrub understory is dominated by *Salix exigua* usually with 35 to 45% cover, but *Forestiera pubescens* and exotic *Tamarix chinensis* can contribute significant cover. The herbaceous layer consists largely of weedy or exotic forbs such as *Ambrosia acanthicarpa, Salsola tragus,* and *Xanthium strumarium,* but natives include *Schoenoplectus pungens* and *Typha* sp. Seedling *Populus fremontii* may also be present in the ground layer.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree canopy	*Populus fremontii, Salix gooddingii*
Tall shrub/sapling	*Salix exigua*
Herb (field)	*Xanthium strumarium*

Globally

Stratum	Species
Tree canopy	*Salix gooddingii*
Tall shrub/sapling	*Salix exigua*

OTHER NOTEWORTHY SPECIES
Arches National Park
Salsola tragus, Tamarix chinensis

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (20-Mar-2006).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Arches National Park Inventory Notes: Plot lies on a sandy wash bottom in a slickrock canyon. Flash flooding is common in the wash.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0704).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Fendlera rupicola Talus Shrubland
Fendlerbush Talus Shrubland

CODE	CEGL002765
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Temperate broad-leaved evergreen shrubland (III.A.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate broad-leaved evergreen shrubland (III.A.2.N.)
FORMATION	Sclerophyllous temperate broad-leaved evergreen shrubland (III.A.2.N.c.)
ALLIANCE	*FENDLERA RUPICOLA* SHRUBLAND ALLIANCE (A.2656) Fendlerbush Shrubland Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This tall shrub association occurs in patches on cool colluvial slopes in Colorado Plateau canyons. Slopes are moderate to very steep and are often oriented to the north or east. Elevations range from 1268 to 1638 m (4160-5375 ft). The high cover of rock on the ground surface acts both to concentrate runoff and as mulch to slow evaporation from the soil. Thus, relatively mesic species are able to persist on otherwise dry sites. Soils are sandy, skeletal, and derived from sandstones over shale. Stands commonly occur where Wingate sandstone colluvium has fallen onto Chinle shale slopes in canyons. Total vegetation cover ranges from 7 to 35% and is characterized by an open tall-shrub canopy of *Fendlera rupicola* that provides 1 to 12% cover. *Juniperus osteosperma* is usually present as scattered seedlings and saplings. Associated shrubs vary depending on the underlying substrate, and may include *Atriplex* spp., *Chrysothamnus viscidiflorus, Ephedra* spp., *Ericameria nauseosa, Cercocarpus montanus, Fraxinus*

anomala, Rhus trilobata, and several species of *Opuntia*. The herbaceous layer is sparse in cover and may include *Leymus salinus, Pleuraphis jamesii, Achnatherum hymenoides*, and *Hesperostipa comata*. Forbs provide sparse cover with no one species providing more than 1% cover. Cryptogam cover is also restricted, rarely covering more than 5% of the ground surface.

DISTRIBUTION

Arches National Park

This association was sampled on colluvial slopes at the Big Bend of the Colorado River, near the first set of rapids.

Globally

This association occurs on rocky canyon slopes in at least two areas of the northern Colorado Plateau of Colorado and Utah. It may also occur in northeastern Arizona.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This shrubland association occurs on colluvial of Wingate sandstone fallen onto Chinle shale slopes in canyons. The one sampled site is on a steep (58%) slope at 1268 m elevation and faces northeast. Most of the unvegetated surface is covered by gravel or large rocks. The soil is a rapidly drained loamy sand.

Globally

This tall-shrub association occurs in patches on cool colluvial slopes in Colorado Plateau canyons. Slopes are moderate to very steep and are often oriented to the north or east. Elevations range from 1268 to 1638 m (4160-5375 feet). Rocks and litter cover most of the unvegetated ground surface. The high cover of rock on the ground surface acts both to concentrate runoff and as mulch to slow evaporation from the soil. Thus, relatively mesic species are able to persist on otherwise dry sites. Soils are sandy, skeletal, and derived from sandstones over shale. Stands commonly occur where Wingate sandstone colluvium has fallen onto Chinle shale slopes in canyons. The combination of sandy rock and soils overlying a substrate that is usually a marine shale allows for both mesic and saline desert species to co-exist.

VEGETATION DESCRIPTION

Arches National Park

This shrubland association is rare, occurring as small stands in the canyon of the Colorado River. Total vegetation cover ranges from 7 to 35%. The vegetation is characterized by an open canopy dominated by *Fendlera rupicola*. Other shrubs typical of colluvial slopes such as *Atriplex confertifolia, Chrysothamnus viscidiflorus, Ephedra torreyana,* and *Ericameria nauseosa* are generally present and may have as much cover as *Fendlera*. The herbaceous layer is sparse, consisting mainly of scattered patches of *Leymus salinus* and *Pleuraphis jamesii* growing where boulders have stabilized the soils. Scattered individual *Juniperus osteosperma* trees may be present but do not form a canopy. Due to the high degree of soil movement, biological soil crusts are not typically a part of this community.

Globally

This shrubland association is rare, occurring in small stands on colluvial canyon slopes. The total vegetation cover ranges from 7 to 35% and is characterized by an open tall-shrub canopy up to 3 m tall of *Fendlera rupicola* that provides 1 to 12% cover. *Juniperus osteosperma* is usually present as scattered seedlings and saplings. Associated shrubs vary from site to site, depending on the underlying substrate, and may include *Atriplex confertifolia, Atriplex canescens, Chrysothamnus viscidiflorus, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Cercocarpus montanus, Fraxinus anomala, Rhus trilobata,* and several species of *Opuntia*. The herbaceous layer is moderate in terms of species composition but provides sparse cover. Common graminoids include *Leymus salinus, Pleuraphis jamesii, Achnatherum hymenoides,* and *Hesperostipa comata*. Forbs provide sparse cover with no one species providing more than 1% cover. Cryptogam cover is also restricted, rarely covering more than 5% of the ground surface.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tall shrub/sapling	*Fendlera rupicola*
Short shrub/sapling	*Atriplex confertifolia, Chrysothamnus viscidiflorus, Ericameria nauseosa, Ephedra*

	torreyana
Herb (field)	*Leymus salinus, Pleuraphis jamesii*

Globally

Stratum	Species
Tall shrub/sapling	*Fendlera rupicola*
Short shrub/sapling	*Ericameria nauseosa*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum

Globally
Bromus tectorum

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (12-Apr-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Fendlera rupicola is an element, and sometimes codominant, of several shrub communities described from colluvial slopes, including *Amelanchier utahensis* Shrubland (CEGL001067). There is a great deal of uncertainty in the classification of these rocky slope shrublands in general, and assignments and concepts should be continually reviewed as new data become available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: This association establishes on east-facing, steep colluvial slopes. Rocks are of different sizes and erosion gullies are present.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0711).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Artemisia filifolia Colorado Plateau Shrubland
Sand Sagebrush Colorado Plateau Shrubland

CODE	CEGL002697
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Microphyllous evergreen shrubland (III.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural microphyllous evergreen shrubland (III.A.4.N.)
FORMATION	Lowland microphyllous evergreen shrubland (III.A.4.N.a.)
ALLIANCE	*ARTEMISIA FILIFOLIA* SHRUBLAND ALLIANCE (A.816) Sand Sagebrush Shrubland Alliance
ECOLOGICAL SYSTEM(S):	Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) Inter-Mountain Basins Active and Stabilized Dune (CES304.775)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This sand sagebrush shrubland association is widespread in the Colorado Plateau of Utah, Arizona and probably New Mexico. It occurs on sandy, often somewhat disturbed sites on valley floors, stream terraces, stabilized dunes

and sandsheets, benches, floodplains and alluvial fans. Most sites are level to gently sloping, with a few on moderate slopes (up to 21%), and may be oriented to any aspect, although there is a slight tendency toward warmer southerly aspects. Elevations range from 1122 to 1769 m (3680-5803 feet). Sand or bare soil covers most of the unvegetated ground surface, although biological soil crusts may have up to 40% cover. Soils are sandy and derived from local sandstones, alluvium, or eolian deposits. Total vegetation cover ranges broadly, from sparsely vegetated disturbed sites with less than 5% total cover to stable, well-developed communities with more than 50% cover. Regardless of cover, the vegetation is characterized by an open shrub canopy dominated by *Artemisia filifolia* that is usually mixed with other shrubs, especially *Atriplex canescens, Ericameria nauseosa,* and *Opuntia* spp. Less commonly, the shrub layer will include *Vanclevea stylosa, Eriogonum leptocladon*, or *Sarcobatus vermiculatus*. *Coleogyne ramosissima, Ephedra viridis,* and *Ephedra torreyana* are generally absent or have only trace cover. The herbaceous layer is moderate in terms of species composition and provides sparse to moderate cover. Graminoids that are consistently present include *Achnatherum hymenoides* and *Bromus tectorum*; some sites may also have *Hesperostipa comata, Pleuraphis jamesii, Sporobolus cryptandrus*, and *Vulpia octoflora*. Forbs vary among sites but are typical of sandy habitats, including *Abronia fragrans, Lepidium montanum, Oenothera pallida, Salsola tragus*, and *Sphaeralcea parvifolia*. Cryptogams may be absent or may provide up to 40% cover.

DISTRIBUTION

Arches National Park

This common association was sampled within the park near Klondike Bluffs, Fiery Furnace, The Windows, The Great Wall, and Sheep Rock, as well as in Courthouse Wash, in Salt Wash, near The Organ, in Salt Valley, in Winter Camp Wash, and along Wolfe Ranch Road.

Globally

This sand sagebrush shrubland association is widespread on sandy sites in the Colorado Plateau of Utah, Colorado, Arizona and New Mexico.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This short-shrub association occurs on plateaus, valley and canyon floors and sides, stream terraces, sand dunes and benches. Stands are on flat to moderately steep slopes (up to 20%) between 1262 and 1591 m elevation. Most of the unvegetated surface is covered by sand or bare soil. A few stands have low cover of large rocks and gravel. Biological soil crusts may be absent or can provide up to 20% cover. Parent materials are Navajo and Entrada sandstones that have eroded and been re-deposited as alluvium or eolian sands. Soils are rapidly drained and usually sandy, although a few stands occur on sandy clays.

Globally

This sand sagebrush shrubland is widespread on sandy sites in the Colorado Plateau of Utah, Colorado, Arizona and New Mexico. This common association occurs on sandy sites on valley floors, valley sides, stream terraces, stabilized dunes and sandsheets, benches, floodplains, terraces and alluvial fans. Most sites are level to gently sloping, with a few on moderate slopes (up to 21%), and may be oriented to any aspect, although there is a slight tendency to occur on warmer southerly aspects. Elevations range from 1122 to 1769 m (3680-5803 feet). Sand or bare soil covers most of the unvegetated ground surface, although cryptobiological soil crusts may have up to 40% cover. Soils are sandy to sometimes gravelly and derived from local sandstones, alluvium, or eolian deposits.

VEGETATION DESCRIPTION

Arches National Park

This sand sagebrush shrubland association is common and widespread within the park. Total vegetation cover ranges from 2 to 55%, with sparser stands tending to occur on alluvial terraces. The vegetation is characterized by an open canopy of *Artemisia filifolia* that ranges in cover from 1 to 35%. Associated shrubs include *Coleogyne ramosissima, Ephedra viridis, Amsonia tomentosa, Opuntia polyacantha,* and *Vanclevea stylosa*. *Atriplex canescens* is often present in alluvial terrace stands. The herbaceous layer provides sparse to low cover. Graminoids commonly present include *Achnatherum hymenoides, Bromus tectorum, Pleuraphis jamesii*, and *Vulpia octoflora*. Common forbs include *Plantago patagonica* and *Sphaeralcea parvifolia*. Biological soil crusts are absent or provide up to 20% cover. Scattered *Juniperus osteosperma* are occasionally present.

Globally

Total vegetation cover ranges broadly, from sparsely vegetated disturbed and alluvial terrace sites with less than 5%

total cover to more stable, well-developed communities with greater than 50% cover. Regardless of cover, the vegetation is characterized by an open shrub canopy of *Artemisia filifolia*, usually mixed with other shrubs, especially *Atriplex canescens, Ericameria nauseosa*, and *Opuntia* spp. Less commonly, the shrub layer will include *Vanclevea stylosa, Eriogonum leptocladon*, or *Sarcobatus vermiculatus*. *Coleogyne ramosissima, Ephedra viridis*, and *Ephedra torreyana* are generally absent or have relatively low cover (usually <1%). The herbaceous layer is moderate in terms of species composition and provides sparse to moderate cover. Graminoids that are consistently present include *Achnatherum hymenoides* and *Bromus tectorum*; some sites may also have *Hesperostipa comata, Pleuraphis jamesii, Sporobolus cryptandrus*, and *Vulpia octoflora*. Forbs vary among sites but are typical of sandy habitats, including *Abronia fragrans, Lepidium montanum, Oenothera pallida, Salsola tragus*, and *Sphaeralcea parvifolia*. Cryptogams may be absent or may provide up to 40% cover.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Artemisia filifolia, Coleogyne ramosissima, Eriogonum leptocladon, Sarcobatus vermiculatus, Ephedra viridis*
Herb (field)	*Gutierrezia sarothrae, Opuntia polyacantha*
Herb (field)	*Amsonia tomentosa, Plantago patagonica, Streptanthella longirostris, Wyethia scabra*
Herb (field)	*Achnatherum hymenoides, Hesperostipa comata, Muhlenbergia pungens, Pleuraphis jamesii, Sporobolus airoides*

Globally

Stratum	Species
Short shrub/sapling	*Artemisia filifolia*

OTHER NOTEWORTHY SPECIES

Arches National Park
Bromus tectorum, Halogeton glomeratus, Malcolmia africana, Salsola tragus

Globally
Bromus rubens, Bromus tectorum, Halogeton glomeratus, Malcolmia africana, Salsola tragus

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (14-Aug-2001).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
This association is distinguished from other *Artemisia filifolia* shrubland associations by its restriction to the Colorado Plateau, the somewhat mixed shrub canopy that usually includes *Atriplex canescens*, a poorly-developed herbaceous layer and often a number of species that indicate disturbance or somewhat alkaline conditions. This association also occurs in a broader range of habitats than other *Artemisia filifolia* types. However, *Artemisia filifolia - Ephedra (torreyana, viridis)* Shrubland (CEGL002786) is poorly defined, and many stands of *Artemisia filifolia* Colorado Plateau Shrubland (CEGL002697) contain one or the other species of *Ephedra*; it is possible that these two associations should be combined.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES

Arches National Park Inventory Notes: Some sites have active dunes and the roots of shrubs are exposed. Drought stress is evident. One stand is in a deflation basin, one at the toe of a talus slope, and others occur on sand flats. One stand is weedy and has soils derived from a shale source instead of sandstone. Some stands have moderate biological soil crust cover. Small mammal burrows are common. Grazing by cattle was evident at two sites.
Arches National Park Field Data: The description is based on 2003 field data (13 plots: ARCH.0011, ARCH.0086, ARCH.0112, ARCH.0116, ARCH.0126, ARCH.0327, ARCH.0328, ARCH.0362, ARCH.0373, ARCH.0374,

ARCH.0678, ARCH.0686, ARCH.0697, and 13 observation points: ARCH.9637, ARCH.9640, ARCH.9659, ARCH.9022, ARCH.9021, ARCH.9352, ARCH.9306, ARCH.9323, ARCH.9321, ARCH.9320, ARCH.9004, ARCH.9358, ARCH.9355).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Cogan et al. 2004, Western Ecology Working Group n.d.

Artemisia tridentata - (Ericameria nauseosa) / Bromus tectorum Semi-natural Shrubland
Basin Big Sagebrush - (Rubber Rabbitbrush) / Cheatgrass Semi-natural Shrubland

CODE	CEGL002699
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Microphyllous evergreen shrubland (III.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural microphyllous evergreen shrubland (III.A.4.N.)
FORMATION	Lowland microphyllous evergreen shrubland (III.A.4.N.a.)
ALLIANCE	*ARTEMISIA TRIDENTATA* SHRUBLAND ALLIANCE (A.829) Basin Big Sagebrush Shrubland Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777) Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This association is common throughout the Colorado Plateau and likely occurs on disturbed sites throughout the range of basin big sagebrush in the western U.S. Stands occur in small to moderate-sized patches on alluvial terraces, floodplains, and point bars, mostly below 2000 m (6560 feet) elevation. *Artemisia tridentata ssp. tridentata* shrubs are always present, often with a lesser component of *Ericameria nauseosa, Atriplex canescens*, or *Chrysothamnus viscidiflorus*. *Bromus tectorum* dominates the occasionally sparse herbaceous layer, frequently accompanied by other weedy exotic or annual grasses and forbs. Individuals or small patches of native grasses and forbs may occur, including *Leymus cinereus, Achnatherum hymenoides*, and *Sporobolus cryptandrus*.

DISTRIBUTION
Arches National Park
This association occurs on stream terraces and in drainages of Cottonwood Canyon, Salt Wash, and Upper Salt Wash.

Globally
This association is widespread in southern Utah and western Colorado and likely occurs on disturbed sites throughout the range of basin big sagebrush in the western U.S.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This association occurs on stream terraces and sometimes within braided washes in valleys. Sites are flat or gently sloping (2 degrees) and lie between 1274 and 1354 m elevation. The unvegetated surface has sparse to high exposure of bare soil and low to high cover of litter. Biological soil crusts are minor. Soils are rapidly drained silts or loamy sands derived from alluvium.

Globally
This association occurs on alluvial terraces, flats and fans or valley floors throughout the Colorado Plateau and extends into the Great Basin. Most stands occur on level to gently sloping sites below 2000 m (6560 feet) elevation, but elevations range from 1130-2045 m. Soils are variable and include sandy loams, silt loams, and clay loams, depending on the size of the stream and the geology of the area. Parent materials is frequently alluvium but includes sandstones, shale, limestone, eolian deposits and Precambrian gneiss. The unvegetated surface often has high cover of litter and bare soil with low cover of rocks. Cryptobiotic soil crusts are often extensive (up to 15% in some

stands).

VEGETATION DESCRIPTION

Arches National Park

The sparse shrub canopy is dominated by *Artemisia tridentata ssp. tridentata* (9-30% cover) and is usually codominated by *Ericameria nauseosa* (3-18% cover) with exotic annual grass *Bromus tectorum* dominating the herbaceous layer with 9-30% cover. Other shrubs present may include *Atriplex canescens, Salix exigua, Sarcobatus vermiculatus,* and *Tamarix chinensis*. Additional herbaceous species may include *Artemisia dracunculus, Melilotus officinalis,* and *Xanthium strumarium.*

Globally

This big sagebrush association is widespread on floodplains and terraces within the Colorado Plateau that have been subject to grazing. *Artemisia tridentata ssp. tridentata* is always present in the sparse to dense shrub canopy (10-70% cover) with cover of sagebrush between 5 and 70% and up to 2 m in height. *Ericameria nauseosa* is not always present but is likely to be present in the vicinity. *Artemisia tridentata ssp. wyomingensis* may be present in some stands. Other shrubs that occur in this community consistently include *Atriplex canescens, Chrysothamnus viscidiflorus*, and *Sarcobatus vermiculatus.* Less common shrubs are *Artemisia nova, Brickellia microphylla, Ephedra viridis, Gutierrezia sarothrae, Opuntia* spp., or *Tetradymia canescens*. In some stands there may be scattered trees of *Pinus edulis, Juniperus osteosperma, Juniperus scopulorum*, and *Populus angustifolia*. The herbaceous layer reflects a long history of disturbance and is dominated by exotic annual *Bromus* species, especially *Bromus tectorum*. Other common exotic herbaceous species include *Bromus rigidus, Ceratocephala testiculata, Erodium cicutarium, Lappula occidentalis, Lactuca serriola*, and *Sisymbrium altissimum*. Because it is dominated by annual species, the total herbaceous cover varies depending on seasonal precipitation. Remnant native herbaceous vegetation may include scattered individuals or patches of *Achnatherum hymenoides, Descurainia pinnata, Elymus elymoides, Hesperostipa comata, Heterotheca villosa, Leptodactylon watsonii, Oenothera caespitosa, Senecio spartioides, Stenotus acaulis,* and others. Exotic perennial species such as *Acroptilon repens, Agropyron cristatum, Bromus inermis, Cardaria draba*, and *Carduus nutans ssp. macrolepis* may also be present because of the disturbed nature of this community.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Artemisia tridentata* ssp. *tridentata*
Herb (field)	*Bromus tectorum*

Globally

Stratum	Species
Tall shrub/sapling	*Artemisia tridentata* ssp. *tridentata*
Herb (field)	*Bromus tectorum*

OTHER NOTEWORTHY SPECIES

Arches National Park

Bromus tectorum, Melilotus officinalis, Salsola tragus, Tamarix chinensis

Globally

Acroptilon repens, Agropyron cristatum, Bromus inermis, Bromus rigidus, Bromus tectorum, Cardaria draba, Carduus nutans ssp. *macrolepis, Ceratocephala testiculata, Erodium cicutarium, Lactuca serriola, Salsola tragus, Sisymbrium altissimum*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (ruderal) (14-Aug-2001).

CLASSIFICATION COMMENTS

Arches National Park

Data are not available.

Globally

This semi-natural association is likely much more widespread across the western U.S. but is not often sampled.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Arches National Park Inventory Notes: Data are not available.
Arches National Park Field Data: The description is based on 2006 field data (4 accuracy assessment points: ARCH_AA.0097, ARCH_AA.0131, ARCH_AA.0322, ARCH_AA.0468).
Local Description Authors: K.A. Schulz
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Cogan et al. 2004, Western Ecology Working Group n.d.

Ericameria nauseosa Desert Wash Shrubland
Rubber Rabbitbrush Desert Wash Shrubland

CODE	CEGL002261
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Microphyllous evergreen shrubland (III.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural microphyllous evergreen shrubland (III.A.4.N.)
FORMATION	Lowland microphyllous evergreen shrubland (III.A.4.N.a.)
ALLIANCE	*ERICAMERIA NAUSEOSA* SHRUBLAND ALLIANCE (A.835) Rubber Rabbitbrush Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Wash (CES304.781)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This association is found in or near temporary watercourses on point bars, basin floors, and low stream terraces in western Colorado and eastern Utah. Stands have been found between 1189 and 2104 m (3900-6900 feet) elevation. Sites are flat to gently sloping (<3 degrees) and of any aspect. The unvegetated surface is mostly bare soil, sand, and/or loose rocks. There is usually little litter, but sometimes woody debris can be deposited by floods. Parent materials are variable, but sandstone, shale, and gneiss are most common on sampled stands. Soils are rapidly drained to well-drained sands or sandy loams. This shrubland association has sparse to moderate total vegetation cover (1-65%). This association is characterized by an open short-shrub layer distributed in linear rows along the intermittent drainages. *Ericameria nauseosa* is the dominant shrub with 1-15% cover. Other shrubs are typically present but contribute little cover. These include *Artemisia tridentata, Atriplex canescens, Atriplex confertifolia, Ephedra viridis, Fraxinus anomala, Gutierrezia sarothrae, Purshia stansburiana, Quercus havardii*, and *Sarcobatus vermiculatus*. The herbaceous stratum has sparse to moderate cover. The exotic *Bromus tectorum* is often abundant. Other herbaceous species commonly found are *Achnatherum hymenoides, Descurainia pinnata, Elymus elymoides, Glycyrrhiza lepidota, Hesperostipa comata, Hordeum jubatum*, and *Pleuraphis jamesii*.

DISTRIBUTION
Arches National Park
This association is uncommon and was sampled along Dalton Wells Road just outside the park as well as several places in Lost Spring Canyon, Salt Valley Wash, and Bloody Mary Wash (park entrance).

Globally
This association has been described in western Colorado and eastern Utah. It is likely found in other parts of the arid interior western U.S.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This association occurs on valley floors along intermittent stream channels. The one sampled site is at 1360 m elevation on a gently sloping wash bottom. The unvegetated surface has high cover of litter with little bare soil. Biological soil crusts provide up to 4% cover. Soils are rapidly drained silt loams derived from alluvium.

Globally

This association is found in or adjacent to temporary watercourses on point bars, basin floors, and low stream terraces. Stands have been found between 1189 and 2104 m (3900-6900 feet) elevation. Sites are flat to gently sloping (<3 degrees) and of any aspect. The unvegetated surface is mostly bare soil, sand, and/or loose rocks. There is usually little litter, but sometimes woody debris can be deposited by floods. Parent materials are variable, but sandstone, shale, and gneiss are most common on sampled stands. Soils are rapidly drained to well-drained sands, sandy loams or silt loams derived from alluvium. Biological soil crusts may be present but do not provide much cover.

VEGETATION DESCRIPTION

Arches National Park

This desert wash type is uncommon within the park, as it is limited to canyons narrow enough to experience periodic scouring but wide enough to allow the development of alluvial terraces. Total vegetation cover ranges from 17 to 65%. The vegetation is dominated by an open canopy of *Ericameria nauseosa* ranging in cover from 5 to 15%, often mixed with lesser amounts of other shrubs typical of desert washes, such as *Fraxinus anomala, Atriplex canescens, Atriplex confertifolia, Purshia stansburiana, Sarcobatus vermiculatus*, and *Quercus havardii*. The herbaceous layer is diverse but provides sparse cover. Grasses include *Achnatherum hymenoides, Elymus elymoides*, and *Pleuraphis jamesii*. The most abundant forbs include *Descurainia pinnata* and *Glycyrrhiza lepidota*. Biotic soil crusts provide up to 4% cover.

Globally

This shrubland association has sparse to moderate total vegetation cover (1-65%). It is characterized by an open to moderately dense short-shrub layer distributed in linear rows along the intermittent drainages. Ericameria nauseosa is the dominant shrub with 1-15% cover. In sparse or patchy stands, *Ericameria nauseosa* acts as an indicator species. Other shrubs are typically present, but contribute little cover. These include *Artemisia tridentata, Atriplex canescens, Atriplex confertifolia, Ephedra viridis, Fraxinus anomala, Gutierrezia sarothrae, Purshia stansburiana, Quercus havardii*, and *Sarcobatus vermiculatus*. The herbaceous stratum has sparse to moderate cover. The exotic *Bromus tectorum* is often abundant. Other herbaceous species commonly found are *Achnatherum hymenoides, Descurainia pinnata, Elymus elymoides, Glycyrrhiza lepidota, Hesperostipa comata, Hordeum jubatum*, and *Pleuraphis jamesii*.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Atriplex canescens, Atriplex confertifolia, Ericameria nauseosa, Quercus havardii* var. *tuckeri, Sarcobatus vermiculatus, Purshia stansburiana*
Herb (field)	*Descurainia pinnata, Glycyrrhiza lepidota*

Globally

Stratum	Species
Short shrub/sapling	*Ericameria nauseosa*

OTHER NOTEWORTHY SPECIES

Arches National Park

Salsola tragus

Globally

Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (10-Jan-2005).

CLASSIFICATION COMMENTS

Arches National Park

Data are not available.

Globally

In sparse or patchy stands, *Ericameria nauseosa* acts as an indicator species.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Cattle have grazed the sampled stand. Site is located in floodplain on terrace that hasn't flooded recently, although smaller overflow channels are present; there are biological soil crusts present.
Arches National Park Field Data: The description is based on 2003 and 2006 field data (1 plot*:* ARCH.0078, and 7 accuracy assessment points: ARCH_AA.0259, ARCH_AA.0383, ARCH_AA.0437, ARCH_AA.0470, ARCH_AA.0546, ARCH_AA.0993, ARCH_AA.1006).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Drake, mod. J. Coles and K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Tamarix spp. Temporarily Flooded Semi-natural Shrubland
Salt-cedar species Temporarily Flooded Semi-natural Shrubland

CODE	CEGL003114
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Microphyllous evergreen shrubland (III.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural microphyllous evergreen shrubland (III.A.4.N.)
FORMATION	Temporarily flooded microphyllous shrubland (III.A.4.N.c.)
ALLIANCE	*TAMARIX* SPP. SEMI-NATURAL TEMPORARILY FLOODED SHRUBLAND ALLIANCE (A.842) Salt-cedar species Semi-natural Temporarily Flooded Shrubland Alliance
ECOLOGICAL SYSTEM(S):	North American Warm Desert Lower Montane Riparian Woodland and Shrubland (CES302.748) North American Warm Desert Riparian Woodland and Shrubland (CES302.753) Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY
Globally
This broadly defined association is composed of shrublands which form moderately dense to dense thickets on banks of larger streams across the western Great Plains, interior and southwestern U.S. and northern Mexico. Stands are dominated by introduced species of *Tamarix*, including *Tamarix ramosissima, Tamarix chinensis, Tamarix gallica*, and *Tamarix parviflora*. *Tamarix* spp. were introduced from the Mediterranean and have become naturalized in various sites, including salt flats and other saline habitats, springs, and especially along streams and regulated rivers, where it replaces the native vegetation, such as shrublands dominated by species of *Salix* or *Prosopis* or woodlands of *Populus* spp. A remnant herbaceous layer may be present, depending on the age and density of the shrub layer, although in many cases this layer also consists of aggressive exotic species such as *Lepidium latifolium*. *Tamarix* species have become a critical nuisance along most large rivers in the semi-arid West and, because of permanent changes in flood regimes and the difficulty of removing trees, reflect irreversibly changed vegetation on many sites.

DISTRIBUTION
Arches National Park
This community is widespread and was sampled in Salt Wash, Courthouse Wash, Sevenmile Canyon, and Winter Camp Wash. Because the park is vigorously removing tamarisk, some of these stands may no longer exist.

Globally
This tall shrubland is found along drainages in the semi-arid western Great Plains, interior and southwestern U.S. and northern Mexico, from central and eastern Montana, south to Colorado, western Oklahoma and Texas, and west to California.

ENVIRONMENTAL DESCRIPTION

Arches National Park
This invasive tall-shrub association is widespread in wash and arroyo bottoms and alluvial terraces throughout the park. Sites are flat to gently sloping (up to 3% gradient). The unvegetated surface has high cover of litter. Soils are poorly developed, well-drained clays and sands derived from alluvium.

Globally
These widespread shrublands are common along larger streams, rivers, and around playas in the western U.S. and Mexico. Elevation ranges from 75 m below sea level to 1860 m. *Tamarix* spp. have become naturalized in various sites including riverbanks, floodplains, basins, sandbars, side channels, springs, salt flats, and other saline habitats. Stands grow especially well along regulated rivers where flood-regenerated native species such as *Populus* are declining, and the absence of regular scouring floods allows *Tamarix* seedlings to become established. Substrates are commonly thin sandy loam soil over alluvial deposits of sand, gravel or cobbles.

VEGETATION DESCRIPTION
Arches National Park
This tamarisk community is less continuous in its distribution than formerly, thanks to an eradication program undertaken by park staff. It is now limited to relatively short reaches along park streams. Total vegetation cover ranges from 55 to 120%. The canopy is composed of open to dense stands of *Tamarix chinensis* shrubs up to 5 m in height. The associated shrub layer is sparse due to the shading and salt concentration of tamarisk but may include *Ericameria nauseosa* and *Sarcobatus vermiculatus*. The herbaceous layer also tends to be sparse. Graminoids include *Agrostis stolonifera, Bromus tectorum, Distichlis spicata, Elymus canadensis, Hordeum jubatum, Juncus balticus, Muhlenbergia asperifolia*, and *Polypogon monspeliensis*. The forb layer may include *Grindelia* sp. and *Heterotheca villosa*.

Globally
This semi-natural shrubland occurs along streams, rivers and playas where it forms a moderate to dense tall-shrub layer that is solely or strongly dominated by species of *Tamarix*, including *Tamarix ramosissima, Tamarix chinensis, Tamarix gallica*, and *Tamarix parviflora*. Other shrubs may include species of *Salix* (especially *Salix exigua*) and *Prosopis, Rhus trilobata*, and *Sarcobatus vermiculatus* but with low cover (if shrub species are codominant, then the stand is classified as a natural shrubland). Scattered *Acer negundo, Salix amygdaloides, Populus* spp., or *Elaeagnus angustifolia* trees may also be present. Depending on stand age and density of the shrub layer, an herbaceous layer may be present. Associated native species include *Distichlis spicata* and *Sporobolus airoides*, and introduced species include *Agrostis gigantea, Agrostis stolonifera*, and *Poa pratensis*. Introduced herbaceous species such as *Polypogon monspeliensis, Conyza canadensis, Lepidium latifolium*, and others have been reported from shrublands in this association.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tall shrub/sapling	*Tamarix chinensis*
Short shrub/sapling	*Ericameria nauseosa, Sarcobatus vermiculatus*
Herb (field)	*Artemisia ludoviciana, Salsola tragus, Sisymbrium altissimum*
Herb (field)	*Agrostis stolonifera, Distichlis spicata, Elymus canadensis, Hordeum jubatum, Juncus balticus, Muhlenbergia asperifolia, Polypogon monspeliensis*

Globally

Stratum	Species
Tall shrub/sapling	*Tamarix chinensis, Tamarix gallica, Tamarix parviflora, Tamarix ramosissima*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Chenopodium album, Lactuca serriola, Xanthium strumarium

Globally
Bromus tectorum, Lepidium latifolium, Poa pratensis

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (invasive) (24-Jul-2001).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
This is a broadly defined plant association that is composed of many diverse *Tamarix* spp.-dominated vegetation communities from a wide variety of environments. Muldavin et al. (2000a) described 8 community types that will be reviewed as possible USNVC associations.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Arches National Park Inventory Notes: This community is present on the banks and terraces of larger streams.
Arches National Park Field Data: The description is based on 2003 field data (2 plots: ARCH.0113, ARCH.0356 and 5 observation points: ARCH.9026, ARCH.9333, ARCH.9374, ARCH.9670, ARCH.9687).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: Baalman 1965, Carsey et al. 2003a, Cogan et al. 2004, Cowardin et al. 1979, Hansen et al. 1995, Hansen et al. 2004b, Hoagland 2000, Holland 1986b, MTNHP 2002b, Muldavin et al. 2000a, Nachlinger and Reese 1996, Ortenberger and Bird 1933, Paysen et al. 1980, Sawyer and Keeler-Wolf 1995, Smith 1989, Stevens and Shannon 1917, Szaro 1989, Ungar 1968, Von Loh et al. 2002, Ware and Penfound 1949, Western Ecology Working Group n.d.

Artemisia bigelovii - Ephedra (viridis, torreyana) Talus Shrubland
Bigelow Sagebrush - (Mormon-tea, Torrey's Joint-fir) Talus Shrubland

CODE	CEGL003755
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland (III.A.5.N.a.)
ALLIANCE	*ARTEMISIA BIGELOVII* SHRUBLAND ALLIANCE (A.1103) Bigelow Sagebrush Shrubland Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765)
Colorado Plateau Mixed Low Sagebrush Shrubland (CES304.762)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This mixed colluvial slope shrubland is known from Arches and Canyonlands national parks and Glen Canyon National Recreation Area in Utah and likely is more widespread throughout the canyonlands of the Colorado Plateau. This sparse mixed shrubland occurs on the colluvial deposits that form the lower slopes of canyons and valleys and on mesatops, steep canyonsides, benches, hills and escarpments. Most stands are on steep slopes (2-80%) between 1193 and 1673 m elevation and tend to occur on warmer exposures. Most of the unvegetated surface is covered by large rocks, gravel and bare soil. The substrate is complex and variable and often consists of an underlying shale covered by fragments of sandstone fallen from cliffs above. Soils are rapidly drained stony sandy loams, loamy sands, and clay loams. The vegetation is characterized by a sparse mixed short-shrub canopy scattered among boulders, which often are larger than the vegetation. Total vegetation cover ranges from 2 to 25% but is usually less than 15%. *Artemisia bigelovii* is always present but may not be dominant. As many as 15 species of shrubs may be associated with this community, none with more than a few percent cover, including *Atriplex canescens, Atriplex confertifolia, Brickellia grandiflora, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Echinocereus triglochidiatus, Ericameria nauseosa, Eriogonum corymbosum,* and *Gutierrezia sarothrae*. *Rhus*

trilobata and *Fraxinus anomala* are generally absent but may be present with very low relative cover. Only scattered herbaceous species are present, providing sparse cover. Common graminoids include *Achnatherum hymenoides, Aristida purpurea*, and *Pleuraphis jamesii*. Forbs occasionally present include *Chamaesyce fendleri, Eriogonum inflatum, Lepidium montanum,* and *Stanleya pinnata*. Biological soil crusts are absent or provide sparse cover. *Juniperus osteosperma* sapling or dwarf-trees are often present with too little cover to constitute a stratum.

DISTRIBUTION

Arches National Park

This association occurs at the base of the valley and canyon sides in Salt Valley, Cache Valley and Salt Wash, below Klondike Bluffs, and along the old highway right-of-way.

Globally

This association is known from Arches and Canyonlands national parks and Glen Canyon National Recreation Area and likely is widespread throughout the canyonlands of the Colorado Plateau in eastern Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This sparse mixed shrubland occurs on the colluvial deposits that form the lower slopes of canyons and valleys in the park. Most stands are on steep slopes (42 to 65%) between 1402 and 1567 m elevation and tend to occur on warmer exposures. Most of the unvegetated surface is covered by large rocks, gravel and bare soil. The substrate is complex and usually consists of an underlying shale (e.g., Chinle, Moenkopi, Brushy Basin) covered by fragments of sandstone (e.g., Salt Wash, Wingate) fallen from cliffs above. Soils are rapidly drained stony sandy loams, loamy sands, and clay loams.

Globally

This sparse mixed shrubland occurs on the colluvial deposits that form the lower slopes of canyons and valleys and on mesatops, benches, hills and escarpments. Stands are on gentle to more typically steep slopes (2-80%) between 1193 and 1673 m elevation and tend to occur on warmer exposures. Most of the unvegetated surface is covered by large rocks, gravel and bare soil with sparse cover of litter, downed wood and cryptogamic soil crust. The substrate is complex and variable and often consists of an underlying shale covered by fragments of sandstone fallen from cliffs above. Soils vary in texture and parent materials. Most are rapidly drained, stony or sandy loam, loamy sand and clay loam in texture and are derived from Cedar Mesa sandstone, Chinle, Moenkopi and Honaker Trail formations.

VEGETATION DESCRIPTION

Arches National Park

This mixed colluvial slope community is common within the park but poorly sampled because of the difficulty of the terrain upon which it occurs. Total vegetation cover ranges from 2 to 25% but is usually less than 15%. This association is characterized by a sparse mixed short-shrub canopy scattered among boulders, which often are larger than the vegetation. *Artemisia bigelovii* is always present but may not be dominant. As many as 15 species of shrubs may be associated with this community, none with more than a few percent cover, including *Coleogyne ramosissima, Ephedra torreyana, Ephedra viridis, Gutierrezia sarothrae, Brickellia grandiflora, Atriplex canescens, Atriplex confertifolia, Ericameria nauseosa,* and *Chrysothamnus viscidiflorus*. *Rhus trilobata* var. *trilobata* and *Fraxinus anomala* are absent or have very low relative cover. Only scattered herbaceous species are present, providing sparse cover. Common graminoids include *Achnatherum hymenoides, Aristida purpurea*, and *Pleuraphis jamesii*. Forbs occasionally present include *Eriogonum inflatum* and *Lepidium montanum*. Biological soil crusts are absent or provide sparse cover. Dwarfed *Juniperus osteosperma* trees are often present with too little cover to constitute a stratum.

Globally

Total vegetation cover ranges from 2 to 25% but is usually less than 15%. It is a mix of xeric shrubs, among which *Artemisia bigelovii* and *Ephedra torreyana* or *Ephedra viridis* are conspicuous, although not always dominant. Many other shrub species are usually present, including *Atriplex canescens, Atriplex confertifolia, Brickellia grandiflora, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Echinocereus triglochidiatus, Ericameria nauseosa, Eriogonum corymbosum,* and *Gutierrezia sarothrae*. *Rhus trilobata* and *Fraxinus anomala* are absent or have no more than trace cover. The herbaceous layer may include many species or few species but is always sparse. *Pleuraphis jamesii, Achnatherum hymenoides, Aristida purpurea, Chamaesyce fendleri, Eriogonum inflatum,*

Lepidium montanum, and *Stanleya pinnata* are the most consistent species. Biological soil crust formation is rare on active slopes, but may be provide sparse cover on gentle slopes. *Juniperus osteosperma* sapling or dwarf-trees are often present with too little cover to constitute a stratum.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Atriplex confertifolia, Chrysothamnus viscidiflorus, Ericameria nauseosa*
Short shrub/sapling	*Artemisia bigelovii, Atriplex canescens, Ephedra torreyana, Ephedra viridis, Purshia stansburiana*
Herb (field)	*Gutierrezia sarothrae*
Herb (field)	*Achnatherum hymenoides, Pleuraphis jamesii*

Globally

Stratum	Species
Short shrub/sapling	*Artemisia bigelovii, Ephedra torreyana, Ephedra viridis*

OTHER NOTEWORTHY SPECIES

Arches National Park
Bromus tectorum, Descurainia pinnata

Globally
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (13-Mar-2006).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
This colluvial slope shrubland association is broadly defined by low cover of common shrub species. The colluvial slope appears to be a defining characteristic as *Artemisia bigelovii, Ephedra torreyana, Ephedra viridis*, and *Gutierrezia sarothrae* are also common on mesatops and ridges. Additional classification work is needed to clarify these colluvial slope types from similar sparsely vegetated types.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Arches National Park Inventory Notes: Stands occur on ledges or very rocky slopes, usually with shallow soils. Some slopes are active. Sheet and rill erosion is evident. Some stands are drought-affected with dead shrubs present.
Arches National Park Field Data: The description is based on 2003 field data (2 plots: ARCH.0348, ARCH.0666, and 3 observation points: ARCH.9325, ARCH.9042, ARCH.9651).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Ephedra torreyana / Achnatherum hymenoides - Pleuraphis jamesii Shrubland
Torrey's Joint-fir / Indian Ricegrass - James' Galleta Shrubland

CODE	CEGL002352
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)

FORMATION	Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland (III.A.5.N.a.)
ALLIANCE	*EPHEDRA TORREYANA* SHRUBLAND ALLIANCE (A.2572) Torrey's Joint-fir Shrubland Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788) Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) Inter-Mountain Basins Active and Stabilized Dune (CES304.775)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This shrubland association occurs in large patches on broad sandy plains, as well as in smaller patches on knolls, toeslopes and pediments. Sites are flat to gentle (up to 8-degree slopes), occur between 1220 and 2000 m elevation, and tend to be oriented to warm south or west aspects. The unvegetated surface has up to 90% exposure of sand or bare soil. Parent materials include Entrada, Navajo, Summerville and Carmel formation materials that have eroded to alluvial or eolian sands and clays. Soils are rapidly drained to well-drained loamy sands where derived from secondary materials or sandy clays where derived from underlying shales. Total vegetation cover ranges from 5 to 25% in this variable community, which includes stands that are shrub-herbaceous in structure as well as shrublands and sparse vegetation. Vegetation composition is characterized by an open canopy of *Ephedra torreyana* that ranges between 2 to 25% cover, with an understory codominated by *Achnatherum hymenoides* and *Pleuraphis jamesii* with between 2 and 15% cover. Associated shrubs include *Atriplex canescens*, *Opuntia polyacantha*, and *Gutierrezia sarothrae*. *Coleogyne ramosissima* is absent or has 1% or less cover. The remaining herbaceous layer often includes *Astragalus amphioxys, Malacothrix sonchoides, Sporobolus airoides, Sporobolus flexuosus,* and *Sphaeralcea parvifolia*.

DISTRIBUTION

Arches National Park

This association is rare and was sampled near the confluence of Drinks Canyon with the Colorado River.

Globally

This association is known from scattered sites in southeastern Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This short-shrub association occurs on alluvial fans in the Colorado River canyon. Sites are on gentle slopes at around 1220 m elevation on southeast aspects. The unvegetated surface is covered by bare soil and gravel. Litter is sparse. Soils are rapidly drained loamy sand derived from alluvium.

Globally

This shrubland association occurs in large patches on broad sandy plains, as well as in smaller patches on knolls, toeslopes and pediments. Sites are flat to gentle (up to 8-degree slopes), occur between 1220 and 2000 m elevation, and tend to be oriented to warm south or west aspects. The unvegetated surface has high exposure of sand and bare soil (up to 90%) and sparse to low cover of litter. Parent materials include Entrada, Navajo, Summerville and Carmel formation exposures that have eroded to alluvial or eolian sands. Soils are rapidly drained to well-drained loamy sands where derived from secondary materials or sandy clays where derived from underlying shales.

VEGETATION DESCRIPTION

Arches National Park

This association is rare within the park and was sampled only once. Total vegetation cover does not exceed 20% in this type. The vegetation is characterized by a sparse canopy of *Ephedra torreyana* with up to 15% cover. The grasses *Achnatherum hymenoides* and *Pleuraphis jamesii* dominate a sparse herbaceous understory. Forbs are variable and inconsistent but include *Eriogonum inflatum, Streptanthella longirostris, Gaillardia pinnatifida, Machaeranthera canescens*, and *Tiquilia latior*. Biological soil crusts provide sparse cover.

Globally

Total vegetation cover ranges from 5 to 25% in this variable community, which includes stands that are shrub-herbaceous in structure as well as shrublands and sparse vegetation. Vegetation composition is characterized

by an open canopy of *Ephedra torreyana* that ranges between 2 to 25% cover, with an understory codominated by *Achnatherum hymenoides* and *Pleuraphis jamesii* with between 2% and 15% cover. Associated shrubs include *Atriplex canescens, Opuntia polyacantha,* and *Gutierrezia sarothrae*. *Coleogyne ramosissima* is absent or has 1% or less cover. The remaining herbaceous layer often includes *Astragalus amphioxys, Malacothrix sonchoides, Sporobolus airoides, Sporobolus flexuosus,* and *Sphaeralcea parvifolia*.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Ephedra torreyana*
Herb (field)	*Achnatherum hymenoides*

Globally

Stratum	Species
Short shrub/sapling	*Atriplex canescens, Ephedra torreyana*
Herb (field)	*Gutierrezia sarothrae, Opuntia polyacantha*
Herb (field)	*Achnatherum hymenoides, Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES

Arches National Park
Bromus tectorum, Salsola tragus

Globally
Salsola tragus

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (21-Mar-2005).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Arches National Park Inventory Notes: The site is moderately gullied.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0713).
Local Description Authors: J. Coles
Global Description Authors: J. Coles

REFERENCES: Western Ecology Working Group n.d.

Ephedra torreyana / Pleuraphis jamesii Shrubland
Torrey's Joint-fir / James' Galleta Shrubland

CODE	CEGL003772
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland (III.A.5.N.a.)
ALLIANCE	*EPHEDRA TORREYANA* SHRUBLAND ALLIANCE (A.2572) Torrey's Joint-fir Shrubland Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This short-shrub association occurs on typically deep alkaline soils on plateaus, mesas, benches, lower slopes and stream terraces in the canyonlands of the Colorado Plateau. Sites are flat to moderately steep (up to 32% slopes) and occur between 1226 and 1506 m elevation. The unvegetated surface has high cover of bare soil and/or gravel with sparse cover of litter. Soils are rapidly drained loamy sands and clay loams. The vegetation ranges from 5 to 25% total cover and is characterized by an open canopy of *Ephedra torreyana* shrubs with up to 15% cover and the short bunchgrass *Pleuraphis jamesii* that ranges in cover from 1 to 5%. Associated shrubs *Atriplex gardneri* and *Coleogyne ramosissima* may be present to codominant. Other shrubs may include *Atriplex confertifolia, Ericameria nauseosa, Eriogonum microthecum, Opuntia* spp., and *Sclerocactus whipplei* The remaining herbaceous component includes grasses such as *Achnatherum hymenoides, Sporobolus cryptandrus,* and *Vulpia octoflora*, and the forbs *Amsonia tomentosa, Chenopodium album, Lepidium lasiocarpum, Plantago patagonica*, and *Streptanthella longirostris*. Biological soil crusts provide sparse cover in some stands.

DISTRIBUTION

Arches National Park

This association is uncommon and was sampled within the park in the Salt Valley, in Negro Bill Canyon, and in the Big Bend area of the Colorado River. Torrey's joint-fir, Indian ricegrass, and James' galleta are widespread throughout the park on many substrates and in many habitats.

Globally

This association is known from Arches and Canyonlands national parks and Glen Canyon National Recreation Area in eastern Utah and likely is widespread throughout the canyonlands of the Colorado Plateau in eastern Utah and possibly southern Arizona.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This short-shrub association occurs on slopes and stream terraces. Sites are flat to moderately steep (up to 32% slopes) and occur between 1226 and 1378 m elevation. The unvegetated surface has up to 96% cover by bare soil, and sparse cover of litter. Parent materials are variable and include alluvium and Mancos shale (Ferron Member). Soils are rapidly drained loamy sands and clay loams.

Globally

This desert short-shrub association occurs on deep alkaline soils on plateaus, mesas, benches, lower slopes and stream terraces in canyonlands of the Colorado Plateau. Sites are flat to moderately steep (up to 32% slopes) and occur between 1226 and 1506 m elevation. The unvegetated surface has high cover of bare soil and/or gravel with sparse cover of litter. Soils are rapidly drained loamy sands, clays or sandy loams derived from alluvium, Mancos shale, Moenkopi Formation or White Rim sandstone.

VEGETATION DESCRIPTION

Arches National Park

This shrub association is uncommon within the park. Total vegetation cover ranges from 5 to 25% and is characterized by an open canopy of *Ephedra torreyana* shrubs with up to 15% cover and the short bunchgrass *Pleuraphis jamesii* that ranges in cover from 1 to 5%. Associated shrubs include *Atriplex gardneri* and *Coleogyne ramosissima* and may be present to codominant. The remaining herbaceous component includes the forbs *Lepidium lasiocarpum, Plantago patagonica*, and *Streptanthella longirostris*. Biological soil crusts provide sparse cover in some stands.

Globally

The vegetation ranges from 5 to 25% total cover and is characterized by an open canopy of *Ephedra torreyana* with up to 15% cover and perennial grasses, especially the short bunchgrass *Pleuraphis jamesii,* which ranges in cover from 1 to 6%. Associated shrubs *Atriplex gardneri* and *Coleogyne ramosissima* may be present to codominant. Other shrubs include *Atriplex confertifolia, Ericameria nauseosa, Eriogonum microthecum, Opuntia erinacea, Opuntia phaeacantha, Opuntia polyacantha*, and *Sclerocactus whipplei*. Other herbaceous species include occasional clumps of *Achnatherum hymenoides, Sporobolus cryptandrus, Vulpia octoflora*, and the exotic annual

Bromus tectorum. Forbs commonly present include *Amsonia tomentosa, Chenopodium album, Lepidium lasiocarpum, Plantago patagonica, Sphaeralcea leptophylla, Streptanthella longirostris*, and the exotic annual *Salsola tragus*. Biological soil crust cover is variable, with some stands having up to 33% cover by mosses and dark cyanobacteria.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia, Coleogyne ramosissima, Ephedra torreyana, Eriogonum bicolor*
Herb (field)	*Pleuraphis jamesii, Sporobolus cryptandrus*

Globally

Stratum	Species
Short shrub/sapling	*Coleogyne ramosissima*
Short shrub/sapling	*Ephedra torreyana*
Herb (field)	*Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES

Arches National Park
Bromus tectorum

Globally
Sclerocactus whipplei

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (30-Mar-2006).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
Except for the absence of *Achnatherum hymenoides*, this association is very similar to *Ephedra torreyana / Achnatherum hymenoides - Pleuraphis jamesii* Shrubland (CEGL002352). More survey and classification work are needed to clarify differences.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Arches National Park Inventory Notes: One stand occupies steep rocky colluvium, another a badlands hill, and another a stream terrace. One site is grazed.
Arches National Park Field Data: The description is based on 2003 field data (3 plots: ARCH.0326, ARCH.0712, ARCH.0719, and two observation points: ARCH.9307, ARCH.9636).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Ephedra viridis / (Achnatherum hymenoides, Hesperostipa comata) Shrubland
Mormon-tea / (Indian Ricegrass, Needle-and-Thread) Shrubland

CODE	CEGL002354
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland (III.A.5.N.a.)
ALLIANCE	*EPHEDRA VIRIDIS* SHRUBLAND ALLIANCE (A.858)

Mormon-tea Shrubland Alliance

ECOLOGICAL SYSTEM(S): North American Warm Desert Active and Stabilized Dune (CES302.744)
Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763)
Inter-Mountain Basins Active and Stabilized Dune (CES304.775)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This short-shrub association occurs on sand dunes and sandsheets deposited on plateaus, benches and valley floors in southeastern Utah. Stands of this association usually occur as patches of one to several hectares within a matrix of other sandy communities dominated by *Coleogyne ramosissima* and *Artemisia filifolia*. Sites occupy gentle to moderately steep slopes (1-45%) between 1378 and 2018 m elevation and oriented to a variety of aspects, with a slight tendency toward northern and eastern aspects. The unvegetated surface has up to 96% sand or bare soil, with the balance covered by litter or dark cyanobacteria. Soils are rapidly drained loamy sands and sandy loams derived from eolian sands or alluvial deposits. Total vegetation cover ranges from 1 to 55% but generally is around 35%. The vegetation is characterized by an open canopy of clonal *Ephedra viridis* shrubs with between 5 and 20% cover with a well-developed grassy understory dominated by either *Achnatherum hymenoides* or *Hesperostipa comata*. The herbaceous layer totals up to 35% cover. Associated shrubs include scattered *Coleogyne ramosissima, Atriplex canescens, Eriogonum leptocladon,* and the succulent *Opuntia polyacantha*. Other grasses include *Aristida purpurea, Muhlenbergia pungens, Sporobolus cryptandrus,* and *Bouteloua gracilis*. If *Pleuraphis jamesii* is present, it is with much less cover than either *Hesperostipa comata* or *Achnatherum hymenoides*. Forbs include many species typical of sandy communities, including *Abronia fragrans, Chaenactis stevioides, Cymopterus newberryi, Oenothera pallida, Machaeranthera canescens, Plantago patagonica,* and *Sphaeralcea parvifolia*. Cryptogams are often present and provide up to 25% cover.

DISTRIBUTION

Arches National Park

This association is uncommon and was sampled on sandy soils of Lost Spring Canyon, Eagle Park, south of The Windows, The Highlands, the pipeline route, and in the Salt Valley within the park, as well as Dalton Wells road in the environs.

Globally

This association is locally common on sandy sites in the Colorado Plateau in southeastern Utah and likely occurs in adjacent states.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This short-shrub association occurs on sand dunes and sandsheets deposited on plateaus and valley floors. Stands are on gentle (2 to 14%), northeast-facing slopes between 1445 and 1604 m elevation. The unvegetated surface has up to 95% exposure of sand or bare soil. There is low to moderate cover by litter, depending on the amount of grass present. Soils are rapidly drained loamy sands, sandy loams, and sands derived from eolian deposits.

Globally

This short-shrub association occurs on sand dunes and sandsheets deposited on plateaus, benches and valley floors in southeastern Utah. Sites occupy gentle to moderately steep slopes (1-45%) between 1378 and 2018 m elevation and oriented to a variety of aspects, with a slight tendency toward northern and eastern aspects. The unvegetated surface has up to 96% sand or bare soil, with the balance covered by litter or dark cyanobacteria. Cover of cryptogamic soil communities is typically sparse (<10%) but ranges from none to 25%. Cover of litter is sparse to low. Soils are rapidly drained loamy sands and sandy loams derived from sandstones and shale now deposited as eolian sands or alluvium.

VEGETATION DESCRIPTION

Arches National Park

This shrubland association is locally common within the park, occurring in distinct patches in a matrix of blackbrush shrublands. Total vegetation cover ranges from 5 to 55%. This open shrub canopy consists of rhizomatous clumps of *Ephedra viridis*, sometimes accompanied by *Opuntia polyacantha*. The perennial bunch grasses *Achnatherum*

hymenoides and *Hesperostipa comata* dominate the herbaceous layer, which grows between the shrubs, not as an understory. Other herbaceous species include *Muhlenbergia pungens, Cymopterus newberryi, Oenothera pallida, Plantago patagonica,* and *Sphaeralcea parvifolia*. Biotic soil crusts are sometimes present with up to 15% cover.

Globally
Stands of this association usually occur as patches of one to several hectares within a matrix of other sandy communities dominated by *Coleogyne ramosissima* and *Artemisia filifolia*, although occasionally it will be the matrix community. The appearance is that of a grassland containing large, low-growing clonal clumps of *Ephedra viridis*. Total vegetation cover ranges from 5 to 55% but generally is between 15 and 35%. The vegetation is characterized by an open canopy of *Ephedra viridis* shrubs with between 5 and 20% cover with a well-developed grassy understory dominated by either *Achnatherum hymenoides* or *Hesperostipa comata*. The herbaceous layer totals up to 35% cover. Associated shrubs include scattered *Coleogyne ramosissima, Atriplex canescens, Eriogonum leptocladon, Gutierrezia sarothrae*, and the succulents *Opuntia erinacea, Opuntia polyacantha*, and *Sclerocactus whipplei*. Other grasses include *Aristida purpurea, Bouteloua gracilis, Muhlenbergia pungens, Sporobolus airoides, Sporobolus cryptandrus,* and *Vulpia octoflora*. If *Pleuraphis jamesii* is present, it is with much less cover than either *Hesperostipa comata* or *Achnatherum hymenoides*. Forbs include many species typical of sandy communities, including *Abronia fragrans, Ambrosia acanthicarpa, Artemisia campestris, Chaenactis stevioides, Cymopterus newberryi, Cryptantha* sp., *Descurainia pinnata, Eriogonum deflexum, Hymenopappus filifolius, Lappula occidentalis, Machaeranthera canescens, Mentzelia multiflora, Oenothera pallida, Packera multilobata, Plantago patagonica*, and *Sphaeralcea parvifolia*. The exotic annual tumbleweed *Salsola tragus* and the exotic annual grass *Bromus tectorum* are common in some stands. Biological soil crusts are often present and provide up to 25% cover.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Coleogyne ramosissima, Ephedra viridis*
Herb (field)	*Opuntia polyacantha*, *Yucca harrimaniae*
Herb (field)	*Chaenactis stevioides*, *Cryptantha crassisepala*, *Lappula occidentalis*, *Oenothera pallida*
Herb (field)	*Achnatherum hymenoides*, *Hesperostipa comata*

Globally

Stratum	Species
Shrub/sapling (tall & short)	*Ephedra viridis*
Herb (field)	*Achnatherum hymenoides*, *Hesperostipa comata*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Chenopodium album, Salsola tragus

Globally
Bromus tectorum, Chenopodium album, Salsola tragus, Sclerocactus whipplei

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (21-Mar-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Arches National Park Inventory Notes: Stands have mounds of sand accumulating around the vegetation with small

deflation basins in between. Drought effects were noted in the form of dead or dying vegetation. Burrowing rodents are common. There is evidence of livestock grazing on some stands.
Arches National Park Field Data: The description is based on 2003 field data (6 plots: ARCH. 0019, ARCH.0042, ARCH.0367, ARCH.0626, ARCH.0630, ARCH.0654, and 3 observation points: ARCH.9337, ARCH.9378, ARCH.9379).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Anderson 2001b, Western Ecology Working Group n.d.

Ephedra viridis / Pleuraphis jamesii Shrubland
Mormon-tea / James' Galleta Shrubland

CODE	CEGL002356
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland (III.A.5.N.a.)
ALLIANCE	*EPHEDRA VIRIDIS* SHRUBLAND ALLIANCE (A.858) Mormon-tea Shrubland Alliance
ECOLOGICAL SYSTEM(S):	Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) North American Warm Desert Active and Stabilized Dune (CES302.744) Inter-Mountain Basins Active and Stabilized Dune (CES304.775)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This shrubland association occurs on partly stabilized dunefields and sandsheets on valley floors, plateau slopes, benches and mesatops. Stands of this association usually occur as patches of one to several hectares within a matrix of other sandy communities dominated by *Coleogyne ramosissima* or *Artemisia filifolia*, although occasionally it will be the matrix community. The appearance is that of a grassland containing large, low-growing clonal clumps of *Ephedra viridis*. Sites are located on gentle slopes (3-10 %) between 1396 and 1850 m (4577-6070 feet) elevation. Aspect is not important in determining the distribution of this association. The unvegetated surface has high exposure of bare soil and low to moderate cover of litter; biological soil crusts provide up to 30% cover. The rapidly drained, fine sandy loam, loamy sand, and sandy clay soils are derived from sandstones and shales, eolian deposits and alluvium. Total vegetation cover ranges from 6 to 85%. The vegetation is characterized by an open canopy of *Ephedra viridis* that ranges in cover from 5 to 55% and the short bunchgrass *Pleuraphis jamesii* that ranges in cover from 1 to 15%. If *Achnatherum hymenoides* and *Hesperostipa comata* are present, it is with much less cover than *Pleuraphis jamesii*. Associated shrubs include *Atriplex canescens, Gutierrezia sarothrae,* and *Opuntia polyacantha*. The herbaceous layer is diverse in terms of species composition and provides sparse to low cover. Associated graminoids include *Aristida purpurea, Bouteloua gracilis, Sporobolus airoides, Sporobolus cryptandrus*, and the annual exotic grass *Bromus tectorum*. Forbs commonly present include *Cryptantha crassisepala, Helianthus petiolaris, Lappula occidentalis, Plantago patagonica*, and *Sphaeralcea parvifolia*.

DISTRIBUTION
Arches National Park
This association is uncommon and was sampled at North Fish Seep Draw, along Yellow Bird Mine Road, on Willow Flat and Yellow Cat Flat, in the Salt Valley, and near the Eye of the Whale within the park.

Globally
This association is known from sandy sites in the Colorado Plateau in southeastern Utah and probably occurs in adjacent states.

ENVIRONMENTAL DESCRIPTION

Arches National Park
This shrub association occurs on toeslopes, valley floors, slopes, and benches. Sites slope gently (2 to 5%), occur between 1396 and 1506 m elevation and typically tend to face north. The unvegetated surface has high exposure of bare soil and low to moderate cover of litter. Soils are rapidly drained sandy loams, loamy sands, and sandy clays derived from the Morrison Formation and alluvium.

Globally
This shrubland association occurs on partly stabilized dunefields and sandsheets on valley floors, plateau slopes, benches and mesatops. Sites are located on flat to gentle slopes (<10 %) between 1396 and 1850 m (4577-6070 feet) elevation. Aspect is not important in determining the distribution of this association. The unvegetated surface is variable but generally has high exposure of bare soil and sparse to moderate cover of litter and cryptogamic soil communities; rare sites will have high cover of colluvial boulders. Cryptogams may provide up to 30% cover. Soils are derived from sandstones and shales, eolian deposits and alluvium. They are rapidly drained, fine sandy loams, loamy sands, and sandy clays. Parent materials include Dakota sandstone that eroded to eolian and sandsheet deposits, Morrison Formation and alluvium.

VEGETATION DESCRIPTION
Arches National Park
This shrub association is uncommon within the park and environs. It occupies small to moderately large patches on level, moderately deep to deep soils in areas otherwise dominated by blackbrush. Total vegetation cover ranges from 6 to 55%. The vegetation is characterized by an open canopy of *Ephedra viridis* shrubs growing in rhizomatous clumps with up to 25% cover. The areas between shrubs are dominated by the short bunchgrass *Pleuraphis jamesii* with between 1 and 15% cover. Associated shrubs contribute little to total canopy cover but may include *Atriplex canescens, Gutierrezia sarothrae,* and the succulent *Opuntia polyacantha*. Additional graminoid species often present include *Achnatherum hymenoides, Hesperostipa comata* (with much less cover than *Pleuraphis jamesii*), and *Sporobolus airoides.* Forbs commonly present include *Cryptantha crassisepala, Lappula occidentalis, Plantago patagonica,* and *Sphaeralcea parvifolia*. Biological soil crusts provide up to 30% cover.

Globally
Stands of this association usually occur as patches of one to several hectares within a matrix of other sandy communities dominated by *Coleogyne ramosissima* or *Artemisia filifolia*, although occasionally it will be the matrix community. The appearance is that of a grassland containing large, low-growing clonal clumps of *Ephedra viridis.* The total vegetation cover ranges from 6 to 85% in these sparsely to moderately vegetated stands. This short-shrub association is characterized by an open to moderately dense canopy of *Ephedra viridis* that ranges in cover from 5 to 55% and the short bunchgrass *Pleuraphis jamesii* that ranges in cover from 1 to 15%. If *Achnatherum hymenoides* and *Hesperostipa comata* are present, it is with much less cover than *Pleuraphis jamesii*. Associated shrubs include *Atriplex canescens, Gutierrezia sarothrae,* and *Opuntia polyacantha*. The herbaceous layer is diverse in terms of species composition and provides sparse to low cover (<20%). Associated graminoids include *Aristida purpurea, Bouteloua gracilis, Sporobolus airoides, Sporobolus cryptandrus*, and the annual exotic grass *Bromus tectorum* (up to 15% cover). Forb cover is low but may be diverse. Associated forbs include *Cryptantha crassisepala, Eriogonum cernuum, Gilia inconspicua, Helianthus petiolaris, Lappula occidentalis, Lupinus pusillus, Mentzelia albicaulis, Packera multilobata, Plantago patagonica,* and *Sphaeralcea parvifolia*.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia*, *Coleogyne ramosissima*, *Ephedra viridis*, *Grayia spinosa*
Herb (field)	*Chrysothamnus viscidiflorus*, *Opuntia polyacantha*
Herb (field)	*Cryptantha crassisepala*, *Eriogonum ovalifolium*, *Lappula occidentalis*, *Lepidium lasiocarpum*, *Salsola tragus*, *Sphaeralcea parvifolia*
Herb (field)	*Achnatherum hymenoides*, *Bromus tectorum*, *Hesperostipa comata*, *Pleuraphis jamesii*, *Sporobolus airoides*, *Sporobolus cryptandrus*

Globally

Stratum	Species
Short shrub/sapling	*Ephedra viridis*

Herb (field) *Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES
Arches National Park
Descurainia pinnata

Globally
Bromus tectorum

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (22-Mar-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
It is not clear what the habitat differences are that determine whether this association or *Ephedra viridis / (Achnatherum hymenoides, Hesperostipa comata)* Shrubland (CEGL002354) will occupy a site; both prefer relatively level sites with loose sandy soils. Yet they are distinct; on the Island in the Sky in Canyonlands National Park, there is a boundary between the two associations so sharp you can stand astride it.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Stands occur on stabilized sand and may have abundant burrowing by rodents. Drought effects were observed. Some stands have well-developed cyanobacteria soil crusts. There is grazing evidence in some stands.
Arches National Park Field Data: The description is based on 2003 field data (8 plots: ARCH.0022, ARCH.0037, ARCH.0117, ARCH.0303, ARCH.0315, ARCH.0642, ARCH.0656, ARCH.0657).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Anderson 2001b, Western Ecology Working Group n.d.

Poliomintha incana - Artemisia filifolia - Vanclevea stylosa Shrubland
Hoary Rosemarymint - Sand Sagebrush - Resinbush Shrubland

CODE	CEGL002418
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland (III.A.5.N.a.)
ALLIANCE	*POLIOMINTHA INCANA* SHRUBLAND ALLIANCE (A.862) Hoary Rosemarymint Shrubland Alliance
ECOLOGICAL SYSTEM(S):	Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) Inter-Mountain Basins Active and Stabilized Dune (CES304.775)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This Colorado Plateau shrubland association occurs where there is loose, blowing sand on dunes, benches, sandsheets, stabilized climbing dunes on steep canyonsides and in intermittent channels on valley floors in southeastern Utah. It usually occurs in small patches within a matrix of shrublands on more stable sands and dominated by *Coleogyne ramosissima* or *Artemisia filifolia*. Stands are located on flat to moderate slopes (up to 30%) between 1271 and 1663 m (4170-5455 feet) elevation and tend to be oriented to southern or eastern aspects.

The unvegetated surface has low cover of litter and moderate to high exposure of sand and bare soil. Biological soil crusts may absent or provide sparse to moderate cover, up to 25% cover. Soils are poorly developed, rapidly drained sands and sandy loams derived from eolian sands and sandy alluvium. Total vegetation cover ranges from 5 to 55% and is characterized by a mixed open canopy consisting of a combination of *Poliomintha incana, Artemisia filifolia*, and *Vanclevea stylosa*. One of these shrubs may be absent, but at a minimum either *Poliomintha incana* or *Vanclevea stylosa* is always present. Associated shrubs commonly include *Atriplex canescens, Ephedra viridis, Eriogonum leptocladon, Gutierrezia sarothrae, Opuntia polyacantha*, and *Yucca harrimaniae*. If *Coleogyne ramosissima* is present, it is with very low cover relative to the diagnostic species. The herbaceous layer is moderate to high in terms of species diversity and typically provides sparse to low cover, except in cases where the exotic annual forb *Salsola tragus* may have up to 15% cover. *Achnatherum hymenoides, Aristida purpurea*, and *Muhlenbergia pungens* are the most consistent grasses other than the exotic annual *Bromus tectorum*. Forb composition varies greatly among stands, but species tend to be sand specialists such as *Abronia fragrans, Ambrosia acanthicarpa, Cryptantha crassisepala, Chamaesyce parryi, Hymenopappus filifolius, Iva acerosa, Oenothera pallida, Stephanomeria exigua*, and *Streptanthella longirostris*. Isolated *Juniperus osteosperma* occur in some stands where the sand is shallow over bedrock.

DISTRIBUTION

Arches National Park

This association is locally common in scattered sites throughout the park. It was sampled along Willow Springs Road, near Klondike Bluffs, northeast of Herdina Park, near Marching Men within Salt Valley, in the Salt Valley, near Balanced Rock, along Willow Springs Road, in the vicinity of Willow Springs, in Courthouse Wash, in Little Valley South, and near The Great Wall within the park.

Globally

This association has been documented from the Colorado Plateau in southeastern Utah, where it is locally common on sandy sites.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This short-shrub association occurs on actively blowing sands within dune fields and sandsheets. Sites are flat to moderately steep (up to 31% slopes), occur between 1271 and 1530 m elevation and are oriented to southern and eastern aspects. The unvegetated surface has low cover of litter and moderate to high exposure of sand. Biological soil crusts may be absent or may provide up to 30% cover. Soils are poorly developed, rapidly drained sands, loamy sands, and sandy loams derived from eolian deposits.

Globally

This short-shrub association occurs where there is loose, blowing sand on dunes, benches, sandsheets, stabilized climbing dunes on steep canyonsides and in intermittent channels in southeastern Utah. Stands are generally located on flat to moderate slopes (up to 30%) between 1271 and 1663 m (4170-5455 feet) elevation and tend to be oriented to southern or eastern aspects. The unvegetated surface has low cover of litter and moderate to high exposure of sand and bare soil. Biological soil crusts may be absent or provide sparse to moderate cover, up to 25% cover. Soils are poorly developed, rapidly drained sands and sandy loams derived from eolian sands and sandy alluvium. Parent materials include Navajo and Entrada sandstone formations that have eroded and distributed as alluvium and eolian deposits.

VEGETATION DESCRIPTION

Arches National Park

This mixed sand shrub association is locally common on active dunes within the park. Total vegetation cover ranges from 5 to 55%. This short-shrub association is characterized by an open canopy that consists of a combination of *Poliomintha incana, Artemisia filifolia*, and *Vanclevea stylosa*. One of these shrubs may be absent, but at a minimum either *Poliomintha* or *Vanclevea* is always present. Additional short and dwarf-shrubs commonly present with low cover include *Atriplex canescens, Coleogyne ramosissima, Ephedra viridis, Eriogonum leptocladon, Opuntia polyacantha*, and *Yucca harrimaniae*. The herbaceous layer is sparse but relatively diverse, including the graminoids *Achnatherum hymenoides, Bromus tectorum*, and *Muhlenbergia pungens*, as well as the forbs *Abronia fragrans, Cryptantha crassisepala, Chamaesyce parryi, Hymenopappus filifolius, Oenothera pallida, Stephanomeria exigua*, and *Streptanthella longirostris*. Biological soil crusts typically are sparse but can provide up to 30% cover. Scattered *Juniperus osteosperma* trees, typically 1-5 m tall, are present in a few stands where the sands are shallow

over bedrock.

Globally
This association often occurs as small patches in a matrix of other sand dune communities typical of the Colorado Plateau and generally dominated by *Coleogyne ramosissima* or *Artemisia filifolia*. Total vegetation cover ranges from 5 to 55%. This short-shrub association is characterized by a mixed, sparse to moderately dense canopy consisting of a combination of *Poliomintha incana, Artemisia filifolia,* and *Vanclevea stylosa*. One of these shrubs may be absent, but at a minimum either *Poliomintha* or *Vanclevea* is always present. Associated shrubs commonly include *Atriplex canescens, Brickellia microphylla, Dalea flavescens, Ephedra viridis, Eriogonum leptocladon, Gutierrezia sarothrae, Opuntia polyacantha,* and *Yucca harrimaniae*. If *Coleogyne ramosissima* is present, it is with very low cover relative to the diagnostic species. The herbaceous layer is moderate to high in terms of species diversity and typically provides sparse to low cover, except in cases where the exotic annual forb *Salsola tragus* may have up to 15% cover. *Achnatherum hymenoides, Aristida purpurea, Muhlenbergia pungens, Sporobolus cryptandrus,* and *Vulpia octoflora* are the most consistent grasses other than the exotic annual *Bromus tectorum*. Forb composition varies greatly among stands, but species tend to be sand specialists such as *Abronia fragrans, Ambrosia acanthicarpa, Astragalus mollissimus, Cryptantha crassisepala, Cryptantha flava, Chamaesyce parryi, Hymenopappus filifolius, Ipomopsis gunnisonii, Iva acerosa, Mentzelia albicaulis, Oenothera pallida, Plantago patagonica, Sphaeralcea parvifolia, Stephanomeria exigua,* and *Streptanthella longirostris*. Cryptogams are absent from some stands but can provide up to 30% cover. Isolated *Juniperus osteosperma* occur in some stands where the sand is shallow over bedrock.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Artemisia filifolia, Atriplex canescens, Coleogyne ramosissima, Eriogonum corymbosum, Ephedra viridis, Poliomintha incana, Quercus havardii* var. *tuckeri, Vanclevea stylosa*
Herb (field)	*Eriogonum leptocladon, Gutierrezia sarothrae, Opuntia polyacantha, Yucca harrimaniae*
Herb (field)	*Chaenactis stevioides, Cryptantha crassisepala, Mentzelia multiflora, Streptanthella longirostris*
Herb (field)	*Achnatherum hymenoides, Aristida purpurea, Bromus tectorum, Hesperostipa comata, Muhlenbergia pungens, Vulpia octoflora*

Globally

Stratum	Species
Short shrub/sapling	*Artemisia filifolia, Eriogonum leptocladon, Poliomintha incana, Vanclevea stylosa*
Herb (field)	*Achnatherum hymenoides, Muhlenbergia pungens*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Salsola tragus, Tamarix chinensis

Globally
Bromus tectorum, Salsola tragus, Tamarix chinensis, Vanclevea stylosa

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (24-Mar-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Sites are typified by loose, blowing sand, although the vegetation anchors some soil. Drought stress is evident in the form of dead plants and dead branches on plants. There are large amounts of small mammal burrowing activity. There is evidence of grazing by livestock at some sites.
Arches National Park Field Data: The description is based on 2003 field data (15 plots: ARCH.0001, ARCH.0004, ARCH.0081, ARCH.0083, ARCH.0084, ARCH.0093, ARCH.0321, ARCH.0331, ARCH.0334, ARCH.0335, ARCH.0379, ARCH.0601, ARCH.0693, ARCH.0694, ARCH.0698).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Allenrolfea occidentalis Shrubland
Iodinebush Shrubland

CODE	CEGL000988
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Facultatively deciduous extremely xeromorphic subdesert shrubland (III.A.5.N.b.)
ALLIANCE	*ALLENROLFEA OCCIDENTALIS* SHRUBLAND ALLIANCE (A.866) Iodinebush Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Playa (CES304.786)
North American Warm Desert Playa (CES302.751)
Inter-Mountain Basins Wash (CES304.781)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This is a sparsely vegetated shrubland found on seasonally wet, alkaline playas, intermittent floodplains or along washes in saline overflow areas below 1680 m (5500 feet) elevation. The dominant species, and playa communities in general, are widely distributed throughout the Intermountain West, ranging from southeastern Oregon south to Texas. These shrublands or barrens are flat to extremely low-gradient, almost always in desert ecosystems with less than 18 cm (7 inches) of rain per year, and usually in areas with very poor drainage that flood during rare rainstorms. Playas and washes dominated by *Allenrolfea occidentalis* generally appear to be small, rare, and poorly understood throughout their range. *Allenrolfea occidentalis* dominates the shrub layer, but cover is often quite low, ranging from 20% to less than 1%. Most stands have barren playa forb understories, but grasses, including *Leymus cinereus, Distichlis spicata, Sporobolus airoides,* and *Sporobolus wrightii,* and succulent forbs, such as *Suaeda suffrutescens* var. *detonsa, Salicornia* spp., and *Nitrophila* spp., are occasionally found. Most stands occur in a matrix of *Sarcobatus vermiculatus*- or *Atriplex canescens*-dominated shrublands, and in small stands, either *Sarcobatus vermiculatus* or *Atriplex canescens* can occur throughout the community.

DISTRIBUTION
Arches National Park
This association is rare within the park and was sampled in Salt Wash both upstream and downstream of Wolfe Ranch but above the point where Salt Wash enters the canyon that empties into the Colorado River.

Globally
This playa community is widely distributed throughout the Intermountain West, ranging from southeastern Oregon south to Texas.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This short-shrub association occurs on the outer margins of the broad Salt Wash floodplain where it crosses Cache Valley. The site is on a gentle gradient (3%) at 1305 m elevation. Bare soil covers most of the unvegetated surface

and there is very little litter. Soils are fine-textured and derived from alluvium (mostly shale).

Globally
This shrubland association occurs across arid and semi-arid portions of the western U.S. at elevations ranging from near sea level to 1680 m. Stands occur on the outer margins of broad intermittent floodplains and playas, or can form landscape mosaics with other saline communities in saline marshes or gypsum-influenced habitats. Bare soil covers most of the unvegetated surface, and there is very little litter. Soils are fine-textured and derived from alluvium.

VEGETATION DESCRIPTION
Arches National Park
This saline short-shrub association is rare within the park, as it is only known from small patches along a short stretch of Salt Wash. Total vegetation cover does not exceed 25%; the open shrub canopy is dominated by *Allenrolfea occidentalis*. Associated shrubs may include scattered individuals of other salt-loving shrubs such as *Sarcobatus vermiculatus* and *Suaeda moquinii (= Suaeda torreyana)*. The herbaceous layer has been greatly reduced by domestic livestock grazing and is dominated by weedy annual species such as Bromus *tectorum* and *Eremopyrum triticeum*. Scattered remnant native grasses such as *Sporobolus airoides* and *Distichlis spicata* may be present. *Salsola tragus* is the only forb present.

Globally
Allenrolfea occidentalis dominates the shrub layer, but the cover is often quite low, ranging from 20% to less than 1%. Most stands have barren playa forb understories, but grasses, including *Leymus cinereus, Distichlis spicata, Sporobolus airoides*, and *Sporobolus wrightii*, and succulent forbs, such as *Suaeda suffrutescens* var. *detonsa, Salicornia* spp., and *Nitrophila* spp., are occasionally found. Most stands occur in a matrix of *Sarcobatus vermiculatus*- or *Atriplex canescens*-dominated shrublands, and in small stands, either *Sarcobatus vermiculatus* or *Atriplex canescens* can occur throughout the community. In the southern extent of its range, scattered *Isocoma drummondii, Iva acerosa*, or *Prosopis glandulosa* may be present. Exotic species, such as occasional *Tamarix* spp., *Bromus tectorum*, or *Salsola tragus*, may occur in this community.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Allenrolfea occidentalis*

Globally

Stratum	Species
Short shrub/sapling	*Allenrolfea occidentalis*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Salsola tragus

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G3 (23-Oct-2002). This is a very widespread, but limited and somewhat rare, alkaline playa vegetation type. It is not well studied, and it is poorly protected, but generally most stands are not very threatened. Where water is available from adjacent mountains, these areas are often converted to agriculture. However, their limited threats require a G3 rank. If many additional sites are discovered in Nevada, it could become a G4, and if the types associated with *Sarcobatus* turn out to be distinct from those with *Atriplex canescens*, it could be ranked higher. Protection of some sites in Nevada is important to assure that it remains secure throughout its range.

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
This appears to be a distinct, widespread type. With additional studies throughout the range of this habitat, it is possible that the type may be split into a number of geographic communities based on associated forbs. However, current data indicate the type is very similar throughout at least the northern half of its range, where it occurs in a matrix composed largely of *Sarcobatus vermiculatus* salt desert scrub. In the southern part of its range, where it is slightly more common, it occurs in a matrix of *Larrea tridentata* or *Ambrosia dumosa*. This is a broadly defined type that may need to be subdivided by characteristics of the understory. Muldavin et al. (2000b) classified five different plant associations in the Tulerosa Basin in southern New Mexico.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: The sampled site occupies a narrow band adjacent to greasewood and tamarisk stands in Salt Wash where it crosses the head of Cache Valley.
Arches National Park Field Data: The description is based on 2003 and 2006 field data (1 observation point: ARCH.9044 and 2 accuracy assessment points: ARCH_AA.0625, ARCH_AA.0605).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Kagan, mod. K.A. Schulz

REFERENCES: Bourgeron and Engelking 1994, Driscoll et al. 1984, Griffiths 1902, Kagan et al. 2000, Muldavin et al. 2000b, ORNHP unpubl. data, Western Ecology Working Group n.d.

Atriplex canescens / Sporobolus airoides Shrubland
Fourwing Saltbush / Alkali Sacaton Shrubland

CODE	CEGL001291
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Facultatively deciduous extremely xeromorphic subdesert shrubland (III.A.5.N.b.)
ALLIANCE	*ATRIPLEX CANESCENS* SHRUBLAND ALLIANCE (A.869) Fourwing Saltbush Shrubland Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784) Chihuahuan Mixed Salt Desert Scrub (CES302.017)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This shrubland occurs in the northern Chihuahua Desert, the Trans-Pecos of Texas, southwestern Great Plains, and Colorado Plateau. Stands are found in washes, floodplains and on alluvial flats, extending up lower slopes of alluvial fans or bajadas. Sites are level to gently sloping. Substrates are typically moderately deep, alkaline, calcareous, fine-textured soils or calcareous sands. Cover of bare soil can be high (>50%). The vegetation is characterized by an open to moderately dense (10-50% cover) short-shrub layer dominated by *Atriplex canescens* with a perennial graminoid layer dominated by *Sporobolus airoides*. The shrub layer has greater cover than the herbaceous layer, which may include other scattered shrubs and dwarf-shrubs, such as *Artemisia filifolia, Atriplex confertifolia, Atriplex obovata, Chrysothamnus viscidiflorus, Ericameria nauseosa, Gutierrezia sarothrae, Isocoma pluriflora, Krascheninnikovia lanata, Lycium* spp., *Opuntia* spp., *Prosopis glandulosa*, and *Sarcobatus vermiculatus*. Associated herbaceous species, such as *Achnatherum hymenoides, Elymus elymoides, Pascopyrum smithii, Pleuraphis jamesii, Sphaeralcea coccinea, Sporobolus cryptandrus, Sporobolus nealleyi*, and *Suaeda* spp., may be present. *Bouteloua gracilis* cover is minor and inconsistent. The *Sporobolus airoides*-dominated herbaceous layer is diagnostic of this association.

DISTRIBUTION
Arches National Park
This association is rare to uncommon in the park. It was sampled in Salt Valley about 3 km west of the overlook.

Globally
This shrubland occurs in the northern Chihuahua Desert extending into Trans-Pecos Texas, the southwestern Great Plains and Colorado Plateau in Colorado, New Mexico, Arizona, and Utah. It is reported from California and likely also occurs in Nevada and Mexico.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This association occurs on the toeslopes of valley sides. The one sampled site is gentle (7% slope), occurs at 1448 m elevation and is oriented to an east aspect. The unvegetated surface has high exposure of bare soil and low cover by litter. The substrate is a mix of sandstones and shale that have eroded and been re-deposited as alluvium. Soils are rapidly drained loamy sand.

Globally
This shrubland occurs on alkaline sites in the northern Chihuahua Desert extending into the Trans-Pecos of Texas, southwestern Great Plains, and Colorado Plateau. Sites are in washes, floodplains and on alluvial flats, extending up lower slopes of alluvial fans or bajadas. Elevation ranges from 915-1890 m (3000-6200 feet). Sites are level to gently sloping (1-5%), and soils are typically moderately deep, alkaline, calcareous, fine-textured soils such as silt loam, loamy clay or clay (Francis 1986, Shaw et al. 1989, Muldavin et al. 2000b), although some sites in active floodplains may be rapidly drained sandy soils. Cover of bare soil may be high (>50%) (Francis 1986). Evidence of overland flow and erosion, e.g., gullies, rills, plant pedestalling, is common (Soil Conservation Service n.d.).

VEGETATION DESCRIPTION
Arches National Park
This alkaline shrub association is rare in the park. Total vegetation cover ranges from 4 to 15%. The vegetation is characterized by a sparse canopy of *Atriplex canescens* that ranges in cover from 1 to 5%, and *Opuntia polyacantha* is usually present. *Sporobolus airoides* dominates the herbaceous layer with between 1 and 5% cover, usually accompanied by *Achnatherum hymenoides, Festuca ovina, Hesperostipa comata, Pleuraphis jamesii*, and *Sporobolus cryptandrus*. Forbs are sparse but include the annual *Cryptantha crassisepala*. Moss provides up to 5% cover.

Globally
The association is characterized by an open to moderately dense (10-50% cover) short-shrub layer dominated by *Atriplex canescens* with a perennial graminoid layer dominated by *Sporobolus airoides* but includes sparse *Atriplex canescens - Sporobolus airoides*-dominated stands(<10% total vegetation cover). The shrub layer generally has greater cover than the herbaceous layer and may include other scattered shrubs and dwarf-shrubs, such as *Artemisia filifolia, Atriplex confertifolia, Atriplex obovata, Chrysothamnus viscidiflorus, Ericameria nauseosa, Gutierrezia sarothrae, Isocoma pluriflora, Krascheninnikovia lanata, Lycium berlandieri, Lycium pallidum, Opuntia imbricata, Opuntia leptocaulis, Opuntia phaeacantha, Prosopis glandulosa*, and *Sarcobatus vermiculatus*. Associated herbaceous species, such as *Achnatherum hymenoides, Elymus elymoides, Pascopyrum smithii, Pleuraphis jamesii, Sphaeralcea* spp., *Sporobolus cryptandrus, Sporobolus nealleyi*, and *Suaeda* spp., may be present. *Bouteloua gracilis* cover is minor and inconsistent (Francis 1986, Shaw et al. 1989, Muldavin et al. 2000b). Introduced species such as *Salsola kali, Bromus tectorum*, or *Marrubium vulgare* may be common.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex canescens*
Herb (field)	*Achnatherum hymenoides, Sporobolus airoides*

Globally

Stratum	Species
Short shrub/sapling	*Atriplex canescens*
Herb (field)	*Sporobolus airoides*

OTHER NOTEWORTHY SPECIES
Arches National Park
Chenopodium album, Salsola tragus

Globally
Bromus tectorum, Marrubium vulgare, Salsola kali

CONSERVATION STATUS RANK
Global Rank & Reasons: G5? (9-Nov-2005). Although this type is widespread, it usually occurs in relatively small patches. Both of the diagnostic species are resistant to moderate grazing, but this association has likely been converted to semi-natural shrublands in heavily grazed areas.

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Stands with relatively low cover of *Atriplex canescens* (10-25%) are included in this association because the shrub density is often variable within stands, but species composition and ecological processes do not change significantly. There are several similar associations that vary according to the abundance of different codominants, especially graminoids. Rangewide review of these types is needed to clarify their extent.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Evidence of drought includes many dead or dying saltbush shrubs. The site is apparently more drought-prone than adjoining soils.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0330).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: Baker 1984a, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Diamond 1993, Dick-Peddie 1986, Donart et al. 1978a, Driscoll et al. 1984, Francis 1986, Hansen et al. 2004b, Muldavin et al. 2000b, Shaw et al. 1989, Soil Conservation Service n.d., USFS 1937, Vest 1962a, Western Ecology Working Group n.d.

Atriplex canescens Shrubland
Fourwing Saltbush Shrubland

CODE	CEGL001281
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Facultatively deciduous extremely xeromorphic subdesert shrubland (III.A.5.N.b.)
ALLIANCE	*ATRIPLEX CANESCENS* SHRUBLAND ALLIANCE (A.869) Fourwing Saltbush Shrubland Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784) Sonora-Mojave Mixed Salt Desert Scrub (CES302.749)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This shrubland association is known from the Great Basin north into the southern Columbia Basin and east into Wyoming and the Colorado Plateau. It is common at middle elevations on alluvial fans and toeslopes in deep, sandy soils but will occur at lower elevations along alluvial benches where soils are often finer-textured and possibly saline/alkaline. Parent materials are variable. The vegetation is characterized by a sparse to moderately dense short-shrub layer (10-35% cover) dominated or codominated by *Atriplex canescens*, typically with a variable and often sparse herbaceous layer. Notable codominants in the shrub layer include *Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ephedra nevadensis, Eriogonum nummulare, Grayia spinosa, Gutierrezia sarothrae,*

Lycium pallidum, or *Psorothamnus* spp. *Artemisia bigelovii, Artemisia tridentata*, and *Ephedra viridis, Krascheninnikovia lanata*, or *Purshia stansburiana* may be present but are not codominants. The herbaceous layer includes low cover of species such as *Achnatherum hymenoides, Aristida purpurea, Elymus elymoides, Pleuraphis jamesii*, and *Sporobolus cryptandrus*. Introduced species, especially *Bromus tectorum, Bromus diandrus*, and *Salsola kali*, are common on disturbed sites and can create an herbaceous layer much denser than on undisturbed sites. Winter annual forb cover is variable depending on annual precipitation.

DISTRIBUTION

Arches National Park

This association is uncommon and was sampled in the Salt Valley, Courthouse Wash, and near Dalton Wells.

Globally

This shrubland association may occur throughout much of the interior western U.S. It is known from the southern Columbia Basin and Great Basin east into Wyoming and the Colorado Plateau.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This short-shrub association occurs on valley floors, stream terraces, hills, and toeslopes. Stands are on warm, gentle (up to 3%) slopes between 1235 and 1543 m elevation. Most of the unvegetated surface is bare soil or sand. Biological soil crusts provide up to 21% cover on minimally disturbed, sandy sites. Soils are rapidly drained sandy loams, loamy sands, and clay loams derived from alluvium and eolian sands.

Globally

This widespread shrubland association occurs throughout much of the western U.S. It is found on bajadas, low stream terraces, valley floors and toeslopes. Sites are flat to gently sloping. It is commonly found on deep, sandy soils at middle elevations (1235-2256 m [4050-7400 feet]) on the Colorado Plateau, but will occur at lower elevations (down to 610 m [2000 feet]) along alluvial benches where soils are often finer-textured and possibly saline/alkaline (Beatley 1976) in the Great Basin region. The unvegetated surface is predominantly bare soil and/or sand. Larger rocks and organic material are rare. Parent materials include volcanic tuff, shale and sandstone. At lower elevations, it may occur as a mosaic with *Lycium pallidum - Grayia spinosa*- or *Atriplex confertifolia*-dominated shrublands.

VEGETATION DESCRIPTION

Arches National Park

This fourwing saltbush association is locally common within the park in alkaline areas that have been disturbed by grazing or roads. Total vegetation cover ranges from 7 to 35%. The vegetation is characterized by a sparse canopy of *Atriplex canescens* that ranges in cover from 1 to 15%, and associated species may include *Ephedra viridis, Gutierrezia sarothrae*, and *Opuntia polyacantha*. The herbaceous layer is typically sparse. Bunch grasses occasionally present include *Achnatherum hymenoides* and *Pleuraphis jamesii*, and scattered forbs tend to be weedy, including *Cryptantha crassisepala, Descurainia pinnata, Erodium cicutarium, Lappula occidentalis, Lepidium montanum, Plantago patagonica*, and *Rumex hymenosepalus*. Biological soil crusts can provide up to 21% cover. Scattered *Juniperus osteosperma* saplings may be present.

Globally

This broadly defined association is characterized by a sparse to moderately dense shrub layer (10-35% cover) dominated or codominated by *Atriplex canescens*, typically with a variable and often sparse herbaceous layer. Total vegetation cover ranges from sparse to moderate (5-56% cover). Notable codominants in the shrub layer include *Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ephedra nevadensis, Eriogonum nummulare, Ericameria nauseosa, Grayia spinosa, Gutierrezia sarothrae, Lycium pallidum, Psorothamnus fremontii*, or *Psorothamnus polydenius*. *Artemisia bigelovii, Artemisia tridentata, Ephedra viridis, Krascheninnikovia lanata*, or *Purshia stansburiana* may be present but are not codominants. *Artemisia filifolia* may be present to subdominant in a few stands. The typically sparse herbaceous layer includes low cover of semi-arid grasses such as *Achnatherum hymenoides, Aristida purpurea, Elymus elymoides, Pleuraphis jamesii*, and *Sporobolus cryptandrus*. Common forb species on sandy sites include *Cymopterus ripleyi, Dalea searlsiae, Lesquerella ludoviciana*, and *Oenothera pallida*, and on disturbed sites *Cryptantha crassisepala, Descurainia pinnata, Erodium cicutarium, Lappula occidentalis, Lepidium montanum, Plantago patagonica*, and *Rumex hymenosepalus* may be present. Winter annual forb cover is variable depending on annual precipitation. Introduced species such as *Bromus tectorum, Bromus diandrus, Salsola*

kali, and *Tribulus terrestris* can be common on disturbed sites and may form a moderately dense herbaceous stratum.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex canescens, Gutierrezia sarothrae, Suaeda moquinii*
Herb (field)	*Cryptantha crassisepala, Erodium cicutarium, Lappula occidentalis, Phacelia crenulata, Sphaeralcea coccinea*

Globally

Stratum	Species
Short shrub/sapling	*Atriplex canescens*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: There is grazing on some sites. Terraces are elevated up to 5 m above washes. Sites also occupy toeslopes and hills and receive water from sheetflow.
Arches National Park Field Data: The description is based on 2003 field data (4 plots: ARCH.0076, ARCH.0384, ARCH.0646, ARCH.0652, and 3 observation points: ARCH.9346, ARCH.9620, ARCH.9641).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Drake, J. Coles, G. Kittel

REFERENCES: Beatley 1976, Bourgeron and Engelking 1994, Cogan et al. 2004, Driscoll et al. 1984, Howard 2003, Ostler et al. 2000, Western Ecology Working Group n.d.

Atriplex confertifolia - Picrothamnus desertorum Shrubland
Shadscale / Bud Sagebrush Shrubland

CODE	CEGL001295
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Facultatively deciduous extremely xeromorphic subdesert shrubland (III.A.5.N.b.)
ALLIANCE	*ATRIPLEX CONFERTIFOLIA* SHRUBLAND ALLIANCE (A.870) Shadscale Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This alkaline desert association occurs the Great Basin, Columbia Basin and Colorado Plateau and is likely more widespread in the intermountain western U.S. It occurs on barren toeslopes and playas on sandy or heavy clay soils, and foothill areas where saline hardpans occur at depths of 1-2 feet. The shrubs are low-statured and open, often with very low cover (5-15%). Dominant shrubs are *Atriplex confertifolia* and *Picrothamnus desertorum*. Other shrubs, such as *Artemisia tridentata* and *Sarcobatus vermiculatus* in Nevada, and *Coleogyne ramosissima, Gutierrezia sarothrae,* and *Tetradymia spinosa* in southern Utah, may be present to codominant. Herbaceous cover is generally very sparse, due to overgrazing or lack of moisture. Graminoids include *Achnatherum hymenoides, Pleuraphis jamesii, Poa secunda,* and *Sporobolus airoides*; common forbs include *Calochortus nuttallii, Cymopterus newberryi, Encelia nutans,* and *Sphaeralcea coccinea*. The annual invasive grass *Bromus tectorum* can be abundant, but cover is variable year to year.

DISTRIBUTION

Arches National Park

This association is rare and was sampled in Little Valley South and The Highlands areas of the mapping area.

Globally

This association is known from the Great Basin, Columbia Basin and Colorado Plateau and is likely more widespread in the intermountain western U.S.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This alkaline desert association occurs on barren toeslopes and lower slopes of valley sides. Sites slope gently (3 to 5%) and occur between 1442 and 1454 m elevation. Most of the unvegetated surface is covered by gravel or bare soil. Biological soil crust cover is generally sparse but may be up to 40%. Soils are rapidly drained clay loams and sandy loams derived from the Morrison Formation.

Globally

This alkaline desert association occurs the Great Basin, Columbia Basin and Colorado Plateau and is likely more widespread in the intermountain western U.S. It occurs on barren toeslopes and playas on sandy or heavy clay soils, and foothill areas where saline hardpans occur at depths of 1-2 feet.

VEGETATION DESCRIPTION

Arches National Park

This desert shrub association is rare within the mapping area. Total vegetation cover ranges from 3 to 15% but rarely exceeds 10%. The vegetation is characterized by a sparse canopy of *Atriplex confertifolia* and *Picrothamnus desertorum* with 1 to 5% cover each. Associated shrubs include *Coleogyne ramosissima, Gutierrezia sarothrae,* and *Tetradymia spinosa*. The herbaceous layer is also sparse. Graminoids include *Achnatherum hymenoides, Pleuraphis jamesii, Poa secunda,* and *Sporobolus airoides*; common forbs include *Calochortus nuttallii, Cymopterus newberryi, Encelia nutans,* and *Sphaeralcea coccinea*.

Globally

The shrubs are low-statured and open, often with very low cover (5-15%). Dominant shrubs are *Atriplex confertifolia* and *Picrothamnus desertorum*. Other shrubs, such as *Artemisia tridentata* and *Sarcobatus vermiculatus* in Nevada, and *Coleogyne ramosissima, Gutierrezia sarothrae,* and *Tetradymia spinosa* in southern Utah, may be present to codominant. Herbaceous cover is generally very sparse, due to overgrazing or lack of moisture. Graminoids include *Achnatherum hymenoides, Pleuraphis jamesii, Poa secunda,* and *Sporobolus airoides*; common forbs include *Calochortus nuttallii, Cymopterus newberryi, Encelia nutans,* and *Sphaeralcea coccinea*. The annual invasive grass *Bromus tectorum* can be abundant, but its presence is variable year to year.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia*
Herb (field)	*Gutierrezia sarothrae, Picrothamnus desertorum*
Herb (field)	*Pleuraphis jamesii*

Globally

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia*
Herb (field)	*Picrothamnus desertorum*

OTHER NOTEWORTHY SPECIES
Arches National Park
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: This association occurs in small stands on barren, saline soils of the Morrison Formation. Sites lie above the active valley floor characterized by stream channels.
Arches National Park Field Data: The description is based on 2003 field data (2 plots: ARCH.0613, ARCH.0633).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: G. Kittel and K.A. Schulz

REFERENCES: Billings 1945, Billings 1949, Blackburn et al. 1969e, Bourgeron and Engelking 1994, Driscoll et al. 1984, Western Ecology Working Group n.d.

Atriplex confertifolia - Sarcobatus vermiculatus Shrubland
Shadscale - Black Greasewood Shrubland

CODE	CEGL001313
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N)
FORMATION	Facultatively deciduous extremely xeromorphic subdesert shrubland (III.A.5.N.b)
ALLIANCE	*ATRIPLEX CONFERTIFOLIA* SHRUBLAND ALLIANCE (A.870) Shadscale Shrubland Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784) Sonora-Mojave Mixed Salt Desert Scrub (CES302.749) Inter-Mountain Basins Greasewood Flat (CES304.780)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This shrub association is found on saline soils on valley floors, alluvial terraces and alluvial fans across the Colorado Plateau. Elevations range from 1350 to 1650 m, slopes range from level to moderately steep (1-50% slopes), and sites can be oriented to any aspect. Soils are fine-textured and poorly drained clays, clay loams and silt loams. Total vegetation cover ranges from less than 20% to more than 50%, with the higher values tending to occur in shrublands located on valley floors and alluvial terraces. The shrub stratum generally consists of *Sarcobatus vermiculatus*

shrubs with between 1 and 20% cover. *Atriplex confertifolia* shrubs are scattered throughout the canopy, with between 1 and 5% cover. Other shrubs present with minor cover include *Gutierrezia sarothrae* and *Suaeda moquinii (= Suaeda torreyana)*. The herbaceous layer is variable but can have as much as 35% cover. This layer tends to reflect a degree of disturbance; common species include *Achnatherum hymenoides, Astragalus nuttallianus, Bromus tectorum, Lappula occidentalis, Lepidium densiflorum, Plantago patagonica*, and *Sphaeralcea parvifolia*. Nonvascular species are generally present on the soil surface and may have as much as 95% cover in undisturbed sites.

DISTRIBUTION

Arches National Park

This association is uncommon and scattered throughout the park in valley bottom locations. Sampled plots are in Salt Valley, Cache Valley, in Salt Wash and in similar sites in the environs.

Globally

This shrub association is found scattered in saline soils on valley floors, alluvial terraces and alluvial fans across the Colorado Plateau, in Arizona and Colorado and extends west into California and Nevada.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This association occupies arid valley bottom sites with gentle to moderate slopes. A few stands are away from drainages. Soil texture and chemistry influence distribution of this type more strongly than aspect or elevation. Bare ground covers most of the unvegetated surface, sometimes with low cover by gravel. Soils tend to be well-drained and alkaline. They are either derived directly from Mancos or Tidwell shale or from alluvium that has a strong component of marine shale. Most sites exhibit the effects of past grazing.

Globally

This shrub association is found scattered in saline habitats across the Colorado Plateau. Miller et al. (1977) report this association as occurring in low-lying, internally drained areas such as abandoned stream channels. Recent plot data from eastern Utah and western Colorado indicate that the habitat for this association includes valley toeslopes and alluvial terraces, as well as low-lying areas on valley floors. Elevations range from 1350 to 1650 m, slopes range from level to moderately steep (1-50% slopes), and sites can be oriented to any aspect. Soils are fine-textured and poorly drained clays, clay loams and silt loams.

VEGETATION DESCRIPTION

Arches National Park

This association is uncommon within the park. Stands tend to be open, with total vegetation cover rarely exceeding 20%. The vegetation is characterized by an open canopy of *Atriplex confertifolia* and *Sarcobatus vermiculatus* shrubs. Associated shrubs may include *Opuntia polyacantha* and *Krascheninnikovia lanata*. The herbaceous layer is moderately diverse and provides sparse to low cover. Common graminoids include *Achnatherum hymenoides* and *Pleuraphis jamesii*. Forbs commonly present include *Plantago patagonica* and *Sphaeralcea parvifolia*, and may consist mostly of exotic annual forbs such as *Cryptantha crassisepala* var. *elachantha*.

Globally

This mixed shrubland association occurs in habitats that are significantly saline, either because of poor drainage or high levels of salts in the soil. Total vegetation cover ranges from less than 20% to more than 50%, with the higher values tending to occur in shrublands located on valley floors and alluvial terraces. Upland sites tend to have sparser vegetation. The shrub stratum generally consists primarily of *Sarcobatus vermiculatus* shrubs not more than 1 m tall, with between 1 and 20% cover. *Atriplex confertifolia* shrubs are scattered throughout the canopy, with between 1 and 5% cover. Other shrubs present with minor cover include *Gutierrezia sarothrae* and *Suaeda moquinii*. The herbaceous layer is variable but can have as much as 35% cover. This layer tends to reflect a degree of disturbance; common species include *Achnatherum hymenoides, Astragalus nuttallianus, Bromus tectorum, Lappula occidentalis, Lepidium densiflorum, Plantago patagonica, Sporobolus airoides*, and *Sphaeralcea parvifolia*. Mosses and ground lichens are generally present and may have as much as 95% cover in undisturbed sites.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species

Short shrub/sapling	*Atriplex confertifolia, Sarcobatus vermiculatus*
Short shrub/sapling	*Chrysothamnus viscidiflorus, Krascheninnikovia lanata, Opuntia polyacantha*
Herb (field)	*Achnatherum hymenoides, Pleuraphis jamesii*

Globally

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia, Sarcobatus vermiculatus*
Herb (field)	*Bromus tectorum*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Cryptantha crassisepala var. *elachantha*

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (23-Feb-1994)

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Most stands show evidence of heavy grazing; a few have cow pies. Mary are in drainages or close to drainages, which encourages the greasewood. Grass is generally in small, scattered patches.
Arches National Park Data: The description is based on 2003 and 2006 field data (5 observation points: ARCH.9040, ARCH.9314, ARCH.9359, ARCH.9368, ARCH.9605, and 4 accuracy assessment points: ARCH_AA.0407, ARCH_AA.0553, ARCH_AA.0727, ARCH_AA.0728).
Local Description Authors: J. Coles
Global Description Authors: J. Coles

REFERENCES: Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Driscoll et al. 1984, Fenemore 1970, Kagan et al. 2004, Miller et al. 1977, NVNHP 2003, Western Ecology Working Group n.d.

Atriplex confertifolia / Pleuraphis jamesii Shrubland
Shadscale / James' Galleta Shrubland

CODE	CEGL001304
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Facultatively deciduous extremely xeromorphic subdesert shrubland (III.A.5.N.b.)
ALLIANCE	*ATRIPLEX CONFERTIFOLIA* SHRUBLAND ALLIANCE (A.870) Shadscale Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This widespread western shrubland association is reported from the southwestern Great Plains, Colorado Plateau, Great Basin, Columbia Plateau and Mojave Desert mountains. It occurs in a variety of habitats and can be found on

two distinct substrates: coarse-textured, non-saline soils derived from sandstone or gravel or deep, fine-textured, alkaline, often saline soils derived from shale. Stands with coarse-textured soils tend to be on slopes, while those with fine-textured soils tend to be on low, relatively flat positions in the landscape (valley bottoms, basins, etc.). The common trait of these different substrates is that they are very dry either because of low precipitation or because of high internal plant moisture stress from soil salinity. The unvegetated surface is composed largely of bare soil, gravel, and large or small rocks. This shrubland association is characterized by a sparse to open canopy (5-25% cover) of short shrubs dominated by *Atriplex confertifolia* with a sparse to moderate graminoid layer dominated by *Pleuraphis jamesii*. It includes sparsely vegetated stands with as little as 1-2% cover of shrubs and 1% cover of *Pleuraphis jamesii*. Total vegetation cover is widely variable (2-70% in sampled stands). Associated shrubs include *Artemisia bigelovii, Artemisia tridentata ssp. wyomingensis, Atriplex canescens, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ephedra torreyana, Ericameria nauseosa, Grayia spinosa, Gutierrezia sarothrae, Krascheninnikovia lanata, Opuntia polyacantha, Picrothamnus desertorum, Sarcobatus vermiculatus, Suaeda calceoliformis, Suaeda moquinii*, and *Tetradymia canescens* depending on substrate. *Amphipappus fremontii, Ambrosia dumosa*, and *Lycium pallidum* occur in the Mojave Desert. If other *Atriplex* species are present, they do not dominate the canopy. Other graminoids include *Achnatherum hymenoides, Sporobolus cryptandrus*, and *Elymus elymoides* on sandy sites and *Bouteloua gracilis* and *Sporobolus airoides* on fine-textured soil. Forbs generally have low cover and may include *Sphaeralcea grossulariifolia, Eriogonum inflatum*, and species of *Chaenactis, Lappula, Phacelia, Plantago*, and *Chenopodium*. Introduced species such as *Bromus tectorum* and *Salsola kali* are common on some sites.

DISTRIBUTION

Arches National Park

This association is common within the park and was sampled along Delicate Arch Trail, in the Salt Valley and in Salt Wash, in The Highlands, in Little Valley South, southeast of Fiery Furnace, in Cache Valley, near Klondike Bluffs, in Yellow Bird Wash, and along Yellow Bird Mine Road. This association is rare within the park and was sampled at The Garden, in Little Valley South, and along the Yellow Bird Mine Road.

Globally

This widespread shrubland association occurs throughout much of the intermountain western U.S. and is reported from the Columbia Plateau south to the Great Basin, Colorado Plateau, and Mojave Desert mountains and east into the southwestern Great Plains.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This short-shrub association occurs on valley toeslopes, hills, ridges, in drainages, and on stream terraces. Sites are flat to moderately steep (up to 36% slope), occur between 1314 and 1492 m elevation and are oriented to many aspects. Rocks and bare soil cover most of the soil surface, except for a subset of plots in which the ground is covered by a desert pavement. Biological soil crusts can provide as much as 40% cover. Parent materials include shales of the Morrison (Brushy Basin), Mancos, and Paradox formations or sandstones of the Morrison (Sand Wash), Wingate and Cedar Mountain formations. Soils are rapidly drained silt loam, silty clays, clay loams, sandy clays, and sandy loams.

Globally

This widespread association occurs in a variety of habitats throughout much of the intermountain western U.S. and extends south to Mojave Desert mountains and east into the southwestern Great Plains. Elevation ranges from 1184 to 1951 m in the Colorado Plateau. It is found on two distinct substrates: coarse-textured (rocky or sandy), non-saline soils derived from sandstone or gravel, or deep fine-textured, poorly drained, alkaline, often-saline soils derived from shale or shale-derived alluvium. Sites with coarse-textured soils include gravel and cobble outcrops, ridges, mesa escarpments, talus slopes, alluvial fans, mountain and hillslopes, canyonsides, benches and along toeslopes of river bluffs. Fine-textured soil sites include canyon bottoms, plains, alluvial flats, floodplains and basins. Stands with coarse-textured soils can be on flat to moderately steep slopes, while stands with fine-textured soils are typically on flat to gently sloping sites. The common trait of these different substrates is that they are very dry either because of low precipitation (15-23 cm annually) or because of high internal plant moisture stress from soil salinity. The unvegetated surface is composed largely of bare soil, gravel, and large or small rocks. Cryptogamic crusts and mosses are important in some stands. Parent materials are variable and in the Colorado Plateau include sandstones and shale of the Burro Canyon Formation, Cedar Mountain Formation, Chinle Formation, Elephant

Canyon Formation, Entrada Formation, Kayenta Formation sandstone, Mancos shale, Morrison Formation, Moenkopi Formation, and Wingate Formation typically deposited as alluvium or eolian sand.

VEGETATION DESCRIPTION

Arches National Park

This desert shrubland association is common in the lower elevations of the mapping area. Total vegetation cover ranges from 1 to 30%. The open canopy is dominated by *Atriplex confertifolia* with between <1 and 15% cover and the short bunchgrass *Pleuraphis jamesii* with between <1 and 15% cover. Associated shrubs, if present, may include *Coleogyne ramosissima, Ephedra torreyana, Gutierrezia sarothrae,* and *Opuntia polyacantha*. The associated herbaceous layer generally has low cover other than the galleta. Graminoids occasionally present include the annual exotic *Bromus tectorum* and the medium-tall bunchgrass *Achnatherum hymenoides*. Forbs commonly present include *Eriogonum inflatum, Lappula occidentalis, Phacelia crenulata, Calochortus nuttallii, Platyschkuhria integrifolia, Sphaeralcea coccinea*, and *Plantago patagonica*. Biological soil crusts are absent in sites with desert pavement but can provide up to 40% cover. Scattered dwarfed *Juniperus osteosperma* may rarely be present.

Globally

This shadscale shrubland association is characterized by an open canopy (5-25% cover) of short shrubs dominated by *Atriplex confertifolia* with a sparse to moderate graminoid layer dominated by *Pleuraphis jamesii*. This association includes sparsely vegetated stands with as little as 1-2% cover of shrubs and 1% cover of *Pleuraphis jamesii*. Total vegetation cover is widely variable (2-70% in sampled stands). Associated shrubs include *Artemisia bigelovii, Artemisia tridentata ssp. wyomingensis, Atriplex canescens, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Eriogonum microthecum, Grayia spinosa, Gutierrezia sarothrae, Krascheninnikovia lanata, Lycium pallidum, Picrothamnus desertorum, Sarcobatus vermiculatus, Suaeda calceoliformis, Suaeda moquinii*, and *Tetradymia canescens* depending on substrate. *Amphipappus fremontii, Ambrosia dumosa,* and *Lycium pallidum* occur in the Mojave Desert. Succulents may include *Echinocereus triglochidiatus, Opuntia erinacea, Opuntia polyacantha, Sclerocactus whipplei*, and *Yucca harrimaniae*. Rarely, tree and tall-shrub species are present and may include *Juniperus osteosperma* and *Fraxinus anomala*. If other *Atriplex* species are present, they do not dominate the canopy. The herbaceous layer is often sparse, less than 10% total cover, but ranges up to 30% cover. Other graminoids include *Achnatherum hymenoides, Sporobolus cryptandrus,* and *Elymus elymoides* on sandy sites and *Bouteloua gracilis, Poa fendleriana, Poa secunda*, and *Sporobolus airoides* on finer-textured soil. Forbs generally have low cover and moderate diversity and may include *Astragalus nuttallianus, Calochortus flexuosus, Calochortus nuttallii, Cirsium* sp., *Cryptantha flavoculata, Cymopterus purpurascens, Descurainia pinnata, Eriogonum inflatum, Eriogonum lonchophyllum, Lappula occidentalis, Lepidium montanum, Oenothera pallida, Phacelia crenulata, Plantago patagonica, Platyschkuhria integrifolia, Rumex hymenosepalus, Senecio integerrimus, Sphaeralcea coccinea, Sphaeralcea grossulariifolia,* and species of *Chaenactis, Cryptantha, Phacelia,* and *Chenopodium*. Introduced annual species such as *Bromus tectorum, Erodium cicutarium,* and *Salsola kali* are common on some sites. Biological soil crusts are variable, with some stands having very little, but cover can be as high as 80%.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia*
Herb (field)	*Pleuraphis jamesii*

Globally

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia*
Short shrub/sapling	*Gutierrezia sarothrae*
Herb (field)	*Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES

Arches National Park

Descurainia pinnata, Erodium cicutarium, Halogeton glomeratus, Malcolmia africana, Salsola tragus

Globally

Bromus tectorum, Sclerocactus whipplei

CONSERVATION STATUS RANK
Global Rank & Reasons: G3G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
This widespread shrubland association is only defined by the codominance of *Atriplex confertifolia* and *Pleuraphis jamesii*. Stands are found in different regions (from southwestern Great Plains to Great Basin), in different environments (clay bottomlands, dunes, desert mountains) and with different associated species. This association will likely need to be subdivided as more classification information becomes available. Stands of this association with a sparse herbaceous layer are similar to *Atriplex confertifolia* Great Basin Shrubland (CEGL001294). Sparse stands included in the concept of this association are very similar to *Atriplex confertifolia* Sparse Shrubland (CEGL003830). More classification work is needed to clarify differences.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Sites occupy slickrock with a thin cover of soil. Some hills have little vegetation cover occupying clay soils. Drought effects are observed in some stands. Some stands have a surface veneer of small rocks. Drainages and gullies are common in this landscape. There are signs of grazing in some stands. Extremely sparse vegetation is usually not greater than 1% cover occurring on pavements of polished sandstone fragments, desert pavement, within the Brushy Basin Member of the Morrison Formation. Desert pavement appears stabilized. There is some grazing of stands.
Arches National Park Field Data: The description is based on 2003 field data (19 plots: ARCH.0008, ARCH.0013, ARCH.0036, ARCH.0040, ARCH.0055, ARCH.0095, ARCH.0099, ARCH.0100, ARCH.0107, ARCH.0111, ARCH.0352, ARCH.0359, ARCH.0360, ARCH.0614, ARCH.0631, ARCH.0635, ARCH.0643, ARCH.0668, ARCH.0670).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Drake and J. Coles

REFERENCES: Annable 1985, Bourgeron and Engelking 1994, Branson and Owen 1970, Branson et al. 1976, CONHP unpubl. data 2003, Campbell 1977, Dastrup 1963, Driscoll et al. 1984, Graham 1937, Harper and Jaynes 1986, Ibrahim et al. 1972, Lusby et al. 1963, Potter et al. 1985, Singh and West 1971, Soil Conservation Service 1978, Tuhy and MacMahon 1988, U.S. Bureau of Reclamation 1976, Von Loh 2000, Welsh 1957, West and Ibrahim 1968

Atriplex confertifolia / Sporobolus cryptandrus Shrubland [Provisional]
Shadscale / Sand Dropseed Shrubland

CODE	CEGL003762
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Facultatively deciduous extremely xeromorphic subdesert shrubland (III.A.5.N.b.)
ALLIANCE	*ATRIPLEX CONFERTIFOLIA* SHRUBLAND ALLIANCE (A.870) Shadscale Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This xeric, alkaline shrub association occurs on hillsides, dry stream terraces and benches. Sites are flat to moderately steep (up to 30% slopes) often on southwestern aspects. Soils are rapidly drained sandy loams and silty clays derived from alluvium. Total vegetation cover ranges from 8 to 40%. The vegetation is characterized by an

open canopy of *Atriplex confertifolia* and an understory dominated by the bunchgrass *Sporobolus cryptandrus*. Associated shrubs include *Opuntia polyacantha* and *Sclerocactus whipplei*. Associated herbaceous species include the annual exotic *Bromus tectorum* and the short bunchgrass *Muhlenbergia pungens*. Forbs occasionally present include *Cryptantha crassisepala, Erodium cicutarium, Gaillardia pinnatifida, Plantago patagonica,* and *Streptanthella longirostris*. Biological soil crusts provide up to 25% cover.

DISTRIBUTION

Arches National Park

This association is rare in the park and was sampled in and downstream of Negro Bill Canyon.

Globally

This association is known from Arches National Park but likely is widespread in the canyonlands of the Colorado Plateau in eastern Utah and may be similar to shadscale types in Nevada.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This xeric, alkaline shrub association occurs on hillsides, dry stream terraces and benches. Sites are flat to moderately steep (up to 30% slopes), occur between 1220 and 1223 m elevation and are oriented to southwestern aspects. Bare ground covers most of the unvegetated surface, with some rocks and gravel. Soils are rapidly drained sandy loams and silty clays derived from alluvium.

Globally

This xeric, alkaline shrub association occurs on hillsides, dry stream terraces and benches. Sites are flat to moderately steep (up to 30% slopes) often on southwestern aspects. Soils are rapidly drained sandy loams and silty clays derived from alluvium. Total vegetation cover ranges from 8 to 40%.

VEGETATION DESCRIPTION

Arches National Park

This shadscale association is rare within the park. Total vegetation cover ranges from 8 to 40%. The vegetation is characterized by an open canopy of *Atriplex confertifolia* with up to 15% cover and an understory dominated by the bunchgrass *Sporobolus cryptandrus* with up to 15% cover. Associated shrubs include *Opuntia polyacantha* and *Sclerocactus whipplei*. Common herbaceous species include the annual exotic *Bromus tectorum* and the native bunchgrass *Muhlenbergia pungens*. Forbs present include *Cryptantha crassisepala, Erodium cicutarium, Gaillardia pinnatifida, Plantago patagonica*, and *Streptanthella longirostris*. Biological soil crusts provide up to 25% cover.

Globally

The vegetation is characterized by an open canopy of *Atriplex confertifolia* and an understory dominated by the bunchgrass *Sporobolus cryptandrus*. Associated shrubs include *Opuntia polyacantha* and *Sclerocactus whipplei*. Associated herbaceous species include the annual exotic *Bromus tectorum* and the short bunchgrass *Muhlenbergia pungens*. Forbs occasionally present include *Cryptantha crassisepala, Erodium cicutarium, Gaillardia pinnatifida, Plantago patagonica,* and *Streptanthella longirostris*. Biological soil crusts provide up to 25% cover.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia, Ephedra torreyana, Opuntia phaeacantha*
Herb (field)	*Erodium cicutarium, Streptanthella longirostris*
Herb (field)	*Bromus tectorum, Sporobolus cryptandrus*

Globally

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia*
Herb (field)	*Sporobolus cryptandrus*

OTHER NOTEWORTHY SPECIES

Arches National Park

Data are not available.

Globally
Sclerocactus whipplei

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (13-Mar-2006).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Arches National Park Inventory Notes: Shrubs are drought-stressed. One site is hot due to reflected and absorbed heat. One site is disturbed by mining in the vicinity.
Arches National Park Field Data: The description is based on 2003 field data (2 plots: ARCH.0714, ARCH.0718).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: G. Kittel and K.A. Schulz

REFERENCES: Blackburn et al. 1968c, Western Ecology Working Group n.d.

Coleogyne ramosissima - Purshia stansburiana - Quercus havardii var. *tuckeri* Shrubland
Blackbrush - Stansbury Cliffrose - Tucker Sand Shinnery Oak Shrubland

CODE	CEGL002348
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Facultatively deciduous extremely xeromorphic subdesert shrubland (III.A.5.N.b.)
ALLIANCE	*COLEOGYNE RAMOSISSIMA* SHRUBLAND ALLIANCE (A.874) Blackbrush Shrubland Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This Colorado Plateau shrub association is characteristic of semi-stabilized sandsheets, dunes and sand-filled pockets in sandstone slickrock in southeastern Utah. Stands occur on plains, ridges, mesatops, canyon rims, escarpments, valley sides, sand dunes, alluvial terraces and benches with flat to gentle slopes (0-12%) between 1275 and 1670 m (4185-5475 feet) elevation. Bare soil, sand, and gravel cover much of the unvegetated surface. Litter cover is sparse to low. Covers of bedrock and biological soil crust are variable; either can be absent to sparse or can provide up to 40% cover. Soils are rapidly drained loamy sands, silt loams, sands, sandy clay loams, or sandy loams derived from eolian sands, alluvium, sandstones or shales. Total vegetation cover ranges from 5 to 70%. The shrub layer is characterized by an open canopy to relatively closed canopy of *Coleogyne ramosissima* accompanied by either or both *Purshia stansburiana* and *Quercus havardii* var. *tuckeri*. Scattered individuals of *Juniperus osteosperma* are present in many stands but not with more than 5% cover. Occasionally *Coleogyne ramosissima* may be absent, but then both *Purshia stansburiana* and *Quercus havardii* var. *tuckeri* are prominent. Associated shrubs include *Artemisia bigelovii, Brickellia microphylla, Ephedra torreyana, Ephedra viridis, Eriogonum leptocladon, Fraxinus anomala, Gutierrezia sarothrae, Opuntia polyacantha,* and *Yucca harrimaniae*. The herbaceous layer is moderately diverse in terms of species composition but provides only sparse cover. Common species include the grasses *Achnatherum hymenoides, Aristida purpurea, Dasyochloa pulchella, Pleuraphis jamesii,* and *Muhlenbergia pungens*. Forbs present include *Chaenactis stevioides, Chamaesyce fendleri, Cryptantha crassisepala, Gilia inconspicua, Tetraneuris acaulis,* and *Streptanthella longirostris*. The exotic annual grass

Bromus tectorum is common on some sites.

DISTRIBUTION

Arches National Park

This association is locally common and was sampled in the head of Lost Spring Canyon, along the Yellow Bird Mine Road, near The Windows, near Devils Garden Campground, in Herdina Park, near Balanced Rock, near The Organ, near the Eye of the Whale, near The Great Wall, in Courthouse Wash, and along Park Avenue within the park.

Globally

This association is locally common on sandy sites at middle elevations at Arches, Canyonlands, and Capitol Reef national parks, and Glen Canyon National Recreation Area in the Colorado Plateau of southeastern Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This association occurs in sand-filled depressions in slickrock on canyon rims, on sandy slopes, valley sides and benches, and on dunes. Sites are flat to gently sloping (up to 12%) between 1311 and 1591 m elevation. Bare ground and bedrock cover most of the unvegetated surface. Biological soil crusts can provide up to 20% cover. Soils are rapidly drained loamy sands, clay loams, and sandy loams.

Globally

This Colorado Plateau shrub association is characteristic of semi-stabilized sandsheets, dunes and sand-filled pockets in sandstone slickrock in southeastern Utah. Stands occur on plains, ridges, mesatops, canyon rims, escarpments, valley sides, sand dunes, alluvial terraces and benches with flat to gentle slopes (0-12%) between 1275 and 1670 m (4185-5475 feet) elevation. Bare soil, sand, and gravel cover much of the unvegetated surface. Litter cover is sparse to low. Bedrock and biological soil crust cover is variable and can be absent to sparse or can provide up to 40% cover. Soils are rapidly drained loamy sands, silt loams, sands, sandy clay loams, or sandy loams derived from eolian sands, alluvium, sandstones of the White Rim, Kayenta, Dakota or Entrada formations, or shales of the Moenkopi Formation or Salt Wash Member of the Morrison Formation.

VEGETATION DESCRIPTION

Arches National Park

This mixed sandy shrub association is locally common, especially in the central and southern portions of the park. Total vegetation cover ranges from 2 to 60%. The vegetation is characterized by a mixed canopy of *Coleogyne ramosissima* (always present) accompanied by *Purshia stansburiana* and/or *Quercus havardii* var. *tuckeri*. Most stands have scattered *Juniperus osteosperma* that are too sparse to constitute a stratum. Associated shrubs include *Ephedra viridis, Fraxinus anomala, Gutierrezia sarothrae, Opuntia polyacantha*, and *Yucca harrimaniae*. The herbaceous layer is diverse but sparse and includes the grasses *Achnatherum hymenoides, Pleuraphis jamesii*, and *Vulpia octoflora*. Forbs occasionally present include *Chaenactis stevioides, Cryptantha crassisepala*, and *Streptanthella longirostris*.

Globally

This association is locally common on sandy sites throughout the northern Colorado Plateau. Total vegetation cover ranges from 5 to 70%. The shrub layer is characterized by an open to relatively closed canopy of *Coleogyne ramosissima* accompanied by either or both *Purshia stansburiana* and *Quercus havardii* var. *tuckeri*. Scattered individuals of *Juniperus osteosperma* are present in many stands but with less than 5% cover. Occasionally *Coleogyne ramosissima* may be absent, but then both *Purshia stansburiana* and *Quercus havardii* var. *tuckeri* are prominent. Associated shrubs include *Artemisia bigelovii, Brickellia microphylla, Ephedra torreyana, Ephedra viridis, Eriogonum leptocladon, Fraxinus anomala, Gutierrezia sarothrae, Opuntia polyacantha*, and *Yucca harrimaniae*. Exceptionally cool or moist sites support *Cercocarpus intricatus* and *Amelanchier utahensis* as part of the mix. The herbaceous layer is moderately diverse in terms of species composition but provides only sparse cover. Common species include the grasses *Achnatherum hymenoides, Aristida purpurea, Dasyochloa pulchella, Pleuraphis jamesii*, and *Muhlenbergia pungens*. Forbs present include *Chaenactis stevioides, Chamaesyce fendleri, Cryptantha crassisepala, Gilia inconspicua, Tetraneuris acaulis*, and *Streptanthella longirostris*. The exotic annual grass *Bromus tectorum* is common on some sites. Biological soil crusts are typically sparse in terms of cover, but one sampled stand had 40% cover.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Tall shrub/sapling	*Fraxinus anomala*
Tall shrub/sapling	*Cercocarpus intricatus*, *Coleogyne ramosissima*, *Ephedra viridis*, *Eriogonum corymbosum*, *Purshia stansburiana*, *Quercus havardii* var. *tuckeri*, *Vanclevea stylosa*
Herb (field)	*Gutierrezia sarothrae*, *Opuntia polyacantha*, *Yucca harrimaniae*
Herb (field)	*Chaenactis stevioides*, *Petradoria pumila*, *Plantago patagonica*

Globally

Stratum	Species
Tall shrub/sapling	*Cercocarpus intricatus*, *Ephedra viridis*, *Purshia stansburiana*, *Quercus havardii* var. *tuckeri*
Herb (field)	*Yucca angustissima*
Herb (field)	*Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES

Arches National Park
Bromus tectorum, *Descurainia pinnata*, *Malcolmia africana*, *Salsola tragus*

Globally
Bromus tectorum

CONSERVATION STATUS RANK

Global Rank & Reasons: G3G4 (11-Jan-2006). This association is somewhat restricted in its range and habitat, but most sampled examples appear to be in good condition, with few exotic species present. The range is restricted by the range of *Quercus havardii* var. *tuckeri*, which is limited to southeastern Utah. Most stands of this association are small, less than 5 hectares in size and often less than 1 ha in size.

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
Quercus havardii var. *tuckeri* is also referred to in Utah as *Quercus undulata* and *Quercus welshii*. The literature for Utah should be reviewed for material relating to this association but using these other names.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Arches National Park Inventory Notes: Sites include thin soils on slickrock canyon rims and on ledges. There is some wind erosion of exposed sites resulting in dunes of blowing sand. Some stands have moderate biological soil crust development. Evidence of grazing by cattle was noted.
Arches National Park Field Data: The description is based on 2003 field data (13 plots: ARCH.0020, ARCH.0039, ARCH.0046, ARCH.0070, ARCH.0075, ARCH.0094, ARCH.0127, ARCH.0312, ARCH.0337, ARCH.0685, ARCH.0699, ARCH.0702, ARCH.0708).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Coleogyne ramosissima Shrubland
Blackbrush Shrubland

CODE	CEGL001332
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)

PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Facultatively deciduous extremely xeromorphic subdesert shrubland (III.A.5.N.b.)
ALLIANCE	*COLEOGYNE RAMOSISSIMA* SHRUBLAND ALLIANCE (A.874) Blackbrush Shrubland Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763)
Mojave Mid-Elevation Mixed Desert Scrub (CES302.742)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This broadly defined, common shrubland association occurs in the Colorado Plateau, southern Great Basin, Mojave Desert, and Sierra Nevada foothills in areas with hot summers and cold winters. Elevations range from 1065-2133 m (3500-7000 feet). Sites are on level to steep slopes, rarely exceeding 45%. In Nevada, stands occur on lower foothills and upper bajadas, often with cooler northern and eastern aspects. In the Colorado Plateau, stands occupy plateaus, ridges, dunes, alluvial fans, benches and colluvial slopes oriented to any aspect. The unvegetated surface is dominated by bare ground, except on some sandy sites, where biological soil crusts may provide more than 50% cover. Substrates range from barren shales to alluvium and eolian sands to broken limestone. Soils tend to be shallow, calcareous, sandy-textured on eolian sand sites, and clay-textured on shale sites. There is often a caliche subhorizon. Gravel, boulders and rock outcrops are common. The vegetation is characterized by an open to moderately dense short-shrub layer that is clearly dominated by the evergreen microphyllous shrub *Coleogyne ramosissima*, sometimes in nearly pure stands. Shrub cover is usually around 20%, although it can range as low as 5% or as high as 50%. Other shrub and dwarf-shrub species may be present with low cover, including *Ambrosia dumosa, Artemisia filifolia, Atriplex canescens, Atriplex confertifolia, Chrysothamnus viscidiflorus, Ephedra funerea, Ephedra torreyana, Ephedra nevadensis, Ephedra viridis, Ericameria linearifolia, Ericameria teretifolia, Gutierrezia sarothrae, Gutierrezia microcephala, Krascheninnikovia lanata, Lycium* spp., *Menodora spinescens, Opuntia* spp., and *Yucca baccata*. Occasional *Juniperus* spp., *Pinus edulis*, or *Pinus monophylla* trees are present in some stands. The herbaceous layer generally includes only sparse cover of graminoids and forbs, except during wet years when cover of annuals may be high. Cover of the introduced annual *Bromus* spp. may be high in disturbed stands, but in general, the substrate does not support the growth of more than a trace of grasses.

DISTRIBUTION

Arches National Park

This association is very common and was sampled along Park Avenue, near the Visitors Center and Balanced Rock, Devil's Garden, in The Windows Section and south of The Windows, Winter Camp Wash, along Willow Springs Road, in Fish Seep Draw, along the Eye of the Whale Road, in Willow Flat, Courthouse Wash, in Herdina Park, northeast of Herdina Park, in Fin Canyon, near South Windows, in Eagle Park, along Klondike Bluffs Road, in Little Valley South, near the Marching Men, in The Highlands, in the Salt Valley, in the Fiery Furnace, east of the Fiery Furnace, along Wolfe Ranch Road, along Yellow Bird Mine Road, near Yellow Bird Mine, along Drill Hole Road, east of Drill Hole Road, Colorado River Gorge, and in Negro Bill Canyon.

Globally

This widespread and common desert shrubland association occurs in the Colorado Plateau, southern Great Basin, Mojave Desert, and Sierra Nevada foothills.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This short-shrub association occurs in two distinct situations. Most stands, and most of the denser and larger stands, are on stabilized sandsheets with gentle to moderate slopes on plains, valley sides and bottoms, plateaus, benches and rims. The smaller group of stands, mostly with sparse cover, are restricted to outcrops of brick red Tidwell shale (Morrison Formation); these stands are on hogbacks, ridges and benches and may be level to steeply sloped (up to 47%). The community is found between 1235 and 1628 m elevation in all sections of the park. Bare ground covers most of the unvegetated surface in both types of stands, but chert outcrops are frequent and characteristic of the Tidwell shale stands. Biological soil crusts occur only in sandy sites and may provide up to 55% cover in these stands. Soils are rapidly drained, and the texture is either sandy loam or silt loam, silty clay, clay loam or sandy clay.

Globally
This broadly defined shrubland association occurs in the Colorado Plateau, southern Great Basin, Mojave Desert, and Sierra Nevada foothills in areas with hot summers and cold winters. Elevations range from 1065-2133 m (3500-7000 feet). Sites are frequently on level to moderate slopes rarely exceeding 20% but have also been found on steep slopes (>45%). In Nevada, stands occur on lower foothills and upper bajadas, often with cooler northern and eastern aspects. In the Colorado Plateau, stands occupy plateaus, ridges, dunes, alluvial fans, canyon rims, bench ledges valleys, plains, and colluvial slopes with any aspect. The upper elevation ecotones are generally narrow, and *Coleogyne ramosissima* may mix with *Artemisia* spp. or *Pinus edulis* and *Juniperus osteosperma*. The lower elevation ecotones tend to be broader, and *Coleogyne ramosissima* may mix with grasslands or with shrublands dominated by *Larrea tridentata, Ambrosia dumosa, Atriplex* spp., or *Grayia spinosa* (Beatley 1976). Stands described from the Colorado Plateau often occur in a mosaic with pinyon-juniper woodlands (Warren et al. 1982). The unvegetated surface is dominated by bare ground, except on some sandy sites, where biological soil crusts may provide more than 50% cover. Substrates range from barren shales to alluvium and eolian sands to broken limestone. Soils tend to be shallow, calcareous, sandy-textured on eolian sand sites, and clay soils on shale sites. There is often with a caliche subhorizon. Gravel, boulders and rock outcrops are common.

VEGETATION DESCRIPTION
Arches National Park
This blackbrush association is the most common and widespread shrubland type within the park. Total vegetation cover ranges from 1 to 80%; cover rarely exceeds 25% on shale substrates, and generally exceeds 25% on sandy substrates. In all stands, the shrub canopy is clearly dominated by *Coleogyne ramosissima*, often associated with *Ephedra viridis, Ephedra torreyana*, and *Opuntia polyacantha*. Stands on Tidwell shale may have significant cover by *Atriplex confertifolia*. The herbaceous layer is sparse. Common graminoids include *Bromus tectorum, Pleuraphis jamesii*, and *Vulpia octoflora*. Forbs noted in the sample plots include *Chaenactis stevioides, Cryptantha crassisepala, Phacelia crenulata, Plantago patagonica*, and *Streptanthella longirostris*. Scattered *Juniperus osteosperma* may be present.

Globally
This common association is characterized by an open to moderately dense short-shrub layer that is clearly dominated by the evergreen microphyllous shrub *Coleogyne ramosissima*. Shrub cover is usually around 20%, although it can range as low as 5% or as high as 50%. It can occur in almost pure stands. Other shrub and dwarf-shrub species may be present with low cover, including *Ambrosia dumosa, Artemisia filifolia, Atriplex canescens, Atriplex confertifolia, Chrysothamnus viscidiflorus, Ephedra funerea, Ephedra torreyana, Ephedra nevadensis, Ephedra viridis, Ericameria linearifolia, Ericameria teretifolia, Gutierrezia sarothrae, Gutierrezia microcephala, Krascheninnikovia lanata, Lycium* spp., *Menodora spinescens, Opuntia* spp., and *Yucca baccata*. Locally, disturbance may reduce abundance of *Coleogyne ramosissima* and favor *Artemisia filifolia* until it nearly codominates. Occasional *Juniperus* spp., *Pinus edulis*, or *Pinus monophylla* trees are present in some stands. The herbaceous layer generally includes only sparse cover of graminoids and forbs, except during wet years when cover of annuals may be high. Cover of the introduced annual *Bromus* spp. may be high in disturbed stands, but in general, the substrate does not support the growth of more than a trace of grasses. Forbs may include species of *Chaenactis, Cryptantha, Phacelia, Plantago*, and *Streptanthella*. Scattered *Juniperus osteosperma* may also be present.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Purshia stansburiana*
Short shrub/sapling	*Artemisia filifolia, Atriplex confertifolia, Brickellia oblongifolia, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Eriogonum corymbosum, Eriogonum leptocladon, Grayia spinosa, Quercus havardii* var. *tuckeri*
Herb (field)	*Gutierrezia sarothrae, Krascheninnikovia lanata, Opuntia polyacantha, Yucca harrimaniae*
Herb (field)	*Abronia fragrans, Chaenactis stevioides, Cryptantha crassisepala, Phacelia crenulata, Plantago patagonica, Salsola tragus, Sphaeralcea leptophylla, Streptanthella longirostris, Wyethia scabra*

Herb (field)	*Bromus tectorum, Muhlenbergia pungens, Pleuraphis jamesii, Vulpia octoflora*

Globally

Stratum	Species
Short shrub/sapling	*Coleogyne ramosissima*

OTHER NOTEWORTHY SPECIES
Arches National Park
Descurainia pinnata, Erodium cicutarium, Malcolmia africana

Globally
Bromus rubens, Bromus tectorum, Ephedra funerea

CONSERVATION STATUS RANK
Global Rank & Reasons: G4G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
This widespread plant association is broadly defined by the strong dominance of *Coleogyne ramosissima* without diagnostic codominate shrubs or a developed herbaceous layer. It is similar to the broadly defined *Coleogyne ramosissima / Pleuraphis jamesii* Shrubland (CEGL001334) and is separated from it by the lack of a *Pleuraphis jamesii*-dominated herbaceous layer. In cases where the grass element is missing or is greatly reduced because of grazing and not because of edaphic factors, there is potential for misclassification of stands.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Arches National Park Inventory Notes: Some stands have become established on slickrock covered by thin soils. Some stands have become established on sand dunes and sandsheets. More diverse flora occurs where soil has not been covered by sand. Recruitment of blackbrush shrubs occasionally occurred. Biological soil crust has formed extensively on some sites. There is evidence of drought stress and gully erosion in some stands. Some shale soils have a chert gravel veneer; shale soils limit species diversity. Some sites are grazed by cattle.
Arches National Park Field Data: The description is based on 2003 field data (68 plots: ARCH.0002, ARCH.0006, ARCH.0010, ARCH.0016, ARCH.0023, ARCH.0024, ARCH.0025, ARCH.0027, ARCH.0028, ARCH.0029, ARCH.0030, ARCH.0033, ARCH.0035, ARCH.0043, ARCH.0045, ARCH.0051, ARCH.0052, ARCH.0054, ARCH.0062, ARCH.0064, ARCH.0066, ARCH.0080, ARCH.0091, ARCH.0092, ARCH.0118, ARCH.0120, ARCH.0121, ARCH.0306, ARCH.0307, ARCH.0308, ARCH.0309, ARCH.0311, ARCH.0314, ARCH.0318, ARCH.0319, ARCH.0320, ARCH.0323, ARCH.0342, ARCH.0343, ARCH.0347, ARCH.0354, ARCH.0361, ARCH.0366, ARCH.0371, ARCH.0603, ARCH.0605, ARCH.0623, ARCH.0624, ARCH.0625, ARCH.0627, ARCH.0634, ARCH.0639, ARCH.0641, ARCH.0648, ARCH.0650, ARCH.0655, ARCH.0658, ARCH.0661, ARCH.0673, ARCH.0674, ARCH.0679, ARCH.0681, ARCH.0684, ARCH.0701, ARCH.0707, ARCH.0715, ARCH.0716, ARCH.0717).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: Annable 1985, Armstrong 1969, BIA 1979, Beatley 1976, Bourgeron and Engelking 1994, Bowns and West 1976, Bradley 1964, Callison et al. 1985, Cogan et al. 2004, Driscoll et al. 1984, Ostler et al. 2000, Peterson 1984, Schultz et al. 1987, Shields et al. 1959, Warren et al. 1982, Wells 1960, West 1983d, Wright 1980

Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii var. *tuckeri* Wooded Shrubland
Utah Juniper - (Two-needle Pinyon) / Blackbrush - Stansbury's Cliffrose - Tucker Sand Shinnery Oak Wooded Shrubland

CODE	CEGL003774
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen shrubland (III.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen shrubland (III.A.5.N.)
FORMATION	Extremely xeromorphic evergreen shrubland with a sparse tree layer (III.A.5.N.e.)
ALLIANCE	*PINUS EDULIS - JUNIPERUS OSTEOSPERMA* WOODED SHRUBLAND ALLIANCE (A.2649) Two-needle Pinyon - Utah Juniper Wooded Shrubland Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765)
Colorado Plateau Pinyon-Juniper Shrubland (CES304.766)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This association has been documented only in the canyonlands of the Colorado Plateau in eastern Utah. This wooded shrubland association occurs where a thin veneer of sand has been deposited in slickrock depressions, on escarpments, plateaus, benches, ridges, hogbacks, valley sides and slopes, dunes, swales, in slot canyons, and washes. Sites are on flat to steep slopes (up to 70%), occur between 1296 and 1890 m elevation, and are oriented to all aspects. Biological soil crust cover is typically low but can be as high as 45%. Soils are derived from eolian deposits and include rapidly drained loams, loamy sands to sandy clays, and sands. This wooded shrubland association has a mixed shrub canopy, occasionally with scattered trees of *Pinus edulis* and/or *Juniperus osteosperma*. Woody plants tend to be rooted in bedrock fractures; herbaceous plants persist in the thin deposits of sand that cover the substrate. Total vegetation cover is variable, ranging from 2 to 65% depending on the degree of fracturing of the underlying bedrock. The vegetation is characterized by an open canopy of stunted *Juniperus osteosperma* or *Pinus edulis* ranging in cover from 1 to 15% and a shrub understory in which *Coleogyne ramosissima* is always present and is always accompanied by either or both *Purshia stansburiana* and *Quercus havardii* var. *tuckeri*. Shrub cover may often exceed total tree cover. *Pinus edulis*, typically 2-5 m tall, may be present with low cover relative to *Juniperus osteosperma*. The shrub layer may contain as many as ten species. Herbaceous species are rarely important in these stands.

DISTRIBUTION

Arches National Park

This common association occurs throughout the park where Navajo, Entrada, Moab Tongue or Salt Wash sandstones appear as slickrock exposures. It was sampled near Delicate Arch, along the Delicate Arch Overlook Trail, near Balanced Rock, near Skyline Arch, near The Great Wall, Willow Flat, along Willow Spring Road, near Willow Spring, in the Salt Valley, on the Salt Valley Rim, in The Highlands, in Little Valley South, Little Valley, Herdina Park, north and northeast of Herdina Park, near Dalton Wells, at Dalton Wells Slickrock, along Drill Hole Road, near Navajo Dunes adjacent to Park Avenue, south of The Windows, in The Windows, near Klondike Bluffs, in Fin Canyon, in Cottonwood Wash, Upper Courthouse Wash, near The Organ, near Dark Angel, the Entrada Cliffs near Eagle Park, and near North Fiery Furnace.

Globally

This association is known only from the canyonlands of the Colorado Plateau in eastern Utah. It is reported from Arches, Canyonlands, and Capitol Reef national parks and Glen Canyon National Recreation Area.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This wooded shrubland association occurs where a thin veneer of sand has been deposited in slickrock depressions, on escarpments, plateaus, benches, ridges, hogbacks, valley sides and slopes, dunes, swales, in slot canyons, and washes. Sites are on flat to steep slopes (up to 70%), occur between 1296 and 1646 m elevation and are oriented to all aspects. Bedrock and bare soil typically cover most of the unvegetated surface. Litter provides sparse to low cover. Biological soil crust cover is typically low but can be as high as 45%. Parent materials are variable and include sandstones of the Wingate, Kayenta, Entrada (including the Dewey Bridge Member), and Navajo sandstone formations, the Moab Tongue of the Curtis Formation, and the Salt Wash member of the Morrison Formation that have eroded and been distributed as eolian deposits. Soils are derived from eolian deposits and include rapidly drained loams, loamy sands, sandy loams, sandy clays, and sands.

Globally
This wooded shrubland association occurs where a thin veneer of sand has been deposited in slickrock depressions, on escarpments, plateaus, benches, ridges, hogbacks, valley sides and slopes, dunes, swales, in slot canyons, and washes. Sites are on flat to steep slopes (up to 70%), occur between 1296 and 1890 m elevation, and are oriented to all aspects. Bedrock and bare soil typically cover most of the unvegetated surface. Litter provides sparse to low cover. Biological soil crust cover is typically low but can be as high as 45%. Soils are rapidly drained sand, sandy loams, sandy clay loams, or loamy sands derived from eolian or alluvium deposits, sandstone and shale bedrock or colluvium. Parent materials are variable and include Cedar Mesa, Wingate, Kayenta, Entrada (including the Dewey Bridge Member), and Navajo sandstone formations, the Moab Tongue of the Curtis Formation, the Chinle Formation and the Salt Wash Member of the Morrison Formation.

VEGETATION DESCRIPTION
Arches National Park
This wooded shrubland association with a mixed shrub understory is common within the park. Stands occasionally contain scattered trees of *Pinus edulis*. Woody plants tend to be rooted in bedrock fractures; herbaceous plants persist in the thin deposits of sand that cover the substrate. Total vegetation cover is variable, ranging from 2 to 65% depending on the degree of fracturing of the underlying bedrock. The vegetation is characterized by an open canopy of stunted *Juniperus osteosperma* ranging in cover from 1 to 15% and a shrub understory in which *Coleogyne ramosissima* is always present and is always accompanied by either or both *Purshia stansburiana* and *Quercus havardii* var. *tuckeri*. Shrub cover may often exceed total tree cover. *Pinus edulis*, typically 2-5 m tall, may be present with low cover relative to *Juniperus osteosperma*. The shrub layer may contain as many as ten species, depending on how xeric or mesic the stand is. Associated shrubs in xeric stands most commonly include *Fraxinus anomala, Ephedra torreyana, Ephedra viridis, Gutierrezia sarothrae, Yucca harrimaniae*, and *Opuntia polyacantha*. In mesic sites, *Cercocarpus intricatus, Artemisia bigelovii, Cercocarpus montanus*, and *Amelanchier utahensis* join the list of associates. Herbaceous species are rarely important in these stands. Common grasses include *Achnatherum hymenoides, Aristida purpurea, Bromus tectorum*, and *Vulpia octoflora*. Forbs commonly present include *Lepidium montanum* and *Streptanthella longirostris*. Biological soil crusts provide up to 15% cover.

Globally
This wooded shrubland association has a mixed shrub canopy, occasionally with scattered trees of *Pinus edulis* and/or *Juniperus osteosperma*. Woody plants tend to be rooted in bedrock fractures; herbaceous plants persist in the thin deposits of sand that cover the substrate. Total vegetation cover is variable, ranging from 2 to 65% depending on the degree of fracturing of the underlying bedrock. The vegetation is characterized by an open canopy of stunted *Juniperus osteosperma* or *Pinus edulis* ranging in cover from 1 to 15% and a shrub understory in which *Coleogyne ramosissima* is always present and is always accompanied by either or both *Purshia stansburiana* and *Quercus havardii* var. *tuckeri*. Shrub cover often exceeds total tree cover. *Pinus edulis*, typically 2-5 m tall, may be present with low cover relative to *Juniperus osteosperma*. The shrub layer may contain as many as ten species, depending on how xeric or mesic the site is. Xeric stands most commonly include *Artemisia bigelovii, Chrysothamnus viscidiflorus, Ephedra torreyana, Ephedra viridis, Fraxinus anomala, Glossopetalon spinescens* var. *meionandrum, Gutierrezia sarothrae, Opuntia polyacantha, Rhus trilobata, Sclerocactus whipplei*, and *Yucca harrimaniae*. In more mesic sites, *Amelanchier utahensis, Cercocarpus intricatus*, or *Cercocarpus montanus* may be present. Herbs are generally too sparse to form a layer but may be diverse. Grasses include *Achnatherum hymenoides, Achnatherum speciosum, Aristida purpurea, Sporobolus cryptandrus, Vulpia octoflora*, and exotic *Bromus tectorum*. Forbs include *Arenaria fendleri, Chamaesyce fendleri, Cryptantha flava, Descurainia pinnata, Hedysarum boreale, Lepidium montanum, Lomatium parryi, Machaeranthera grindelioides, Plantago patagonica, Petradoria pumila, Streptanthella longirostris*, and *Tetraneuris acaulis*. Exotic forbs are sometimes present and include *Chenopodium album, Erodium cicutarium*, and *Salsola tragus*. Biological soil crust cover is generally sparse (<15%), although some stands have nearly 50% cover, and is usually well-developed.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree (canopy & subcanopy)	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Purshia stansburiana, Amelanchier utahensis, Fraxinus anomala*
Short shrub/sapling	*Artemisia bigelovii, Cercocarpus intricatus, Cercocarpus montanus, Chrysothamnus*

	viscidiflorus, Coleogyne ramosissima, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Quercus havardii var. *tuckeri, Rhus trilobata*
Herb (field)	*Ephedra viridis, Opuntia polyacantha, Yucca harrimaniae*
Herb (field)	*Hedysarum boreale, Lomatium parryi, Petradoria pumila, Streptanthella longirostris*
Herb (field)	*Achnatherum speciosum, Aristida purpurea, Sporobolus cryptandrus*

Globally

Stratum	Species
Tree (canopy & subcanopy)	*Juniperus osteosperma*
Tall shrub/sapling	*Fraxinus anomala, Purshia stansburiana*
Short shrub/sapling	*Coleogyne ramosissima, Quercus havardii* var. *tuckeri*

OTHER NOTEWORTHY SPECIES
Arches National Park
Chenopodium album, Erodium cicutarium, Salsola tragus

Globally
Sclerocactus whipplei

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (15-Mar-2006).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Arches National Park Inventory Notes: This is the most common and widely distributed wooded association in Arches National Park, occurring on all slickrock habitats where soil has developed in cracks, fissures and pockets. It represents two phases or subassociations, one on xeric sites and one (including *Cercocarpus intricatus*) on more mesic sites. Sites have exposed bedrock and pockets of sand where vegetation grows on this slickrock community. One site has shallow soil and the trees are reclining, others have active dunes. Some trees are stunted, others are showing insect effects. Some stands have well-developed biotic crust. Some stands have many erosion channels. Some stands are grazed.
Arches National Park Field Data: The description is based on 2003 field data (47 plots: ARCH.0003, ARCH.0009, ARCH.0015, ARCH.0026, ARCH.0041, ARCH.0047, ARCH.0048, ARCH.0065, ARCH.0072, ARCH.0073, ARCH.0077, ARCH.0079, ARCH.0082, ARCH.0115, ARCH.0122, ARCH.0125, ARCH.0128, ARCH.0317, ARCH.0324, ARCH.0336, ARCH.0339, ARCH.0344, ARCH.0345, ARCH.0346, ARCH.0350, ARCH.0351, ARCH.0369, ARCH.0370, ARCH.0372, ARCH.0380, ARCH.0604, ARCH.0612, ARCH.0619, ARCH.0622, ARCH.0628, ARCH.0629, ARCH.0638, ARCH.0640, ARCH.0647, ARCH.0651, ARCH.0665, ARCH.0672, ARCH.0682, ARCH.0691, ARCH.0692, ARCH.0695, ARCH.0696).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: G. Kittel, mod. K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Quercus gambelii / Sparse Understory Shrubland
Gambel Oak / Sparse Understory Shrubland

CODE	CEGL002337
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous shrubland (III.B.2.)

PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N.)
FORMATION	Temperate cold-deciduous shrubland (III.B.2.N.a.)
ALLIANCE	*QUERCUS GAMBELII* SHRUBLAND ALLIANCE (A.920) Gambel Oak Shrubland Alliance

ECOLOGICAL SYSTEM(S): Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This association occurs on flat to gently sloping, usually narrow high terraces in canyons of the Colorado Plateau. The terraces are usually at least 3 m above bankfull stage and rarely, if ever, flood. Elevations range from 1220 to 1840 m (4000-6035 feet). The substrate is a fine sandy alluvium, and oak leaf litter generally covers nearly all the unvegetated surface. The canopy consists of even-aged *Quercus gambelii* stems 5-15 m high with 50-80% canopy closure. The understory consists primarily of oak sprouts less than 0.5 m tall. Scattered individuals of other woody species may occur throughout stands, including *Juniperus scopulorum, Ericameria nauseosa, Rhus trilobata*, and *Acer negundo*. Herbaceous species are usually sparse because of the dense shade cast by the relatively closed canopy but may include *Piptatherum micranthum, Maianthemum stellatum, Stanleya pinnata*, and *Clematis ligusticifolia*.

DISTRIBUTION

Arches National Park

This association is rare in and near the park and was sampled on the Big Bend area of the Colorado River as well as in two places along Salt Wash.

Globally

This association has been documented in the Colorado Plateau of eastern Utah. It has been observed at Mesa Verde National Park (not sampled) and in the Front Range foothills of eastern Colorado as well (Castlewood Canyon State Park). It is likely to occur sporadically anywhere high alluvial terraces develop within the range of *Quercus gambelii*.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This woodland/shrubland association occurs on high terraces at the base of colluvial slopes in the canyon of the Colorado River. The one sampled site slopes gently (up to 2%), occurs at 1220 m elevation and is oriented to a southeast aspect. The unvegetated surface has high cover of litter and low cover of dead wood. Soils are rapidly drained sandy loams, often with well-developed horizons and derived from alluvium.

Globally

This association occurs on flat to gently sloping, usually narrow high terraces in canyons of the Colorado Plateau. The terraces are usually at least 3 m above bankfull stage and rarely, if ever, flood. Elevations range from 1220 to 1840 m (4000-6035 feet). The substrate is a fine sandy alluvium, and the soils may have a dark surface horizon with a relatively high percentage of organic matter. Oak leaf litter generally covers nearly all the unvegetated surface, although wood litter from fallen branches and trunks may be significant in some older stands.

VEGETATION DESCRIPTION

Arches National Park

This Gambel oak tall shrubland is rare within the park, being restricted to upper terraces of the Colorado River canyon. Total vegetation cover can exceed 100% in these densely vegetated stands. This woodland type is characterized by a relatively closed canopy of *Quercus gambelii* trees that range in cover from 55 to 65% and between 10-15 m tall. There is no developed shrub layer, but scattered individuals of *Ericameria nauseosa* may be present. The herbaceous layer consists primarily of ankle-high sprouts of *Quercus gambelii*, with scattered forbs such as *Stanleya pinnata*.

Globally

Stands of this community usually take the form of a dwarf-woodland, with the canopy high enough that it is possible to walk upright through a stand. Stands usually consist of a single clone of *Quercus gambelii* with roughly even-aged stems 8-20 cm in diameter, 5-15 m tall, and with 50 to 80% canopy closure. The understory consists

primarily of oak sprouts less than 0.5 m tall. Scattered individuals of other woody species may occur throughout stands, including *Juniperus scopulorum, Ericameria nauseosa, Rhus trilobata*, and *Acer negundo*. Herbaceous species are usually sparse because of the dense shade cast by the relatively closed canopy but may include *Piptatherum micranthum, Maianthemum stellatum, Stanleya pinnata*, and *Clematis ligusticifolia*. Exotic annual grass *Bromus tectorum* is common in some stands.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree canopy	*Quercus gambelii*
Short shrub/sapling	*Ericameria nauseosa*
Herb (field)	*Stanleya pinnata*
Herb (field)	*Bromus tectorum*

Globally

Stratum	Species
Tree canopy	*Quercus gambelii*

OTHER NOTEWORTHY SPECIES

Arches National Park
Elymus lanceolatus

Globally
Bromus tectorum

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (12-Jan-2005).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
This association is distinguished from other Gambel oak associations occurring in the Colorado Plateau by its position on level, abandoned alluvial terraces and the lack of a developed understory.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Arches National Park Inventory Notes: This association has become established on second terraces higher than mixed stands of tamarisk and coyote willow. Stands are at the base of colluvial slopes and rarely flood.
Arches National Park Field Data: The description is based on 2003 and 2006 field data (1 plot*:* ARCH.0710 and 3 accuracy assessment points: ARCH_AA.0120, ARCH_AA.0413, ARCH_AA.0842).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Quercus havardii var. *tuckeri* Shrubland
Tucker Sand Shinnery Oak Shrubland

CODE	CEGL002486
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous shrubland (III.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N.)
FORMATION	Temperate cold-deciduous shrubland (III.B.2.N.a.)
ALLIANCE	*QUERCUS HAVARDII* VAR. *TUCKERI* SHRUBLAND ALLIANCE (A.2654) Tucker Sand Shinnery Oak Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Active and Stabilized Dune (CES304.775)
Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This short-shrub association is restricted to dunes, sandsheets and pockets of sand on mesas, plateaus and valley bottoms in southeastern Utah. Sites are generally on flat or gentle slopes, with a few sites on moderately steep (50%) slopes. Elevations range between 1335 and1772 m, and aspect is not a major factor in determining the distribution of this association. Bare ground or loose sand cover most of the unvegetated surface, although in less-disturbed sites biological soil crusts can have as much as 30% cover. Soils are rapidly drained, deep loamy sands and sandy loams derived from alluvium or eolian deposits. Total vegetation cover ranges from 10 to 110% in these sparsely to moderately vegetated stands. The vegetation is dominated by patches of *Quercus havardii* var. *tuckeri* shrubs that range in cover from 5 to 85%. Because shrub roots anchor the sandy soil in this erosive habitat, *Quercus havardii* var. *tuckeri* shrubs often occupy hummocks of sand as much as a meter high. Associated shrubs include *Coleogyne ramosissima, Ephedra viridis, Gutierrezia sarothrae, Shepherdia rotundifolia*, and *Opuntia polyacantha*. The herbaceous layer provides sparse cover. Graminoids present often include *Achnatherum hymenoides, Muhlenbergia pungens, Pleuraphis jamesii*, and *Vulpia octoflora*. Scattered forbs may include *Cryptantha* sp., *Streptanthella longirostris, Hymenopappus filifolius*, and *Lepidium montanum*. Scattered *Juniperus osteosperma* trees are present in some stands.

DISTRIBUTION

Arches National Park

This association is locally common and was sampled near the Marching Men, in Salt Valley, near Eye of the Whale, south of The Windows, in Winter Camp Wash, in Herdina Park, and along Park Avenue.

Globally

This association occurs in southeastern Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This association occurs where deep sand deposits form dunes and dune-like formations on colluvial slopes, plateaus, valley floors, and stream terraces. Sites are flat to gently sloping (up to 12%) and occur between 1335 and 1567 m elevation. Loose sand covers most of the unvegetated surface, except under the trees and shrubs, where litter covers the ground. Biological soil crusts are typically low in cover but can have as much as 30% cover. Soils are rapidly drained loamy sands and sandy loams derived from eolian deposits and alluvium.

Globally

This short-shrub association is restricted to dunes, sandsheets and pockets of sand on mesas, plateaus and valley bottoms in southeastern Utah. Sites are generally on flat or gentle slopes, with a few sites on moderately steep (50%) colluvial slopes. Elevations range between 1335 and 1772 m, and aspect is not a major factor in determining the distribution of this association. Bare ground or sand cover most of the unvegetated surface, although in less-disturbed sites biological soil crusts can have as much as 30% cover. Soils are rapidly drained, deep loamy sands and sandy loams derived from Cedar Mesa, Dakota, Entrada or Morrison formation sandstones that have eroded and been distributed to alluvium or eolian deposits.

VEGETATION DESCRIPTION

Arches National Park

This shrubland association is common in sandy sections of the park. Total vegetation cover ranges from 1 to 65% depending on how long the sand has been stable. Many stands present a hummocky or coppiced appearance because the oak catches and holds sand while loose sand blows away from between shrubs. The vegetation is characterized by an open canopy of *Quercus havardii* var. *tuckeri* that ranges in cover from <1 to 55%. Commonly associated shrubs include *Coleogyne ramosissima, Ephedra viridis, Gutierrezia sarothrae*, and *Opuntia polyacantha*. The herbaceous layer is generally sparse, and most species grow in the shelter of oak or other shrubs. Graminoids may include *Achnatherum hymenoides, Pleuraphis jamesii*, and *Vulpia octoflora*; forbs include *Cryptantha* sp., *Hymenopappus filifolius*, and *Lepidium montanum*. Biological soil crusts tend to be in the early stages of development but may provide up to 30% cover. Scattered *Juniperus osteosperma* may be present in some stands.

Globally
This uncommon shrubland association has total vegetation cover ranging from 10 to 110% in these sparsely to densely vegetated stands. This shrubland is dominated by patches of *Quercus havardii* var. *tuckeri* shrubs that range in cover from 5 to 85%. Because shrub roots anchor the sandy soil in this erosive setting, *Quercus havardii* var. *tuckeri* shrubs often occupy hummocks of sand as much as a meter high. Associated shrubs include *Chrysothamnus viscidiflorus, Coleogyne ramosissima, Eriogonum microthecum, Ephedra torreyana, Ephedra viridis, Fraxinus anomala, Gutierrezia sarothrae, Shepherdia rotundifolia, Opuntia erinacea, Opuntia polyacantha, Purshia stansburiana, Shepherdia rotundifolia*, and *Yucca angustissima*. The herbaceous layer provides sparse cover. Graminoids present often include *Achnatherum hymenoides, Muhlenbergia pungens, Pleuraphis jamesii*, and *Vulpia octoflora*; forbs may include *Cryptantha* sp., *Streptanthella longirostris, Hymenopappus filifolius*, and *Lepidium montanum*. Scattered *Juniperus osteosperma* trees are present in some stands. The herbaceous layer tends to be sparse and depauperate. Grasses present may include *Achnatherum hymenoides, Aristida purpurea, Muhlenbergia pungens, Pleuraphis jamesii, Sporobolus cryptandrus, Vulpia octoflora*, and the exotic *Bromus tectorum*. Scattered forbs *Chenopodium album, Chenopodium atrovirens, Comandra umbellata, Cryptantha* sp., *Eriogonum shockleyi, Hymenopappus filifolius, Lepidium montanum, Packera multilobata, Rumex hymenosepalus, Streptanthella longirostris*, and *Tetraneuris acaulis* may be present. Biological soil crusts do not exceed 20% cover and tend to be in an early stage of development (mostly mosses and dark cyanobacteria). Occasional *Juniperus osteosperma* and *Pinus edulis* may be present, and *Juniperus osteosperma* seedlings were observed near one stand.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Tall shrub/sapling	*Cercocarpus montanus, Fraxinus anomala*
Short shrub/sapling	*Artemisia filifolia, Coleogyne ramosissima, Ephedra torreyana, Ephedra viridis, Purshia stansburiana, Quercus havardii* var. *tuckeri*
Herb (field)	*Packera multilobata*
Herb (field)	*Achnatherum hymenoides, Bouteloua gracilis, Hesperostipa comata, Pleuraphis jamesii*

Globally

Stratum	Species
Short shrub/sapling	*Quercus havardii* var. *tuckeri*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Descurainia pinnata

Globally
Bromus tectorum

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (29-Mar-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Sand substrate is deep and is formed from Entrada Formation fins at one site. Mounds of sand are stabilized by the oak shrubs; there are sometimes wind-scoured flats between dunes. One stand has several gullies. Drought effects, in the form of dead branches, are notable for some oak shrubs.

Arches National Park Field Data: The description is based on 2003 and 2004 field data (9 plots: ARCH.0085, ARCH.0313, ARCH.0340, ARCH.0341, ARCH.0358, ARCH.0368, ARCH.0675, ARCH.0689, ARCH.0700).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Rhus trilobata - Ephedra (viridis, torreyana) Talus Shrubland
Skunkbush Sumac - (Mormon-tea, Torrey's Joint-fir) Talus Shrubland

CODE	CEGL003776
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous shrubland (III.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N.)
FORMATION	Temperate cold-deciduous shrubland (III.B.2.N.a.)
ALLIANCE	*RHUS TRILOBATA* SHRUBLAND ALLIANCE (A.3569) Skunkbush Sumac Shrubland Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This Colorado Plateau mixed shrub assemblage occurs on steep, rocky colluvial slopes and bedrock canyon rims associated with mesas, canyons, benches, ravines, hills, hogbacks, escarpments and valley sides. Slopes are typically moderate and range from level to steep (0-70%), occur between 1238 and 1700 m (4000-5580 feet) elevation, and tend to occur on southerly to westerly aspects (less often east-facing slopes). Soils are shallow and rocky and range from rapidly drained clay loams to sandy loams derived from shales and sandstones. It tends to be slightly more mesic than most other talus type vegetation. Total vegetation cover is sparse, not exceeding 25%. It is characterized by a scattered mixture of shrubs, among which *Rhus trilobata* var. *trilobata* and *Ephedra torreyana* or *Ephedra viridis* are conspicuous and either dominant or codominant. As many as ten other species of shrubs may also be present, including *Amelanchier utahensis, Artemisia bigelovii, Atriplex confertifolia, Brickellia microphylla, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ericameria nauseosa, Eriogonum corymbosum*, and *Philadelphus microphyllus*. *Fraxinus anomala* is absent, and if *Pinus edulis* or *Juniperus osteosperma* are present, cover is less than 1%. Herbaceous cover is sparse and variable. Biological soil crust formation is rare on these active slopes.

DISTRIBUTION
Arches National Park
This community is uncommon and was sampled in the Cache Valley, near the mouth of Courthouse Wash and northwest of the park entrance.

Globally
This association is known from Arches National Park but likely is widespread in the canyonlands of the Colorado Plateau in eastern Utah.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This mixed shrub assemblage occurs on steep talus slopes, hogbacks, and valley sides. The sampled sites are on a Chinle shale slope overlain by talus of Wingate sandstone, a Cedar Mountain sandstone hogback, and a ledgy slope of Navajo sandstone. Slopes are moderately steep (40 to 57%), occur between 1238 and 1366 m elevation and tend to have a west or south aspect. Most of the unvegetated surface is covered by gravel, bedrock and large rocks. Soils include rapidly drained clay loams and sandy loams.

Globally
This Colorado Plateau mixed shrub assemblage occurs on steep, rocky colluvial slopes and bedrock canyon rims

associated with mesas, canyons, benches, ravines, hills, hogbacks, escarpments and valley sides. Slopes are typically moderate and range from level to steep (0-70%), occur between 1238 and 1700 m (4000-5580 feet) elevation, and tend to occur on southerly to westerly aspects (less often east-facing slopes). Soils are shallow and range from rapidly drained clay loams to sandy loams. Parent materials include shales (Moenkopi, Chinle) and sandstones (Cedar Mountain, Navajo, Wingate). Most of the unvegetated surface is covered by gravel, talus, bedrock and large rocks, and occasionally petrified wood. There is little dead wood, biological soil crust or litter. It tends to be slightly more mesic than most other talus type vegetation.

VEGETATION DESCRIPTION

Arches National Park

This mixed talus vegetation assemblage is uncommon in the park, occurring in Cache Valley, the Colorado River canyon and in Moab Valley. It tends to be slightly more mesic than most of the talus vegetation types in the park. Total vegetation cover is sparse, not exceeding 15%. This community is characterized by a scattered mixture of shrubs, among which *Rhus trilobata* var. *trilobata* is conspicuous and either dominant or codominant. As many as 10 other species of shrubs may also be present, including *Amelanchier utahensis, Artemisia bigelovii, Philadelphus microphyllus, Ephedra viridis, Ephedra torreyana, Chrysothamnus viscidiflorus,* and *Eriogonum corymbosum. Fraxinus anomala* is absent, and if *Pinus edulis* or *Juniperus osteosperma* are present, it is with less than 1% cover. The herbaceous layer contributes little in terms of cover but may be moderately diverse. Graminoids commonly present include *Bromus tectorum* and *Leymus salinus.* Forbs tend to vary across the park from stand to stand.

Globally

This shrubland association has sparse to low cover of vegetation, not exceeding 25% total cover. It is characterized by a scattered mixture of shrubs, among which *Rhus trilobata* var. *trilobata* and *Ephedra torreyana* or *Ephedra viridis* are conspicuous and either dominant or codominant. As many as ten other species of shrubs may also be present, including *Amelanchier utahensis, Artemisia bigelovii, Atriplex confertifolia, Brickellia microphylla, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ericameria nauseosa, Eriogonum corymbosum,* and *Philadelphus microphyllus*. *Fraxinus anomala* is absent or has trace cover, and if *Pinus edulis* or *Juniperus osteosperma* are present, cover is less than 1%. The herbaceous layer may include many species but never provides more than a few percent cover. *Achnatherum hymenoides, Aristida purpurea, Elymus elymoides, Pleuraphis jamesii, Leymus salinus,* and exotic annual grasses *Bromus rubens* or *Bromus tectorum* are common grasses. Forbs compositions are variable; common species include *Artemisia ludoviciana, Chaetopappa ericoides, Stanleya pinnata,* and *Plantago patagonica*. Biological soil crust formation is rare on these active slopes.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tall shrub/sapling	*Amelanchier utahensis*, *Philadelphus microphyllus*, *Rhus trilobata* var. *trilobata*
Short shrub/sapling	*Eriogonum corymbosum*
Herb (field)	*Gutierrezia sarothrae*

Globally

Stratum	Species
Tall shrub/sapling	*Amelanchier utahensis*, *Rhus trilobata* var. *trilobata*

OTHER NOTEWORTHY SPECIES

Arches National Park

Bromus rubens, Bromus tectorum

Globally

Bromus rubens, Bromus tectorum

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (20-Mar-2006).

CLASSIFICATION COMMENTS

Arches National Park

Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: The community is a mix of shrubs occupying rocky canyon walls and ledges. Slopes are steep, rocky, and active.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0098 and 3 observation points: ARCH.9043, ARCH.9045, ARCH.9048).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: G. Kittel and K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Rhus trilobata Intermittently Flooded Shrubland
Skunkbush Sumac Intermittently Flooded Shrubland

CODE	CEGL001121
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous shrubland (III.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N.)
FORMATION	Intermittently flooded cold-deciduous shrubland (III.B.2.N.c.)
ALLIANCE (A.938)	*RHUS TRILOBATA* INTERMITTENTLY FLOODED SHRUBLAND ALLIANCE Skunkbush Sumac Intermittently Flooded Shrubland Alliance

ECOLOGICAL SYSTEM(S): Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY
Globally
This association is known from both mesic riparian and non-riparian situations in Utah, western Colorado, and the Snake River canyon and its tributaries of southern Idaho. Throughout its range, the association occurs at low to mid elevations (701-1676 m [2300-5500 feet] in Idaho and 1555-2000 m [5100-6560 feet] in Colorado), most often along mid-order to large rivers, but also in narrow canyons of small creeks and intermittent drainages. This association often forms linear bands above the high-water line on steep shorelines, along rocky toeslopes at cliff bases, on benches, and in intermittent arroyos, usually where there is minimal floodplain development. Stands also occur on rocky hillsides in association with springs and seeps emanating from canyon walls. In broad river bottoms, stands occur in the floodplain on second terraces between older *Populus* spp. forests on upper terraces and *Salix exigua* shrublands next to the river. In these large floodplains, habitats are in flux with stream meanders, channel downcutting, and sediment deposition; sites where this shrubland persists are generally too dry for the establishment of *Populus* and *Salix* spp. The association is found on well-drained, fine silty clay to sandy loam soils overlying coarse alluvium, bedrock or talus. *Rhus trilobata* often forms tall, dense, and nearly impenetrable thickets with 30-98% cover. Associated shrubs can sometimes be codominant, but no single species has consistently high cover or constancy across the range of the association. Associated shrubs include *Celtis laevigata* var. *reticulata, Clematis ligusticifolia, Cornus sericea, Ericameria nauseosa, Ribes aureum, Rosa woodsii, Salix exigua, Salix lasiolepis, Salix lutea, Shepherdia argentea*, and *Toxicodendron rydbergii*. Saplings of *Populus fremontii, Populus angustifolia*, or *Salix amygdaloides* may be present. Total understory herbaceous cover and diversity are low, and herbaceous species are often confined to shrub canopy gaps. *Bromus tectorum* and *Galium aparine* are the most frequently occurring species, but native grasses such as *Elymus canadensis, Equisetum* spp., *Hordeum jubatum, Muhlenbergia asperifolia, Leymus cinereus, Pascopyrum smithii*, and *Phragmites australis* are sometimes also present. Forb associates include *Apocynum cannabinum* and *Artemisia ludoviciana*. Non-native species are common in disturbed stands.

DISTRIBUTION

Arches National Park
This association was sampled in a slickrock canyon in Herdina Park.

Globally
This association is known from western Colorado, Utah and southern Idaho. This minor shrubland association is known from the Yampa, San Miguel and Dolores river basins of the western slope of Colorado, along the Green River in northeastern Utah and Idaho, and the Colorado River in western Colorado and eastern Utah.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This mesic shrub association occurs on deep sediments deposited in narrow slickrock canyons. The canyon bottoms are sheltered from direct sun for much of the day, and thus can support mesic vegetation even without surface water being present. The water table tends to remain high throughout the growing season. The one sampled site slopes gently (not exceeding 2%), lies at 1457 m elevation and is oriented to the southeast. The unvegetated surface has high cover of litter and moderate cover of downed wood. There is low exposure of bare soil. Soils are rapidly drained loamy sands derived from eolian sands and alluvium.

Globally
This minor association occurs in mesic, often riparian sites in western Colorado, eastern Utah and southwestern Idaho. Elevation ranges from 940 to 2000 m (3085-6560 feet). These small shrublands are reported from stream and river bottoms and terraces, and upland in mesic swales and on hillslopes below seeps and springs. Along the Yampa, San Miguel, and Dolores rivers stands often form linear bands on rocky, well-drained benches and toeslopes where it is often confined between the high-water mark of a river and adjacent cliff faces and has access to the high water table. Along the Green River stands occur in the floodplain on second terraces between older *Populus fremontii* forests on upper terraces and *Salix exigua* shrublands next to the river. In large floodplains, habitats are in flux with stream meanders, channel downcutting, and sediment deposition; sites where this shrubland persists are generally too dry for the establishment of *Populus* and *Salix* spp. Substrates are variable and range from shallow loamy sand to silt loam over coarse alluvium, boulders or bedrock, to fine silty clay with the depth to groundwater between 2-4 m. Adjacent riparian vegetation includes communities dominated by *Schoenoplectus* spp., *Typha* spp., *Phragmites australis, Salix exigua, Alnus incana, Betula occidentalis, Populus angustifolia*, and *Populus fremontii*.

VEGETATION DESCRIPTION
Arches National Park
This shrubland association is rare in the park, as it requires well-drained, mesic soils in a shaded canyon setting. Total vegetation cover easily exceeds 100%. The vegetation is characterized by *Rhus trilobata* tall shrubs with 50 to 75% cover. The remaining shrub layer includes *Salix lutea* that provides moderate cover. The herbaceous layer provides sparse cover and typically includes the sand-loving *Achnatherum hymenoides*. Common forbs include *Artemisia ludoviciana, Equisetum hyemale*, and *Solidago canadensis*. The vine *Clematis ligusticifolia* may contribute up to 65% cover. A few trees of *Populus fremontii* may emerge from this community but do not form a canopy layer.

Globally
This plant association is characterized by a dense short-shrub layer dominated by 30-90% cover of *Rhus trilobata* sometimes forming near monocultures. However, the tall shrub *Salix exigua* is often present to codominant on mesic sites. Drier sites further from watercourses can have significant amounts of *Artemisia tridentata ssp. tridentata, Amelanchier utahensis*, or *Chrysothamnus linifolius*. Other associated shrubs include *Ericameria nauseosa, Ribes aureum, Salix lutea, Shepherdia argentea, Toxicodendron radicans*, and occasional saplings of *Populus fremontii, Populus angustifolia*, or *Salix amygdaloides*. In cooler, mesic sites *Cornus sericea, Salix ligulifolia, Berberis fendleri, Rosa woodsii*, and *Clematis ligusticifolia* may be present to abundant. The herbaceous layer is relatively sparse (<20% cover) and is composed primarily of graminoids such as *Elymus canadensis, Leymus cinereus, Equisetum* spp., *Hordeum jubatum, Muhlenbergia asperifolia, Pascopyrum smithii* or *Phragmites australis*. Forb associates include *Apocynum cannabinum, Artemisia ludoviciana, Equisetum hyemale*, and *Solidago canadensis*. Exotic species are common and may include *Elaeagnus angustifolia, Tamarix ramosissima, Lepidium latifolium, Cirsium arvense, Thinopyrum intermedium, Poa pratensis, Agropyron cristatum, Melilotus officinalis*, and *Helianthus annuus*.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tree canopy	*Populus fremontii*
Tall shrub/sapling	*Rhus trilobata, Salix lutea*
Herb (field)	*Artemisia ludoviciana, Clematis ligusticifolia, Solidago canadensis*
Herb (field)	*Equisetum hyemale*

Globally

Stratum	Species
Tall shrub/sapling	*Salix exigua*
Short shrub/sapling	*Rhus trilobata*

OTHER NOTEWORTHY SPECIES

Arches National Park
Data are not available.

Globally
Agropyron cristatum, Cirsium arvense, Elaeagnus angustifolia, Helianthus annuus, Lepidium latifolium, Melilotus officinalis, Poa pratensis, Tamarix ramosissima, Thinopyrum intermedium

CONSERVATION STATUS RANK

Global Rank & Reasons: G3 (22-Oct-2002). Throughout its relatively broad range (i.e., western Colorado through Utah to southern Idaho), this association is restricted to hot and dry, low- to mid-elevation creeks and rivers. At least 35 plots have been sampled and 21 other stand observations documented, however, less than 20% of these occurrences are in good to excellent ecological condition. Further inventories throughout the range of the plant association will likely find more occurrences and possibly support classification of additional, distinct *Rhus trilobata* associations. This association often forms large, dense patches that are resistant to minor or occasional disturbance (e.g., fire, livestock damage). However, exotic species, especially *Bromus tectorum*, frequently occur in the understory. In southern Idaho, most stands are protected from land development. Based on the moderate number of occurrences, broad range, and relative resilience of the *Rhus trilobata* association, it is best ranked as G3 rather than G2. Nevertheless, the association is definitely globally rare, being discontinuously distributed through an ecologically degraded landscape with on-going and growing threats, such as agricultural and housing development, livestock grazing, fires and conversion to exotic species, and hydrologic alteration (e.g., irrigation diversions, hydroelectric development, and groundwater pumping).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
This association has been quantitatively described from numerous locations: 28 plots and 12 stand observations from southern Idaho (Cole 1995, 1996, Jankovsky-Jones et al. 2001, Hansen and Hall 2002) and a number of plots from western Colorado (e.g., Kittel et al. 1999a). Several riparian communities dominated by, or with high cover of, *Rhus trilobata* have been documented along the Snake River by Cole (1995, 1996). Due to their degraded stand conditions (indicated by abundant *Bromus tectorum*) and to inconsistency in the cover and constancy of associated or codominant shrubs, these 4 communities are considered synonymous variants of this more broadly defined *Rhus trilobata* association. In addition, no diagnostic herbaceous species useful for differentiating between possible *Rhus trilobata* associations is apparent (Jankovsky-Jones et al. 2001, Hansen and Hall 2002). *Rhus trilobata - Salix exigua* has been proposed as a different association, but *Salix exigua* has only moderate constancy in otherwise similar stands sampled from Idaho and Colorado. Although this *Rhus trilobata* plant association occurs in two distinct wetland settings (riverine and canyon-slope seeps or springs), no other distinct *Rhus trilobata* associations have been observed in these different settings. *Rhus trilobata* also occurs as a dominant species in xeric upland stands, especially east of the Continental Divide (Kittel et al. 1999a). These stands are separated by their clearly non-riparian settings and species.

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES

Arches National Park Inventory Notes: The stand occupies sheltered, deep moist soils in a narrow section of a slickrock canyon.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0690).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. C. Murphy, J. Drake, J. Coles

REFERENCES: Bourgeron and Engelking 1994, CONHP Ecology Team 2001, Cole 1995, Cole 1996, Driscoll et al. 1984, Goodrich and Neese 1986, Hall and Hansen 1997, Hansen and Hall 2002, IDCDC 2005, IDCDC 2002, Jankovsky-Jones et al. 2001, Kittel and Lederer 1993, Kittel et al. 1999b, Padgett et al. 1989, Welsh et al. 1987

Suaeda moquinii Shrubland
Shrubby Seepweed Shrubland

CODE	CEGL001991
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B)
PHYSIOGNOMIC GROUP	Cold-deciduous shrubland (III.B.2)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N)
FORMATION	Intermittently flooded cold-deciduous shrubland (III.B.2.N.c)
ALLIANCE	*SUAEDA MOQUINII* INTERMITTENTLY FLOODED SHRUBLAND ALLIANCE
(A.941)	Shrubby Seepweed Intermittently Flooded Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Playa (CES304.786)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY
Globally
These shrublands occur in desert basins or playas in Nevada, Arizona, and southern and eastern California. Sites are generally flat to gently sloping saline valley bottoms, floodplains and playas, saline seeps, and along intermittent washes at elevations ranging from sea level to 1640 m (5381 feet). Soils are deep, saline, alkaline clay loams. The vegetation has a generally sparse shrub layer that is less than 1.5 m tall and strongly dominated by *Suaeda moquinii (= Suaeda torreyana)* with scattered *Atriplex polycarpa, Atriplex canescens, Allenrolfea occidentalis*, or *Sarcobatus vermiculatus* in some stands. The sparse herbaceous layer may include the forbs *Bassia hyssopifolia* and *Salicornia maritima*. Graminoids are not abundant except for *Distichlis spicata* and occasional *Sporobolus airoides* or *Sporobolus cryptandrus*. The adjacent shrublands are dominated by *Sarcobatus vermiculatus* or *Atriplex* spp.

DISTRIBUTION
Arches National Park
This association is known from one site on a terrace of Salt Wash on the floor of Cache Valley.

Globally
This broadly defined shrubland association occurs in saline overflow areas in bottomlands in the Great Basin, Mojave, Colorado, and Sonoran deserts, in the Colorado Plateau, and in the southern part of the Great Central Valley of California. The species occurs throughout the western U.S., so this type may be more widespread.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This dwarf-shrub association was sampled in a playa-like ponded area in the floodplain of Salt Wash at 1329 m elevation. The unvegetated surface has high exposure of bare soil and low cover by litter. The soil is derived from alluvium with a high component of alkaline clay. A white salt crust covers part of the soil surface.

Globally
These shrublands occur in desert basins or playas in Nevada, Arizona, and southern and eastern California. Sites are generally flat to gently sloping saline valley bottoms, floodplains and playas, saline seeps, and along intermittent washes at elevations ranging from sea level to 1640 m (5381 feet). Soils are deep, saline, alkaline clay loams derived from alluvium. *Suaeda moquinii* is a halophyte, and high soil salinity appears to be an important environmental variable for this community.

VEGETATION DESCRIPTION
Arches National Park
This dwarf-shrub association is rare in the park. Total cover by perennial vegetation does not exceed 10% and consists of scattered individual *Suaeda moquinii* and *Sarcobatus vermiculatus* shrubs. The herbaceous layer consists of patches of *Kochia americana* plants. No other species were recorded in the sampled plot.

Globally
This association is characterized by a sparse to open shrub layer less than 1.5 m tall that is strongly dominated by *Suaeda moquinii* sometimes with scattered *Atriplex polycarpa, Atriplex canescens, Allenrolfea occidentalis,* or *Sarcobatus vermiculatus*. The sparse herbaceous layer may include the forbs *Bassia hyssopifolia* and *Salicornia maritima*. Graminoids are not abundant except for *Distichlis spicata* and occasional *Sporobolus airoides* or *Sporobolus cryptandrus.*

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Sarcobatus vermiculatus, Suaeda moquinii*
Herb (field)	*Kochia americana*

Globally

Stratum	Species
Short shrub/sapling	*Sarcobatus vermiculatus, Suaeda moquinii*
Herb (field)	*Distichlis spicata, Sporobolus cryptandrus*

OTHER NOTEWORTHY SPECIES
Arches National Park
N/A

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (23 Feb 1994) .

CLASSIFICATION COMMENTS
Arches National Park
This type was included in the ARCH classification because it is also found in similar sites in Canyonlands NP.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Playa-like clay with narrow deep gullies running through. Most of the *Suaeda* died from drought stress.
Arches National Park Field Data: The description is based on 2003 field data (1 observation point: ARCH.9311).
Local Description Authors: J. Coles
Global Description Authors: K.A. Schulz, mod J. Coles

REFERENCES: Western Ecology Working Group n.d.

Salix exigua / Barren Shrubland
Coyote Willow / Barren Shrubland

CODE	CEGL001200
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B.)

PHYSIOGNOMIC GROUP	Cold-deciduous shrubland (III.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N.)
FORMATION	Temporarily flooded cold-deciduous shrubland (III.B.2.N.d.)
ALLIANCE	*SALIX (EXIGUA, INTERIOR)* TEMPORARILY FLOODED SHRUBLAND ALLIANCE (A.947) (Coyote Willow, Sandbar Willow) Temporarily Flooded Shrubland Alliance
ECOLOGICAL SYSTEM(S):	North American Warm Desert Riparian Woodland and Shrubland (CES302.753) Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY

Globally

This riparian shrubland is common in the Rocky Mountains, Colorado Plateau and Great Basin. It is composed of nearly pure stands of *Salix exigua*, with few other species. Exposed gravel, cobbles or sand characterize the ground cover, but an undergrowth of a few, scattered forbs and grasses is usually present. This association occurs within the annual flood zone of rivers on point bars, islands, sand or cobble bars, and streambanks.

DISTRIBUTION

Arches National Park

This association was sampled in Courthouse Wash within the park.

Globally

This riparian shrubland association is common along waterways of all sizes at lower to middle elevations in the Great Basin, Colorado Plateau and Rocky Mountains extending out into the western Great Plains along major rivers.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This riparian association occurs on banks and channels of Courthouse Wash and its larger tributaries. It is restricted to sites with perennial surface water or at least a high water table throughout the growing season. Many sites are prone to frequent flooding. Sites are flat to gentle (not exceeding 3% slope) and lie between 1244 and 1293 m elevation. Bare soil or sand cover most of the unvegetated surface. Soils are poorly developed, moderately well-drained loamy sands derived from alluvium.

Globally

This riparian shrubland is common in the Rocky Mountains, Colorado Plateau and Great Basin. Elevation ranges from 780-2600 m. This association occurs within the annual flood zone of rivers on point bars, islands, sand or cobble bars, and on streambanks occurring along a wide variety of stream reaches, from moderately sinuous and moderate-gradient reaches. It can form large, wide stands on mid-channel islands in larger rivers or narrow stringer bands on small, rocky tributaries. Substrates are typically coarse alluvial deposits of sand, silt and cobbles that are highly stratified vertically from flooding scour and deposition, often consisting of alternating layers of finer textured soil with organic material over coarser alluvium. Occasionally, this association occurs on deep pockets of sand. The lack of soil development and high ground cover of coarse alluvial material are key indicators for this association.

VEGETATION DESCRIPTION

Arches National Park

This coyote willow association is documented from Courthouse Wash within the park, although it likely also occurs in Salt Wash above Wolfe Ranch. Total vegetation cover ranges from 36% to more than 100% depending on the degree of soil moisture. The vegetation is dominated by *Salix exigua* ranging in cover from 35 to 95%. Associated shrubs include *Tamarix chinensis*. The herbaceous understory is sparse, as it tends to be scoured clean by frequent flooding. The forb *Xanthium strumarium* provides 1% cover in one stand. Scattered individuals of *Populus fremontii* and *Salix gooddingii* 5-10 m tall provide sparse cover in some stands.

Globally

This riparian association is characterized by a sparse to dense, tall-shrub (1.5-3 m) canopy composed of *Salix exigua*, with ground cover of exposed gravel, cobbles or sand. *Salix exigua* may be the only shrub in the community, or other shrubs and trees may be present with relatively low cover, including *Alnus incana, Ericameria nauseosa*,

Rhus trilobata, Salix monticola, Salix ligulifolia, Salix irrorata, Salix lucida, Abies lasiocarpa, Acer negundo, Populus angustifolia, Populus deltoides, Populus fremontii, and *Salix gooddingii*. A sparse herbaceous layer may be present among the bare soil, gravel, cobbles, or boulders, consisting of a wide variety of forbs and graminoids. *Mentha arvensis* and species of *Carex, Eleocharis, Juncus, Schoenoplectus*, and *Equisetum* are often present. Introduced species, such as *Elaeagnus angustifolia, Tamarix* spp., *Bromus tectorum, Bromus inermis, Elymus repens, Poa pratensis, Agrostis stolonifera* (and other exotic forage species), *Taraxacum officinale, Conyza canadensis*, and *Lepidium latifolium*, have been reported from some stands.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species	
Tree canopy	*Populus fremontii,*	*Salix gooddingii*
Tall shrub/sapling	*Salix exigua*	
Herb (field)	*Xanthium strumarium*	

Globally

Stratum	Species
Tall shrub/sapling	*Salix exigua*

OTHER NOTEWORTHY SPECIES

Arches National Park
Bromus tectorum, Halogeton glomeratus, Melilotus officinalis, Tamarix chinensis

Globally
Bromus tectorum, Elaeagnus angustifolia, Elymus repens, Lepidium latifolium, Melilotus officinalis, Tamarix chinensis, Taraxacum officinale, Xanthium strumarium

CONSERVATION STATUS RANK

Global Rank & Reasons: G5 (15-Jun-2001).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
In the western Great Plains this association includes stands composed of intermediates between *Salix interior* and *Salix exigua* (Dorn 1997, G. Kittel pers. comm. 2001). Until recently these taxa were combined at the species level (Kartesz 1999). More information on the distribution of introgression between *Salix interior* and *Salix exigua* is needed to fully understand the ranges of these two species.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES

Arches National Park Inventory Notes: Sites are on washes that regularly flood, eliminating understory and depositing debris. A high water table throughout the growing season is also necessary to maintain this association.
Arches National Park Field Data: The description is based on 2003 field data (3 plots: ARCH.0088, ARCH.0703, ARCH.0721, and 1 observation point: ARCH.9684).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Carsey et al. 2003a, Christy 1973, Cogan et al. 2004, Cowardin et al. 1979, Culver et al. 1996, Donnelly et al. 2006, Dorn 1997, Driscoll et al. 1984, Durkin et al. 1995b, Hall and Hansen 1997, Hansen et al. 1995, Hansen et al. 2004b, IDCDC 2005, Johnston 1987, Jones and Walford 1995, Kagan et al. 2004, Kittel and Lederer 1993, Kittel et al. 1994, Kittel et al. 1995, Kittel et al. 1996, Kittel et al. 1999a, Kovalchik 1987, Manning and Padgett 1995, Muldavin et al. 2000a, Padgett 1981, Padgett et al. 1988b, Padgett et al. 1989, Richard et al. 1996, Tuhy and Jensen 1982, Von Loh et al. 2002

Salix ligulifolia Shrubland

Strapleaf Willow Shrubland

CODE	CEGL001218
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous shrubland (III.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N.)
FORMATION	Temporarily flooded cold-deciduous shrubland (III.B.2.N.d.)
ALLIANCE	*SALIX LIGULIFOLIA* TEMPORARILY FLOODED SHRUBLAND ALLIANCE (A.978) Strapleaf Willow Temporarily Flooded Shrubland Alliance

ECOLOGICAL SYSTEM(S): Rocky Mountain Subalpine-Montane Riparian Shrubland (CES306.832)
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY

Globally

This association is a medium to tall (1.5-3 m [5-15 feet]) willow shrubland occurring in saturated areas at montane elevations of 2045 to 3295 m (6700-10,800 feet) in Colorado and at 1424 m elevation in Utah. It occurs in the wettest part of the riparian area, usually adjacent to the channel on low point bars, islands, and overflow channels. The higher elevation distribution of *Salix ligulifolia* in Colorado occurs in relatively broad valley bottoms along low terraces and floodplains, and along streambanks of narrower reaches. Soils are saturated sandy loams and clay loams with a high organic matter content in the upper layers. *Salix ligulifolia* is found in mixed stands with other willows such as *Salix monticola, Salix geyeriana,* and *Salix drummondiana*. *Salix ligulifolia* is the key diagnostic species; other willows may have equal cover, but in general do not exceed that of *Salix ligulifolia*. The herbaceous undergrowth can be dense in undisturbed stands with *Carex utriculata* (1-40%), *Carex nebrascensis* (1-5%), *Carex pellita* (1-3%), *Juncus balticus* (1-20%), and *Calamagrostis canadensis* (1-27%). Forb cover is generally low. *Salix exigua - Salix ligulifolia* Shrubland (CEGL002655) is a closely related association occurring in the Colorado foothills at lower elevations.

DISTRIBUTION

Arches National Park

This association is rare within the park and was sampled in Clover Canyon.

Globally

This association occurs in the mountains of Colorado, where it has a fairly broad range in Colorado. This association is known from the San Juan National Forest, Rio Grande National Forest, Pike-San Isabel National Forest, and the Arapaho-Roosevelt National Forest.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This riparian shrubland occurs on the rims of slickrock potholes below pour-offs. The sampled site slopes gently (not exceeding 2%) and lies at 1424 m elevation. The unvegetated surface has high cover by litter and sand. Soils are saturated to poorly drained sand.

Globally

This willow association occurs at montane elevations in the southern Rocky Mountains and Colorado Plateau in moderately wide valleys along low terraces and floodplains, and streambanks of narrower reaches. The plant association occurs along reaches with vegetated islands between multiple channels below an active beaver pond (Rosgen's Channel Type: D3), along slightly sinuous broad channels (Rosgen's Channel Type: B2, B4), along more sinuous channels with well-developed floodplains (Rosgen's Channel Type: C4), and along steep narrow gullies (Rosgen's Channel Type: G3) (Rosgen 1996). Soils are saturated sandy loams and clay loams with a high organic matter content in the upper layers.

VEGETATION DESCRIPTION

Arches National Park

This yellow willow association is rare in the park, recorded only from the rims of tinajas. Total vegetation cover

ranges from 10 to 25%. The shrub canopy is dominated by *Salix ligulifolia* with between 10 and 25% cover. *Salix amygdaloides* may provide sparse cover in some stands. Other tall shrubs include *Rhus trilobata* var. *trilobata, Salix exigua*, and the exotic *Tamarix chinensis*. The herbaceous layer is composed primarily of forbs, including *Erigeron utahensis, Heterotheca villosa*, and *Packera multilobata*.

Globally
This association has a canopy dominated by 15-66% cover of *Salix ligulifolia* usually mixed with several other willow species. *Salix ligulifolia* is the key diagnostic species; other willows may have equal cover, but in general do not exceed that of *Salix ligulifolia*. Other willows that may be present include *Salix monticola* (3-43% cover), *Salix geyeriana* (1-12% cover), *Salix bebbiana* (3% cover), *Salix lucida ssp. lasiandra* (1-20% cover), *Salix exigua* (1-10% cover), *Salix wolfii* (11% cover), and *Salix planifolia* (8% cover). Additional shrubs that may be present include *Alnus incana* (3-10% cover), *Cornus sericea* (21%), and *Dasiphora fruticosa ssp. floribunda* (1-9% cover). The herbaceous undergrowth can be dense in undisturbed stands with *Carex utriculata* (1-40%), *Carex nebrascensis* (1-5%), *Carex pellita* (1-3%), *Juncus balticus* (1-20%), and *Calamagrostis canadensis* (1-27%). Forb cover is generally low, but some species are abundant, including *Taraxacum officinale* (1-10%), *Achillea millefolium* (1%), *Thalictrum fendleri* (1-19%), and *Fragaria virginiana* (1-12%).

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tall shrub/sapling	*Salix ligulifolia*

Globally

Stratum	Species
Shrub/sapling (tall & short)	*Salix ligulifolia*
Herb (field)	*Heracleum maximum, Mertensia ciliata*
Herb (field)	*Carex nebrascensis, Equisetum arvense, Juncus balticus, Poa pratensis*

OTHER NOTEWORTHY SPECIES
Arches National Park
Tamarix chinensis

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G2G3 (30-Nov-1998). This is a recently described association, presently known only from Colorado, but it is expected to occur in New Mexico. It has a somewhat naturally restricted acreage, being found only on the saturated soils of riparian areas of montane elevations, and is often associated with beaver activity. Improper livestock grazing, mining, hydrological alterations, loss of beaver activity, and the invasion of exotic species are threats that have been noted to threaten the viability of this association at specific sites. Ten locations are known in Colorado with an additional 20-50 expected to occur within its possible range.

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
The stand at Florissant Fossil Beds National Monument is borderline between the foothills *Salix exigua - Salix ligulifolia* Shrubland (CEGL002655) and the montane *Salix ligulifolia* Shrubland (CEGL001218) in Colorado. The overwhelming abundance of *Salix ligulifolia* (60%) to relatively low cover of *Salix exigua* (<10%), and the elevation (2560 m [8400 feet]) place it in the upper elevation *Salix ligulifolia* shrubland.

Dorn (1995) has combined *Salix lutea* and *Salix ligulifolia* (as used in Colorado literature) into *Salix eriocephala*. Nearly all Colorado specimens called *Salix lutea* and *Salix ligulifolia* have been placed into *Salix eriocephala* var. *ligulifolia*, which Kartesz (1999) treats as *Salix ligulifolia*. *Salix lutea* specimens found in the extreme northwestern part of Colorado (north of Dinosaur National Monument) have been renamed *Salix eriocephala* var. *watsonii* (Dorn

1995), and *Salix lutea* specimens from extreme northeastern Colorado (along the South Platte River near Julesberg) have been renamed *Salix eriocephala* var. *famelica* (Dorn 1995). Kartesz (1999) accepts *Salix lutea* and *Salix ligulifolia* as valid species, and places *Salix eriocephala* var. *watsonii* and *Salix eriocephala* var. *famelica* into *Salix lutea*. Except for those found in the extreme northwest and northeast of Colorado, Colorado specimens of *Salix lutea, Salix ligulifolia,* and *Salix eriocephala* var. *ligulifolia* are called *Salix ligulifolia* by the Kartesz (1999) treatment.

Salix lutea (*sensu* Welsh et al. 1987) and *Salix eriocephala* (*sensu* Welsh et al. 2003) are, according to Welsh et al., *Salix ligulifolia*, and thus *Salix eriocephala* var. *ligulifolia*. Dorn (1995), however, places nearly all Utah specimens in *Salix eriocephala* var. *watsonii*. To keep with local consistency, we will follow Welsh et al's treatment, which by Kartesz (1999) would equal *Salix ligulifolia*.

Several closely related *Salix lutea*-dominated community types occur in Montana (Hansen et al. 1995), eastern Wyoming and western Idaho (Youngblood et al. 1985a), and in Nevada (Manning and Padgett 1995). These communities would be dominated by *Salix eriocephala* var. *watsonii*, if we apply Dorn's (1995) nomenclature.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Site is the rim of a pothole below a pour-off. It has deep soil that stores water.
Arches National Park Field Data: The description is based on data collected during the 2003 field season (1 observation point: ARCH.9015).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: L. Tasker, mod. G. Kittel and K.A. Schulz

REFERENCES: Baker 1989b, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Carsey et al. 2003a, Dorn 1995, Dorn 1997, Driscoll et al. 1984, Hansen et al. 1995, Kartesz 1999, Kittel and Lederer 1993, Kittel et al. 1996, Kittel et al. 1999a, Kittel et al. 1999b, Manning and Padgett 1995, Padgett et al. 1989, Richard et al. 1996, Rosgen 1996, Welsh et al. 1987, Welsh et al. 2003, Western Ecology Working Group n.d., Youngblood et al. 1985a

Grayia spinosa Shrubland
Spiny Hopsage Shrubland

CODE	CEGL002358
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic deciduous shrubland (III.B.3.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic deciduous shrubland (III.B.3.N.)
FORMATION	Extremely xeromorphic deciduous subdesert shrubland without succulents (III.B.3.N.a.)
ALLIANCE	*GRAYIA SPINOSA* SHRUBLAND ALLIANCE (A.1038) Spiny Hopsage Shrubland Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This global summary is based on the local description from Arches National Park. More information will be added when it becomes available. This association occurs on benches, plains, and alluvial fans. Soils are rapidly drained clay loam. This spiny hop-sage community is common but may occur as smaller patches in alluvial flat shrublands. Total vegetation cover ranges from 5 to 25%, most of which is concentrated in an open canopy of *Grayia spinosa* shrubs. Associated shrubs include *Coleogyne ramosissima, Ephedra viridis, Gutierrezia sarothrae,* and the succulents *Opuntia polyacantha* and *Yucca harrimaniae*. The herbaceous layer contributes little to the community, being both sparse and depauperate. Herbaceous species include *Pleuraphis jamesii, Chamaesyce fendleri,* and *Lepidium montanum*. Biological soil crusts provide less than 5% cover.

DISTRIBUTION

Arches National Park
This association was sampled along Drill Hole Road within the park as well as in Long Valley. It is best developed on the broad sandy plains northeast of the park near the head of Lost Spring Canyon.

Globally
This association occurs the Great Basin and the eastern Mojave Desert and east into the Colorado Plateau of southern Utah.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This association occurs on benches and plains within the park and is more common in the buffer. One site is on a moderately steep (18°) southeast-facing slope at 1479 m elevation. The soil is a rapidly drained clay loam derived from the Tidwell Member of the Morrison Formation. This type is more abundant on sandy soils outside the park.

Globally
This global summary is based on the local description from Arches National Park. More information will be added when it becomes available. This association occurs on benches, plains, and alluvial fans. Soils are rapidly drained clay loam. This spiny hop-sage community is common but may occur as smaller patches in alluvial flat shrublands.

VEGETATION DESCRIPTION
Arches National Park
This spiny hop-sage community is rare within the park but is more common in the environs on the northeast side. Total vegetation cover ranges from 5 to 25%, most of which is concentrated in an open canopy of *Grayia spinosa* shrubs. Associated shrubs include *Coleogyne ramosissima, Ephedra viridis, Gutierrezia sarothrae,* and the succulents *Opuntia polyacantha* and *Yucca harrimaniae*. The herbaceous layer contributes little to the community, being both sparse and depauperate. Herbaceous species in this association in the park include *Pleuraphis jamesii, Chamaesyce fendleri,* and *Lepidium montanum*. Biological soil crusts provide less than 5% cover.

Globally
Total vegetation cover ranges from 5 to 25%, most of which is concentrated in an open canopy of *Grayia spinosa* shrubs. Associated shrubs include *Coleogyne ramosissima, Ephedra viridis, Gutierrezia sarothrae,* and the succulents *Opuntia polyacantha* and *Yucca harrimaniae*. The herbaceous layer contributes little to the community, being both sparse and depauperate. Herbaceous species include *Pleuraphis jamesii, Chamaesyce fendleri,* and *Lepidium montanum*. Biological soil crusts provide less than 5% cover.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Coleogyne ramosissima*, *Ephedra viridis*, *Grayia spinosa*
Herb (field)	*Gutierrezia sarothrae*
Herb (field)	*Pleuraphis jamesii*

Globally

Stratum	Species
Short shrub/sapling	*Grayia spinosa*

OTHER NOTEWORTHY SPECIES
Arches National Park
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (22-Mar-2005).

CLASSIFICATION COMMENTS
Arches National Park

Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Arches National Park Inventory Notes: Site occurs on ridges sloping to the south from a bench. There is evidence of grazing by cattle.
Arches National Park Field Data: The description is based on 2003 and 2006 field data (1 plot*:* ARCH.0021, 1 accuracy assessment point: ARCH_AA.0014).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: G. Kittel and K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Sarcobatus vermiculatus / Artemisia tridentata Shrubland
Greasewood / Basin Big Sagebrush Shrubland

CODE	CEGL001359
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic deciduous shrubland (III.B.3.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic deciduous shrubland (III.B.3.N.)
FORMATION (III.B.3.N.b.)	Intermittently flooded extremely xeromorphic deciduous subdesert shrubland
ALLIANCE	*SARCOBATUS VERMICULATUS* INTERMITTENTLY FLOODED SHRUBLAND ALLIANCE (A.1046) Greasewood Intermittently Flooded Shrubland Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Greasewood Flat (CES304.780) Inter-Mountain Basins Playa (CES304.786) Northwestern Great Plains Shrubland (CES303.662)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY
Globally
This mixed bottomland shrubland is characteristic of stream terraces and floodplains of the Intermountain West. The presence of other shrubs in the canopy indicates less saline conditions than found in *Sarcobatus vermiculatus* Disturbed Shrubland (CEGL001357). Soils are deep and generally sandy, but a few sites are on well-drained silt loams or clays. The sagebrush element may be either *Artemisia tridentata ssp. tridentata* or *Artemisia tridentata ssp. wyomingensis*, and either the sagebrush or *Sarcobatus vermiculatus* may have the greater cover. *Atriplex canescens, Ericameria nauseosa*, and *Chrysothamnus viscidiflorus* are other common minor elements of the shrub canopy. Total shrub cover is between 5 and 30%. The understory is variable; cover by herbaceous species may be sparse to dense, or exotic species may dominate the field layer.

DISTRIBUTION
Arches National Park
This association is locally common within the park. It was sampled in Little Valley, Little Valley South, Cache Valley, Salt Wash, and Cottonwood Wash.

Globally
This mixed bottomland shrubland is characteristic of stream terraces and floodplains of the Intermountain West. Stands are reported from the Colorado Plateau and Great Basin from western Colorado and Utah, extending to Big Horn Basin across western Wyoming and south-central Montana.

ENVIRONMENTAL DESCRIPTION

Arches National Park
This mixed shrubland occurs on valley floors, on stream terraces and wash bottoms. Sites are at least 3 m above the water table, slope gently (up to 3%) and lie between 1317 and 1433 m elevation. Most of the unvegetated surface consists of bare ground or sand. Biological soil crusts are commonly present and can provide up to 60% cover. The mixed canopy indicates mildly alkaline soils derived from alluvium that are rapidly drained to well-drained with sandy loam, loamy sand, and sandy textures.

Globally
This minor shrub association occurs on stream terraces, alluvial fans, floodplains, toeslopes and valley floors. Elevations range from 1300 to 2027 m. Slopes are generally gentle, and the upper soil layers are somewhat saline. Soils are deep and generally sandy, but a few sites are on well-drained silt loams or clays. The parent materials are sandstones and shales that have eroded and deposited as secondary stream alluvium or eolian sand deposits, . Bare soil and litter cover most of the ground surface. Biological soil crusts are commonly present and can provide up to 60% cover.

VEGETATION DESCRIPTION
Arches National Park
This bottomland shrubland is uncommon within the park. Total vegetation cover ranges from 15% to more than 100%, mostly depending on the cover of cheatgrass. The shrub canopy is dominated by *Sarcobatus vermiculatus* and *Artemisia tridentata ssp. tridentata* with up to 50% total cover. Common associated shrubs include *Atriplex canescens, Ericameria nauseosa,* and *Opuntia polyacantha*. The herbaceous layer provides sparse to high cover depending on precipitation, as most of the cover is provided by exotic spring ephemeral species. Common graminoids include the exotic annual grass *Bromus tectorum*. Common forbs include *Chaenactis stevioides, Cryptantha crassisepala, Descurainia pinnata*, and *Salsola tragus*. The vine *Clematis ligusticifolia* provides moderate cover in one stand. Scattered *Juniperus osteosperma* may be present in some stands.

Globally
This mixed bottomland shrubland is characteristic of stream terraces and floodplains of the Intermountain West. The sagebrush element may be either *Artemisia tridentata ssp. tridentata* or *Artemisia tridentata ssp. wyomingensis*, and either the sagebrush or *Sarcobatus vermiculatus* may have the greater cover. *Atriplex canescens, Atriplex confertifolia, Ericameria nauseosa, Chrysothamnus viscidiflorus*, and *Opuntia polyacantha* are common minor elements of the open to moderately dense shrub canopy. Total shrub cover is between 5 and 50%. The understory is variable; cover by herbaceous species may be sparse to dense, or exotic species may dominate the field layer. Common graminoids include *Elymus lanceolatus, Poa secunda*, and the exotic annual grass *Bromus tectorum*. Additional grasses with low cover may include *Achnatherum hymenoides, Aristida purpurea, Hesperostipa comata*, and *Sporobolus airoides*. Common forbs include *Antennaria dimorpha, Chaenactis stevioides, Cryptantha crassisepala, Descurainia pinnata, Lappula occidentalis, Lepidium densiflorum, Oenothera pallida, Phlox hoodii, Plantago patagonica, Streptanthella longirostris,* and exotic species *Ceratocephala testiculata, Erodium cicutarium,* and *Salsola tragus*. Scattered *Juniperus osteosperma* may be present in some stands. Cryptogam cover is moderate, up to 35%.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Tree canopy	*Fraxinus anomala*
Shrub/sapling (tall & short)	*Amelanchier utahensis*, *Artemisia filifolia, Artemisia tridentata* ssp. *tridentata, Atriplex canescens, Ericameria nauseosa, Rhus trilobata* var. *trilobata, Sarcobatus vermiculatus*
Herb (field)	*Opuntia polyacantha*
Herb (field)	*Ambrosia acanthicarpa*, *Artemisia campestris*, *Artemisia ludoviciana, Clematis ligusticifolia, Cycloloma atriplicifolium, Descurainia pinnata, Glycyrrhiza lepidota, Plantago patagonica, Salsola tragus*
Herb (field)	*Achnatherum hymenoides*, *Bromus tectorum*, *Distichlis spicata*

Globally

Stratum	Species
Short shrub/sapling	*Sarcobatus vermiculatus*
Short shrub/sapling	*Artemisia tridentata* ssp. *tridentata*, *Artemisia tridentata* ssp. *wyomingensis*

OTHER NOTEWORTHY SPECIES
Arches National Park
Tragopogon dubius, Xanthium strumarium

Globally
Bromus tectorum, Ceratocephala testiculata, Erodium cicutarium, Salsola tragus

CONSERVATION STATUS RANK
Global Rank & Reasons: G4 (1-Feb-1996).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Arches National Park Inventory Notes: Stands are established on deep alluvial soils of valley floors, stream terraces along dry washes, washbanks, and wash bottoms. There is evidence of grazing on some sites. Biological soil crusts are commonly present and sometimes abundantly so.
Arches National Park Field Data: The description is based on 2003 field data (6 plots: ARCH.0007, ARCH.0108, ARCH.0355, ARCH.0357, ARCH.0609, ARCH.0621).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Bourgeron and Engelking 1994, Driscoll et al. 1984, Lesica and DeVelice 1992, MTNHP 2002b

Sarcobatus vermiculatus / Sporobolus airoides Shrubland
Greasewood / Alkali Sacaton Shrubland

CODE	CEGL001368
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic deciduous shrubland (III.B.3.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic deciduous shrubland (III.B.3.N.)
FORMATION (III.B.3.N.b.)	Intermittently flooded extremely xeromorphic deciduous subdesert shrubland
ALLIANCE	*SARCOBATUS VERMICULATUS* INTERMITTENTLY FLOODED SHRUBLAND ALLIANCE (A.1046) Greasewood Intermittently Flooded Shrubland Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Greasewood Flat (CES304.780) Inter-Mountain Basins Wash (CES304.781) Inter-Mountain Basins Playa (CES304.786) Central Mixedgrass Prairie (CES303.659)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY
Globally
This association occurs in the Columbia and Wyoming basins, Colorado Plateau and western Great Plains from eastern Oregon, central and northeastern Wyoming, northwestern and southeastern Colorado, and eastern Utah. Stands of this type usually occur as small, relict patches on level to gently sloping valley floors, on alluvial fans

along intermittent washes and streams, and on abandoned stream terraces with fine-textured to sandy, alkaline soils derived from alluvium. The water table rarely reaches the surface, and these sites flood only occasionally. Elevations range from 1180 to 1950 m (3870-6400 feet) in Colorado and Utah. *Sarcobatus vermiculatus* typically dominates the open to moderately dense shrub layer with between 10 and 50% cover and includes sparse and open steppe stands with 5-10% shrub cover. Other shrubs present with low cover may include *Atriplex canescens, Ericameria nauseosa*, and *Artemisia tridentata ssp. tridentata*. The herbaceous understory is typically dominated by *Sporobolus airoides*, usually with a number of other species present, including *Pascopyrum smithii, Hordeum jubatum, Hesperostipa comata, Bouteloua gracilis, Elymus elymoides, Elymus lanceolatus ssp. lanceolatus*, and *Distichlis spicata*. Forbs generally contribute little cover, although several weedy or exotic forbs may be abundant.

DISTRIBUTION

Arches National Park

This association is rare within the park and was sampled in Salt Wash Canyon.

Globally

This association occurs in the Columbia and Wyoming basins, Colorado Plateau and western Great Plains from eastern Oregon, central and northeastern Wyoming, northwestern and southeastern Colorado, and eastern Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This saline shrub association occurs on terraces and points adjacent to intermittent washes. The sampled site slopes gently (7%) and lies at 1335 m elevation. Litter covers most of the unvegetated surface. Soils are well-drained sandy loams derived from alluvium.

Globally

Stands of this type usually occur as small, relict patches on level to gently sloping valley floors and on abandoned stream terraces with fine-textured to sandy, alkaline soils derived from alluvium. Elevations range from 1180 to 1950 m (3870-6400 feet) in Colorado and Utah. The water table is usually within 1 m of the surface for at least part of the growing season, although it may be a perched water table held by a hard pan just below the ground surface.

VEGETATION DESCRIPTION

Arches National Park

This association is rare within the park. Total vegetation cover averages around 60%. The shrub canopy is dominated by *Sarcobatus vermiculatus*, usually accompanied by *Allenrolfea occidentalis, Chrysothamnus viscidiflorus*, and *Ericameria nauseosa*. The herbaceous understory is dominated by *Sporobolus airoides* with up to 25% cover. Additional herbaceous species include *Hesperostipa comata*. Forbs are uncommon and variable. Biological soil crust cover is sparse, not exceeding 5% cover.

Globally

Sarcobatus vermiculatus dominates the shrub layer with between 10 and 50% cover. Other shrubs present with low cover may include *Atriplex canescens, Atriplex confertifolia, Allenrolfea occidentalis, Chrysothamnus viscidiflorus, Ericameria nauseosa, Suaeda moquinii (= Suaeda torreyana)*, and *Artemisia tridentata ssp. tridentata*. The herbaceous understory contains and is often dominated by *Sporobolus airoides* and usually a number of other species, including *Pascopyrum smithii, Hordeum jubatum, Bouteloua gracilis, Elymus elymoides, Elymus lanceolatus ssp. lanceolatus*, and *Distichlis spicata*. Forbs generally contribute little cover, although several weedy or exotic forbs may be abundant.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Allenrolfea occidentalis, Chrysothamnus viscidiflorus, Ericameria nauseosa, Sarcobatus vermiculatus*
Herb (field)	*Distichlis spicata, Hesperostipa comata, Sporobolus airoides*

Globally

Stratum	Species
Short shrub/sapling	*Sarcobatus vermiculatus*

Herb (field) *Sporobolus airoides*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G3? (1-Dec-2000). This association has been named from the Thunder Basin National Grassland of northeastern Wyoming, and it apparently also occurs along the North Platte and Sweetwater rivers in central Wyoming. It is ranked G3 because it has been described from a limited geographic range, and many stands seem to contain exotic plants. The lack of detailed descriptions or stand data make the rank questionable. As additional data become available and the full range of the association becomes better understood, this rank should be revisited. It appears that many stands in the Colorado Plateau that historically were this association have been degraded by grazing and water table collapse.

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
This association was renamed to a shrubland association and moved from a sparsely vegetated to a shrubland alliance based on literature and plot review that indicated that, although some stands are sparse (<10% total vegetation cover), most are not and some have rather dense cover (50% cover of shrubs). This description is based on information from northeastern Wyoming, northwestern and southeastern Colorado and southern Utah. A general vegetation description and habitat description from central Wyoming are also available. The plant species listed for this association also occur in *Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus)* Shrub Herbaceous Vegetation (CEGL001508), and this type may also be similar to *Sarcobatus vermiculatus / Distichlis spicata* Shrubland (CEGL001363). These three associations apparently are differentiated on the basis of the relative amounts of the various grass species in the undergrowth. Grass dominance varies with soil salinity and aeration, and this association may represent the more saline but well-aerated conditions. Also compare this association with *Sarcobatus vermiculatus / Distichlis spicata - (Puccinellia nuttalliana)* Shrub Herbaceous Vegetation (CEGL002146).

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: The sampled site is 5 m above the streambed on a terrace in the bends of drainages. There is no apparent disturbance given the density of the litter layer.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0124).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: G.P. Jones, mod. J. Coles and K.A. Schulz

REFERENCES: Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Driscoll et al. 1984, Jones 1992b, Kagan et al. 2004, Shaw et al. 1989, Terwilliger et al. 1979a, Terwilliger et al. 1979b, Warren n.d.

Sarcobatus vermiculatus Disturbed Shrubland
Greasewood Disturbed Shrubland

CODE	CEGL001357
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic deciduous shrubland (III.B.3.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic deciduous shrubland (III.B.3.N.)
FORMATION (III.B.3.N.b.)	Intermittently flooded extremely xeromorphic deciduous subdesert shrubland

ALLIANCE *SARCOBATUS VERMICULATUS* INTERMITTENTLY FLOODED SHRUBLAND ALLIANCE (A.1046)
Greasewood Intermittently Flooded Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Greasewood Flat (CES304.780)
Inter-Mountain Basins Wash (CES304.781)
Inter-Mountain Basins Playa (CES304.786)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY

Globally

This greasewood shrubland occurs on saline soils of terraces, swales, alluvial fans and flats, valley floors, playas, toeslopes and ridges throughout the Colorado Plateau and Great Basin and extends to mountain valleys in the southern Rocky Mountains. It is distinguished from other *Sarcobatus vermiculatus* associations in that disturbance has removed most or all of the native herbaceous understory. Black greasewood will increase in density at the expense of grasses such as *Sporobolus airoides* under conditions of heavy grazing, since the shrub is only moderately palatable and is somewhat poisonous to livestock. Soil textures in these communities range from sandy loam to silty clay and may have a white salt crust on the soil surface. *Sarcobatus vermiculatus* dominates the sparse to moderately dense shrub layer, usually with a minor component of *Ericameria nauseosa, Suaeda moquinii (= Suaeda torreyana), Opuntia polyacantha*, *Atriplex canescens*, or *Atriplex confertifolia*. If *Artemisia tridentata* is present, it is with very low cover. The understory ranges from sparse to dense in cover, but native species typically have very low cover. The dominant herbaceous species tend to be weedy and/or exotic; *Vulpia octoflora, Bromus tectorum, Descurainia pinnata, Salsola tragus, Alyssum desertorum*, and *Halogeton glomeratus* are typical understory species.

DISTRIBUTION

Arches National Park

This association is uncommon within the park and was sampled in Courthouse Wash, Upper Courthouse Wash, Salt Valley, Salt Wash, and in Spring Canyon.

Globally

This association is likely to be widespread on floodplains and valley floors throughout the interior western United States. It is currently documented from the Colorado Plateau, Great Basin, Uinta Basin and San Luis Valley from northwestern New Mexico, southern and western Colorado, Utah, Nevada, and eastern California.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This saline association occurs on plateaus, valley floors, stream terraces, and slopes. Sites are flat to gentle (up to 7% slopes), occur between 1265 and 1387 m elevation and tend to be oriented to southwest exposures. Most of the unvegetated surface consists of bare soil. Biological soil crusts provide up to 25% cover. Soils are derived from mixed alluvium, are rapidly drained and have sandy loam, sandy clay, and silty clay textures.

Globally

This widespread but patchy shrubland occurs throughout the Colorado Plateau and Great Basin and extends to mountain valleys in the southern Rocky Mountains. Stands are found on terraces, swales, coppice dunes, playas, alluvial fans and flats, valley floors, toeslopes and ridges. Elevation ranges between 1200 and 2308 m (3940-7570 feet), and slopes tend to be gentle. Soils are typically derived from mixed alluvium (shale, sandstone and gneiss), from shale that erodes into moderate to steep gullies and slopes (badlands), or from eolian deposits. Soil textures range from sand to silty clay and tend to be alkaline and saline, often with a white salt crust on the soil surface. Sabkha substrates (carbonate cemented sand) occur on subirrigated areas near dunes in southern Colorado. Biological soil crusts are typically absent or provide low cover, but occasionally have higher (up to 25%) cover . Bare ground values tend to be high, up to 80%, unless *Bromus tectorum* is a major component of the system, in which case litter cover values are high.

VEGETATION DESCRIPTION

Arches National Park

This black greasewood association is uncommon within the park. Total vegetation cover ranges from 3 to 30%. The shrub canopy consists of *Sarcobatus vermiculatus* shrubs, usually accompanied by *Atriplex canescens* and *Opuntia*

polyacantha. The herbaceous layer provides sparse to dense cover, depending on the amount of spring precipitation. Common graminoids include *Achnatherum hymenoides* and *Vulpia octoflora*. Forbs may include the annual exotic *Salsola tragus*.

Globally
This shrubland occurs where conditions support *Sarcobatus vermiculatus*, but disturbance has removed most or all of the native herbaceous understory. *Sarcobatus vermiculatus* dominates the sparse to moderately dense shrub layer with a cover of 10-60%. Other shrubs commonly present may include *Atriplex canescens, Atriplex confertifolia, Atriplex gardneri, Chrysothamnus viscidiflorus, Ericameria nauseosa, Grayia spinosa, Opuntia polyacantha, Picrothamnus desertorum, Suaeda moquinii (= Suaeda torreyana),* and *Tetradymia canescens*. If *Artemisia tridentata* is present, it is with very low cover. The understory ranges from sparse to dense in cover, but native species typically have very low cover. The dominant herbaceous species tend to be weedy and/or exotic; *Vulpia octoflora, Bromus tectorum, Descurainia pinnata, Erodium cicutarium, Salsola tragus, Alyssum desertorum,* and *Halogeton glomeratus* are typical understory dominants.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Artemisia tridentata* ssp. *tridentata, Atriplex canescens, Sarcobatus vermiculatus*
Herb (field)	*Cryptantha crassisepala, Salsola tragus*
Herb (field)	*Bromus tectorum, Pleuraphis jamesii*

Globally

Stratum	Species
Short shrub/sapling	*Sarcobatus vermiculatus*

OTHER NOTEWORTHY SPECIES
Arches National Park
Descurainia pinnata, Halogeton glomeratus

Globally
Alyssum desertorum, Bromus tectorum, Descurainia pinnata, Erodium cicutarium, Halogeton glomeratus, Salsola tragus

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Stands included in this association are often affected by livestock grazing, and either lack an understory or possess an understory dominated by weedy or exotic herbaceous species.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Stands occupy the valley floor at the mouth of a large canyon, dune-like undulations, deep alluvium on stream terraces, and larger dunes. There are some drought effects and wind scour. There has been grazing at some sites. This association is distinguished from other greasewood shrublands by either a lack of an understory or an understory dominated by herbaceous exotic annual species.
Arches National Park Field Data: The description is based on 2003 field data (6 plots: ARCH.0017, ARCH.0087, ARCH.0364, ARCH.0376, ARCH.0637, ARCH.0706).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Bourgeron and Engelking 1994, Brotherson et al. 1986, Dastrup 1963, Donovan et al. 1996, Driscoll et al. 1984, Francis 1986, Ganskopp 1986, Graham 1937, Groeneveld and Crowley 1988, Shantz and

Piemeisel 1940, Western Ecology Working Group n.d., Young et al. 1986

Kraschenninnikovia lanata / Pleuraphis jamesii Dwarf-shrubland
Winterfat / James' Galleta Dwarf-shrubland

CODE	CEGL001322
PHYSIOGNOMIC CLASS	Dwarf-shrubland (IV)
PHYSIOGNOMIC SUBCLASS	Evergreen dwarf-shrubland (IV.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen dwarf-shrubland (IV.A.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen dwarf-shrubland (IV.A.2.N.)
FORMATION	Extremely xeromorphic evergreen subdesert dwarf-shrubland (IV.A.2.N.a.)
ALLIANCE	*KRASCHENINNIKOVIA LANATA* DWARF-SHRUBLAND ALLIANCE (A.1104) Winterfat Dwarf-shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY

Globally

This minor dwarf-shrubland association is reported from throughout the Colorado Plateau. Stands typically occur on alluvial flats and plains. Sites are typically flat to gently sloping, occurring on any aspect. Soils are generally moderately deep, calcareous, moderately alkaline and derived from sandstone, shale or alluvium. Soil texture ranges from sandy loam to silty clay. The ground surface has high cover of bare soil (70-90%). Vegetation is characterized by a sparse to moderately dense dwarf-shrub layer dominated by *Kraschenninnikovia lanata* and sometimes codominated by *Gutierrezia sarothrae*. Other woody species may include scattered *Artemisia tridentata, Artemisia bigelovii, Chrysothamnus viscidiflorus, Opuntia imbricata, Opuntia polyacantha*, or *Yucca glauca*. The herbaceous layer has sparse to moderately dense cover that is dominated or codominated by *Pleuraphis jamesii* with scattered perennial forbs. Associated graminoids may include *Achnatherum hymenoides, Bouteloua gracilis, Elymus elymoides, Hesperostipa comata*, and *Sporobolus airoides*. Scattered perennial forbs may be present, such as *Chaetopappa ericoides, Helianthus petiolaris, Machaeranthera pinnatifida*, and *Sphaeralcea* spp. Exotic annuals may include *Bromus tectorum, Salsola kali*, and *Sisymbrium altissimum*.

DISTRIBUTION

Arches National Park

This association occurs throughout Salt Valley within the park. It was also observed in Cache Valley, in Eagle Park, and on the sand plains near Fiery Furnace.

Globally

This dwarf-shrubland association is reported from alluvial flats in northwestern New Mexico in the upper Rio Puerco basin, in western Colorado on the margins of the Grand Valley and in eastern Utah in flats above the Green River floodplain. It likely occurs throughout the Colorado Plateau.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This dwarf-shrub association occurs on sandsheets deposited against the base of valley walls. The one sampled site slopes gently (2%), occurs at 1506 m elevation and is oriented to the east. The unvegetated surface has high exposure of bare soil and moderate cover of litter. The soil is a rapidly drained sandy loam derived from eolian sands.

Globally

This minor dwarf-shrubland association is reported from northwestern New Mexico, western Colorado and eastern Utah, but likely occurs throughout the Colorado Plateau. Elevations range from 1400-2050 m. Climate is temperate and semi-arid. Annual precipitation ranges from 20-30 cm with most occurring during the growing season, often as short-duration, convectional thunderstorms. Stands occur on plains, alluvial flats, valley floors, canyon bottoms, benches, alluvial fans and stabilized sand dunes. Sites are flat to moderately sloping, occurring on any aspect. Soils are generally moderately deep, calcareous, moderately alkaline and derived from sandstone, shale or alluvium, but include rapidly drained sandy loam derived from eolian sands and sheetwash deposits.. Soil texture ranges from

sand to silty clay. The ground surface has high cover of bare soil (70-90%).

VEGETATION DESCRIPTION

Arches National Park

This dwarf-shrub association is uncommon within the park and was sampled only once. Total vegetation cover does not exceed 30%. The vegetation is characterized by an open canopy of *Krascheninnikovia lanata* with around 20% cover and the perennial bunchgrass *Pleuraphis jamesii* with around 10% cover. No associated species has cover exceeding 1%. The other grass species present is the tall bunchgrass *Sporobolus airoides*. Forbs include *Helianthus petiolaris, Oenothera pallida,* and *Sphaeralcea parvifolia*. Biological soil crusts provide less than 1% cover.

Globally

This association is characterized by a sparse to moderately dense dwarf-shrub layer dominated by *Krascheninnikovia lanata* and sometimes codominated by *Gutierrezia sarothrae*, and a sparse to moderately dense herbaceous layer dominated by the perennial graminoid *Pleuraphis jamesii*. Scattered *Artemisia tridentata, Atriplex canescens, Artemisia bigelovii, Chrysothamnus viscidiflorus, Ephedra viridis, Opuntia imbricata, Opuntia polyacantha*, or *Yucca glauca* may also be present in the woody layer. Other graminoids present in minor amounts may include *Achnatherum hymenoides, Bouteloua gracilis, Elymus elymoides, Hesperostipa comata*, and *Sporobolus airoides*. Scattered perennial forbs may be present, such as *Chaetopappa ericoides, Helianthus petiolaris, Machaeranthera pinnatifida, Oenothera pallida, Sphaeralcea coccinea,* and *Sphaeralcea parvifolia*. Exotic annuals may include *Bromus tectorum, Salsola kali,* and *Sisymbrium altissimum.*

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Krascheninnikovia lanata*
Herb (field)	*Pleuraphis jamesii*

Globally

Stratum	Species
Short shrub/sapling	*Gutierrezia sarothrae, Krascheninnikovia lanata*
Herb (field)	*Bromus tectorum, Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES

Arches National Park

Data are not available.

Globally

Bromus tectorum, Salsola kali, Sisymbrium altissimum

CONSERVATION STATUS RANK

Global Rank & Reasons: G3G4 (23-Feb-1994).

CLASSIFICATION COMMENTS

Arches National Park

Data are not available.

Globally

Stands described by Francis (1986) were generally too sparse to be classified as dwarf-shrublands and may be better classified in a shrub herbaceous association. Current and past livestock management can have a large impact on cover and composition of the woody and herbaceous layers. Both *Krascheninnikovia lanata* (winter-fat) and *Pleuraphis jamesii* are valuable livestock forage and are negatively impacted by heavy use. *Gutierrezia sarothrae* increases under heavy livestock use. Significant small mammal burrows and plant pedestalling caused by wind erosion were reported from the Utah stands.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Arches National Park Inventory Notes: Stand occupies a sandsheet adjacent to the wall within the Salt Valley. There are small erosion channels present.

Arches National Park Field Data: The description is based on 2003 and 2006 field data (1 plot*:* ARCH.0667, 7 accuracy assessment points: ARCH_AA.0037, ARCH_AA.0109, ARCH_AA.0254, ARCH_AA.0284, ARCH_AA.0301, ARCH_AA.0486, ARCH_AA.0533).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: Bourgeron and Engelking 1994, Driscoll et al. 1984, Francis 1986, Gates et al. 1956, Von Loh 2000

Krascheninnikovia lanata Dwarf-shrubland
Winterfat Dwarf-shrubland

CODE	CEGL001320
PHYSIOGNOMIC CLASS	Dwarf-shrubland (IV)
PHYSIOGNOMIC SUBCLASS	Evergreen dwarf-shrubland (IV.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen dwarf-shrubland (IV.A.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen dwarf-shrubland (IV.A.2.N.)
FORMATION	Extremely xeromorphic evergreen subdesert dwarf-shrubland (IV.A.2.N.a.)
ALLIANCE	*KRASCHENINNIKOVIA LANATA* DWARF-SHRUBLAND ALLIANCE (A.1104) Winterfat Dwarf-shrubland Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784) Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY
Globally
This association is known from Colorado Plateau west into to the Great Basin and northern Mojave Desert and east into the northern panhandle of Texas and is likely to be more widespread in similar habitats in the southwestern Great Plains. It is an alkaline dwarf-shrub association that occurs primarily on sandsheets, slopes and plains often on eolian deposits near canyon walls and in alkaline flats in and around playas and along washes. Sites are flat to steep (up to 40% slope) and occur between 800 and 1770 m (2620-5800 feet) elevation. Soils are rapidly drained loamy sands or sandy loams derived from alluvium from a variety of parent materials and sandstones that have eroded and been redeposited by wind and water. It occurs on low to high levels of soil salinity and alkalinity. Total vegetation cover ranges from 5 to 45% and is characterized by the dwarf-shrub *Krascheninnikovia lanata* with cover between 5 and 30%. In southern Nevada, scattered *Ambrosia dumosa, Atriplex polycarpa, Larrea tridentata, Lycium andersonii, Sphaeralcea ambigua*, and *Suaeda moquinii (= Suaeda torreyana)* may be present. The herbaceous layer is poorly developed but may contain tufts of the grass *Achnatherum hymenoides*. Forbs commonly present include *Eriogonum* spp., *Opuntia polyacantha, Oenothera pallida, Plantago patagonica*, and *Sphaeralcea parvifolia*. Biological soil crusts may provide up to 45% cover. Introduced annuals *Bromus tectorum, Bromus rubens*, and *Salsola tragus* may be abundant on some sites.

DISTRIBUTION
Arches National Park
This association was sampled in the Salt Valley and in Courthouse Wash within the park.

Globally
This association is known from the Colorado Plateau west into the Great Basin and northern Mojave Desert.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This alkaline dwarf-shrub association occurs primarily on sandsheets deposited against the base of valley sides or canyon walls. Sites are gentle to steep (up to 40% slope), occur between 1268 and 1515 m elevation and tend to be oriented to north aspects. The unvegetated surface has high exposure of bare soil and low to moderate cover of litter. Soils are rapidly drained sandy loams derived from Navajo and Entrada sandstones that have eroded and been redeposited by wind and water.

Globally
This association is known from the Colorado Plateau west into the Great Basin and northern Mojave Desert and in the panhandle of Texas. It is an alkaline dwarf-shrub association that occurs primarily on sandsheets, slopes and plains often on eolian deposits near canyon walls and in alkaline flats in and around playas and along washes. Sites are gentle to steep (up to 40% slope) and occur between 800 and 1770 m (2620-5800) feet elevation. Soils are rapidly drained loamy sands from alluvium derived from a mixture of rocks such as granodiorite, quartzite, latite, limestone and basalt in southern Nevada (Faden 1977), and sandy loams derived from Navajo and Entrada sandstones in southeastern Utah that have eroded and been redeposited by wind and water. It occurs on low to high levels of soil salinity and alkalinity.

In Texas, this community occurs on shallow soils on ridges and on footslopes along the Canadian River. In general, the soils are redbed-derived and shallow in nature. It would seem that this shrub is able to grow on a variety of soils but prefers the more shallow, rocky areas. It is often found growing in association with other shrubs but may grow alone in small colonies. When this community is found, it is never extensive and rarely occupies more than a third of an acre. There is usually some evidence of deer browsing on this species, and in areas where it is accessible, domestic livestock will browse it as well.

VEGETATION DESCRIPTION
Arches National Park
This association is uncommon within the park. Total vegetation cover ranges from 5 to 45% and is characterized by the dwarf-shrub *Krascheninnikovia lanata* with cover between 5 and 15%. The main associated shrub is *Opuntia polyacantha*. The herbaceous layer is poorly developed but may contain tufts of the grass *Achnatherum hymenoides*. Forbs commonly present include *Oenothera pallida, Plantago patagonica,* and *Sphaeralcea parvifolia*. Biological soil crusts provide up to 45% cover.

Globally
On the Colorado Plateau, total vegetation cover ranges from 5 to 45% and is characterized by the dwarf-shrub *Krascheninnikovia lanata* with cover between 5 and 30%. In southern Nevada, scattered *Ambrosia dumosa, Atriplex polycarpa, Larrea tridentata, Lycium andersonii, Sphaeralcea ambigua,* and *Suaeda moquinii (= Suaeda torreyana)* may be present (Faden 1977). The herbaceous layer is poorly developed but may contain tufts of the grass *Achnatherum hymenoides*. Forbs commonly present include *Eriogonum* spp., *Opuntia polyacantha, Oenothera pallida, Plantago patagonica*, and *Sphaeralcea parvifolia*. Biological soil crusts provide up to 45% cover. Introduced annuals *Bromus tectorum, Bromus rubens*, and *Salsola tragus* may be abundant on some sites.

In Texas, this small community is dominated by *Krascheninnikovia lanata*, with some other short shrubs also being present in lesser amounts. Associated shrubs present in the community include *Dalea formosa, Mimosa borealis, Atriplex canescens*, and occasionally small *Prosopis glandulosa*. The community gives the appearance of being droughty and forbs are few. *Tetraneuris scaposa, Gutierrezia sarothrae, Chaetopappa ericoides, Paronychia jamesii*, and *Eriogonum longifolium* are the most common. The most common grasses are *Aristida purpurea, Hesperostipa neomexicana, Bouteloua gracilis*, and *Bouteloua curtipendula*.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Krascheninnikovia lanata*
Herb (field)	*Alyssum alyssoides, Plantago patagonica*
Herb (field)	*Bromus tectorum, Sporobolus cryptandrus*

Globally

Stratum	Species
Short shrub/sapling	*Krascheninnikovia lanata*

OTHER NOTEWORTHY SPECIES
Arches National Park
Data are not available.

Globally

Bromus tectorum

CONSERVATION STATUS RANK
Global Rank & Reasons: G5? (23-Feb-1994).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
This is a broadly defined association that includes stands from the Colorado Plateau, Great Basin and northern Mojave Desert characterized by the dominance of *Krascheninnikovia lanata* without a notable herbaceous layer. The herbaceous layer is typically absent or sparse or dominated by introduced species such as *Bromus tectorum* or *Salsola tragus*. This is a very-small-patch association as presently defined from Lake Meredith National Recreation Area, Texas. The concept will need further review to determine if it is a viable association or should be considered as patches within a broader association.

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Arches National Park Inventory Notes: Most stands occur on sandy toeslopes on the floor of the Salt Valley near Klondike Bluffs. Soils of one stand have a physical crust.
Arches National Park Field Data: The description is based on 2003 field data (2 plots: ARCH.0382, ARCH.0653, 1 observation point: ARCH.9691, and 4 accuracy assessment points: ARCH_AA.0134, ARCH_AA.0224, ARCH_AA.0316, ARCH_AA.0365).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz and J. Drake

REFERENCES: Bourgeron and Engelking 1994, Driscoll et al. 1984, Faden 1977, Mitchell et al. 1966

Atriplex corrugata Dwarf-shrubland
Mat Saltbush Dwarf-shrubland

CODE	CEGL001437
PHYSIOGNOMIC CLASS	Dwarf-shrubland (IV)
PHYSIOGNOMIC SUBCLASS	Evergreen dwarf-shrubland (IV.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen dwarf-shrubland (IV.A.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen dwarf-shrubland (IV.A.2.N.)
FORMATION	Facultatively deciduous subdesert dwarf-shrubland (IV.A.2.N.b.)
ALLIANCE	*ATRIPLEX CORRUGATA* DWARF-SHRUBLAND ALLIANCE (A.1109) Mat Saltbush Dwarf-shrubland Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Mat Saltbush Shrubland (CES304.783) Inter-Mountain Basins Shale Badland (CES304.789)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This dwarf-shrubland association is found on lower hillslopes, clay barrens and alkaline flats on Colorado Plateau portions of northwestern New Mexico, western Colorado and Utah. Sites are gently sloping to moderately steep ridges and hills shaped into badlands by water and wind erosion. Soils are typically derived from Mancos shale or other marine shales. They are moderately deep, strongly saline, moderately alkaline, fine-textured (clayey), poorly developed and typically have high erosion rates. The soil surface is mostly barren. The vegetation is characterized by a very sparse to moderate cover (5-25%) of woody vegetation that is dominated by the halophytic evergreen dwarf-shrub *Atriplex corrugata*. There is typically very low species diversity, but depending on soil salinity and moisture, other plants may be present, including the shrubs *Atriplex gardneri, Atriplex confertifolia, Tetradymia spinosa, Picrothamnus desertorum (= Artemisia spinescens), Suaeda calceoliformis,* and *Krascheninnikovia lanata*. The herbaceous layer is very sparse. Only scattered perennial forbs, such as *Xylorhiza glabriuscula, Xylorhiza*

venusta, and *Sphaeralcea grossulariifolia*, and the perennial grasses *Achnatherum hymenoides, Elymus elymoides*, and *Pleuraphis jamesii* have been reported. Annuals are seasonally present and may include *Eriogonum inflatum, Phacelia splendens, Plantago tweedyi*, and *Atriplex argentea*. Introduced species such as *Bromus tectorum* and *Salsola kali* are often present.

DISTRIBUTION

Arches National Park

This association is uncommon and appears to be restricted to Cache Valley within the park.

Globally

Shrublands in this association are found on lower hillslopes and alkaline flats on Colorado Plateau portions of northwestern New Mexico, western Colorado and eastern Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This dwarf-shrub association occurs on alkaline badlands eroded into Mancos shale. Stands are located on gentle to moderately steep sites with 7 to 32% slopes between 1317 and 1345 m elevation. The unvegetated surface consists almost entirely of bare soil, often up to 99%. Soils are rapidly drained clay loam.

Globally

This dwarf-shrubland association is found on lower hillslopes, clay barrens and alkaline flats on Colorado Plateau portions of northwestern New Mexico, western Colorado and eastern Utah. Climate is semi-arid with most of the highly variable precipitation falling in July and August as high-intensity thunderstorms. Mean annual precipitation is approximately 23 cm. Elevation ranges from 1300-1975 m (4265-6480 feet). Sites are gently sloping to moderately steep ridges and hills shaped into badlands by water and wind erosion. Soils are typically derived from Mancos shale or, less often, from other Paleozoic or Mesozoic marine shales. They are moderately deep, strongly saline, moderately alkaline, fine-textured (clayey), poorly developed and typically have high erosion rates. The soil surface is mostly barren. In the Badger Wash Basin in Colorado, a relatively lush stand had 25% *Atriplex corrugata*, 60% bare ground, 8% litter and 8% algal crusts (Branson et al. 1976).

VEGETATION DESCRIPTION

Arches National Park

This mat saltbush association is locally common in the north end of Cache Valley, but absent from the rest of the park. Total vegetation cover ranges from 1 to 20% but rarely exceeds 15%. The vegetation is characterized by a sparse canopy of low-growing *Atriplex corrugata*, often growing as the only shrub but occasionally accompanied by scattered *Atriplex gardneri* and *Tetradymia spinosa*. The herbaceous layer is sparse but predictable, consisting of scattered tufts of *Achnatherum hymenoides* or *Pleuraphis jamesii* with *Eriogonum inflatum*.

Globally

These shrublands are found on the slopes of marine shale badlands and alkaline flats on the Colorado Plateau. Stands have very sparse to moderate cover (1-25%) of woody vegetation that is dominated by the halophytic evergreen dwarf-shrub *Atriplex corrugata*. Sparse stands are often solely dominated by this plant. Stands typically have very low species diversity. Depending on soil salinity and moisture, other plants may be present, including the shrubs *Atriplex gardneri, Atriplex confertifolia, Tetradymia spinosa, Gutierrezia sarothrae, Picrothamnus desertorum (= Artemisia spinescens), Suaeda calceoliformis*, and *Krascheninnikovia lanata*. The herbaceous layer is very sparse. Scattered perennial forbs, such as *Xylorhiza glabriuscula, Xylorhiza venusta*, and *Sphaeralcea grossulariifolia*, and the perennial grasses *Achnatherum hymenoides, Aristida purpurea, Elymus elymoides*, and *Pleuraphis jamesii* have been reported. Annuals are seasonally present and may include *Eriogonum inflatum, Phacelia splendens, Plantago tweedyi, Stenogonum salsuginosum*, and *Atriplex argentea*. Introduced species include *Bromus tectorum, Halogeton glomeratus, Malcolmia africana*, and *Salsola kali*. Perennial plants may be pedestalled because of high erosion on these sites.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex corrugata*, *Atriplex gardneri*

Globally

Stratum	Species
Short shrub/sapling	*Atriplex corrugata*

OTHER NOTEWORTHY SPECIES
Arches National Park
Data are not available.

Globally
Bromus tectorum, Malcolmia africana

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Vegetation cover in this association may vary greatly depending on soil chemistry and slope. Some stands should be classified as shrublands with 25-30% shrub cover (Branson et al. 1976, Potter et al. 1985). However, most stands are in the 3-20% shrub cover range and should be classified in a sparsely vegetated alliance (West and Ibraham 1968, Ibraham et al. 1972, Harper and Jaynes 1986, Von Loh 2000). Further investigation is needed throughout its range to resolve this issue. *Atriplex corrugata* also occurs an as element in mat saltbush shrublands dominated by other species of *Atriplex* (e.g., *Atriplex gardneri* (including *Atriplex cuneata*) and *Atriplex confertifolia*). It is not always clear in the field where to draw the line between these three classes of mat saltbush shrublands, as the mix of the three species may change with small changes in slope, soil texture, topographic position and aspect.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Arches National Park Inventory Notes: Sites occupy dissected badlands in Mancos shale. Sheet and gully erosion is common, as is soil crusting.
Arches National Park Field Data: The description is based on 2003 and 2006 field data (3 plots: ARCH.0096, ARCH.0102, ARCH.0103, and 1 accuracy assessment point: ARCH_AA.0584).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: Baker 1984a, Bourgeron and Engelking 1994, Branson 1966, Branson et al. 1967, Branson et al. 1976, CONHP unpubl. data 2003, Collins 1984, Dastrup 1963, Driscoll et al. 1984, Graham 1937, Harper and Jaynes 1986, Ibrahim et al. 1972, Lusby et al. 1963, Potter et al. 1985, Romme et al. 1993, Shantz 1925, Shute and West 1978, Tuhy and MacMahon 1988, U.S. Bureau of Reclamation 1976, Von Loh 2000, Welsh 1957, West and Ibrahim 1968

Atriplex gardneri / Pleuraphis jamesii Dwarf-shrubland
Gardner's Saltbush / James' Galleta Dwarf-shrubland

CODE	CEGL001441
PHYSIOGNOMIC CLASS	Dwarf-shrubland (IV)
PHYSIOGNOMIC SUBCLASS	Evergreen dwarf-shrubland (IV.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen dwarf-shrubland (IV.A.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen dwarf-shrubland (IV.A.2.N.)
FORMATION	Facultatively deciduous subdesert dwarf-shrubland (IV.A.2.N.b.)
ALLIANCE	*ATRIPLEX GARDNERI* DWARF-SHRUBLAND ALLIANCE (A.1110) Gardner's Saltbush Dwarf-shrubland Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Mat Saltbush Shrubland (CES304.783) Inter-Mountain Basins Shale Badland (CES304.789)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This association occurs on barren shale slopes and flats in the northern Colorado Plateau of Colorado and Utah. The vegetation is generally sparse and consists of an open canopy of dwarf-shrubs consisting primarily or entirely of *Atriplex gardneri* and an open to sparse herbaceous stratum in which *Pleuraphis jamesii* is conspicuous. Other grasses, such as *Achnatherum hymenoides* and *Poa secunda*, and a diversity of forbs that are typical of shale badlands are also usually present with sparse cover. The substrate is fine-textured soil derived from marine shale, but there is often a layer of gravel or small rocks on the ground surface.

DISTRIBUTION

Arches National Park

This association is rare and was sampled in Little Valley South just outside the park. It was also recorded from the toeslopes of Cache Valley south of Delicate Arch.

Globally

This association is known from the Colorado Plateau of eastern Utah, including the Grand Valley and the Four Corners area of western Colorado.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This dwarf-shrub association occurs on the slopes of ridges in the mapping area. Stands are on gently sloping (6 to 11%), northwest-facing sites at around 1433 m elevation. Large rocks, bare ground and gravel cover most of the unvegetated surface. The soils are rapidly drained derived from the Morrison Formation.

Globally

This association occurs on slopes of ridges, hills, eroded pediment slopes and badlands of the Colorado Plateau in eastern Utah and western Colorado. Elevation ranges between 1225 and 1975 m (4020-6480 feet) on slopes from gentle to steep (10-65%). The substrate is a saline, alkaline, well- to rapidly drained sandy loam, sandy clay loam, silt loam, clay loam or silty clay derived from marine shale, including the Brushy Basin Member of the Morrison Formation, Chinle shale, Mancos shale, or Moenkopi Formation. The soil surface often has a coating of gravel or small rocks, although large rocks may be present.

VEGETATION DESCRIPTION

Arches National Park

This sparse dwarf-shrub association is rare within the mapping area. Total vegetation cover ranges from 4 to 20%. The vegetation is characterized by a sparse canopy of *Atriplex gardneri* with a sparse to moderate understory of the short bunchgrass *Pleuraphis jamesii*. Associated shrubs and herbaceous species contribute little to the community; consistent species include the shrubs *Opuntia polyacantha, Picrothamnus desertorum*, and *Sclerocactus whipplei* and the herbaceous species *Calochortus nuttallii*, *Cymopterus purpurascens, Lappula occidentalis, Plantago patagonica, Platyschkuhria integrifolia*, and *Xylorhiza venusta*. Biological soil crusts provide up to 25% cover.

Globally

This association occurs on alkaline shale badlands, often where the soil surface is modified by a layer of gravel or small rocks. The vegetation is characterized by a typically sparse canopy (1-10% cover) of *Atriplex gardneri* with a sparse to moderate understory of the short bunchgrass *Pleuraphis jamesii*. Total vegetation is generally sparse, rarely exceeding 20%. Occasionally stands have an open to closed canopy of *Atriplex gardneri* dwarf-shrubs that range in cover from 26 to 76% and a herbaceous layer that ranges in cover from 26 to 50%. Total vegetation may exceed 100% in these stands. Other low shrubs and cacti are often present with low cover, including *Atriplex confertifolia, Artemisia bigelovii, Artemisia nova, Atriplex confertifolia, Chrysothamnus viscidiflorus, Ephedra torreyana, Ericameria nauseosa, Gutierrezia sarothrae, Krascheninnikovia lanata, Opuntia polyacantha, Picrothamnus desertorum, Sclerocactus whipplei, Shepherdia rotundifolia*, or *Yucca angustissima*. Scattered *Juniperus osteosperma* trees may also be present. The generally sparse herbaceous layer is composed of a mixture of grasses and forbs. *Pleuraphis jamesii, Achnatherum hymenoides*, and *Poa secunda* are the most abundant grasses. A diversity of forbs that are typical of shale badlands is also usually present with sparse cover, including *Astragalus amphioxys, Astragalus mollissimus, Calochortus nuttallii, Cymopterus purpurascens, Eriogonum inflatum, Lappula*

occidentalis, Oenothera caespitosa, Plantago patagonica, Platyschkuhria integrifolia, Sphaeralcea coccinea, Sphaeralcea leptophylla, and *Xylorhiza venusta*. Biological soil crusts provide up to 25% cover.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex gardneri*
Herb (field)	*Lappula occidentalis, Platyschkuhria integrifolia*
Herb (field)	*Pleuraphis jamesii*

Globally

Stratum	Species
Short shrub/sapling	*Atriplex gardneri*
Herb (field)	*Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum

Globally
Ceratocephala testiculata, Malcolmia africana, Sclerocactus whipplei

CONSERVATION STATUS RANK
Global Rank & Reasons: G3G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Sparse community occurring on Morrison Formation shale with some cover of large rocks. Rocks function to provide mulch on the soil surface, contributing to vegetation density.
Arches National Park Field Data: The description is based on 2003 and 2006 field data (2 plots: ARCH.0610, ARCH.0611, and 2 accuracy assessment points: ARCH_AA.0538, ARCH_AA.0550).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Driscoll et al. 1984, Ibrahim et al. 1972, Singh and West 1971, U.S. Bureau of Reclamation 1976, Utah Environmental and Agricultural Consultants 1973, West and Ibrahim 1968, Western Ecology Working Group n.d.

Atriplex gardneri Dwarf-shrubland
Gardner's Saltbush Dwarf-shrubland

CODE	CEGL001438
PHYSIOGNOMIC CLASS	Dwarf-shrubland (IV)
PHYSIOGNOMIC SUBCLASS	Evergreen dwarf-shrubland (IV.A.)
PHYSIOGNOMIC GROUP	Extremely xeromorphic evergreen dwarf-shrubland (IV.A.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural extremely xeromorphic evergreen dwarf-shrubland (IV.A.2.N.)
FORMATION	Facultatively deciduous subdesert dwarf-shrubland (IV.A.2.N.b.)
ALLIANCE	*ATRIPLEX GARDNERI* DWARF-SHRUBLAND ALLIANCE (A.1110) Gardner's Saltbush Dwarf-shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Mat Saltbush Shrubland (CES304.783)

Inter-Mountain Basins Shale Badland (CES304.789)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This dwarf-shrubland association is reported from northern and eastern Utah, western Colorado, Wyoming and Montana. Sites are flat to steep (58%). Soils are calcareous, alkaline, and typically saline and fine-textured. One site has a gravelly/cobbly substrate. Total vegetation cover is generally sparse, rarely exceeding 15%. The vegetation is composed solely of or dominated by *Atriplex gardneri* without an herbaceous layer. Associated shrubs may include minor cover of *Atriplex confertifolia, Atriplex corrugata, Chrysothamnus viscidiflorus, Ephedra torreyana, Eriogonum corymbosum, Gutierrezia sarothrae, Picrothamnus desertorum, Sarcobatus vermiculatus,* and/or *Tetradymia spinosa*. No herbaceous layer is reported, though scattered grasses such as *Achnatherum hymenoides, Pleuraphis jamesii,* and *Elymus elymoides* may be present. Invasive species such as *Bromus tectorum, Halogeton glomeratus,* and *Malcolmia africana* are present in some stands. Biological soil crusts may cover up to 50% of the ground surface. The dominance of *Atriplex gardneri* and the lack of a significant herbaceous layer are diagnostic of this association.

DISTRIBUTION

Arches National Park

This association is rare to uncommon and was sampled in the Salt Valley, along Wolfe Ranch Road, and at the park boundary in Cache Valley.

Globally

This dwarf-shrubland association is reported from northern and eastern Utah, western Colorado, Wyoming and Montana, but likely has a wider distribution in the interior West. *Atriplex gardneri* is common on shales that cover large areas of the Colorado Plateau, such as the Moenkopi, Mancos, Wasatch, and Morrison formations.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This sparse dwarf-shrub association occurs on the slopes of badland ridges and hills within the park. Sites are gentle to steep (up to 65% slopes) and occur between 1311 and 1415 m elevation. Aspect does not affect the distribution of this association. Bare ground or gravel comprise most of the unvegetated surface. Litter is typically sparse, providing less than 5% cover. Soils are rapidly drained clay loams and silty clays derived from Mancos Formation shales.

Globally

This dwarf-shrubland association is reported from northern and eastern Utah, western Colorado, Wyoming and Montana. Elevation ranges from 1196-2101 m. Climate is temperate and semi-arid. In Utah stands occur in Curlew Valley, a dry Pleistocene lakebed north of the Great Salt Lake, and alluvial fans and hillsides along the Green River and slopes of badland ridges and canyonsides, colluvial slopes, ridges, hills, badlands, mesas, and benches along the Colorado River. Sites are flat to steep (58%). Soils are calcareous, alkaline, and typically saline and fine-textured, often derived from alluvium or shale from Chinle, Moenkopi, Mancos, Morrison, and Wasatch formations. One site has a gravelly/cobbly substrate. Bare soil covers much of the unvegetated surface.

VEGETATION DESCRIPTION

Arches National Park

This sparse dwarf-shrub association is uncommon on badlands within the park. Total vegetation cover ranges from <1 to 20% but rarely exceeds 10%. The canopy consists of *Atriplex gardneri*, usually accompanied by *Atriplex confertifolia, Atriplex corrugata, Chrysothamnus viscidiflorus, Ephedra torreyana, Sarcobatus vermiculatus*, and/or *Tetradymia spinosa*. The herbaceous layer is absent or a minor component, consisting of scattered annual forbs and grasses such as a few stems of *Eriogonum inflatum* or small clumps of *Achnatherum hymenoides*. Many stands include the exotic species *Bromus tectorum* and *Halogeton glomeratus*.

Globally

This association is broadly defined as a dwarf-shrubland composed solely of or dominated by *Atriplex gardneri* without a herbaceous layer. Total vegetation cover is generally sparse, rarely exceeding 15%, and sometimes as low as 1% or as high as 35%. Associated shrubs may include scattered *Artemisia arbuscula ssp. longiloba, Artemisia*

tridentata ssp. wyomingensis, Atriplex confertifolia, Atriplex corrugata, Chrysothamnus viscidiflorus, Ephedra torreyana, Eriogonum corymbosum, Gutierrezia sarothrae, Krascheninnikovia lanata, Picrothamnus desertorum, Sarcobatus vermiculatus, and/or *Tetradymia spinosa*. No herbaceous layer is reported, though scattered clumps of grass such as *Achnatherum hymenoides, Pleuraphis jamesii,* and *Elymus elymoides* or occasional *Eriogonum inflatum* may be present. Invasive species such as *Agropyron cristatum, Bromus tectorum, Ceratocephala testiculata, Halogeton glomeratus,* and *Malcolmia africana* are present in some stands. Biological soil crusts may cover up to 50% of the ground surface; those stands that are protected from grazing are advanced in development and include *Collema* sp., *Fulgensia* sp., *Psora* sp., mosses, and dark cyanobacteria. The dominance of *Atriplex gardneri* and the lack of a significant herbaceous layer are diagnostic of this association.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex corrugata, Atriplex gardneri, Eriogonum bicolor*
Herb (field)	*Eriogonum inflatum*

Globally

Stratum	Species
Short shrub/sapling	*Atriplex gardneri*

OTHER NOTEWORTHY SPECIES

Arches National Park
Bromus tectorum, Halogeton glomeratus, Malcolmia africana

Globally
Agropyron cristatum, Bromus tectorum, Ceratocephala testiculata, Halogeton glomeratus, Malcolmia africana

CONSERVATION STATUS RANK

Global Rank & Reasons: G3G5 (23-Feb-1994).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
This association is poorly defined and is only referred to as a "pure, evidently stable stand of saltsage" in Mitchell et al. (1966). Mitchell et al. (1966) investigated the relatively sharp boundaries between the *Atriplex gardneri* and the *Krascheninnikovia lanata* communities at their study site; no edaphic factor was identified to explain the abrupt change. This association is separated from other *Atriplex gardneri*-dominated associations by the lack of codominant shrubs or significant herbaceous layer. It includes both sparse stands growing on harsh, windswept sites and/or strong saline/alkaline substrates, and occasional moderately dense to dense saltbush stands that lack an herbaceous layer because of disturbance. Some stands may be a seral community in areas with a history of over-grazing by livestock. More classification work is needed to further define this association.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Arches National Park Inventory Notes: The community is limited to barren adobe slopes of Mancos Formation shale, particularly the lowest, dark brown layer. Soils have physical crusts. Some sites are gullying, and sites can be rock-strewn.
Arches National Park Field Data: The description is based on 2003 field data (8 plots: ARCH.0101, ARCH.0104, ARCH.0105, ARCH.0110, ARCH.0310, ARCH.0325, ARCH.0676, ARCH.0677).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: Bourgeron and Engelking 1994, Branson et al. 1976, Driscoll et al. 1984, Gates et al. 1956, Johnston 1987, MTNHP 2002b, MTNHP unpubl. data, Mitchell et al. 1966, Von Loh 2000

Achnatherum hymenoides Colorado Plateau Herbaceous Vegetation
Indian Ricegrass Colorado Plateau Herbaceous Vegetation

CODE	CEGL002343
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N.)
FORMATION	Medium-tall bunch temperate or subpolar grassland (V.A.5.N.d.)
ALLIANCE	*ACHNATHERUM HYMENOIDES* HERBACEOUS ALLIANCE (A.1262) Indian Ricegrass Herbaceous Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Semi-Desert Grassland (CES304.787)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This herbaceous vegetation association usually occurs in small patches (<1 hectare) on upland eolian sand deposits, as well as on sandy alluvial terraces and point bars along intermittent washes in eastern Utah and northwestern Colorado. It is likely to occur in small patches throughout the Colorado Plateau. Disturbance is usually a factor; upland sites often have blowing sand, and wash sites are subject to periodic flooding. Sites are flat to gently sloping (not exceeding 10%) between 1220 and 1815 m elevation. The unvegetated surface has high cover by bare soil or sand, low cover by litter, and biological soil crusts may have up to 30% cover. Soils are rapidly drained sands or sandy loams derived from alluvium or eolian deposits. Total vegetation cover in upland sites with blowing sand is usually quite sparse, rarely exceeding 10%. Sites on sandy terraces and point bars may have up to 30% cover by vascular plants, with another 25% cover provided by biological soil crusts. *Achnatherum hymenoides* is the dominant species, ranging in cover between 3 and 15%. A scattering of shrubs may be present, with no species exceeding 1% cover and the total not exceeding 5% cover. Associated shrubs include *Amsonia tomentosa, Artemisia filifolia, Atriplex canescens, Ephedra torreyana, Ephedra viridis, Poliomintha incana, Vanclevea stylosa, Gutierrezia sarothrae,* and *Opuntia polyacantha*. Some stands may contain scattered *Juniperus osteosperma* trees or saplings. Associated graminoids include the short bunch grasses *Aristida purpurea, Sporobolus cryptandrus,* and *Pleuraphis jamesii*. Forbs present include *Abronia fragrans* and *Sphaeralcea parvifolia*.

DISTRIBUTION

Arches National Park

This association is rare in the park and was sampled on the valley floor in Upper Courthouse Wash, west of the point where the main park road crosses the wash. It was also reported from Eagle Park and Salt Valley.

Globally

This association is documented from eastern Utah and northwestern Colorado. It is likely to occur in small stands, 0.1 to 1 ha in size, scattered throughout the Colorado Plateau.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This herbaceous vegetation association occurs on sandy higher terraces in the larger canyons. The one sampled site is flat and lies at 1271 m elevation. Bare soil covers most of the unvegetated surface and litter has low cover. The basal area of live plants provides sparse cover. Soils are rapidly drained sandy loams derived from alluvium or eolian sands.

Globally

This herbaceous vegetation association occurs on upland eolian sand deposits, as well as on sandy alluvial terraces and point bars along intermittent washes in eastern Utah and northwestern Colorado. It is likely to occur in small patches throughout the Colorado Plateau. Sites are flat to gently sloping (not exceeding 10%) between 1220 and 1815 m elevation. The unvegetated surface has high cover by bare soil or sand, low cover by litter, and biological soil crusts may have up to 30% cover. Soils are rapidly drained sands or sandy loams derived from alluvium or eolian deposits.

VEGETATION DESCRIPTION

Arches National Park
This rare sparse grassland type occurs only in small patches on terraces and point bars within the park's larger drainages. Total vegetation cover ranges from 7 to 25%. The vegetation is dominated by the tall bunchgrass *Achnatherum hymenoides* that ranges between 5 and 15% cover. The shrub layer is relatively diverse but is too sparse to constitute a layer, and no species has more than 1% cover. Associated shrubs include *Artemisia filifolia, Poliomintha incana, Vanclevea stylosa, Gutierrezia sarothrae*, and *Opuntia polyacantha*. The herbaceous layer provides sparse to low cover; common species include *Aristida purpurea, Pleuraphis jamesii, Mentzelia multiflora*, and *Sphaeralcea parvifolia*.

Globally
Small patches (usually less than 1 hectare) of this distinctive grassland type occur sporadically in the Colorado Plateau of southeastern Utah. Total vegetation cover in upland sites with blowing sand is usually quite sparse, rarely exceeding 10%. Sites on sandy terraces and point bars may have up to 30% cover by vascular plants, with another 25% cover provided by biological soil crusts. *Achnatherum hymenoides* is the dominant species, ranging in cover between 3 and 15%. A scattering of shrubs may be present, with no species exceeding 1% cover and the total not exceeding 5% cover. Associated shrubs include *Amsonia tomentosa, Artemisia filifolia, Atriplex canescens, Ephedra torreyana, Ephedra viridis, Gutierrezia sarothrae, Opuntia polyacantha, Poliomintha incana*, and *Vanclevea stylosa*. Some stands may contain scattered *Juniperus osteosperma* trees or saplings. Associated graminoids include the short bunch grasses *Aristida purpurea, Sporobolus cryptandrus*, and *Pleuraphis jamesii*. Forbs present include *Abronia fragrans* and *Sphaeralcea parvifolia*.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Herb (field)	*Achnatherum hymenoides, Aristida purpurea, Pleuraphis jamesii*

Globally

Stratum	Species
Herb (field)	*Achnatherum hymenoides*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Salsola tragus

Globally
Bromus tectorum, Salsola tragus

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (16-Mar-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: The plot was in a grassland stand with a diversity of shrubs with low cover. Some shrubs are showing drought stress. There are scattered Utah juniper trees.
Arches National Park Field Data: The description is based on 2003 and 2006 field data (1 plot*:* ARCH.0377, 1 observation point: ARCH.9646, and 4 accuracy assessment points: ARCH_AA.0039, ARCH_AA.0190, ARCH_AA.0050).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles

REFERENCES: Western Ecology Working Group n.d.

Hesperostipa comata Great Basin Herbaceous Vegetation
Needle-and-Thread Great Basin Herbaceous Vegetation

CODE	CEGL001705
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N.)
FORMATION	Medium-tall bunch temperate or subpolar grassland (V.A.5.N.d.)
ALLIANCE	*HESPEROSTIPA COMATA* BUNCH HERBACEOUS ALLIANCE (A.1270) Needle-and-Thread Bunch Herbaceous Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Semi-Desert Grassland (CES304.787)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This semi-arid grassland occurs on the Great Basin and Colorado Plateau east into the western slope of the southern Rocky Mountains. Stands are found on a variety of sites, such as on point bars, stream terraces, in sand-filled potholes in slickrock washes, on plains, valleys, canyon floors, gentle hillslopes, knolls and bluffs, mesatops, and plateau parks. Sites are generally flat to gently sloping, but occasionally are steep (to 53% slope). Soils are variable and range from sand to silty clay. The unvegetated surface has moderate to high cover of bare soil with sparse to moderate cover of litter. Biological soil crusts are often present with low cover. The vegetation is characterized by a relatively sparse to moderate herbaceous layer (10-40% cover) that is strongly dominated by the medium-tall, cool-season bunchgrass *Hesperostipa comata*, but it may also include stands with less than 10% total vegetation cover. Low cover of other grasses, such as *Achnatherum hymenoides, Achnatherum lettermanii, Aristida purpurea, Elymus elymoides, Koeleria macrantha, Leymus salinus, Pleuraphis jamesii, Poa fendleriana*, or *Sporobolus cryptandrus*, may be present. However, *Bouteloua eriopoda* is not present. Forb cover ranges from sparse to moderate and may be diverse. Associated forbs include *Balsamorhiza sagittata, Hymenopappus filifolius, Machaeranthera canescens, Sphaeralcea coccinea, Vicia americana*, and species of *Antennaria, Astragalus, Cryptantha, Eriogonum, Gilia*, and *Lappula*. Scattered shrubs and dwarf-shrubs may present with less than 5% total cover. Common species include *Artemisia tridentata, Chrysothamnus viscidiflorus, Ericameria nauseosa, Gutierrezia sarothrae, Krascheninnikovia lanata, Opuntia polyacantha*, and *Symphoricarpos oreophilus*. The widespread introduced annual grass *Bromus tectorum* often contributes significant cover in disturbed stands. Some stands have high cover of biological soil crusts.

DISTRIBUTION

Arches National Park

This association was sampled in Salt Wash Canyon and in Herdina Park.

Globally

This grassland is found on the west slope of the Colorado Rocky Mountains, Colorado Plateau and Great Basin in Colorado and Utah, and probably occurs in adjacent states.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This herbaceous association occurs on point bars, stream terraces and in sand-filled potholes in slickrock washes. Stands are on gentle slopes (up to 11%) between 1277 and 1470 m elevation. Bare ground and litter cover most of the unvegetated surface, and biological soil crusts provide low cover. Soils are rapidly drained sandy loams and loamy sands derived from eolian or alluvial deposits.

Globally

This grassland occurs on the Great Basin and Colorado Plateau east into the western slope of the southern Rocky Mountains. Stands are found a variety of sites, such as on point bars, stream terraces, in sand-filled potholes in slickrock washes, on plains, valleys, canyon floors, gentle hillslopes, knolls and bluffs, mesatops, and plateau parks. Sites are generally flat to gently sloping, but occasionally are steep (to 53% slope). Elevation ranges from

1250-2320 m. The unvegetated surface has moderate to high cover of bare soil with sparse to moderate cover of litter. Biological soil crusts are often present with low cover. Soils are variable and include sand, cobbles, sandy, silt and clay loams and silty clay. Common parent materials are sandstones and shale that have been eroded and redistributed in alluvial and eolian deposits, but include Tertiary volcanic rocks. Fires may be important in maintaining these grasslands by reducing woody cover, but burning during the growing season could also damage *Hesperostipa comata* plants.

VEGETATION DESCRIPTION

Arches National Park

This herbaceous association is rare within the park, occurring in small patches less than 0.5 ha in size. Total vegetation cover ranges from 6 to 45%. The herbaceous layer is dominated by the tall bunchgrass *Hesperostipa comata*, usually accompanied by lesser amounts of *Aristida purpurea, Achnatherum hymenoides*, and *Vulpia octoflora*. Forbs include *Astragalus* sp., *Cryptantha crassisepala*, and *Sphaeralcea coccinea*. Scattered shrubs may be present, including *Purshia stansburiana, Gutierrezia sarothrae*, and *Amsonia tomentosa*. Biological soil crusts provide up to 30% cover in stands with little disturbance.

Globally

This association is characterized by a relatively sparse to moderate herbaceous layer (10-40% cover) that is strongly dominated by the medium-tall, cool-season bunchgrass *Hesperostipa comata,* but it may also include stands with less than 10% total vegetation cover. Low cover of other grasses, such as *Achnatherum hymenoides, Achnatherum lettermanii, Aristida purpurea, Elymus elymoides, Koeleria macrantha, Leymus salinus, Pleuraphis jamesii, Poa fendleriana, Poa secunda,* or *Sporobolus cryptandrus*, may be present. However, *Bouteloua eriopoda* is not present. Forb cover ranges from sparse to moderate and may be diverse. Associated species include *Artemisia campestris, Artemisia dracunculus, Artemisia ludoviciana, Balsamorhiza sagittata, Cirsium arizonicum, Cryptantha crassisepala, Hymenopappus filifolius, Machaeranthera canescens, Sphaeralcea coccinea, Vicia americana*, and species of *Antennaria, Astragalus, Eriogonum, Gilia*, and *Lappula*. Scattered shrubs and dwarf-shrubs may present with less than 5% total cover. *Artemisia tridentata ssp. tridentata, Artemisia tridentata ssp. vaseyana, Chrysothamnus depressus, Chrysothamnus viscidiflorus, Ericameria nauseosa, Gutierrezia sarothrae, Krascheninnikovia lanata, Opuntia polyacantha, Purshia tridentata, Ribes cereum*, and *Symphoricarpos oreophilus* have been reported from this grassland. The widespread introduced annual grass *Bromus tectorum* often contributes significant cover in disturbed stands. Several other exotic species may be present to abundant and include *Salsola tragus, Bassia scoparia, Poa pratensis, Sisymbrium altissimum*, and *Tragopogon dubius*. Some stands have high cover of cryptogams on the soil, including *Collema tenax, Tortula ruralis, Buellia papillata,* and *Fulgensia bracteata* (Kleiner and Harper 1977).

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Tall shrub/sapling	*Purshia stansburiana*
Herb (field)	*Amsonia tomentosa, Gutierrezia sarothrae*
Herb (field)	*Bouteloua gracilis, Hesperostipa comata, Muhlenbergia pungens*

Globally

Stratum	Species
Herb (field)	*Hesperostipa comata*

OTHER NOTEWORTHY SPECIES

Arches National Park

Bromus tectorum

Globally

Arabis crandallii, Astragalus anisus, Bassia scoparia, Bromus tectorum, Cirsium arizonicum, Poa pratensis, Salsola tragus, Sisymbrium altissimum, Tragopogon dubius

CONSERVATION STATUS RANK

Global Rank & Reasons: G2G4 (23-Feb-1994).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
This association is composed of relatively pure *Hesperostipa comata* grasslands in the Intermountain West. The similar associations are distinguished by the codominance by other grass species or a shrub layer.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Stands occupy sandy substrates in potholes and on terraces in the larger drainages and are present as small patches of vegetation. Some stands have well-developed biological soil crusts.
Arches National Park Field Data: The description is based on 2003 field data (2 plots: ARCH.0123, ARCH.0688 and 1 observation point: ARCH.9006).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Cogan et al. 2004, Coles pers. comm., Daubenmire 1970, Driscoll et al. 1984, FEIS 1998, Kleiner 1968, Kleiner 1983, Kleiner and Harper 1977, Thilenius et al. 1995, Western Ecology Working Group n.d.

Sporobolus airoides Southern Plains Herbaceous Vegetation
Alkali Sacaton Southern Plains Herbaceous Vegetation

CODE	CEGL001685
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N.)
FORMATION	Medium-tall bunch temperate or subpolar grassland (V.A.5.N.d.)
ALLIANCE	*SPOROBOLUS AIROIDES* HERBACEOUS ALLIANCE (A.1267) Alkali Sacaton Herbaceous Alliance
ECOLOGICAL SYSTEM(S):	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland (CES302.746) Inter-Mountain Basins Greasewood Flat (CES304.780) Western Great Plains Floodplain (CES303.678) Western Great Plains Saline Depression Wetland (CES303.669) Western Great Plains Shortgrass Prairie (CES303.672) Inter-Mountain Basins Wash (CES304.781) Inter-Mountain Basins Semi-Desert Grassland (CES304.787)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This alkali sacaton mesic grassland community is found in the southwestern Great Plains, on the Colorado Plateau, in the southwestern United States, and adjacent Mexico. Stands occur on slightly to moderately saline, nearly level bottomlands and terraces. Additional moisture from washes and sheetflow runoff are important for most stands. Substrates are shallow, moderately well- to poorly drained, silty clay soils formed in alluvium. The community is dominated by medium-tall and short grasses. *Sporobolus airoides* is a dominant, often accompanied by *Symphyotrichum subulatum, Pascopyrum smithii, Buchloe dactyloides, Distichlis spicata, Hordeum jubatum,* and *Bouteloua gracilis*. Scattered shrubs, such as *Atriplex* spp. or *Sarcobatus vermiculatus*, may be present. Forb cover is also minor.

DISTRIBUTION
Arches National Park
This association was sampled on the floor of Cache Valley. It occurs in scattered small patches on the floors of many drainages within the park.

Globally
This alkali sacaton mesic grassland community is found in the southwestern Great Plains, Colorado Plateau and elsewhere in the southwestern United States and Mexico, ranging from Kansas and Colorado south to Texas, New Mexico and west to Arizona, Utah, and possibly California.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This herbaceous association occurs on alkaline valley floors in Cache Valley. The sampled site is gentle (3% slope) and lies at 1323 m elevation. Most of the unvegetated surface consists of bare ground, although biological soil crusts provide up to 20% cover. Soils are rapidly drained loamy sand derived from alluvium.

Globally
This grassland community occurs on alluvial toeslopes and flats, terraces, floodplain depressions, and sandy streambanks and washes in bottomlands throughout the southern Great Plains and Colorado Plateau. Additional moisture from washes and sheetflow runoff are important for most stands. Elevations range from below 1000 m (3050 feet) to over 2000 m (6100 feet). Sites are typically flat to gently sloping but may be as steep as 30% slope. Soils are shallow to moderately deep, moderately well- to poorly drained, alkaline, and often saline with sandy, silty or clay soils (Francis 1986, Johnston 1987, Kittel et al. 1999a, Lauver et al. 1999, Von Loh et al. 2002). Other parent materials include lavaflow, cinders, relict Pleistocene river cobbles, and sandstone.

VEGETATION DESCRIPTION
Arches National Park
This sparse grassland is rare in the park and was sampled on alluvium in Cache Valley. Total vegetation cover does not exceed 25%. The vegetation is dominated by *Sporobolus airoides* with up to 15% cover, often accompanied by *Pleuraphis jamesii*. *Delphinium nuttallianum* was the only forb species recorded. The short shrub *Atriplex confertifolia* provides sparse cover.

Globally
This association is characterized by a sparse to moderately dense (15-75% cover), medium-tall graminoid layer dominated by *Sporobolus airoides*. Associated species include *Achnatherum hymenoides, Symphyotrichum subulatum, Buchloe dactyloides, Distichlis spicata, Hordeum jubatum, Bouteloua gracilis, Panicum obtusum, Pleuraphis jamesii, Sphaeralcea* spp., *Sporobolus cryptandrus,* and *Pascopyrum smithii* (Francis 1986, Johnston 1987, Kittel et al. 1999a, Lauver et al. 1999, Von Loh et al. 2002). Scattered shrubs may be present, such as *Atriplex canescens, Atriplex confertifolia, Ephedra* spp., *Ericameria nauseosa, Gutierrezia sarothrae,* or *Sarcobatus vermiculatus*. Total shrub cover is low (<10%), and forb cover is minor.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia*
Herb (field)	*Pleuraphis jamesii, Sporobolus airoides*

Globally

Stratum	Species
Herb (field)	*Sporobolus airoides*

OTHER NOTEWORTHY SPECIES
Arches National Park
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G3Q (9-Apr-1998). The number of occurrences is unknown. The community is reported from Arizona, Colorado (S3), Kansas, New Mexico (S2), Texas, Utah, and Mexico and may occur in California. The community is found on slightly to moderately saline, nearly level bottomland and terraces with alluvial silty clay soils.

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Compare this association with *Sporobolus airoides - Bouteloua gracilis* Herbaceous Vegetation (CEGL001686) and *Pleuraphis jamesii - Sporobolus airoides* Herbaceous Vegetation (CEGL001778). Stands in Montana are placed with *Sporobolus airoides* Northern Plains Herbaceous Vegetation (CEGL002274), ot the northwestern Great Plains, and this type is restricted to the southwestern Great Plains and southwestern United States. In the southeastern Plains see *Distichlis spicata - (Hordeum jubatum, Poa arida, Sporobolus airoides)* Herbaceous Vegetation (CEGL002042).

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Arches National Park Inventory Notes: Occurs in large patches over much of the floor of the northern part of Cache Valley on alluvium; may occur in smaller patches elsewhere on valley floors or stream terraces. This stand has moderately to well-developed biological soil crusts.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0097).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Drake, mod. K. Schulz and J. Coles

REFERENCES: Aldous and Shantz 1924, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Carsey et al. 2003a, Donnelly et al. 2006, Driscoll et al. 1984, Francis 1986, Hansen et al. 2004b, Johnston 1987, Kittel and Lederer 1993, Kittel et al. 1999b, Lauver et al. 1999, Lindauer 1970, Soil Conservation Service 1978, Steward 1982, Von Loh et al. 2002, Western Ecology Working Group n.d.

Sporobolus cryptandrus Great Basin Herbaceous Vegetation
Sand Dropseed Great Basin Herbaceous Vegetation

CODE	CEGL002691
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N.)
FORMATION	Medium-tall bunch temperate or subpolar grassland (V.A.5.N.d.)
ALLIANCE	*SPOROBOLUS CRYPTANDRUS* HERBACEOUS ALLIANCE (A.1252) Sand Dropseed Herbaceous Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Semi-Desert Grassland (CES304.787)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This plant association is described from the Uinta Basin and Colorado Plateau where it occurs on alluvial terraces of major rivers, sandy upper stream terraces along intermittent washes, and on sand deposits on mesas and plains. Elevation ranges from 1226 to 1630 m. Soils are loamy sands and sandy loams derived from alluvium, eolian deposits or sandstone residuum. Sites have generally been disturbed by flooding, shifting sands, livestock grazing, or human recreation. The vegetation is dominated by the warm-season perennial graminoid *Sporobolus cryptandrus*. *Hesperostipa comata, Pleuraphis jamesii, Sporobolus contractus, Sporobolus giganteus,* or *Equisetum variegatum* frequently occur in low abundance. Low cover of native forbs such as *Sphaeralcea grossulariifolia* or *Chamaesyce fendleri* may be present. The introduced annual grass *Bromus tectorum* and several other exotic species such as *Bromus rigidus, Salsola kali, Helianthus annuus, Sisymbrium altissimum,* or *Tribulus terrestris* may be present to abundant, especially in disturbed stands. Occasional *Brickellia* spp. or other shrubs may occur, but they are not dense enough to form a shrub layer.

DISTRIBUTION
Arches National Park
This association was sampled on stream terraces in Courthouse Wash within the park.

Globally
The association is found on terraces of large rivers in the Colorado Plateau and Uinta Basin and likely occurs elsewhere in the southwestern U.S.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This herbaceous association occurs on sandy upper stream terraces in Courthouse Wash. The one sampled site is flat and occurs at 1226 m elevation. The unvegetated surface has high cover by bare soil and low cover of litter. Biological soil crusts are generally present and provide up to 30% cover. Soils are poorly developed, rapidly drained loamy sands derived from alluvium.

Globally
This grassland is described from the Uinta Basin and Colorado Plateau where it occurs on alluvial terraces of large rivers, sandy upper stream terraces along intermittent washes, and on sand deposits on mesas and plains. Elevation ranges from 1226-1630 m. Sites are flat to gently sloping valley bottoms, plains or plateaus. Soils are loamy sands and sandy loams derived from alluvium, eolian deposits or sandstone residuum. Biological soil crusts are generally present and may provide up to 30% cover. Stands have generally been disturbed by flooding, shifting sands, livestock grazing, or human recreation.

VEGETATION DESCRIPTION
Arches National Park
This sparse bunchgrass association is rare in the park and was sampled on high terraces in Courthouse Wash. Total vegetation cover does not exceed 25%. The vegetation is dominated by *Sporobolus cryptandrus* with up to 15% cover. Other grass species present may include *Sporobolus contractus, Sporobolus giganteus*, and the annual *Vulpia octoflora*. Forbs include *Abronia fragrans, Plantago patagonica*, and *Sphaeralcea parvifolia*.

Globally
This plant association is found on alluvial terraces of large rivers and on sand deposits on mesas and plains. The sparse to moderately dense (10-30% cover) herbaceous layer is characterized by the dominance of the warm-season perennial graminoid *Sporobolus cryptandrus*. *Hesperostipa comata, Pleuraphis jamesii, Sporobolus contractus, Sporobolus giganteus*, or *Equisetum variegatum* may occur in low abundance. Low cover of native forbs, such as *Abronia fragrans, Chamaesyce fendleri, Plantago patagonica, Sphaeralcea grossulariifolia, Sphaeralcea parvifolia*, or the succulent *Opuntia polyacantha* may be present. The widespread introduced annual grass Bromus tectorum and several other exotic species such as *Bromus rigidus, Salsola kali, Helianthus annuus, Sisymbrium altissimum*, or *Tribulus terrestris* may be present to abundant, especially on disturbed riparian stands. An occasional *Brickellia* spp or other shrubs may occur, but they are not dense enough to form a shrub layer. Moss is important in some stands.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Opuntia polyacantha*
Herb (field)	*Sporobolus contractus*, *Sporobolus cryptandrus*

Globally

Stratum	Species
Herb (field)	*Sporobolus cryptandrus*

OTHER NOTEWORTHY SPECIES
Arches National Park
Data are not available.

Globally
Bromus rigidus, Bromus tectorum, Helianthus annuus, Salsola kali, Sisymbrium altissimum, Tribulus terrestris

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (26-Jul-2001).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
The association is broadly defined to include *Sporobolus cryptandrus*-dominated stands from both riparian and sandy upland sites. This plant association is similar to the threatened, regionally endemic *Sporobolus cryptandrus* plant associations from the Columbia Basin and lower Snake River that have declined significantly due to loss of habitat from hydroelectric dam construction and conversion of land to cultivation. Many of the riparian stands in these associations are in poor condition because of past management and invasion of introduced species.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Arches National Park Inventory Notes: Occurs on terraces or pointbars in larger drainages like Courthouse Wash. Scattered cottonwood and Russian-olive trees are present.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0383).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz

REFERENCES: Cogan et al. 2004, Cowardin et al. 1979, USFS 1937, Von Loh et al. 2002

Pleuraphis jamesii - Sporobolus airoides Herbaceous Vegetation
James' Galleta - Alkali Sacaton Herbaceous Vegetation

CODE	CEGL001778
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N.)
FORMATION	Short sod temperate or subpolar grassland (V.A.5.N.e.)
ALLIANCE	*PLEURAPHIS JAMESII* HERBACEOUS ALLIANCE (A.1287) James' Galleta Herbaceous Alliance
ECOLOGICAL SYSTEM(S):	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland (CES302.746) Inter-Mountain Basins Greasewood Flat (CES304.780) Inter-Mountain Basins Semi-Desert Grassland (CES304.787) Apacherian-Chihuahuan Semi-Desert Grassland and Steppe (CES302.735)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This once-extensive grassland of the northern Chihuahuan Desert, Colorado Plateau and Great Basin has been described in New Mexico from White Sands Missile Range and the upper Rio Puerco watershed, as well as in north-central Arizona and southeastern Utah. It has, however, experienced significant declines throughout its range. It primarily occurs in swales within open valley bottoms and alluvial flats, although sandsheets and dunes also can support the association. Sites are on level to gentle slopes (<15%) at elevations between 1300-2075 m (4260-6800 feet). Soils are generally deep, with surface textures ranging from loamy sands, fine loams to silty clay loams and clays, derived from substrates that include lava flows, cinders, eolian sands, alluvium and relict Pleistocene river cobbles. The vegetation is characterized by a sparse to moderately dense perennial herbaceous layer that is dominated by *Pleuraphis jamesii* with *Sporobolus airoides* as a subdominant. Total vegetation cover in grazed sites generally does not exceed 20% but may be as high as 50% in protected areas. Occasionally, *Sporobolus airoides* may be codominant or dominant over *Pleuraphis jamesii*. This association usually has a sparse but diverse shrub layer that may include scattered *Atriplex canescens, Atriplex confertifolia, Atriplex obovata, Coleogyne ramosissima, Ephedra torreyana, Ericameria nauseosa, Gutierrezia sarothrae, Krascheninnikovia lanata, Opuntia imbricata, Opuntia macrorhiza, Opuntia phaeacantha, Sarcobatus vermiculatus,* and *Yucca angustissima*. The key graminoid species dominate the herbaceous layer and account for more than 80% of the total plant cover. Associated

herbaceous species, such as *Achnatherum hymenoides, Bouteloua gracilis, Muhlenbergia porteri, Muhlenbergia pungens, Muhlenbergia torreyi, Pascopyrum smithii, Scleropogon brevifolius, Sphaeralcea coccinea,* and *Sporobolus cryptandrus,* may be present with low cover. Biological soil crusts may be extensive in undisturbed examples of this association.

DISTRIBUTION

Arches National Park

This association was sampled in Cordova Canyon inside the park and along Yellow Bird Mine Road in the environs.

Globally

This once-extensive grassland of the northern Chihuahuan Desert, Colorado Plateau and Great Basin is reported in New Mexico from White Sands Missile Range and the upper Rio Puerco watershed. More recently, it has been documented in north-central Arizona and southeastern Utah. It has experienced significant declines throughout its range.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This association occurs on sandy valley floors. Sites are flat to gently sloping (not exceeding 3%) and occur between 1384 and 1433 m elevation. Most of the unvegetated surface consists of bare soil. Biological soil crusts can have up to 48% cover. Soils are rapidly drained and texturally are sandy loams derived from eolian deposits or sand.

Globally

This grassland association is described in New Mexico from White Sands Missile Range and the upper Rio Puerco watershed, as well as in north-central Arizona and southeastern Utah. It primarily occurs in swales within open valley bottoms and alluvial flats, although sandsheets and dunes also can support the association. Sites are on level to gentle slopes (<15%) at elevations between 1300-2075 m (4260-6800 feet). Soils are generally deep, with surface textures ranging from loamy sands, fine loams to silty clay loams and clays, derived from substrates that include lava flows, cinders, eolian sands, alluvium and relict Pleistocene river cobbles.

VEGETATION DESCRIPTION

Arches National Park

This grassland association is rare to uncommon within the park, most stands having been eliminated by grazing. Total vegetation cover ranges from 7 to 55%. The vegetation is characterized by patchy clumps of *Pleuraphis jamesii* and *Sporobolus airoides* bunch grasses that range in cover up to 40%. Either species may be dominant, but both are always present. The remaining herbaceous layer is high in terms of species diversity but provides sparse cover. Commonly associated forbs include *Chaenactis stevioides, Cryptantha* sp., *Cymopterus newberryi, Ipomopsis gunnisonii, Lappula occidentalis,* and *Plantago patagonica*. Scattered shrubs may be present but do not form a stratum; most are strays from adjacent shrub communities. Common shrub species include *Coleogyne ramosissima, Ephedra torreyana, Opuntia polyacantha,* and *Sarcobatus vermiculatus*.

Globally

This association is characterized by a sparse to moderately dense perennial herbaceous layer that is codominated by *Pleuraphis jamesii* and *Sporobolus airoides*. Total vegetation cover generally does not exceed 20% in grazed sites but may be as high as 75% in protected areas. Occasionally, *Sporobolus airoides* may be codominant or dominant over *Pleuraphis jamesii*. This association usually has a sparse but diverse shrub layer that may include scattered *Atriplex canescens, Atriplex confertifolia, Atriplex obovata, Coleogyne ramosissima, Ephedra torreyana, Ericameria nauseosa, Gutierrezia sarothrae, Krascheninnikovia lanata, Opuntia imbricata, Opuntia macrorhiza, Opuntia phaeacantha, Opuntia polyacantha, Sarcobatus vermiculatus,* and *Yucca angustissima*. The key graminoid species dominate the herbaceous layer and typically account for more than 80% of the total plant cover. Associated herbaceous species, such as *Achnatherum hymenoides, Chaenactis stevioides, Cryptantha* sp., *Cymopterus newberryi, Bouteloua gracilis, Ipomopsis gunnisonii, Lappula occidentalis, Muhlenbergia porteri, Muhlenbergia pungens, Muhlenbergia torreyi, Pascopyrum smithii, Plantago patagonica, Scleropogon brevifolius, Sphaeralcea coccinea,* and *Sporobolus cryptandrus,* may be present with low cover (Francis 1986, Muldavin et al. 2000b). Biological soil crusts may be extensive in undisturbed examples of this association.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Coleogyne ramosissima, Ephedra torreyana, Sarcobatus vermiculatus*
Herb (field)	*Pleuraphis jamesii, Sporobolus airoides*

Globally

Stratum	Species
Herb (field)	*Pleuraphis jamesii, Sporobolus airoides*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Descurainia pinnata, Salsola tragus

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G2G3 (14-Nov-2005). This once-extensive grassland of the Great Basin and Chihuahuan Desert ecoregions has been described in New Mexico from the Upper Rio Puerco watershed and White Sands Missile Range, as well as isolated areas in north-central Arizona and southeastern Utah. It has experienced significant declines throughout its range. Remaining examples that have not been negatively impacted by grazing and/or invaded by shrubs are rare. However, this grassland is probably more widespread than is documented and hence the rank of G2G3.

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
In the classification of the plant communities of the upper Rio Puerco watershed, Francis (1986) described two plant communities codominated by *Pleuraphis jamesii - Sporobolus airoides* that were separated by the relative dominance of the key species. Both plant communities were combined into this association. *Sporobolus airoides* is larger and often more abundant than *Pleuraphis jamesii* which suggests that this association should be moved to the *Sporobolus airoides* Herbaceous Alliance (A.1267).

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Sites are on nearly flat valley bottoms. Grazing is heavy on one site.
Arches National Park Field Data: The description is based on 2003 field data (2 plots: ARCH.0032, ARCH.0069).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: Y. Chauvin, mod. K.A. Schulz and J. Coles

REFERENCES: Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Driscoll et al. 1984, Francis 1986, Hansen et al. 2004b, Muldavin et al. 1998b, Muldavin et al. 2000b, West et al. 1972

Pleuraphis jamesii Herbaceous Vegetation
James' Galleta Herbaceous Vegetation

CODE	CEGL001777
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N.)
FORMATION	Short sod temperate or subpolar grassland (V.A.5.N.e.)
ALLIANCE	*PLEURAPHIS JAMESII* HERBACEOUS ALLIANCE (A.1287) James' Galleta Herbaceous Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Semi-Desert Grassland (CES304.787)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This widespread grassland association is found on alluvial flats, plateau parks, mesas and plains in the Colorado Plateau and elsewhere in the southwestern U.S. Landforms vary from mesatops and slopes to basin floors. Stands may be small woodland parks or more extensive grasslands on the plains. Soils in bottomland stands tend to be fine-textured; however, stands also occur on a variety of substrates. Vegetation is characterized by a relatively sparse to moderately dense (10-60% cover) perennial herbaceous layer that is strongly dominated by the warm-season bunchgrass *Pleuraphis jamesii*. Low cover of other grasses, such as *Achnatherum hymenoides, Bouteloua eriopoda, Bouteloua gracilis, Hesperostipa comata, Muhlenbergia porteri, Sporobolus airoides*, or *Sporobolus cryptandrus*, may be present. Forb cover is usually sparse and includes species of *Plantago, Gilia, Lappula*, and prickly pear cacti (*Opuntia* spp.). Many species of shrubs and dwarf-shrubs may be present; however, they are not dense enough to form a shrub layer. Some stands have high cover of cryptogams on the soil surface.

DISTRIBUTION

Arches National Park

This association was sampled near Klondike Bluffs, along Yellow Bird Mine Road, in the Salt Valley, in Little Valley South, near Mollie Hogans, and near the Big Bend on the Colorado River.

Globally

This widespread grassland association is found on alluvial flats, plateau parks and plains in the Colorado Plateau and elsewhere in the southwestern U.S.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This herbaceous association occurs on toeslopes, valley floors, benches, hillsides, washes, and colluvial slopes. Sites are flat to moderately steep (up to 53% slope), occur between 1265 and 1512 m elevation and may be oriented to any aspect. Most of the unvegetated surface is bare soil, with low cover of litter. Some sites have moderate cover by gravel. Soils are rapidly drained clay loams, sandy loams, silty clays, loamy sands, and silt loams derived from Tidwell and Salt Wash members of the Morrison Formation and limestones of the Honaker Trail Formation.

Globally

This widespread grassland association is found on a variety of sites, including alluvial flats, toeslopes, valley floors, benches, hillsides, washes, colluvial slopes, plateau parks, mesas and plains in the Colorado Plateau and elsewhere in the southwestern U.S. Elevation ranges from 1220-1930 m, with a few sites on the western edge of the southern Rocky Mountains extending to 2400 m. Landforms vary from mesatops and slopes to basin floors. Sites are flat to moderately steep (up to 53% slope). Stands may be small woodland parks or more extensive on the plains. Soils are variable. In bottomland stands, soils tend to be fine-textured; however, stands also occur on sandy loams derived from sandstone, remnant lavaflow, basaltic cobbles, black or red cinders, or alluvium derived from relict Pleistocene river cobbles, sandstone, sand, or clay soils.

VEGETATION DESCRIPTION

Arches National Park

This grassland association is locally common within the park. Total vegetation cover ranges from 6 to 85% depending on substrate and grazing history. The vegetation is characterized by the perennial bunchgrass *Pleuraphis jamesii* that ranges in cover from 1 to 35%. Other herbaceous species present may include *Achnatherum hymenoides, Bromus tectorum, Sporobolus airoides, Cymopterus newberryi, Phacelia crenulata, Plantago patagonica, Sphaeralcea parvifolia*, and *Townsendia annua*. Scattered shrubs are usually present, including *Krascheninnikovia lanata, Gutierrezia sarothrae*, and *Opuntia polyacantha*. Biological soil crust cover is usually sparse but can be as high as 15%.

Globally

This association is characterized by a sparse to moderately dense perennial herbaceous layer (5-60% cover) that is strongly dominated by the warm-season bunchgrass *Pleuraphis jamesii*. Low cover of other grasses, such as *Aristida* spp., *Achnatherum hymenoides, Achnatherum speciosum, Bouteloua eriopoda, Bouteloua gracilis, Hesperostipa comata, Muhlenbergia porteri, Sporobolus airoides*, or *Sporobolus cryptandrus*, may be present. Forb cover is

usually sparse and includes *Artemisia campestris, Cymopterus newberryi, Eriogonum inflatum, Phacelia crenulata, Plantago patagonica, Sphaeralcea parvifolia*, and *Townsendia annua* along with species of *Gilia, Lappula, Zinnia*, and prickly-pear cacti (*Opuntia* spp.). Many species of shrubs and dwarf-shrubs may be present, but they are not abundant enough to form a shrub layer. Woody species may include *Artemisia bigelovii, Artemisia filifolia, Atriplex canescens, Atriplex confertifolia, Brickellia oblongifolia, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Fallugia paradoxa, Gutierrezia* spp., *Krascheninnikovia lanata, Tetradymia* spp., and occasional *Juniperus* spp. trees. The widespread introduced annual grass *Bromus tectorum* and several other exotic species, such as *Salsola kali, Bassia scoparia*, and *Sisymbrium altissimum*, may be present to abundant, especially on disturbed sites. Some stands have high cover of cryptogams on the soil, including *Collema tenax, Tortula ruralis, Buellia papillata*, and *Fulgensia bracteata*.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia, Coleogyne ramosissima, Ephedra torreyana, Ericameria nauseosa, Sarcobatus vermiculatus*
Herb (field)	*Krascheninnikovia lanata, Opuntia polyacantha*
Herb (field)	*Artemisia dracunculus, Artemisia ludoviciana, Cryptantha crassisepala, Eriogonum inflatum, Halogeton glomeratus, Lappula occidentalis, Phacelia crenulata, Plantago patagonica, Sphaeralcea parvifolia*
Herb (field)	*Achnatherum hymenoides, Aristida purpurea, Bromus tectorum, Leymus salinus, Pleuraphis jamesii, Sporobolus airoides, Vulpia octoflora*

Globally

Stratum	Species
Herb (field)	*Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES

Arches National Park
Chenopodium album, Descurainia pinnata, Malcolmia africana, Salsola tragus

Globally
Bassia scoparia, Bromus tectorum, Salsola kali, Sisymbrium altissimum

CONSERVATION STATUS RANK

Global Rank & Reasons: G2G4 (23-Feb-1994).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
This association is defined by the dominance of *Pleuraphis jamesii* in the graminoid layer without codominance of other grass species or the presence of a shrub layer.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Arches National Park Inventory Notes: Some stands are heavily grazed. Some stands have biological soil crust development. Some stands have many small mammal burrows. One stand is on talus or colluvium. One stand has a caliche layer present.
Arches National Park Field Data: The description is based on 2003 field data (13 plots: ARCH.0005, ARCH.0034, ARCH.0050, ARCH.0056, ARCH.0057, ARCH.0304, ARCH.0329, ARCH.0333, ARCH.0363, ARCH.0606, ARCH.0636, ARCH.0649, ARCH.0709).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles and G. Kittel

REFERENCES: Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Cannon 1960, Cogan et al. 2004, Collins 1984, Driscoll et al. 1984, Francis 1986, Francis and Aldon 1983, Hansen et al. 2004b, Helm 1981, Kleiner

1968, Kleiner 1983, Kleiner and Harper 1972, Kleiner and Harper 1977, Marr et al. 1973a, Nichol 1937, Stewart et al. 1940, USFS 1937, Utah Environmental and Agricultural Consultants 1973, Von Loh et al. 2002, Weaver and Albertson 1956, West et al. 1972, Western Ecology Working Group n.d.

Schoenoplectus pungens Herbaceous Vegetation
Common Threesquare Herbaceous Vegetation

CODE	CEGL001587
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N.)
FORMATION	Semipermanently flooded temperate or subpolar grassland (V.A.5.N.l.)
ALLIANCE	*SCHOENOPLECTUS PUNGENS* SEMIPERMANENTLY FLOODED HERBACEOUS ALLIANCE (A.1433) Common Threesquare Semipermanently Flooded Herbaceous Alliance
ECOLOGICAL SYSTEM(S):	North American Arid West Emergent Marsh (CES300.729) Inter-Mountain Basins Interdunal Swale Wetland (CES304.059) Western Great Plains Saline Depression Wetland (CES303.669)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY

Globally

This bulrush wet meadow community is found in the western United States in the intermountain basins, as far north as southern British Columbia, as well as in western parts of the Great Plains north into Alberta, Canada. Stands are found along low-gradient, meandering, usually perennial streams and springs and around the margins of ponds and marshes. Substrates are generally dark, organic, fine-textured soils derived from alluvium. *Schoenoplectus pungens* dominates the dense, 0.3- to 0.6-m tall herbaceous vegetation layer. Other species that often are present include *Schoenoplectus maritimus, Spartina gracilis, Hordeum jubatum, Pascopyrum smithii, Juncus balticus, Eleocharis palustris, Lemna minor, Sagittaria latifolia*, and *Typha* spp. Stands of this association contain no tree or shrub layer, but a few scattered trees and shrubs may be present, most commonly *Populus deltoides, Populus fremontii, Salix amygdaloides, Salix exigua, Salix gooddingii, Symphoricarpos occidentalis*, or *Sarcobatus vermiculatus.*

DISTRIBUTION

Arches National Park

This association is rare within the park, occupying areas where the wash has incised sufficiently to intercept springs, and was sampled in Courthouse Wash near the park boundary.

Globally

This community is found in the western United States in the intermountain basins, as well as in western parts of the Great Plains, from east-central Alberta, Canada south to Colorado and west into Nevada, and Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This wetland association occurs adjacent to perennial pools in Courthouse Wash. The sampled site slopes gently (not exceeding 2%) and lies at 1305 m elevation. Sand covers most of the unvegetated surface, with low cover by open water and bare soil. Soils are saturated loamy sands derived from alluvium.

Globally

Stands of this widespread association are found throughout much of the western U.S., north into British Columbia and east to Alberta, Canada, in appropriate wetland habitats. Elevations range from 1000-2400 m. Stands occur along low-gradient, meandering, usually perennial streams, along springs, around the margins of ponds and marshes, in low-lying swales, adjacent to perennial pools in intermittent washes, and abandoned or overflow channels where the soils remain saturated (Hansen et al. 1995, Jones and Walford 1995, Walford 1996, Kittel et al. 1999a). It also occurs on silt and sand bars within the active channel. Soils are generally derived from alluvium and are fine-textured or sandy, and often are black, alkaline, organic anoxic with gleying. Soils range from normal to saline

with pH ranging from 7.4-9.1. Typical pH reported for Alberta stands is 8.5 (Thompson and Hansen 2002).

VEGETATION DESCRIPTION

Arches National Park

This herbaceous wetland association is rare within the park, as there are few areas with perennial surface water. Total vegetation cover does not exceed 50%. The vegetation is dominated by *Schoenoplectus pungens* with up to 35% cover. Associated graminoids include *Juncus balticus, Muhlenbergia asperifolia*, and *Typha domingensis*. Forb cover is sparse and consists mostly of exotic species. Scattered woody species occur around the margins of the community and may include *Salix exigua, Salix gooddingii*, and *Populus fremontii*.

Globally

This widespread wetland association is characterized by a dense, 0.3- to 0.6-m tall herbaceous vegetation layer that is dominated by *Schoenoplectus pungens*. Associated species include *Schoenoplectus maritimus, Equisetum* spp., *Spartina gracilis, Distichlis spicata, Hordeum jubatum, Muhlenbergia asperifolia, Pascopyrum smithii, Juncus balticus, Eleocharis palustris, Lemna minor, Sagittaria latifolia,* and *Typha* spp. Stands of this association contain no tree or shrub layer, but a few scattered trees and shrubs may be present, most commonly *Populus deltoides, Populus fremontii, Salix amygdaloides, Salix exigua, Salix gooddingii, Symphoricarpos occidentalis,* or *Sarcobatus vermiculatus*. Northern stands are dominantly *Schoenoplectus pungens* with 50% cover or greater with no other constant or significant species.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Herb (field)	*Schoenoplectus pungens, Typha domingensis*

Globally

Stratum	Species
Herb (field)	*Schoenoplectus pungens*

OTHER NOTEWORTHY SPECIES

Arches National Park

Melilotus officinalis, Tamarix chinensis, Xanthium strumarium

Globally

Agrostis stolonifera, Melilotus officinalis, Spiranthes diluvialis

CONSERVATION STATUS RANK

Global Rank & Reasons: G3G4 (9-Apr-1998).

CLASSIFICATION COMMENTS

Arches National Park

Data are not available.

Globally

Muldavin et al. (2000a) described five *Schoenoplectus pungens* community types from New Mexico. Most are codominated with an associated species listed in the vegetation description, e.g., *Eleocharis palustris, Distichlis spicata, Paspalum distichum*, and *Equisetum laevigatum*, with one being a *Schoenoplectus pungens* Monotype Community Type reported from the Gila River basin. Muldavin et al.'s (2000a) concept of this community type states that it can be dominated by *Schoenoplectus pungens* or *Schoenoplectus americanus*. Hansen et al. (1995) also include *Schoenoplectus americanus* in their *Scirpus pungens* Habitat Type. The range of *Schoenoplectus americanus*, however, does not extend into Alberta, so this may be less of an issue moving north. This association needs further review to clarify whether to include stands where *Schoenoplectus pungens* is not the dominant species.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Arches National Park Inventory Notes: This is a rare type occurring where intermittent stream channels intercept the water table, creating surface flow for short distances. Occurs where wash bottom drops to the water table and intercepts small springs, creating a permanent water flow in a shallow channel.

Arches National Park Field Data: The description is based on 2003 field data (1 plot: ARCH.0705).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: G.P. Jones, mod. K. Schulz, J. Coles, L. Allen

REFERENCES: Bourgeron and Engelking 1994, Brotherson and Barnes 1984, Bundy et al. 1996, Butler et al. 2002, CONHP unpubl. data 2003, Carsey et al. 2003a, Driscoll et al. 1984, Gleason and Cronquist 1991, Great Plains Flora Association 1986, Hansen et al. 1991, Hansen et al. 1995, IDCDC 2005, Jones 1992b, Jones and Walford 1995, Kittel and Lederer 1993, Kittel et al. 1994, Kittel et al. 1999b, Larson 1993, Lauver et al. 1999, MTNHP 1988, MTNHP 2002b, MacKenzie and Moran 2004, Muldavin et al. 2000a, NDNHI n.d., Thompson and Hansen 2002, Walford 1996

Typha (latifolia, angustifolia) Western Herbaceous Vegetation
(Broadleaf, Narrowleaf Cattail) Western Herbaceous Vegetation

CODE	CEGL002010
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial graminoid vegetation (V.A)
PHYSIOGNOMIC GROUP	Temperate or subpolar grassland (V.A.5)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N)
FORMATION	Semipermanently flooded temperate or subpolar grassland (V.A.5.N.l)
ALLIANCE	*TYPHA (ANGUSTIFOLIA, LATIFOLIA) - (SCHOENOPLECTUS* SPP) SEMIPERMANENTLY FLOODED HERBACEOUS ALLIANCE (A.1436) (Narrowleaf Cattail, Broadleaf Cattail) - (Clubrush species) Semipermanently Flooded Herbaceous Alliance
ECOLOGICAL SYSTEM(S):	North American Arid West Emergent Marsh (CES300.729) Inter-Mountain Basins Interdunal Swale Wetland (CES304.059) Northern Columbia Plateau Basalt Pothole Ponds (CES304.058) Western Great Plains Open Freshwater Depression Wetland (CES303.675) Temperate Pacific Freshwater Emergent Marsh (CES200.877) Western Great Plains Floodplain (CES303.678)
USFWS WETLAND SYSTEM:	Palustrine

CONCEPT SUMMARY
Globally
This association is widespread across the western United States and western Great Plains occurring near streams, rivers, and ponds. The soil is flooded or saturated for at least part of the growing season. The alluvial soils have variable textures ranging from sand to clay and usually with a high organic content. The dominant species, *Typha latifolia* or *Typha angustifolia*, often form dense, almost monotypic stands. Other species typical of wetlands may be found in lesser amounts in this community; among these are shallower water emergents such as *Carex* spp., *Eleocharis macrostachya, Eleocharis palustris, Glyceria* spp., *Juncus balticus, Juncus torreyi, Mentha arvensis, Schoenoplectus acutus*, and *Veronica* spp. In deeper water, *Lemna minor, Potamogeton* spp., *Sagittaria* spp., *Azolla filiculoides*, and other aquatics may be present in trace amounts.

DISTRIBUTION
Arches National Park
This association is known only from a ponded area (beaver or muskrat) in Salt Wash upstream of the Delicate Arch parking area. This location contains standing water throughout the growing season.

Globally
This association is widely distributed, occurring across the western United States and western Great Plains.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This herbaceous association is restricted to a section of the Salt Wash floodplain that has been flooded by beaver activity. Water is at the surface (up to 1m deep) throughout the growing season.

Globally
This widespread community is found along streams, rivers, canals, and the banks of ponds and lakes. Elevations range from near sea level to 2000 m. Sites are nearly level. The soil is saturated or flooded for much of the year from freshwater sources such as springs or streams. The alluvial soils have variable textures ranging from sand to clay and usually with a high organic content.

VEGETATION DESCRIPTION
Arches National Park
This wetland association is known from only one site in the park. The vegetation in this site consists solely of *Typha latifolia*, with 50% cover.

Globally
This community is dominated by hydrophytic macrophytes, especially *Typha latifolia* or *Typha angustifolia*, which grow from approximately 2-3 m tall. *Typha latifolia* and *Typha angustifolia* often form dense, near-monotypic stands (70-98% cover), almost to the exclusion of other species. In some stands the two *Typha* species are codominant. Other species typical of wetlands may be found in lesser amounts in this community; among these are shallower water emergents such as *Carex* spp., *Eleocharis macrostachya, Eleocharis palustris, Glyceria* spp., *Juncus balticus, Juncus torreyi, Mentha arvensis, Schoenoplectus acutus*, and *Veronica* spp. In deeper water, *Lemna minor, Potamogeton* spp., *Sagittaria* spp., *Azolla filiculoides*, and other aquatics may be present in trace amounts. Trace amounts of grasses like *Agrostis stolonifera, Beckmannia syzigachne, Hordeum jubatum, Muhlenbergia asperifolia*, and *Phalaris arundinacea* may also be present.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Herb (field)	*Typha latifolia*

Globally

Stratum	Species
Herb (field)	*Typha angustifolia, Typha latifolia*

OTHER NOTEWORTHY SPECIES
Arches National Park
N/A

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Arches National Park
This community type was included in the classification because it represents an important and unique community type within the park.

Globally
This community is a common element found in many wetland systems, but has received little attention. Consequently, the diagnostic features and species of this community are not well known. Many ecologists (Hansen et al. 1995, Kittel et al. 1999b) have included *Typha angustifolia* as a codominant in this association. More classification work is needed to clarify the concept of this association.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Beavers have flooded this section of the wash. The cattails look dead, but it's possible they just haven't started growing for this season.
Arches National Park Field Data: The description is based on 2006 data (1 accuracy assessment point: ARCH_AA.0417).

Local Description Authors: J. Coles
Global Description Authors: J. Drake, mod. K. Schulz, mod. M.S. Reid

REFERENCES: Baker 1984a, Boss 1983, Bourgeron and Engelking 1994, Bundy et al. 1996, Bunin 1985, CONHP unpubl. data 2003, Carsey et al. 2003a, Christy 1973, Christy 2004, Crowe and Clausnitzer 1997, Crowe et al. 2004, Dethier 1990, Driscoll et al. 1984, Hansen et al. 1991, Hansen et al. 1995, Holland 1986b, IDCDC 2005, Jankovsky-Jones et al. 2001, Johnston 1987, Jones 1992b, Jones and Walford 1995, Kagan et al. 2000, Kittel et al. 1996, Kittel et al. 1999a, Kittel et al. 1999b, Kovalchik 1993, Kovalchik 2001, Kunze 1994, Lindauer 1978, Lindauer and Christy 1972, MTNHP 2002b, Marriott and Faber-Langendoen 2000, Masek 1979, McEachern 1979, Muldavin et al. 1993b, Muldavin et al. 2000a, Murray 2000, NVNHP 2003, Padgett et al. 1989, Ramaley 1939b, Sanville et al. 1986, Titus et al. 1996, Tolstead 1942, Von Loh 2000, WNHP unpubl. data, Youngblood et al. 1985a

Sphaeralcea (coccinea, parvifolia) Herbaceous Vegetation
(Scarlet, Narrowleaf Globemallow) Herbaceous Vegetation

CODE	CEGL005366
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial forb vegetation (V.B.)
PHYSIOGNOMIC GROUP	Temperate or subpolar perennial forb vegetation (V.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar perennial forb vegetation (V.B.2.N.)
FORMATION	Low temperate or subpolar perennial forb vegetation (V.B.2.N.b.)
ALLIANCE	*SPHAERALCEA (COCCINEA, PARVIFOLIA)* HERBACEOUS ALLIANCE (A.2688) (Scarlet Globemallow, Narrowleaf Globemallow Herbaceous Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Semi-Desert Grassland (CES304.787)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This herbaceous association occurs in valleys in the Colorado Plateau. Sites are flat to gently sloping on stream terraces, grabens, and canyon and valley bottoms at 1197-1687 m elevation. There is moderate to high ground surface cover of bare soil and low to moderate cover of litter (1-50 %). Some stands have moderate cover of biological soil crusts (30-40%). Substrate is sandy soil derived from alluvium or eolian sand. Disturbance appears important in some stands; small mammal burrows are present on some sites. Presence of ruderal species indicates recent or past disturbance. The vegetation is characterized by an open to moderately dense, perennial herbaceous layer dominated by *Sphaeralcea coccinea* or *Sphaeralcea parvifolia* (less often) with 4-15% cover, often with *Achnatherum hymenoides* and/or *Sporobolus cryptandrus*. Scattered shrubs and dwarf-shrubs may be present such as *Atriplex canescens, Ephedra* spp., *Krascheninnikovia lanata*, and *Opuntia* spp. Other herbaceous species include *Cryptantha* spp., *Plantago patagonica, Pleuraphis jamesii, Oenothera pallida*, and *Rumex hymenosepalus*. Introduced annual species such as *Bromus tectorum* and *Salsola tragus* may be present.

DISTRIBUTION
Arches National Park
This association is known from three sites in Salt Valley.

Globally
This herbaceous association occurs in disturbed canyon bottoms and stream terraces in Arches and Canyonlands national parks and is likely widespread in the Colorado Plateau.

ENVIRONMENTAL DESCRIPTION
Arches National Park
Stands occur in valleys at 1477-1504 m elevation. Ground surface ranges from 50-70% cover bare soil and 30-50% cover litter. Substrate is sandy soil. Sites are riddled with small to medium-sized burrows. Presence of ruderal species indicates recent disturbance.

Globally
Stands occur in valleys in the Colorado Plateau. Sites are flat to gently sloping on stream terraces, grabens, and

canyon and valley bottoms at 1197-1687 m elevation. Ground surface ranges from 46-97% cover bare soil and low cover of litter (1-15%). A few known stands had moderate cover of biological soil crusts (30-40%). Substrate is sandy soil with one known site occurring on eolian sand. Disturbance appears important in some stands; small mammal burrows are present on some sites. Presence of ruderal species indicates recent or past disturbance.

VEGETATION DESCRIPTION

Arches National Park

This association is characterized by an open to moderately dense herbaceous layer dominated by *Sphaeralcea parvifolia* with 4-15% cover, often with *Oenothera pallida* and *Sporobolus cryptandrus*. Scattered shrubs and dwarf-shrubs may be present such as *Atriplex canescens, Ephedra viridis, Krascheninnikovia lanata*, and *Opuntia polyacantha*. Other herbaceous species include *Cryptantha crassisepala, Descurainia incana, Pleuraphis jamesii, Machaeranthera tanacetifolia, Rumex hymenosepalus*, and *Townsendia annua*. Introduced species such as *Bromus tectorum* may have moderate to high cover.

Globally

This association is characterized by an open to moderately dense, perennial herbaceous layer dominated by *Sphaeralcea coccinea* or *Sphaeralcea parvifolia* with 4-15%, often with *Achnatherum hymenoides* and/or *Sporobolus cryptandrus*. Scattered shrubs and dwarf-shrubs may be present such as *Atriplex canescens, Ephedra torreyana, Hesperostipa comata, Krascheninnikovia lanata, Opuntia erinacea*, and *Opuntia polyacantha*. Other herbaceous species include *Cryptantha crassisepala, Machaeranthera tanacetifolia, Mentzelia albicaulis, Plantago patagonica, Pleuraphis jamesii, Oenothera pallida, Rumex hymenosepalus*, and *Townsendia annua*. Introduced annual species such as *Bromus tectorum, Helianthus annuus*, or *Salsola tragus* are frequently present.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Herb (field)	*Sphaeralcea parvifolia*

Globally

Stratum	Species
Herb (field)	*Sphaeralcea coccinea, Sphaeralcea parvifolia*

OTHER NOTEWORTHY SPECIES

Arches National Park
Bromus tectorum

Globally
Bromus tectorum, Salsola tragus

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (6-May-2008).

CLASSIFICATION COMMENTS

Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Arches National Park Inventory Notes: Data are not available.
Arches National Park Field Data: The description is based on 2006 field data (3 accuracy assessment points: ARCH_AA.0128, ARCH_AA.0135, ARCH_AA.0251).
Local Description Authors: K.A. Schulz
Global Description Authors: K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Aquilegia micrantha - Mimulus eastwoodiae Herbaceous Vegetation
Mancos Columbine - Eastwood Monkeyflower Herbaceous Vegetation

CODE	CEGL002729
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Perennial forb vegetation (V.B.)
PHYSIOGNOMIC GROUP	Temperate or subpolar perennial forb vegetation (V.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar perennial forb vegetation (V.B.2.N.)
FORMATION	Saturated temperate perennial forb vegetation (V.B.2.N.f.)
ALLIANCE	*AQUILEGIA MICRANTHA* SATURATED HANGING GARDEN HERBACEOUS ALLIANCE (A.2506) Mancos Columbine Saturated Hanging Garden Herbaceous Alliance

ECOLOGICAL SYSTEM(S): Colorado Plateau Hanging Garden (CES304.764)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY

Globally

These wetland communities are scattered throughout the canyons of the Colorado Plateau in Utah, northern Arizona and western Colorado, where groundwater emerges from cracks, crevices, alcoves and ledges in cliffs to create permanently moist seeps. Hanging gardens form exclusively in sedimentary rocks; the best developed examples occur in massive bedded sandstones of eolian origin, such as Navajo, Wingate, Cedar Mesa and Entrada sandstones. Water chemistry is variable, ranging from potable to calcareous to saline. The structure of these communities ranges from a simple crack in a vertical cliff face supporting a narrow line of herbaceous vegetation to deep, shaded alcoves supporting different plant assemblages on the back wall and on the wet colluvial floor of the alcove. Elevations range from 1250 to 1890 m (4100-6200 feet), and aspect is not important in determining stand distribution. Soils are typically poorly developed sandy loams and generally are saturated throughout the growing season. The dominant species within the seep are generally forbs, ferns and graminoids; however, shrubs and trees sometimes form a margin sheltering the gardens. The forb component includes a number of rare and endemic species. Characteristic forbs include *Adiantum capillus-veneris, Aquilegia micrantha, Mimulus eastwoodiae, Cirsium* spp., *Epipactis gigantea, Platanthera zothecina, Zigadenus vaginatus, Maianthemum stellatum, Primula specuicola, Solidago velutina*, and *Dodecatheon pulchellum*. Graminoids tend to be more variable from stand to stand; common species include *Juncus ensifolius, Calamagrostis scopulorum, Agrostis gigantea, Schizachyrium scoparium, Carex aurea*, and *Carex curatorum*. The woody species that occur on the margins of these wetlands are also variable and may include *Populus* spp., *Pinus edulis, Juniperus scopulorum, Rhus trilobata, Toxicodendron rydbergii, Clematis ligusticifolia, Cercocarpus intricatus, Ericameria nauseosa*, and *Cercocarpus montanus*.

DISTRIBUTION

Arches National Park

This association was sampled along Delicate Arch Trail within the park. It is locally common on the northeast limb of the Salt Valley Anticline at the contact between the base of the Moab Tongue and the top of the Entrada sandstone. Extensive hanging gardens occupy alcoves in Sevenmile canyon as well (southwest limb).

Globally

This association is restricted to massive sandstone cliffs and slopes in canyons of the Colorado Plateau in western Colorado and southeastern Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This herbaceous association occurs in cracks, joints and alcoves in vertical cliffs throughout the park. Most examples occur at the contact between the base of the Moab Tongue (Curtis Formation) and the top of the Entrada sandstone, sometimes forming linear horizontal bands of wetland vegetation that extend hundreds of meters along the cliff face. Many are inaccessible without climbing gear. Soils are poorly developed, saturated and often have an alkaline crust.

Globally

These wetland communities are scattered throughout the canyons of the Colorado Plateau in Utah, northern Arizona and western Colorado. Occurrences are defined by cracks, crevices, alcoves and ledges in cliffs where groundwater emerges to create permanently moist seeps. Hanging gardens form exclusively in sedimentary rocks; the best developed examples occur in massive bedded sandstones of eolian origin, such as Navajo, Wingate, Cedar Mesa, Moab Tongue and Entrada sandstones. Water chemistry is variable, ranging from potable to calcareous to saline. The structure of these communities ranges from a simple crack in a vertical cliff face supporting a narrow line of herbaceous vegetation to deep, shaded alcoves supporting different plant assemblages on the back wall and on the wet colluvial floor of the alcove. Elevations range from 1250 to 1890 m (4100-6200 feet), and aspect is not important in determining stand distribution. Soils are typically poorly developed sandy loams and generally are saturated throughout the growing season and may have an alkaline crust.

VEGETATION DESCRIPTION

Arches National Park

This otherwise rare association is common at Arches, occurring in cliff alcoves and on ledges where seeps emerge. Total vegetation cover ranges from 81 to 135% and is dominated by the forbs *Aquilegia micrantha* and *Mimulus eastwoodiae*. This is a rich and diverse community; other common herbaceous species include *Cirsium rydbergii, Toxicodendron radicans, Euphorbia brachycera, Heterotheca villosa*, and *Primula specuicola*, among the forbs, and *Juncus ensifolius, Dichanthelium acuminatum*, and *Schizachyrium scoparium*, among the graminoids. Shrubs and occasionally trees may occur on the margins of the community, rooted in bedrock cracks. Moss provides up to 15% cover in the wetter alcoves.

Globally

The dominant species within the seep are generally forbs, ferns and graminoids; however, mesophytic shrubs and trees sometimes form a margin sheltering the gardens. Vegetative components of hanging gardens are diverse and include a number of rare and endemic species. *Aquilegia micrantha* and *Mimulus eastwoodiae* are present to codominant. Other characteristic forbs present in many hanging gardens include *Adiantum capillus-veneris, Cirsium rydbergii, Dodecatheon pulchellum, Epipactis gigantea, Euphorbia brachycera, Heterotheca villosa, Platanthera zothecina, Zigadenus vaginatus, Maianthemum stellatum, Primula specuicola*, and *Solidago velutina*. Graminoids tend to be more variable from stand to stand; common species include *Juncus ensifolius, Calamagrostis scopulorum, Dichanthelium acuminatum, Agrostis gigantea, Schizachyrium scoparium, Carex aurea*, and *Carex curatorum*. The woody species that occur on the margins of these wetlands are also variable and may include *Populus* spp., *Pinus edulis, Juniperus scopulorum, Rhus trilobata, Toxicodendron radicans, Toxicodendron rydbergii, Clematis ligusticifolia, Cercocarpus intricatus, Ericameria nauseosa*, and *Cercocarpus montanus*.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Herb (field)	*Aquilegia micrantha, Cirsium rydbergii, Euphorbia brachycera, Heterotheca villosa, Mimulus eastwoodiae, Primula specuicola*
Herb (field)	*Dichanthelium acuminatum, Juncus ensifolius, Schizachyrium scoparium*

Globally

Stratum	Species
Herb (field)	*Aquilegia micrantha, Mimulus eastwoodiae*
Herb (field)	*Adiantum capillus-veneris*

OTHER NOTEWORTHY SPECIES

Arches National Park

Data are not available.

Globally

Carex curatorum, Erigeron kachinensis, Mimulus eastwoodiae, Platanthera zothecina, Primula specuicola, Tamarix chinensis, Toxicodendron radicans, Zigadenus vaginatus

CONSERVATION STATUS RANK

Global Rank & Reasons: G2G3 (14-Nov-2005). This association tends to be undersampled because many stands are located on inaccessible vertical cliffs.

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
This association is part of a complex of herbaceous communities collectively known as "hanging gardens." Few systematic studies of these communities have been completed (e.g., Welsh and Toft 1981, Welsh 1989, Fowler 1995), and even fewer quantitative data are available, partly because stands can be difficult or dangerous to access. The National Park Service is undertaking systematic surveys of vegetation, particularly spring and seep communities, throughout the Colorado Plateau (A. Evenden pers. comm. 2005). As more data become available, the various hanging garden associations should be revisited. John Spence, botanist at Glen Canyon National Recreation Area, is reported to be in the process of publishing a comprehensive study and classification of hanging gardens in the Colorado Plateau (J. Spence pers. comm. 2005).

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Arches National Park Inventory Notes: Seeps and hanging gardens contain the diagnostic species *Aquilegia micrantha* and *Mimulus eastwoodiae*. Hanging gardens occur in cliff joints and in deep overhanging alcoves.
Arches National Park Field Data: The description is based on general field observation and 2003 field data (1 plot*:* ARCH.0669 and 2 observation points: ARCH.9693, ARCH.9689).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Spence, mod. J. Coles and K.A. Schulz

REFERENCES: CONHP unpubl. data 2003, Carsey et al. 2003a, Evenden pers. comm., Fowler 1995, Malanson 1980, Malanson 1982, Malanson and Kay 1980, Romme et al. 1993, Spence pers. comm., Welsh 1989, Welsh and Toft 1981, Western Ecology Working Group n.d.

Bromus tectorum Semi-natural Herbaceous Vegetation
Cheatgrass Semi-natural Herbaceous Vegetation

CODE	CEGL003019
PHYSIOGNOMIC CLASS	Herbaceous Vegetation (V)
PHYSIOGNOMIC SUBCLASS	Annual graminoid or forb vegetation (V.D.)
PHYSIOGNOMIC GROUP	Temperate or subpolar annual grasslands or forb vegetation (V.D.2.)
PHYSIOGNOMIC SUBGROUP (V.D.2.N.)	Natural/Semi-natural temperate or subpolar annual grasslands or forb vegetation
FORMATION	Short temperate annual grassland (V.D.2.N.d.)
ALLIANCE	*BROMUS TECTORUM* SEMI-NATURAL HERBACEOUS ALLIANCE (A.1814) Cheatgrass Semi-natural Herbaceous Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Semi-Desert Grassland (CES304.787)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This herbaceous vegetation type is found throughout much of western North America from the western Great Plains to the Intermountain West. It occurs most often after disturbance of a natural shrub- or grass-dominated community that results in the replacement of the natural vegetation by non-native, annual grass species of *Bromus*. *Bromus tectorum* typically dominates the community with over 80-90% of the total vegetation cover, making it difficult to determine what natural community was formerly present. This vegetation also includes grasslands dominated or codominated by other Eurasian introduced annual *Bromus* species such as *Bromus hordeaceus, Bromus madritensis, Bromus japonicus, Bromus rigidus,* or *Bromus rubens*. It is distinct from the annual *Bromus* communities found along the Pacific Coast typical of the Mediterranean or maritime climates.

DISTRIBUTION
Arches National Park
This association was sampled outside the park in Salt Valley and Long Valley, where it is the dominant association

on the canyon floor.

Globally
This alliance-level herbaceous vegetation type is found throughout much of western North America from the western Great Plains to intermountain and southwestern U.S.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This annual grassland type occurs in large patches on valley floors and low hills. Stands are on flat to gentle (0 to 5%) slopes between 1494 and 1817 m elevation. In dry years, up to 90% of the ground surface is bare soil; in years with abundant spring moisture, litter cover is higher and bare ground less exposed. Soils are rapidly drained silt loams derived from mixed lithologies deposited by wind and sheet erosion from the surrounding uplands.

Globally
This herbaceous vegetation type is found from the western Great Plains to the Intermountain and southwestern U.S. Elevation ranges from sea level to 2200 m. Stands become established after disturbance of a natural shrub- or grass-dominated community, resulting in the replacement of the native vegetation by non-native, annual species of *Bromus*, although invasion of undisturbed sites has also been reported (e.g., Evans et al. 2001). In the Great Basin, *Bromus tectorum* grasslands have invaded large areas of burned-over sagebrush steppe. *Bromus tectorum* increases the fire frequency of these communities, which eliminates thesagebrush (FEIS 2001).

VEGETATION DESCRIPTION
Arches National Park
This cheatgrass association covers large areas outside the park boundary but is limited in its extent within the park. Total vegetation cover ranges from 8 to 75% depending on spring moisture and when in the year the plot is visited. This herbaceous association is clearly dominated by the exotic annual grass *Bromus tectorum*. Remnants of the original grass community may be present with low cover, primarily *Pleuraphis jamesii*. The forb component tends to consist primarily of exotic species, especially *Halogeton glomeratus* and *Lappula occidentalis*. A few scattered shrubs such as *Opuntia polyacantha* may be present. Sparse cover by biological soil crusts occurs in some stands, but consistent heavy grazing has eliminated the biological soil crusts in most areas.

Globally
This vegetation type is characterized by a sparse to dense, short, annual graminoid layer that is typically dominated by *Bromus tectorum* with over 80-90% of the total vegetation cover. Other Eurasian introduced annual species of *Bromus* which may alternatively dominate or codominate are *Bromus carinatus, Bromus hordeaceus, Bromus madritensis, Bromus japonicus, Bromus rigidus,* or *Bromus rubens*. Although there may be remnant species of the former native vegetation, the high cover of annual bromes makes it difficult to determine what natural community was formerly present. Weedy and exotic annual forbs may also have significant cover in some stands. Scattered shrubs and dwarf-shrubs, especially *Chrysothamnus viscidiflorus, Ericameria nauseosa, Ephedra viridis, Gutierrezia sarothrae,* and *Opuntia polyacantha*, may be present with low cover. At Wind Cave National Park in South Dakota, this weedy non-native graminoid vegetation is usually dominated by several perennial and annual brome grasses, including *Bromus inermis, Bromus japonicus*, and *Bromus tectorum*. Cover is variable (H. Marriott pers. comm. 1999), and in drought years, *Bromus tectorum* may be sparse or absent.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Opuntia polyacantha*
Herb (field)	*Eriogonum inflatum, Gilia leptomeria, Halogeton glomeratus, Lappula occidentalis, Salsola tragus*
Herb (field)	*Bromus tectorum*

Globally

Stratum	Species
Herb (field)	*Bromus hordeaceus, B. japonicus, B. madritensis, B. rigidus, B. rubens, B. tectorum*

OTHER NOTEWORTHY SPECIES

Arches National Park
Chenopodium album, Descurainia pinnata, Malcolmia africana

Globally

CONSERVATION STATUS RANK
Global Rank & Reasons: GNA (invasive) (1-Dec-1997).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
This alliance also includes grasslands dominated or codominated by other Eurasian introduced annual *Bromus* species. It is distinct from the annual *Bromus* communities found along the Pacific Coast with Mediterranean or maritime climates because it does not have the introduced annual oatgrass (*Avena barbata* and *Avena fatua*), or other species typical of the California annual grassland (Sawyer and Keeler-Wolf 1995).

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Sites are disturbed by grazing. One stand is a thin strip of vegetation along a drainage.
Arches National Park Field Data: The description is based on 2003 field data (3 plots: ARCH.0044, ARCH.0049, ARCH.0053 and 7 observation points: ARCH.9692, ARCH.9003, ARCH.9009, ARCH.9658, ARCH.9619, ARCH.9038, ARCH.9010).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: D. Faber-Langendoen, mod. K. Schulz and J. Coles

REFERENCES: Beatley 1976, Cogan et al. 2004, Daubenmire 1975, Englund 2004, Evans et al. 2001, FEIS 2001, Karl et al. 1999, Marriott pers. comm., Naumann pers. comm., Redente et al. 1992, Sawyer and Keeler-Wolf 1995, Western Ecology Working Group n.d., Young and Evans 1973, Young and Evans 1978

Ephedra torreyana - (*Atriplex* spp.) / Nonvascular Gypsum Sparse Vegetation
Torrey Joint-fir - (Saltbush species) / Nonvascular Gypsum Sparse Vegetation

CODE	CEGL002349
PHYSIOGNOMIC CLASS	Sparse Vegetation (VII)
PHYSIOGNOMIC SUBCLASS	Unconsolidated material sparse vegetation (VII.C.)
PHYSIOGNOMIC GROUP	Sparsely vegetated soil slopes (VII.C.3.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural sparsely vegetated soil slopes (VII.C.3.N.)
FORMATION	Dry slopes (VII.C.3.N.b.)
ALLIANCE	*EPHEDRA TORREYANA* SPARSELY VEGETATED ALLIANCE (A.2571) Torrey's Joint-fir Sparsely Vegetated Alliance
ECOLOGICAL SYSTEM(S):	Colorado Plateau Blackbrush-Mormon-tea Shrubland (CES304.763) Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765) Inter-Mountain Basins Shale Badland (CES304.789)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This sparse shrubland is restricted to the barren slopes of badlands, ridges, hills and gullies with gypsum soils in the northern Colorado Plateau of eastern Utah and western Colorado. Sites are flat to moderately steep (0- to 36-degree slopes), occur between 1280 and 1845 m (4200-6050 feet) elevation, and are oriented to all aspects. The unvegetated surface has up to 95% cover of ground lichens or bare soil. Litter and rocks are scarce, but surface erosion may expose a layer of gravel. Parent materials are gypsiferous shales of the Paradox, Moenkopi or Carmel formations. Soils are rapidly drained and range in texture from sandy loam to silty clay, although the sand often consists entirely

of unweathered gypsum crystals. The vegetation is characterized by the moderate to near-total cover by gypsophilous ground lichens. The total vascular vegetation cover ranges from 1 to 10% and rarely as high as 30%. It consists of a scattering of *Ephedra torreyana* shrubs that ranges in cover from 1 to 15%. Other shrubs may be present, including *Atriplex canescens, Atriplex confertifolia, Ericameria nauseosa,* and *Opuntia polyacantha*. The herbaceous layer is absent to extremely sparse in terms of cover, but some plots may contain occasional plants of *Achnatherum hymenoides, Poa fendleriana, Pleuraphis jamesii*, and the forbs *Eriogonum inflatum, Lepidium montanum, Lappula occidentalis*, and *Sphaeralcea parvifolia*.

DISTRIBUTION

Arches National Park

This association is rare and was sampled in Salt Valley, including near Skyline Arch, within the park.

Globally

This association is known from gypsum outcrops and soils in eastern Utah and western Colorado.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This sparse vegetation association is restricted to unmodified exposures of gypsiferous strata of the Paradox Formation. Landforms include badlands, ridges, hills and gullies. Sites are flat to moderately steep (up to 18%), occur between 1445 and 1515 m elevation and are oriented to northeastern and southeastern aspects. The unvegetated surface is almost entirely covered by gypsophilic lichens with up to 93% total cover. A few sites have some exposed bare soil or gravel Soils are rapidly drained sandy loams, silt loams, and silty clays derived from the Paradox Formation.

Globally

This sparse shrubland is restricted to the barren slopes of badlands, ridges, hills and gullies with gypsum soils in the northern Colorado Plateau of eastern Utah and western Colorado. Sites are flat to moderately steep (0- to 36-degree slopes), occur between 1280 and 1845 m (4200 - 6050 feet) elevation, and are oriented to all aspects. The unvegetated surface has up to 95% cover of ground lichens or bare soil. Litter and rocks are scarce, but surface erosion may expose a layer of gravel. Parent materials are gypsiferous shales of the Paradox, Moenkopi or Carmel formations. Soils are rapidly drained and range in texture from sandy loam to silty clay, although the sand often consists entirely of unweathered gypsum crystals.

VEGETATION DESCRIPTION

Arches National Park

This sparse shrubland association is restricted to Salt Valley within the park. Total vegetation cover ranges from 1 to 30%. The open canopy is characterized by *Ephedra torreyana* shrubs, usually with scattered *Atriplex canescens, Atriplex confertifolia,* and/or *Opuntia polyacantha*. The herbaceous layer is often extremely sparse but may include occasional stems of *Pleuraphis jamesii, Eriogonum inflatum, Lappula occidentalis,* and *Sphaeralcea parvifolia*.

Globally

This unusual sparse shrubland is limited by soils within the Colorado Plateau. This association is characterized by the moderate to near-total cover by gypsophilous ground lichens. The total vascular vegetation cover ranges from 1 to 10% and rarely as high as 30%. It consists of a scattering of *Ephedra torreyana* shrubs that ranges in cover from 1 to 15%. Other shrubs may be present, including *Atriplex canescens, Atriplex confertifolia, Ericameria nauseosa*, and *Opuntia polyacantha*. The herbaceous layer is absent to extremely sparse in terms of cover, but some plots may contain occasional plants of *Achnatherum hymenoides, Poa fendleriana, Pleuraphis jamesii*, and the forbs *Eriogonum inflatum, Lepidium montanum, Lappula occidentalis*, and *Sphaeralcea parvifolia*.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Artemisia filifolia, Atriplex canescens, Coleogyne ramosissima, Ephedra torreyana*
Herb (field)	*Lappula occidentalis*
Herb (field)	*Pleuraphis jamesii*

Globally

Stratum	Species
Short shrub/sapling	*Ephedra torreyana*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Descurainia pinnata, Salsola tragus

Globally
Bromus tectorum, Descurainia pinnata, Salsola tragus

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (21-Mar-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Arches National Park Inventory Notes: Sites occur on the Paradox Formation gypsum exposures. Some sites have shale gravel on the surface. There is sheet erosion from these stands.
Arches National Park Field Data: The description is based on 2003 field data (8 plots: ARCH.0058, ARCH.0302, ARCH.0332, ARCH.0659, ARCH.0660, ARCH.0662, ARCH.0663, ARCH.0664).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles

REFERENCES: Western Ecology Working Group n.d.

Ephedra torreyana Sparse Vegetation
Torrey's Joint-fir Sparse Vegetation

CODE	CEGL002353
PHYSIOGNOMIC CLASS	Sparse Vegetation (VII)
PHYSIOGNOMIC SUBCLASS	Unconsolidated material sparse vegetation (VII.C.)
PHYSIOGNOMIC GROUP	Sparsely vegetated soil slopes (VII.C.3.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural sparsely vegetated soil slopes (VII.C.3.N.)
FORMATION	Dry slopes (VII.C.3.N.b.)
ALLIANCE	*EPHEDRA TORREYANA* SPARSELY VEGETATED ALLIANCE (A.2571) Torrey's Joint-fir Sparsely Vegetated Alliance
ECOLOGICAL SYSTEM(S):	Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765) Inter-Mountain Basins Shale Badland (CES304.789)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This very sparse shrub association is locally common in eastern Utah, occurring on alluvial fans, pediments, terraces, benches, mesas, rocky canyon slopes and stabilized dunes. This community occupies sites that are often actively eroding steep slopes, with pedestalled shrubs and gullies. A few stands are on level to gently sloping sandsheets that are subject to blowouts. Sampled stands are located between 1220 and 1780 m (4000-5840 feet) elevation. Bare ground, rocks and gravel cover most of the unvegetated surface, although biological soil crusts may cover up to 50% of the surface in sandier sites. Soils tend to be rapidly drained, shallow, alkaline sandy loams, clay loams and loamy sands derived from shaly sandstones (or sandy shales) such as the Morrison, Moenkopi, Cutler and Summerville formations. Total vegetation cover ranges from 1 to 15% but is generally less than 10%. The vegetation is dominated or codominated by a sparse canopy of *Ephedra torreyana* with between 1 and 10% cover.

Associated shrubs may include *Atriplex confertifolia, Eriogonum leptocladon, Eriogonum corymbosum, Ericameria nauseosa, Gutierrezia sarothrae, Xylorhiza* spp., *Opuntia* spp., and *Coleogyne ramosissima*. The herbaceous layer may have as much cover as the shrubs but will rarely exceed a few percent and may often be nearly absent. Common herbaceous species include *Pleuraphis jamesii, Eriogonum inflatum*, and *Sphaeralcea* spp. *Achnatherum hymenoides* is absent or has only trace cover. *Bromus tectorum* may be abundant in disturbed sites.

DISTRIBUTION

Arches National Park

Most examples of this association occur outside the park in the environs. Known locations include the vicinity of Willow Flat, Willow Springs, Seven Mile Canyon, Drinks Canyon, Jackass Canyon, and Dalton Wells.

Globally

This association has been documented from southeastern Utah. It is likely to be fairly restricted in both its range and in the size of occurrences.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This short-shrub association occurs on extremely xeric hillslopes. Sites have up to 36% slopes, occur around 1350 m elevation and are oriented to southerly aspects. The unvegetated surface is covered by mudstone fragments and bare ground. Litter is sparse. Parent materials are the Tidwell Member of the Morrison Formation shale. Soils are rapidly drained sandy loams and clay loams.

Globally

This very sparse shrub association occurs in patches scattered throughout the northern Colorado Plateau on a broad range of landforms, including alluvial fans, pediments, terraces, benches, mesas, rocky canyon slopes and stabilized dunes. Stands are located on level to moderately steep slopes (to 50%) between 1220 and 1780 m (4000-5840 feet) elevation. Most plots are on cooler north or east aspects, with few plots on south or west aspects. Bare ground, rocks and gravel cover most of the unvegetated surface, although biological soil crusts may cover up to 50% of the surface in sandier sites. There is little litter. Parent materials are Tidwell Member of the Morrison Formation shale eroded to form old alluvial deposits. Soils tend to be rapidly drained, shallow and alkaline, derived from shaly sandstones (or sandy shales) of the Morrison Moenkopi, Cutler and Summerville formations.

VEGETATION DESCRIPTION

Arches National Park

This sparse desert shrubland is rare within the park. Total vegetation cover is always less than 10% and often less than 5%. This shrub association is characterized by a sparse canopy of *Ephedra torreyana* short shrubs that range in cover from 1 to 5%. Other shrubs that may be present with trace cover include *Coleogyne ramosissima* and *Gutierrezia sarothrae*. The herbaceous layer is sparse and inconsistent to absent, consisting of a few tufts of grass such as *Pleuraphis jamesii*. Common forbs include desert annuals such as *Eriogonum inflatum* and *Phacelia crenulata*. Biological soil crusts provide sparse cover.

Globally

This sparse shrub association is locally common in eastern Utah. Total vegetation cover ranges from 1 to 15% but is generally less than 10%. The vegetation is dominated or codominated by a sparse canopy of *Ephedra torreyana* with between 1 and 10% cover. Associated shrubs may include *Atriplex confertifolia, Eriogonum leptocladon, Eriogonum corymbosum, Ericameria nauseosa, Gutierrezia sarothrae, Xylorhiza* spp., *Opuntia* spp., and *Coleogyne ramosissima*. The herbaceous layer may have as much cover as the shrubs but will rarely exceed a few percent and may often be nearly absent. Diversity is moderate considering the sparse nature of the community and often includes *Pleuraphis jamesii, Eriogonum inflatum, Phacelia crenulata*, and *Sphaeralcea* spp. *Achnatherum hymenoides* is absent or has only trace cover. *Bromus tectorum* may be abundant in disturbed sites.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Ephedra torreyana*

Globally

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia, Ephedra torreyana*
Herb (field)	*Eriogonum leptocladon*

OTHER NOTEWORTHY SPECIES
Arches National Park
Salsola tragus

Globally
Bromus tectorum, Salsola tragus

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (21-Mar-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
All *Ephedra torreyana* shrubland types are relatively sparse, and many have some degree of graminoid understory. This association is distinguished from others by having only *Pleuraphis jamesii* in the understory and lacking any significant cover by *Bouteloua gracilis* or *Achnatherum hymenoides*. However, there is relatively little quantitative data and no literature to support these associations; as additional data become available, it may be necessary to revisit and revise association concepts.

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Arches National Park Inventory Notes: Sites occupy south-facing slopes where drought stress is significant.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0119 and 8 observation points: ARCH.9329, ARCH.9338, ARCH.9350, ARCH.9370, ARCH.9373, ARCH.9375, ARCH.9685, ARCH.9686).
Local Description Authors: J. Coles
Global Description Authors: J. Coles

REFERENCES: Western Ecology Working Group n.d.

Leymus salinus Shale Sparse Vegetation
Salinas Lyme Grass Shale Sparse Vegetation

CODE	CEGL002745
PHYSIOGNOMIC CLASS	Sparse Vegetation (VII)
PHYSIOGNOMIC SUBCLASS	Unconsolidated material sparse vegetation (VII.C.)
PHYSIOGNOMIC GROUP	Sparsely vegetated soil slopes (VII.C.3.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural sparsely vegetated soil slopes (VII.C.3.N.)
FORMATION	Dry slopes (VII.C.3.N.b.)
ALLIANCE	*LEYMUS SALINUS* SPARSELY VEGETATED ALLIANCE (A.1258) Saline Wildrye Sparsely Vegetated Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Cliff and Canyon (CES304.779) Inter-Mountain Basins Shale Badland (CES304.789)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This generally sparse association typically occurs on cool, sparsely vegetated badland slopes of Mancos, Morrison, or other shale formations in the Colorado Plateau of southeastern Utah and western Colorado. Elevations range between 1341 and 1971 m (4400-6465 feet), and slopes tend to be north- to east-facing and moderately steep to steep (38-71% slope). The physical appearance of the community is characterized by a moderate cover of colluvial

rocks and blocks fallen from sandstone ledges above the stand. Total vegetation cover is characteristically sparse (<10%) but ranges widely, from 3 to 55% depending on aspect and slope. The tall bunchgrass *Leymus salinus* is visually dominant, with between 2 and 10% cover. Freeze-thaw, shrink-swell action, frequent rolling rocks and sheet erosion of the clay soils tend to create bare soils between the scattered bunches of *Leymus salinus* and dwarf-shrubs such as *Chrysothamnus viscidiflorus* var. *stenophyllus, Gutierrezia sarothrae,* and *Atriplex confertifolia,* which total between 1 and 5% cover.

DISTRIBUTION

Arches National Park

This association is limited in distribution but easily found in the right habitats throughout the park and environs. It was sampled on shale badlands along Delicate Arch Trail, near Winter Camp Wash, near The Highlands, in Little Valley, in Salt Valley, in Cache Valley, and along the Yellow Bird Mine Road.

Globally

This association typically occurs on cool, sparsely vegetated badland slopes of Mancos, Morrison, or other shale formations in the Colorado Plateau of southeastern Utah and western Colorado.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This sparse herbaceous vegetation association occurs on slopes of hills, ridges, escarpments, hogbacks, and canyons within the park. Sites are moderately steep to steep (38 to 71% slopes), occur between 1341 and 1537 m elevation and occupy northern aspects. The unvegetated surface has moderate to high cover of colluvial gravel and large rocks and low to moderate cover of litter. There is low to moderate exposure of bare soil. Parent materials are Chinle Formation shale and Morrison Formation shale, including the Brushy Basin, Tidwell, and Salt Wash members. Soils are rapidly drained clays, clay loams, silt loams or sandy loams.

Globally

This association typically occurs on sparsely vegetated shale slopes in the Colorado Plateau of southeastern Utah and western Colorado between 1341 and 1971 m (4400-6465 feet). Slopes tend to be moderately steep to steep (38-71%) and are generally north- to east-facing. The soil surface usually has moderate cover of colluvial rocks and blocks from sandstone ledges above the stand. Soil textures range from clays to clay loams, and the effects of shrink-swell action and sheet erosion in these soils is evident in the high percentage of bare ground. Parent materials include Chinle Formation shale and Morrison Formation shale, including the Brushy Basin, Tidwell, and Salt Wash members.

VEGETATION DESCRIPTION

Arches National Park

This Salinas lyme grass herbaceous association is uncommon in the park, occurring on shale badlands and north-facing exposures. Total vegetation cover ranges from 3 to 55% in these sparsely to moderately vegetated stands. This tall bunchgrass association is characterized by *Leymus salinus* that ranges in cover from 1 to 35%. Associated graminoids are low in species diversity, provide sparse cover and include *Bromus tectorum, Pleuraphis jamesii,* and *Poa secunda*. Forbs are high in species diversity, provide sparse cover and include *Lappula occidentalis*. The canopy tree *Juniperus osteosperma* is present as 1- to 2-m tall saplings or dwarf-trees, providing sparse cover in two stands and is present as seedlings in four stands. Short and dwarf-shrubs are commonly present, can provide sparse cover, usually 5% or less, and include *Artemisia bigelovii, Atriplex confertifolia, Chrysothamnus viscidiflorus, Ephedra torreyana, E. viridis,* and *Gutierrezia sarothrae*. Sparse to low biological soil crust cover is present, typically providing less than 15% cover.

Globally

This generally sparse herbaceous association occurs throughout the northern Colorado Plateau in its characteristic habitat of steep, northerly shale slopes. Total vegetation cover is characteristically sparse (<10%) but ranges widely, from 3 to 55% locally depending on aspect and slope, with cooler north-facing slopes tending to support denser vegetation. The tall bunchgrass *Leymus salinus* is visually dominant, with between 2 and 10% cover. Other grasses and forbs may be present, usually with less than 1% cover except in wet years. Short and dwarf-shrubs may have nearly equal cover to the grass and include species such as *Chrysothamnus viscidiflorus* var. *stenophyllus, Atriplex confertifolia, Ephedra* spp., and *Gutierrezia sarothrae*. In some stands, scattered individuals of *Juniperus osteosperma* may be present.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Artemisia bigelovii, Atriplex confertifolia, Chrysothamnus viscidiflorus, Ephedra torreyana, Ephedra viridis, Eriogonum corymbosum*
Herb (field)	*Arenaria fendleri*
Herb (field)	*Leymus salinus, Pleuraphis jamesii*

Globally

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia*
Herb (field)	*Leymus salinus*

OTHER NOTEWORTHY SPECIES
Arches National Park
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (26-Jun-2001).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Occurs on north-facing shale slopes that are often rocky. Some slopes are active and prone to gullying and landslide. One site has large rock outcrops. Some slopes are being grazed.
Arches National Park Field Data: This description is based on 2003 field data (10 plots: ARCH.0012, ARCH.0031, ARCH.0059, ARCH.0114, ARCH.0322, ARCH.0353, ARCH.0607, ARCH.0616, ARCH.0632, ARCH.0671).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Comer pers. comm., Western Ecology Working Group n.d.

Atriplex spp. Desert Pavement Sparse Vegetation
Saltbush species Desert Pavement Sparse Vegetation

CODE	CEGL003767
PHYSIOGNOMIC CLASS	Sparse Vegetation (VII)
PHYSIOGNOMIC SUBCLASS	Unconsolidated material sparse vegetation (VII.C.)
PHYSIOGNOMIC GROUP	Sparsely vegetated soil slopes (VII.C.3.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural sparsely vegetated soil slopes (VII.C.3.N.)
FORMATION	Dry slopes (VII.C.3.N.b.)
ALLIANCE	PAINTED DESERT SPARSELY VEGETATED ALLIANCE (A.2545) Painted Desert Sparsely Vegetated Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Shale Badland (CES304.789)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally

This association is known from Arches National Park but likely is widespread in the canyonlands of the Colorado Plateau in eastern Utah. Stands are restricted to flats and low hills of the Morrison Formation (Brushy Basin Member) armored by a nearly solid veneer of pebbles and small rocks polished and stained to form a desert pavement. Elevations range from 1396 to 1451 m, and slopes do not exceed 5 degrees. The silty or sandy clay soils are exposed only where drainages cross the pavement or fossorial rodents have churned it. Some sites have a hardpan only a few inches below the surface, preventing the penetration of roots and dwarfing the vegetation. The vegetation is sparse and does not exceed 5% total cover and often is as low as 1 or 2%. Stands consist of scattered shrubs of *Atriplex gardneri* or *Atriplex confertifolia* separated by broad expanses of dark, wind-polished desert pavement. Herbaceous species are variable but never exceed 1% cover. Common species include *Encelia nutans, Sphaeralcea* spp., *Calochortus nuttallii*, and *Platyschkuhria integrifolia*.

DISTRIBUTION

Arches National Park

This association is limited to exposures of the Brushy Basin Member of the Morrison Formation outside the park. It was sampled in Little Valley South and was also observed in the Yellow Cat in the environs.

Globally

This association is known from Arches National Park but likely is widespread in the canyonlands of the Colorado Plateau in eastern Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This association is restricted to flats and low hills of the Morrison Formation (Brushy Basin Member) armored by a nearly solid veneer of pebbles and small rocks polished and stained to form a desert pavement. Elevations range from 1396 to 1451 m, and slopes do not exceed 5 degrees. The silty or sandy clay soils are exposed only where drainages cross the pavement or fossorial rodents have churned it. Some sites have a hardpan only a few inches below the surface, preventing the penetration of roots and dwarfing the vegetation.

Globally

Stands are restricted to flats and low hills of the Morrison Formation (Brushy Basin Member) armored by a nearly solid veneer of pebbles and small rocks polished and stained to form a desert pavement. Elevations range from 1396 to 1451 m, and slopes do not exceed 5 degrees. The silty or sandy clay soils are exposed only where drainages cross the pavement or fossorial rodents have churned it. Some sites have a hardpan only a few inches below the surface, preventing the penetration of roots and dwarfing the vegetation.

VEGETATION DESCRIPTION

Arches National Park

This extremely sparse type is restricted to the mapping area environs. Total vegetation cover does not exceed 5% and often is as low as 1 or 2%. The vegetation consists of scattered *Atriplex gardneri* or *Atriplex confertifolia* separated by broad expanses of dark, wind-polished desert pavement. Herbaceous species are variable but never exceed 1% cover. Common species include *Encelia nutans, Sphaeralcea* spp., *Calochortus nuttallii*, and *Platyschkuhria integrifolia*.

Globally

The vegetation is sparse and does not exceed 5% total cover and often is as low as 1 or 2%. Stands consist of scattered shrubs of *Atriplex gardneri* or *Atriplex confertifolia* separated by broad expanses of dark, wind-polished desert pavement. Herbaceous species are variable but never exceed 1% cover. Common species include *Encelia nutans, Sphaeralcea* spp., *Calochortus nuttallii*, and *Platyschkuhria integrifolia*.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia, Platyschkuhria integrifolia*
Herb (field)	*Pleuraphis jamesii*

Globally

Stratum	Species

Short shrub/sapling	*Atriplex confertifolia, Platyschkuhria integrifolia*
Herb (field)	*Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES
Arches National Park
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (30-Mar-2006).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Arches National Park Inventory Notes: Rocks are uniformly stained black and somewhat polished by wind. Plants are sparse, found in slivers of soil between rocks and in openings in the pavement resulting from disturbance and/or soil movement. Well-developed pavement may protect sites from erosion, and rodents are contributing to a concentration of vegetation where they provide open soil from burrowing.
Arches National Park Field Data: The description is based on 2003 field data (5 plots: ARCH.0038, ARCH.0602, ARCH.0608, ARCH.0615, ARCH.0618).
Local Description Authors: J. Coles
Global Description Authors: K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Eriogonum corymbosum Badlands Sparse Vegetation
Crispleaf Wild Buckwheat Badlands Sparse Vegetation

CODE	CEGL002979
PHYSIOGNOMIC CLASS	Sparse Vegetation (VII)
PHYSIOGNOMIC SUBCLASS	Unconsolidated material sparse vegetation (VII.C.)
PHYSIOGNOMIC GROUP	Sparsely vegetated soil slopes (VII.C.3.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural sparsely vegetated soil slopes (VII.C.3.N.)
FORMATION	Dry slopes (VII.C.3.N.b.)
ALLIANCE	PAINTED DESERT SPARSELY VEGETATED ALLIANCE (A.2545) Painted Desert Sparsely Vegetated Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Shale Badland (CES304.789)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This unusual sparse short-shrub association occurs on barren shale badlands. Sites are flat to gentle to moderately steep, occur between 1219 and 1945 m (4000-6380 feet) elevation, and are oriented to all aspects. The unvegetated surface has high exposure of bare soil, up to 88%. Litter is sparse. Parent materials are Moenkopi, Morrison, Mancos or Chinle shales that erode to badlands deposits. Vegetation has difficulty taking hold on the highly erosive surface. Soils are rapidly drained clay loams or silty loams. Total vascular vegetation cover for this association rarely exceeds 20% and is usually closer to 10%. The vegetation is characterized by an open canopy of *Eriogonum corymbosum* that ranges in foliar cover from 5 to 20%. Associated shrubs include *Atriplex confertifolia, Ephedra torreyana, Ericameria nauseosa, Psorothamnus fremontii, Salvia dorrii, Gutierrezia sarothrae*, and *Coleogyne*

ramosissima. The herbaceous layer is low in species diversity and provides sparse cover. No species of graminoid or forb provides greater than 1% cover; *Pleuraphis jamesii* and *Elymus elymoides* are among the few herbaceous species recorded in this association.

DISTRIBUTION

Arches National Park

This association is rare and was sampled in Cache Valley, including along the Wolfe Ranch Road, within the park.

Globally

This association has been described from southern and eastern Utah.

ENVIRONMENTAL DESCRIPTION

Arches National Park

This association occurs on shale badlands and hogbacks. Stands are on steep (50°) slopes between 1348 and 1351 m elevation and tend to be oriented to north aspects. Bare ground covers up to 95% of the unvegetated surface. Soils are rapidly drained clay loams derived from Mancos shale and Brushy Basin shale (Morrison Formation).

Globally

This unusual sparse short-shrub association occurs on barren shale badlands. Sites are flat to gentle to moderately steep, occur between 1219 and 1945 m (4000-6380 feet) elevation, and are oriented to all aspects. The unvegetated surface has high exposure of bare soil, up to 88%, although some slopes have a moderate cover of colluvial boulders. Litter is sparse. Parent materials are Moenkopi, Morrison, Mancos or Chinle shales that erode to badlands deposits. Vegetation has difficulty taking hold on the highly erosive surface. Soils are rapidly drained sandy clays or silty clays.

VEGETATION DESCRIPTION

Arches National Park

This sparse shrub association is restricted to steep badland slopes in Cache Valley. Total vegetation cover ranges from 1 to 5%, consisting mostly of scattered *Eriogonum corymbosum*. Few other species are present, but the community may include trace cover of *Atriplex confertifolia, Atriplex gardneri, Ephedra torreyana, Achnatherum hymenoides,* and *Leymus salinus*.

Globally

Total vascular vegetation cover for this association rarely exceeds 20% and is often closer to 10%. The vegetation is characterized by an open canopy of *Eriogonum corymbosum* that ranges in foliar cover from 5 to 20%. Associated shrubs include *Amsonia tomentosa, Atriplex confertifolia, Ephedra torreyana, Ericameria nauseosa, Psorothamnus fremontii, Salvia dorrii, Gutierrezia sarothrae,* and *Coleogyne ramosissima*. The herbaceous layer is low in species diversity and provides sparse cover. No species of graminoid or forb provides greater than 1% cover; *Pleuraphis jamesii, Elymus elymoides,* and *Xylorhiza glabriuscula* are some of the herbaceous associates.

MOST ABUNDANT SPECIES

Arches National Park

Stratum	Species
Short shrub/sapling	*Eriogonum corymbosum*

Globally

Stratum	Species
Short shrub/sapling	*Eriogonum corymbosum*

OTHER NOTEWORTHY SPECIES

Arches National Park

Data are not available.

Globally

Bromus tectorum, Halogeton glomeratus

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Jan-2002).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Occurs as small vegetation patches on badlands with "popcorn" soil texture, often on steep slopes. Plants grow where sandstone boulders have fallen and stabilized the soils. Area is generally heavily grazed by cattle.
Arches National Park Field Data: The description is based on 2003 field data (2 plots: ARCH.0106, ARCH.0680).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles

REFERENCES: Cogan et al. 2004, Western Ecology Working Group n.d.

Zuckia brandegeei Sparse Vegetation
Siltbush Sparse Vegetation

CODE	CEGL002493
PHYSIOGNOMIC CLASS	Sparse Vegetation (VII)
PHYSIOGNOMIC SUBCLASS	Unconsolidated material sparse vegetation (VII.C.)
PHYSIOGNOMIC GROUP	Sparsely vegetated soil slopes (VII.C.3.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural sparsely vegetated soil slopes (VII.C.3.N.)
FORMATION	Dry slopes (VII.C.3.N.b.)
ALLIANCE	*ZUCKIA BRANDEGEEI* SPARSE VEGETATION ALLIANCE (A.2653) Siltbush Sparse Vegetation Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Shale Badland (CES304.789)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This sparsely vegetated association is common on plateaus at Petrified Forest National Park but occurs elsewhere on plains, alluvial fans, steep colluvial and badlands slopes or shale hogbacks in the Colorado Plateau of northern Arizona and eastern Utah. Elevation ranges from 1341-1890 m (4397-6200 feet). The soil is a rapidly drained clay loam derived from shales such as the Salt Wash Member of the Morrison Formation or Chinle, Moenkopi and Curtis formations. The unvegetated surface typically has high cover of shale chips, sandstone rocks, basalt gravel, conglomerate or petrified wood forming a desert pavement surface. Exposure of bare soil is low. The vegetation has a sparse canopy consisting of *Zuckia brandegeei* with scattered *Atriplex confertifolia* and *Gutierrezia microcephala*. The herbaceous layer is low in diversity and provides sparse cover. The bunch grasses *Leymus salinus* and *Pleuraphis jamesii* are present. Forbs include *Platyschkuhria integrifolia* and *Xylorhiza venusta*.

DISTRIBUTION
Arches National Park
This association occurs in the Cache Valley east of Delicate Arch.

Globally
This association is known from Arches, Capitol Reef and Petrified Forest national parks but likely is widespread in the painted desert and canyonlands regions of the Colorado Plateau in eastern Utah and northern Arizona.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This dwarf-shrub association occurs on shale hogbacks. The single sampled site is on a steep (44%), east-facing slope at 1341 m elevation. The unvegetated surface has high cover of shale chips and sandstone rocks. Exposure of

bare soil is low. The soil is a rapidly drained clay loam derived from the underlying Salt Wash Member of the Morrison Formation.

Globally
This sparsely vegetated association is common on plateaus at Petrified Forest National Park but occurs elsewhere on plains, alluvial fans, steep colluvial and badlands slopes or shale hogbacks in the Colorado Plateau of northern Arizona and eastern Utah. Elevation ranges from 1341-1890 m (4397-6200 feet). The soil is a rapidly drained clay loam derived from shales. Parent material include the Salt Wash Member of the Morrison Formation, or Chinle, Moenkopi and Curtis formations or mixed colluvium. The unvegetated surface typically has high cover of shale chips, sandstone rocks, basalt gravel, conglomerate or petrified wood forming a desert pavement surface.

VEGETATION DESCRIPTION
Arches National Park
This siltbush dwarf-shrub association is rare in the park occurring on one hogback. Total vegetation cover ranges from 1 to 5%, and the sparse canopy consists of *Zuckia brandegeei* with scattered *Atriplex confertifolia* and *Gutierrezia microcephala*. The herbaceous layer is low in diversity and provides sparse cover. The bunch grasses *Leymus salinus* and *Pleuraphis jamesii* are present. Forbs include *Platyschkuhria integrifolia* and *Xylorhiza venusta*.

Globally
This association has a sparse canopy consisting of *Zuckia brandegeei* with scattered *Artemisia bigelovii, Atriplex confertifolia, Atriplex obovata, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ericameria nauseosa, Eriogonum corymbosum, Eriogonum leptocladon, Ephedra torreyana, Ephedra viridis, Xylorhiza glabriuscula, Gutierrezia microcephala*, and *Gutierrezia sarothrae*. The herbaceous layer is low in diversity and provides sparse cover. The bunch grasses *Achnatherum hymenoides, Leymus salinus,* and *Pleuraphis jamesii* are present. Forbs include *Arabis holboellii, Cryptantha* sp., *Cymopterus acaulis, Eriogonum inflatum, Galium coloradoense, Penstemon barbatus, Platyschkuhria integrifolia*, and *Xylorhiza venusta*. The exotic annual grass *Bromus tectorum* may occur in some stands.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Zuckia brandegeei*

Globally

Stratum	Species
Short shrub/sapling	*Zuckia brandegeei*
Herb (field)	*Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES
Arches National Park
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (29-Mar-2005).

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Arches National Park Inventory Notes: Plot represents the butt end of a hogback. The site has a mix of Morrison

Formation shales and sandstones and a unique aspect that favors this very sparse community.
Arches National Park Field Data: The description is based on 2003 field data (1 plot*:* ARCH.0109).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Chrysothamnus viscidiflorus Shrubland Alliance
Green Rabbitbrush Shrubland Alliance

CODE	CEGL002799
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Microphyllous evergreen shrubland (III.A.4.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural microphyllous evergreen shrubland (III.A.4.N.)
FORMATION	Lowland microphyllous evergreen shrubland (III.A.4.N.a.)
ALLIANCE	*CHRYSOTHAMNUS VISCIDIFLORUS* SHRUBLAND ALLIANCE (A.2651) Green Rabbitbrush Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This alliance includes associations found in the Colorado Plateau extending east into the southern Rocky Mountains. Stands occur on a variety of sites and range from level to moderately sloping, disturbed sites on ridges and in valleys to moderately steep to steep colluvial or talus slopes. Elevations range from 1296 to 2440 m (4250-8000 feet). Substrates include eolian sands, alluvium, metamorphic rocks, granite or limestone, and the soil is likewise variable, with textures ranging from silt loam to sandy loam to loamy sand. Talus slope substrates are generally softer sedimentary rocks such as limestone and shale overlain by sandstone colluvium. Bare soil covers most of the unvegetated ground surface. The vegetation is characterized by an open to moderately dense (10-35% cover) shrub layer dominated by *Chrysothamnus viscidiflorus*. Other short shrubs that may be present and provide sparse cover include *Artemisia bigelovii, Artemisia tridentata ssp. tridentata, Artemisia tridentata ssp. wyomingensis, Atriplex canescens, Atriplex confertifolia, Eriogonum corymbosum, Ephedra viridis, Shepherdia rotundifolia, Symphoricarpos oreophilus,* and *Tetradymia canescens*. The herbaceous layer is variable and ranges from being moderately dense, diverse and bunchgrass-dominated to sparse and often depauperate herbaceous cover (talus slopes). The total vegetation cover rarely exceeds 60%. The herbaceous layer is diverse in terms of species composition. Associated graminoids include *Achnatherum hymenoides, Bouteloua gracilis, Elymus elymoides, Hesperostipa comata, Pascopyrum smithii, Poa fendleriana,* and *Poa secunda*. Forbs may be diverse but typically contribute very little cover. Disturbance-adapted species, such as the introduced annual grass *Bromus tectorum*, have become important in some stands. Disturbance appears important for most of these communities. Some stands occur on eolian substrates and others on unstable slopes where occasional rockfalls tend to maintain this association in early- to mid-seral succession; fire may also be an important factor.

DISTRIBUTION
Arches National Park
This alliance is uncommon at Arches NP and was observed and sampled in Courthouse Wash within the Park.

Globally
This shrubland alliance is currently known from Colorado and Utah in the Colorado Plateau extending east into the southern Rocky Mountains. Stands are likely more widespread in the intermountain western U.S.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This short shrubland alliance was observed on valley floors near drainages or perennial seeps. The site is flat and occurs at 1296 m. The unvegetated surface has high cover of litter and low exposure of bare soil. Downed wood is common, up to 10% cover. Parent materials are variable and include sandstones and shale that have eroded and been

deposited as new alluvium. Soils are rapidly drained and texturally are sandy loam.

Globally
This shrubland alliance includes associations found in the Colorado Plateau extending east into the southern Rocky Mountains. Stands occur on a variety of sites and range from level to moderately sloping, disturbed sites on ridges and in valleys to moderately steep to steep colluvial or talus slopes. Elevations range from 1296 to 2440 m (4250-8000 feet). Substrates include eolian sands, alluvium, metamorphic rocks, granite or limestone, and the soil is likewise variable, with textures ranging from silt loam to sandy loam to loamy sand. Talus slope substrates are generally softer sedimentary rocks such as limestone and shale overlain by sandstone colluvium. Bare soil covers most of the unvegetated ground surface.

VEGETATION DESCRIPTION
Arches National Park
This rabbitbrush community is rare and is restricted to large washes within the Park. The total vegetation cover ranges from 73% to 105% in this densely vegetated stand. This shrubland alliance is characterized by a closed canopy of *Chrysothamnus viscidiflorus* short shrubs that range in cover from 65% to 75%. The remaining tall and short shrub layers include sparse to low cover of *Artemisia tridentata* ssp. *tridentata* and the exotic *Tamarix chinensis.* A sparse canopy, from 1-2 m tall, of *Populus fremontii* saplings provides sparse cover. The herbaceous layer is low in terms of species composition and provides sparse to low cover. The common grass is the exotic annual *Bromus tectorum*. Forbs commonly present include *Castilleja linariifolia*. Cryptogams provide sparse cover.

Globally
Stands included in this shrubland alliance are characterized by an open to moderately dense (10-35% cover) shrub layer dominated by *Chrysothamnus viscidiflorus*. Other short shrubs that may be present and provide sparse cover include *Artemisia bigelovii, Artemisia tridentata ssp. tridentata, Artemisia tridentata ssp. wyomingensis, Atriplex canescens, Atriplex confertifolia, Eriogonum corymbosum, Ephedra viridis, Symphoricarpos oreophilus, Shepherdia rotundifolia,* and *Tetradymia canescens*. The herbaceous layer is variable and ranges from being moderately dense, diverse and bunchgrass-dominated to a sparse and often depauperate herbaceous cover (talus slopes). The total vegetation cover rarely exceeds 60%. The herbaceous layer is diverse in terms of species composition. Associated graminoids include *Achnatherum hymenoides, Bouteloua gracilis, Elymus elymoides, Hesperostipa comata, Pascopyrum smithii, Poa fendleriana,* and *Poa secunda*. Forbs may be diverse but typically contribute very little cover. Species include *Chenopodium leptophyllum, Castilleja linariifolia, Crepis acuminata, Cryptantha cinerea* var. *jamesii, Erigeron engelmannii, Eriogonum umbellatum, Heterotheca villosa, Leptodactylon pungens, Lupinus caudatus, Packera tridenticulata, Sedum lanceolatum, Schoenocrambe linifolia,* and *Stenotus acaulis.* Disturbance-adapted species, such as the introduced annual grass *Bromus tectorum,* have become important in some stands.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Short shrub/sapling	*Artemisia tridentata* ssp. *tridentata, Chrysothamnus viscidiflorus*
Herb (field)	*Castilleja linariifolia*

Globally

Stratum	Species
Short shrub/sapling	*Chrysothamnus viscidiflorus*

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Tamarix chinensis

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: Not applicable.

CLASSIFICATION COMMENTS
Arches National Park

Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: Not applicable

ELEMENT SOURCES
Arches National Park Inventory Notes: Site receives more shade than surrounding area and is somewhat confined by a canyon wall.
Arches National Park Plots *Field Data*: This description is based on 2003 field data (1 plot*:* ARCH.0089).
Local Description Authors: J. Von Loh
Global Description Authors: J. Coles and K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Slickrock Fin Pocket [Park Special]

CODE	Park Special
PHYSIOGNOMIC CLASS	Not Applicable
PHYSIOGNOMIC SUBCLASS	Not Applicable
PHYSIOGNOMIC GROUP	Not Applicable
PHYSIOGNOMIC SUBGROUP	Not Applicable
FORMATION	Not Applicable
ALLIANCE	Not Applicable

ECOLOGICAL SYSTEM(S): Colorado Plateau Mixed Bedrock Canyon and Tableland (CES304.765)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
Data are not available.

DISTRIBUTION
Arches National Park
This loosely defined community was sampled in Herdina Park north of Willow Springs. It has also been reported from Broken Arch, Marching Men, near Delicate Arch and Sand Dune Arch, Upper Courthouse Wash, and near Devil's Garden.

Globally
Data are not available.

ENVIRONMENTAL DESCRIPTION
Arches National Park
This woodland association occurs in narrow sandy slot canyons containing slickrock potholes. One site is on a moderate 14° slope oriented to the southwest at 1445 m elevation. Most of the unvegetated surface consists of bedrock and sand. Litter cover is low. The soils are rapidly drained sands derived from Entrada Sandstone.

Globally
Data are not available.

VEGETATION DESCRIPTION
Arches National Park
This mixed woodland community is uncommon in the mapping area and was sampled only near Willow Springs. Total vegetation cover ranges up to 65%. This woodland community is characterized by an open canopy of *Populus fremontii, Pinus edulis*, and *Juniperus osteosperma* trees that each range in cover from 1 to 5%. Seedling *Juniperus osteosperma* may be present. The shrub layer is diverse but provides sparse to low cover. Shrubs commonly present include *Fraxinus anomala, Artemisia bigelovii, Purshia stansburiana, Yucca harrimaniae, Brickellia microphylla,*

and *Gutierrezia sarothrae*. The herbaceous layer is also sparse. Graminoids commonly present include *Aristida purpurea, Distichlis spicata*, and *Schizachyrium scoparium*. Common forbs include *Grindelia* sp. and *Heterotheca villosa*. Biological soil crusts provide less than 1% cover.

Globally
Data are not available.

MOST ABUNDANT SPECIES
Arches National Park

Stratum	Species
Tree canopy	*Populus fremontii, Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Fraxinus anomala*
Short shrub/sapling	*Artemisia bigelovii, Purshia stansburiana, Yucca harrimaniae, Brickellia microphylla, Gutierrezia sarothrae*
Herb (field)	*Aristida purpurea, Distichlis spicata, Schizachyrium scoparium*
Herb (field)	*Grindelia sp., Heterotheca villosa*

Globally
Data are not available.

OTHER NOTEWORTHY SPECIES
Arches National Park
Bromus tectorum, Tragopogon dubius, Tamarix chinensis

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: Not applicable.

CLASSIFICATION COMMENTS
Arches National Park
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: Not applicable

ELEMENT SOURCES
Arches National Park Inventory Notes: The community is typical of narrow, sandy slots between sandstone fins. Slot canyon is a series of potholes and pour-offs. Site is subject to periodic floods and plants are flood-adapted.
Arches National Park Field Data: The description is based on 2003 and 2006 field data (1 plot: ARCH.0338, 2 observation points: ARCH.9008, ARCH.9655, and 9 accuracy assessment points: ARCH_AA.0286, ARCH_AA.0656, ARCH_AA.0683, ARCH_AA.0763, ARCH_AA.0980, ARCH_AA.1018, ARCH_AA.1040, ARCH_AA.1041, ARCH_AA.1042).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: N/A

REFERENCES: N/A

Bibliography for Arches National Park

Aldous, A. E., and H. L. Shantz. 1924. Types of vegetation in the semiarid portion of the United States and their economic significance. Journal of Agricultural Research 28(2):99-128.

Anderson, M. D. 2001b. Ephedra viridis. In: Fire Effects Information System [Online]. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). [Available: http://www.fs.fed.us/database/feis/] (accessed 15 October 2007).

Annable, C. R. 1985. Vegetation and flora of the Funeral Mountains, Death Valley National Monument. California-Nevada Cooperative National Park Resources Studies Unit, National Park Service/University of Nevada Contribution 016/07. Las Vegas, NV. 188 pp.

Armstrong, J. D. 1969. Vegetation of the Virgin Mountains, Clark County, Nevada. Unpublished thesis, University of Nevada, Las Vegas. 104 pp.

BIA [Bureau of Indian Affairs]. 1979. The secretarial land use plan for the addition to the Havasupai Indian Reservation. Unpublished draft Environmental Statement INT DES 79-42. Prepared by USDI Bureau of Indian Affairs, Phoenix Area Office with the assistance of Office of Arid Land Studies, University of AZ, Tucson.

Baalman, R. J. 1965. Vegetation of the Salt Plains National Wildlife Refuge, Jet, Oklahoma. Unpublished Ph.D. dissertation, University of Oklahoma, Norman.

Baker, W. L. 1980a. Alpine vegetation of the Sangre De Cristo Mountains, New Mexico: Gradient analysis and classification. Unpublished thesis, University of North Carolina, Chapel Hill. 55 pp.

Baker, W. L. 1983b. Some aspects of the presettlement vegetation of the Piceance Basin, Colorado. Great Basin Naturalist 43(4):687-699.

Baker, W. L. 1983c. Natural vegetation of part of northwestern Moffat County, Colorado. Unpublished report prepared for the State of Colorado Natural Areas Program, Department of Natural Resources, Denver by Colorado Natural Heritage Inventory, Denver.

Baker, W. L. 1984a. A preliminary classification of the natural vegetation of Colorado. Great Basin Naturalist 44(4):647-676.

Baker, W. L. 1988. Size-class structure of contiguous riparian woodlands along a Rocky Mountain river. Physical Geography 9(1):1-14.

Baker, W. L. 1989a. Macro- and micro-scale influences on riparian vegetation in western Colorado. Annals of the Association of American Geographers 79(1):65-78.

Baker, W. L. 1989b. Classification of the riparian vegetation of the montane and subalpine zones in western Colorado. Great Basin Naturalist 49(2):214-228.

Baker, W. L. 1990. Climatic and hydrologic effects on the regeneration of *Populus angustifolia* James along the Animas River, Colorado. Journal of Biogeography 17:59-73.

Baker, W. L., and S. C. Kennedy. 1985. Presettlement vegetation of part of northwestern Moffat County, Colorado, described from remnants. Great Basin Naturalist 45(4):747-777.

Barbour, M. G., and J. Major, editors. 1977. Terrestrial vegetation of California. John Wiley and Sons, NY. 1002 pp.

Barbour, M. G., and J. Major, editors. 1988. Terrestrial vegetation of California: New expanded edition. California Native Plant Society, Special Publication 9, Sacramento. 1030 pp.

Barbour, M. G., and W. D. Billings, editors. 1988. North American terrestrial vegetation. Cambridge University Press, New York. 434 pp.

Beatley, J. C. 1976. Vascular plants of the Nevada Test Site and central-southern Nevada: Ecological and geographic distributions. Technical Information Center, Energy Research and Development Administration. TID-26881. Prepared for Division of Biomedical and Environmental Research. 297 pp.

Billings, W. D. 1945. The plant associations of the Carson Desert region, western Nevada. Butler University Botanical Studies 7:89-123.

Billings, W. D. 1949. The shadscale vegetation zone of Nevada and eastern California in relation to climate and soils. The American Midland Naturalist 42(1):87-109.

Bjork, C. R. 1997. Vernal pools of the Columbia Plateau of eastern Washington. Report to the Washington Field Office of The Nature Conservancy. 29 pp. plus 7 appendices.

Blackburn, W. H., P. T. Tueller, and R. E. Eckert, Jr. 1968c. Vegetation and soils of the Duckwater Watershed. Nevada Agricultural Experiment Station Bulletin R-40. Reno. 76 pp.

Blackburn, W. H., R. E. Eckert, Jr., and P. T. Tueller. 1969e. Vegetation and soils of the Crane Springs Watershed. Nevada Agricultural Experiment Station Bulletin R-55. Reno. 63 pp.

Blaisdell, J. P., and R. C. Holmgren. 1984. Managing intermountain rangelands-salt-desert shrub ranges. General Technical Report INT-163. USDA Forest Service, Intermountain Forest and Range Experiment Station,

Ogden, UT. 52 pp.
Bourgeron, P.S., and L.D. Engelking, editors. 1994. A preliminary vegetation classification of the western United States. Unpublished report. The Nature Conservancy, Western Heritage Task Force, Boulder, CO. 175 pp. + app.
Bowns, J. E., and N. E. West. 1976. Blackbrush (*Coleogyne ramosissima* Torr.) on southwestern Utah rangelands. Utah Agricultural Experiment Station Research Report 27. Logan, UT. 27 pp.
Bradley, A. F., N. V. Noste, and W. C. Fischer. 1992. Fire ecology of forests and woodlands in Utah. USDA Forest Service, Intermountain Research Station. General Technical Report INT-287. Ogden, UT. 128 pp.
Bradley, W. G. 1964. The vegetation of the desert game range with special reference to the desert bighorn. Pages 43-67 in: Transcripts of the Desert Bighorn Council. Las Vegas, NV.
Branson, F. A. 1966. Geographic distribution and factors affecting the distribution of salt desert shrubs in the U.S. Pages 13-43 in Proceedings from the Salt Desert Shrub Symposium, 1-4 August 1966. USDI Bureau of Land Management, Cedar City, Utah.
Branson, F. A., R. F. Miller, and I. S. McQueen. 1967. Geographic distribution and factors affecting the distribution of salt desert shrubs in the United States. Journal of Range Management 29(5):287-296.
Branson, F. A., R. F. Miller, and I. S. McQueen. 1976. Moisture relationships in twelve northern desert shrub communities near Grand Junction, Colorado. Ecology 57:1104-1124.
Branson, F. A., and J. B. Owen. 1970. Plant cover, runoff, and sediment yield relationships on Mancos shale in western Colorado. Water Resources Research 6:783-790.
Britton, C. M., and H. A. Wright. 1983. Brush management with fire. Pages 61-68 in: K. C. McDaniel, editor. Proceedings--brush management symposium: 1983 February 16; Albuquerque, NM. Society for Range Management, Denver, CO.
Brotherson, J. D., L. L. Rasmussen, and R. D. Black. 1986. Comparative habitat and community relationships of *Atriplex confertifolia* and *Sarcobatus vermiculatus* in central Utah. Great Basin Naturalist 46(2):348-357.
Brotherson, J. D., and S. J. Barnes. 1984. Habitat relationships of *Glaux maritima* in central Utah. Great Basin Naturalist 44(2):299-309.
Brown, D. E., editor. 1982. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.
Bundy, R.M., J.V. Baumgartner, M.S. Reid, P.S. Bourgeron, H.C. Humphries, and B.L. Donohue. 1996. Ecological classification of wetland plant associations in the Lahontan Valley, Nevada. Prepared for Stillwater National Wildlife Refuge and USDI Fish & Wildlife Service. 53 pp. not including inventories, tables and graphs.
Butler, J., D. Crawford, S. Menard, and T. Meyer. 2002. Lacreek National Wildlife Refuge, South Dakota. USGS-USFWS Vegetation Mapping Program. Final report. Technical Memorandum 8260-02-02, Remote Sensing and GIS Group, Technical Service Center, Bureau of Reclamation, Denver, CO.
CONHP [Colorado Natural Heritage Program]. 2003. List of Elements and Elcodes converted and entered into Biotics Tracker 4.0. Colorado Natural Heritage Program, Colorado State University, Ft. Collins, CO.
Cable, D. R. 1967. Fire effects on semidesert grasses and shrubs. Journal of Range Management 20:170-176.
Cable, D. R. 1969. Competition in the semidesert grass-shrub type as influenced by root systems, growth habits, and soil moisture extraction. Ecology 50:27-38.
Cable, D. R. 1975. Influence of precipitation on perennial grass production in the semidesert southwest. Ecology 56:981-986.
Callison, J., Jr., J. D. Brotherson, and J. E. Bowns. 1985. The effects of fire on the blackbrush (*Coleogyne ramosissima*) community of southwestern Utah. Journal of Range Management 38(6):535-538.
Campbell, V. O. 1977. Certain edaphic and biotic factors affecting vegetation in the shadscale community of the Kaiparowitz area. Unpublished thesis, Brigham Young University, Provo, UT. 59 pp.
Cannon, H. L. 1960. The development of botanical methods of prospecting for uranium on the Colorado Plateau. USDI Geological Survey Bulletin 1085-A. Washington, DC. 50 pp.
Carsey, K., G. Kittel, K. Decker, D. J. Cooper, and D. Culver. 2003a. Field guide to the wetland and riparian plant associations of Colorado. Colorado Natural Heritage Program, Fort Collins, CO.
Christensen, E. M. 1955. Ecological notes on the mountain brush in Utah. Proceedings of the Utah Academy of Science, Arts, and Letters 32:107-111.
Christy, S. 1973. An analysis of the woody vegetation on the South Platte River flood plain in northeastern Colorado. Unpublished thesis, University of Northern Colorado, Greeley. 82 pp.
Cogan, D., M. Reid, K. Schulz, and M. Pucherelli. 2004. Zion National Park, Utah 1999-2003. Vegetation Mapping Project. Technical Memorandum 8260-03-01. Remote Sensing and GIS Group Technical Service Center,

Bureau of Reclamation, Denver, CO. Appendix F: Vegetation Association Descriptions for Zion.
Cole, N. K. 1995. Cover type map and vegetation classification of the Hagerman study area, southwestern Idaho. Technical appendix E.3.3-A for new license application: Upper Salmon Falls (FERC No. 2777), Lower Salmon Falls (FERC # 2061), Bliss (FERC # 1975). Vol. 4. Idaho Power Company, Boise. 61 pp. plus apps.
Cole, N. K. 1996. Cover type map and vegetation classification of the Shoshone Falls study area, southwestern Idaho. Technical appendix E.3.3-A for new license application: Shoshone Falls (FERC No. 2778), Volume 2. Idaho Power Company, Boise ID. 38 pp. plus appendices.
Coles, Janet. Personal communication. Ecologist/Project Manager, NatureServe, Boulder, CO.
Collins, E. I. 1984. Preliminary classification of Wyoming plant communities. Unpublished classification prepared for the Wyoming Natural Heritage Program, The Nature Conservancy, Laramie, WY.
Colorado Natural Heritage Program Ecology Team. 2001. A classification of the native vegetation of Colorado. Colorado Natural Heritage Program, Colorado State University, Fort Collins.
Comer, P. J., M. S. Reid, R. J. Rondeau, A. Black, J. Stevens, J. Bell, M. Menefee, and D. Cogan. 2002. A working classification of terrestrial ecological systems in the Northern Colorado Plateau: Analysis of their relation to the National Vegetation Classification System and application to mapping. NatureServe. Report to the National Park Service. 23 pp. plus appendices.
Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
Comer, Pat. Personal communication. Regional Ecologist. NatureServe, Western Resource Office, Boulder, CO.
Cooper, D. J. 1986b. Community structure and classification of Rocky Mountain wetland ecosystems. Pages 66-147 in: J. T. Windell, et al. An ecological characterization of Rocky Mountain montane and subalpine wetlands. USDI Fish & Wildlife Service Biological Report 86(11). 298 pp.
Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Biological Service Program. FWS/OBS-79/31. Washington, DC. 103 pp.
Cronquist, A., N. H. Holmgren, and P. K. Holmgren. 1997. Intermountain flora: Vascular plants of the Intermountain West, USA. Vol. 3, Part A, subclass Rosidae (except Fabeles). New York Botanical Garden, Bronx, NY. 446 pp.
Crowe, E. A., and R. R. Clausnitzer. 1997. Mid-montane wetland plant associations of the Malheur, Umatilla, and Wallowa-Whitman national forests. USDA Forest Service, Pacific Northwest Region. Technical Paper R6-NR-ECOL-TP-22-97.
Culver, D. R., M. A. March, S. M. Kettler, and C. A. Pague. 1996. Natural Heritage Inventory of significant animals and plants and classification of riparian plant Associations Timpas Grazing District and Kim Grazing Association. Report prepared for USDA Forest Service, Pike-San Isabel National Forest, La Junta, CO, by Colorado Natural Heritage Program, Fort Collins.
Dastrup, B. C. 1963. Vegetational changes of the Uinta Basin since settlement. Unpublished thesis, Brigham Young University, Provo, UT. 118 pp.
Daubenmire, R. 1952. Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. Ecological Monographs 22(4):301-330.
Daubenmire, R. 1975. Floristic plant geography of eastern Washington and northern Idaho. Journal of Biogeography 2:1-18.
Daubenmire, R. F. 1970. Steppe vegetation of Washington. Washington State University Agricultural Experiment Station Technical Bulletin No. 62. 131 pp.
DeVelice, R. L., and P. Lesica. 1993. Plant community classification for vegetation on BLM lands, Pryor Mountains, Carbon County, Montana. Unpublished report by Montana Natural Heritage Program, Helena, MT. 78 pp.
Diamond, D. D. 1993. Classification of the plant communities of Texas (series level). Unpublished document. Texas Natural Heritage Program, Austin. 25 pp.
Dick-Peddie, W. A. 1986. Draft manuscript for book on vegetation of New Mexico to be published by University of New Mexico Press.
Dick-Peddie, W. A. 1993. New Mexico vegetation: Past, present, and future. University of New Mexico Press, Albuquerque. 244 pp.
Dodd, J. D., and R. T. Coupland. 1966. Vegetation of saline areas in Saskatchewan. Ecology 47(6):958-968.
Donart, G. B., D. Sylvester, and W. Hickey. 1978a. A vegetation classification system for New Mexico, USA. Pages

488-490 in: Rangeland Congress, Denver, CO, 14-18 August 1978. Society for Range Management, Denver.
Donnelly, P., D. Lindsey, E. Muldavin, Y. Chauvin, and A. Browder. 2006. Vegetation communities of Bosque del Apache National Wildlife Refuge. Prepared by U.S. Fish and Wildlife Service, National Wildlife Refuge Remote Sensing Lab, Albuquerque, NM, and Natural Heritage New Mexico, University of New Mexico, Albuquerque. Final report submitted to U.S. Fish and Wildlife Service, Southwest Region (R2), National Wildlife Refuge System (NWR), NWR Remote Sensing Lab, Division of Planning. 27 pp. [http://www.fws.gov/data/documents/BDA%20NVCS%20Veg%20Community%20Report%20Example.pdf]
Donovan, L. A., J. H. Richards, and M. W. Muller. 1996. Water relations and leaf chemistry of Chrysothamnus nauseosus ssp. consimilis (Asteraceae) and Sarcobatus vermiculatus (Chenopodiaceae). American Journal of Botany 83(12):1637-1646.
Dorn, R. D. 1995. A taxonomic study of *Salix* section *Cordatae* subsection *Luteae* (Salicaceae). Brittonia 47(2):160-174.
Dorn, R. D. 1997. Rocky Mountain region willow identification field guide. Renewable Resources R2-RR-97-01. USDA Forest Service, Rocky Mountain Region, Denver, CO. 107 pp.
Driscoll, R. S., D. L. Merkel, D. L. Radloff, D. E. Snyder, and J. S. Hagihara. 1984. An ecological land classification framework for the United States. USDA Forest Service. Miscellaneous Pub. #1439. Washington, DC. 56 pp.
Durkin, P., E. Muldavin, M. Bradley, S. E. Carr, A. Metcalf, R. A. Smartt, S. P. Platania, C. Black, and P. Mehlhop. 1995b. The biodiversity of the Ladder Ranch. Unpublished final report prepared by The Nature Conservancy, New Mexico Field Office, Santa Fe, NM, and the New Mexico Natural Heritage Program, University of New Mexico, Department of Biology, Albuquerque, NM.
Englund, S. R. 2004. Bromus tectorum impacts soil carbon storage in semiarid grasslands of Canyonlands National Park. M.S. thesis, University of Utah, Salt Lake City.
Erdman, J. A. 1962. Ecology of the pinyon-juniper woodland of Wetherill Mesa, Mesa Verde National Park, Colorado. Unpublished thesis, University of Colorado, Boulder. 109 pp.
Erdman, J. A. 1969. Pinyon-juniper succession after fires on residual soils of the Mesa Verde, Colorado. Unpublished dissertation, University of Colorado, Boulder. 81 pp.
Evans, R. D., R. Rimer, L. Sperry, and J. Belnap. 2001. Exotic plant invasion alters nitrogen dynamics in an arid grassland. Ecological Applications 11(5):1301-1310.
Evenden, Angela. Personal communication. Northern Colorado Plateau Network Vegetation Program Manager, Canyon Country Research Learning Center, Moab, UT.
Eyre, F. H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.
FEIS [Fire Effects Information System] 1996. Prescribed fire and fire effects research work unit, Rocky Mountain Research Station (producer). [www.fs.fed.us/database/feis/] (accessed 1998 March 12)
FEIS [Fire Effects Information System]. 1998. USDA Forest Service. URL http://www.fs.fed.us/database/feis/.
FEIS [Fire Effects Information System]. 2001. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2001, May). http://www.fs.fed.us/database/feis/. Accessed [07-20-01].
Faber-Langendoen, D., J. Drake, G. Jones, D. Lenz, P. Lesica, and S. Rolfsmeier. 1997. Rare plant communities of the northern Great Plains. Report to Nebraska National Forest, The Nature Conservancy. 155 pp.
Faden, A. O. 1977. Vegetation zonation of a Mohave Desert playa. Unpublished thesis, Univ.of NV, Las Vegas.
Fowler, J. F. 1995. Biogeography of hanging gardens on the Colorado Plateau. Ph.D. dissertation, University of Wyoming, Laramie, WY. 209 pp plus abstract, appendices.
Francis, R. E. 1986. Phyto-edaphic communities of the Upper Rio Puerco Watershed, New Mexico. USDA Forest Service, RM Forest and Range Experiment Station. Research Paper RM-272. Ft Collins, CO. 73 pp.
Francis, R. E., and E. F. Aldon. 1983. Preliminary habitat types of a semiarid grassland. Pages 62-66 in: W. H. Moir and L. Hendzel, technical coordinators. Proceedings of the workshop on southwestern habitat types, 6-8 April 1983, Albuquerque, NM. USDA Forest Service, Southwestern Region, Albuquerque, NM.
Ganskopp, D. C. 1986. Tolerances of sagebrush, rabbitbrush, and greasewood to elevated water tables. Journal of Range Management 39(4): 334-337.
Gates, D. H., L. A. Stoddart, and C. W. Cook. 1956. Soil as a factor influencing plant distribution on salt-deserts of Utah. Ecological Monographs 26(2):155-175.
Gleason, H. A., and A. Cronquist. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. New York Botanical Garden, Bronx, NY. 910 pp.
Goodrich, S., and E. Neese. 1986. Uinta Basin flora. Cooperative Project of Ashley National Forest and USDI

Bureau of Land Management, Vernal District. USDA Forest Service, Intermountain Region, Ogden, UT. 320 pp.
Graham, E. H. 1937. Botanical studies in the Uinta Basin of Utah and Colorado. Annals of the Carnegie Museum 26:28-432.
Graybosch, R. A., and H. Buchanan. 1983. Vegetative types and endemic plants of the Bryce Canyon Breaks. Great Basin Naturalist 43:701-712.
Great Plains Flora Association. 1986. Flora of the Great Plains. University Press of Kansas, Lawrence. 1402 pp.
Griffiths, D. 1902. Forage conditions in the northern border of the Great Basin. USBureau of Plant Industry Bull 15.
Groeneveld, D. P., and D. E. Crowley. 1988. Root system response to flooding in three desert shrub species. Functional Ecology 2:491-497.
Hall, J. B., and P. L. Hansen. 1997. A preliminary riparian habitat type classification system for the Bureau of Land Management districts in southern and eastern Idaho. Riparian and Wetland Research Program, School of Forestry, University of Montana. Idaho Bureau of Land Management, Technical Bulletin No. 97-11. 381 pp.
Hansen, M., J. Coles, K. A. Thomas, D. Cogan, M. Reid, J. Von Loh, and K. Schulz. 2004b. USGS-NPS Vegetation Mapping Program: Wupatki National Monument, Arizona, vegetation classification and distribution. U.S. Geological Survey Technical Report. Southwest Biological Science Center, Flagstaff, AZ.
Hansen, P. L., R. D. Pfister, K. Boggs, B. J. Cook, J. Joy, and D. K. Hinckley. 1995. Classification and management of Montana's riparian and wetland sites. Montana Forest and Conservation Experiment Station, School of Forestry, University of Montana, Miscellaneous Publication No. 54. 646 pp. + posters.
Hansen, P. L., and J. B. Hall. 2002. Classification and management of the USDI Bureau of Land Management's riparian and wetland sites in eastern and southern Idaho. Unpublished draft prepared for the Upper Snake River District, Bureau of Land Management, by Bitterroot Restoration, Inc., Corvallis, MT.
Hansen, P., K. Boggs, and R. Pfister. 1991. Classification and management of riparian and wetland sites in Montana. Unpublished draft version prepared for Montana Riparian Association, Montana Forest and Conservation Experiment Station, School of Forestry, University of Montana, Missoula. 478 pp.
Hanson, H. C. 1929. Range resources of the San Luis Valley. Pages 5-61 in: Range resources of the San Luis Valley. Bulletin 335. Colorado Experiment Station, Fort Collins, CO.
Harper, K. T., and R. A. Jaynes. 1986. Some edaphic and compositional characteristics of *Artemisia tridentata* and associated plant communities in southeastern Utah. Pages 265-272 in: E. D. McArthur and B. L. Welch, compilers. Proceedings-Symposium on the Biology of *Artemisia* and *Chrysothamnus*, 9-13 July, Provo, UT. USDA Forest Service, General Technical Report INT-200. Intermountain Research Station, Ogden, UT.
Helm, D. J. 1981. Vegetation diversity indexes in several vegetation types of western Colorado. Unpublished dissertation, Colorado State University, Fort Collins. 113 pp.
Hess, K., and C. H. Wasser. 1982. Grassland, shrubland, and forest habitat types of the White River-Arapaho National Forest. Unpublished final report 53-82 FT-1-19. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 335 pp.
Hironaka, M., M. A. Fosberg, and A. H. Winward. 1983. Sagebrush-grass habitat types of southern Idaho. Forestry, Wildlife, and Range Experiment Station Bulletin No. 15, University of Idaho, Moscow. 44 pp.
Hoagland, B. 2000. The vegetation of Oklahoma: A classification for landscape mapping and conservation planning. The Southwestern Naturalist 45(4):385-420.
Holland, R. F. 1986b. Preliminary descriptions of the terrestrial natural communities of California. Unpublished report prepared for the California Department of Fish and Game, Nongame-Heritage Program and Natural Diversity Database, Sacramento. 156 pp.
Holland, V. L., and D. J. Keil. 1995. California vegetation. Kendall/Hunt Publishing Co., Dubuque, IA. 516 pp.
Howard, J. L. 2003. Atriplex canescens. In: Fire Effects Information System [Online]. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). [Available: <http://www.fs.fed.us/database/feis/>] (accessed 13 July 2007).
IDCDC [Idaho Conservation Data Center]. 2002. Unpublished riparian and wetland association occurrence and plot data on file at the Idaho Conservation Data Center, Idaho Department of Fish and Game, Boise, ID.
IDCDC [Idaho Conservation Data Center]. 2005. Wetland and riparian plant associations in Idaho. Idaho Conservation Data Center, Idaho Department of Fish and Game, Boise. [http://fishandgame.idaho.gov/tech/CDC/ecology/wetland_riparian_assoc.cfm] (accessed 14 June 2005).
Ibrahim, K. M., N. E. West, and D. L. Goodwin. 1972. Phytosociological characteristics of perennial *Atriplex*-dominated vegetation of southeastern Utah. Vegetatio 24:13-22.
Isaacson, H. E. 1967. Ecological provinces within the pinyon-juniper type of the Great Basin and Colorado Plateau.

Unpublished thesis, Utah State University, Logan. 44 pp.
Jankovsky-Jones, M., C. J. Murphy, and C. L. Coulter. 2001. Riparian and wetland plant associations of southwestern Idaho in the Lower Snake River District, Bureau of Land Management. Idaho Conservation Data Center, Idaho Department of Fish and Game, Boise.
Johnston, B. C. 1987. Plant associations of Region Two: Potential plant communities of Wyoming, South Dakota, Nebraska, Colorado, and Kansas. R2-ECOL-87-2. USDA Forest Service, Rocky Mountain Region. Lakewood, CO. 429 pp.
Johnston, B. C., and L. Hendzel. 1985. Examples of aspen treatment, succession and management in western Colorado. USDA Forest Service, Range Wildlife Fisheries and Ecology. Denver, CO. 164 pp.
Jones, G. 1992b. Wyoming plant community classification. WY Natural Diversity Database, Laramie. 183 pp.
Jones, G. P., and G. M. Walford. 1995. Major riparian vegetation types of eastern Wyoming. Submitted to Wyoming Department of Environmental Quality, Water Quality Division. Wyoming Natural Diversity Database, Laramie, WY. 245 pp.
Kagan, J. S., J. A. Christy, M. P. Murray, and J. A. Titus. 2000. Classification of native vegetation of Oregon. Oregon Natural Heritage Program, Portland. 63 pp.
Kagan, J. S., J. A. Christy, M. P. Murray, and J. A. Titus. 2004. Classification of native vegetation of Oregon. January 2004. Oregon Natural Heritage Information Center, Portland. 52 pp.
Karl, M. G., R. K. Heitschmidt, and M. R. Haferkamp. 1999. Vegetation biomass dynamics and patterns of sexual reproduction in a northern mixed-grass prairie. The American Midland Naturalist 141:227-237.
Kartesz, J. T. 1999. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. First edition. In: J. T. Kartesz and C. A. Meacham. Synthesis of the North American Flora, Version 1.0. North Carolina Botanical Garden, Chapel Hill, NC.
Kennedy, K. L. 1983a. A habitat-type classification for the pinyon-juniper woodlands of the Lincoln National Forest. Unpublished thesis, New Mexico State University, Las Cruces. 87 pp.
Kittel, G. M., and N. D. Lederer. 1993. A preliminary classification of the riparian vegetation of the Yampa and San Miguel/Dolores river basins. Unpublished report prepared for Colorado Department of Health and the Environmental Protection Agency by The Nature Conservancy, Colorado Field Office, Boulder.
Kittel, G., E. Van Wie, M. Damm, R. Rondeau, S. Kettler, A. McMullen, and J. Sanderson. 1999b. A classification of riparian and wetland plant associations of Colorado: A user's guide to the classification project. Colorado Natural Heritage Program, Colorado State University, Fort Collins CO. 70 pp. plus appendices.
Kittel, G., E. Van Wie, M. Damm, R. Rondeau, S. Kettler, and J. Sanderson. 1999a. A classification of the riparian plant associations of the Rio Grande and Closed Basin watersheds, Colorado. Unpublished report prepared by the Colorado Natural Heritage Program, Colorado State University, Fort Collins.
Kittel, G., R. Rondeau, N. Lederer, and D. Randolph. 1994. A classification of the riparian vegetation of the White and Colorado River basins, Colorado. Final report submitted to Colorado Department of Natural Resources and the Environmental Protection Agency. Colorado Natural Heritage Program, Boulder. 166 pp.
Kittel, G., R. Rondeau, and A. McMullen. 1996. A classification of the riparian vegetation of the Lower South Platte and parts of the Upper Arkansas River basins, Colorado. Submitted to Colorado Department of Natural Resources and the EPA, Region VIII. Prepared by Colorado Natural Heritage Program, Fort Collins. 243 pp.
Kittel, G., R. Rondeau, and S. Kettler. 1995. A classification of the riparian vegetation of the Gunnison River Basin, Colorado. Submitted to Colorado Department of Natural Resources and the Environmental Protection Agency. Prepared by Colorado Natural Heritage Program, Fort Collins. 114 pp.
Kleiner, E. F. 1968. Comparative study of grasslands of Canyonlands National Park. Unpublished dissertation, University of Utah, Salt Lake City. 58 pp.
Kleiner, E. F. 1983. Successional trends in an ungrazed, arid grassland over a decade. Journal of Range Management 36(1):114-118.
Kleiner, E. F., and K. T. Harper. 1972. Environment and community organization in grasslands of Canyonlands National Park. Ecology 53(2):299-309.
Kleiner, E. F., and K. T. Harper. 1977. Occurrence of four major perennial grasses in relation to edaphic factors in a pristine community. Journal of Range Management 30(4):286-289.
Knight, D.H. 1994. Mountains & plains: Ecology of Wyoming landscapes. Yale Univ.Press, New Haven. 338 pp.
Knight, D. H., G. P. Jones, Y. Akashi, and R. W. Myers. 1987. Vegetation ecology in the Bighorn Canyon National Recreation Area. Unpublished report prepared for the USDI National Park Service and University of Wyoming-National Park Service Research.
Kovalchik, B. L. 1987. Riparian zone associations - Deschutes, Ochoco, Fremont, and Winema national forests.

USDA Forest Service Technical Paper 279-87. Pacific Northwest Region, Portland, OR. 171 pp.
Kovalchik, B. L. 1992. Riparian zone associations on the national forests of eastern Washington. USDA Forest Service, Pacific Northwest Region. Draft. 203 pp.
Kunzler, L. M., K. T. Harper, and D. B. Kunzler. 1981. Compositional similarity within the oakbrush type in central and northern Utah. Great Basin Naturalist 41(1):147-153.
Kunzler, L. M., and K. T. Harper. 1980. Recovery of Gambel oak after fire in central Utah. Great Basin Naturalist 40:127-130.
LaMarche, V. C., Jr., and H. A. Mooney. 1972. Recent climatic change and development of the bristlecone pine (*P. longaeva* (Bailey)) krummholz zone, Mount Washington, Nevada. Arctic and Alpine Research 4(1):61-72.
Larson, G. E. 1993. Aquatic and wetland vascular plants of the northern Great Plains. USDA Forest Service General Technical Report RM-238. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 681 pp.
Larson, M., and W. H. Moir. 1987. Forest and woodland habitat types of northern New Mexico and northern Arizona. Edition 2. USDA Forest Service, Southwestern Region, Albuquerque, NM.
Lauver, C. L., K. Kindscher, D. Faber-Langendoen, and R. Schneider. 1999. A classification of the natural vegetation of Kansas. The Southwestern Naturalist 44:421-443.
Lesica, P., and R. L. DeVelice. 1992. Plant communities of the Pryor Mountains. Preliminary report prepared by the Montana Natural Heritage Program, Helena, MT.
Lindauer, I. E. 1970. The vegetation of the flood plain of the Arkansas River in southeastern Colorado. Unpublished dissertation, Colorado State University, Fort Collins. 92 pp.
Loope, W. L., and N. E. West. 1979. Vegetation in relation to environments of Canyonlands National Park. Pages 195-199 in: R. M. Linn, editor. Proceedings of the 1st Conference of Scientific Resources in the National Parks, Vol. I. Nov. 9-13, 1976, New Orleans. National Park Service Transactions and Proceedings Series 5.
Lusby, G. C., G. T. Turner, J. R. Thompson, and V. H. Reid. 1963. Hydrologic and biotic characteristics of grazed and ungrazed watersheds of the Badger Wash Basin in western Colorado, 1953-1958. U.S. Geological Survey Water-Supply Paper 1532-B.
MTNHP [Montana Natural Heritage Program]. 1988. Draft guide to the natural vegetation of Montana. Montana Natural Heritage Program, Helena. 389 pp.
MTNHP [Montana Natural Heritage Program]. 2002b. List of ecological communities for Montana. Montana Natural Heritage Program, Montana State Library, Helena, MT.
MTNHP [Montana Natural Heritage Program]. No date. Unpublished data on file. Helena, MT.
MacKenzie, W. H., and J. R. Moran. 2004. Wetlands of British Columbia: A guide to identification. Land Management Handbook #52. Province of British Columbia, Research Branch, Ministry of Forests & Lands, Victoria. 287 pp.
Malanson, G. P. 1980. Habitat and plant distributions in hanging gardens of the Narrows, Zion National Park, Utah. Great Basin Naturalist 40(2):178-182.
Malanson, G. P. 1982. The assembly of hanging gardens: Effects of age, area, and location. The American Naturalist 119:145-150.
Malanson, G. P., and J. Kay. 1980. Flood frequency and the assemblage of dispersal types in hanging gardens of the Narrows, Zion National Park, Utah. Great Basin Naturalist 40(2):365-371.
Manning, M. E., and W. G. Padgett. 1995. Riparian community type classification for Humboldt and Toiyabe national forests, Nevada and eastern California. USDA Forest Service, Intermountain Region. 306 pp.
Marr, J. W., D. Buckner, and C. Mutel. 1973a. Ecological analyses of potential shale oil products pipeline corridors in Colorado and Utah. Unpublished report prepared for Colony Development Operation, Atlantic Richfield Company, Denver, by Thorne Ecological Institute and University of Colorado, Boulder. 96 pp. plus apps.
Marr, J. W., R. Fritz, J. Meyer, and P. Murphy. 1979. Final report-terrestrial plant ecology-stand ecosystem data tables, Juniper/Cross Mountain Project. Report prepared for Colorado River Water Conservation District, Glenwood Springs, CO, by University of Colorado, Boulder. 47 pp.
Marriott, Hollis J. Personal communication. Former Heritage Botanist, WYNDD, and former Public Lands Coordinator, The Nature Conservancy. 655 N. Cedar, Laramie, WY 82070. (307) 721-4909.
Mast, J. N., T. T. Veblen, and M. E. Hodgson. 1997. Tree invasion within a pine/grassland ecotone: An approach with historic aerial photography and GIS modeling. Forest Ecology and Management 93:181-94.
Mast, J. N., T. T. Veblen, and Y. B. Linhart. 1998. Disturbance and climatic influences on age structure of ponderosa pine at the pine/grassland ecotone, Colorado Front Range. Journal of Biogeography 25:743-755.
McClaran, M. P., and T. R. Van Devender. 1995. The desert grassland. University of Arizona Press, Tucson. 346 pp.
McKell, C. M. 1950. A study of plant succession in the oak brush (*Quercus gambelii*) zone after fire. Unpublished

thesis, University of Utah, Salt Lake City. 79 pp.
Medina, A. L. 1986. Riparian plant communities of the Fort Bayard watershed in southwestern New Mexico. Southwestern Naturalist 31(3):345-359.
Midwestern Ecology Working Group of NatureServe. No date. International Ecological Classification Standard: International Vegetation Classification. Terrestrial Vegetation. NatureServe, Minneapolis, MN.
Milton, N. M., and T. L. Purdy. 1983. Plant and soil relationships in two hydrothermally altered areas of the Great Basin. Great Basin Naturalist 43(3):457-469.
Mitchell, J. E., N. E. West, and R. W. Miller. 1966. Soil physical properties in relation to plant community patterns in the shadscale zone of northwestern Utah. Ecology 47(4):627-630.
Moir, W. H. 1963. Vegetational analysis of three southern New Mexico mountain ranges. Unpublished thesis, New Mexico State University, Las Cruces. 77 pp.
Moir, W. H., and J. A. Ludwig. 1979. A classification of spruce-fir and mixed conifer habitat types of Arizona and New Mexico. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Research Paper RM-207. Fort Collins, CO. 47 pp.
Moir, W. H., and J. O. Carleton. 1987. Classification of pinyon-juniper (P-J) sites on national forests in the Southwest. Pages 216-226 in: R. L. Everett, editor. Proceedings of the Pinyon-Juniper Conference, Reno, NV, 13-16 January 1986. USDA Forest Service, Intermountain Forest and Range Experiment Station. General Technical Report. Ogden, UT. 581 pp.
Muldavin, E., B. Sims, and L. Johnson. 1993b. Pecos Wild and Scenic River in stream flow report. Final Report prepared for the USDA National Forest Service, Santa Fe National Forest, Santa Fe, NM.
Muldavin, E., G. Harper, P. Neville, and Y. Chauvin. 1998b. The vegetation of White Sands Missile Range, New Mexico. Volume II. Vegetation map. Final report for Cooperative Agreement No. 14-16-00-91-233 White Sands Missile Range, USFWS. The Nature Conservancy and the University of New Mexico.
Muldavin, E., P. Durkin, M. Bradley, M. Stuever, and P. Mehlhop. 2000a. Handbook of wetland vegetation communities of New Mexico: Classification and community descriptions (volume 1). Final report to the New Mexico Environment Department and the Environmental Protection Agency prepared by the New Mexico Natural Heritage Program, University of New Mexico, Albuquerque, NM.
Muldavin, E., Y. Chauvin, and G. Harper. 2000b. Vegetation of White Sands Missile Range, New Mexico: Volume I. Handbook of vegetation communities. Final Report to White Sands Missile Range by New Mexico Natural Heritage Program, University of New Mexico, New Mexico. 192 pp.
NDNHI [North Dakota Natural Heritage Inventory]. No date. Vegetation classification of North Dakota. North Dakota Natural Heritage Inventory, North Dakota Parks & Recreation Department, Bismarck.
NMNHP [New Mexico Natural Heritage Program]. No date. Unpublished data on file. Albuquerque, NM.
Nachlinger, J. L., and G. A. Reese. 1996. Plant community classification of the Spring Mountains National Recreation Area, Clark and Nye counties, Nevada. Unpublished report submitted to USDA Forest Service, Humboldt-Toiyabe National Forest, Spring Mountains National Recreation Area, Las Vegas, NV. The Nature Conservancy, Northern Nevada Office, Reno, NV. 85 pp. plus figures and appendices.
Nachlinger, J., K. Sochi, P. Comer, G. Kittel, and D. Dorfman. 2001. Great Basin: An ecoregion-based conservation blueprint. The Nature Conservancy, Reno, NV. 160 pp. plus appendices.
Naumann, Tamara. Personal communication. Botanist, National Park Service, Dinosaur National Monument, CO.
Neely, B., P. Comer, C. Moritz, M. Lammerts, R. Rondeau, C. Prague, G. Bell, H. Copeland, J. Jumke, S. Spakeman, T. Schulz, D. Theobald, and L. Valutis. 2001. Southern Rocky Mountains: An ecoregional assessment and conservation blueprint. Prepared by The Nature Conservancy with support form the U.S. Forest Service, Rocky Mountain Region, Colorado Division of Wildlife, and Bureau of Land Management.
Nichol, A. A. 1937. The natural vegetation of Arizona. University of Arizona Agricultural Experiment Station Technical Bulletin 68:177-222.
Northcutt, B. E. 1978. The plant ecology of Butler Wash, southeastern Utah. Unpublished thesis, University of Colorado, Boulder. 118 pp.
ORNHP [Oregon Natural Heritage Program]. No date. Unpublished data files. Oregon Natural Heritage Program, The Nature Conservancy, Portland, OR.
Ortenberger, A. I., and R. D. Bird. 1933. The ecology of the western Oklahoma salt plains. Publications of the University of Oklahoma Biological Survey 5:49-64.
Ostler, W. K., D. J. Hansen, D. C. Anderson, and D. B. Hall. 2000. Classification of Vegetation on the Nevada Test Site. U.S. Dept. of Energy, DOE/NV/11718-477. Bechtel Nevada Ecological Services, Las Vegas. 102 pp.
Padgett, W. G. 1981. Ecology of riparian plant communities in southern Malheur National Forest. M.S. thesis.

Oregon State University, Corvallis. 143 pp.
Padgett, W. G., A. P. Youngblood, and A. H. Winward. 1988b. Riparian community type classification of Utah. USDA Forest Service, Intermountain Region Publication R4-ECOL-88-01. Ogden, UT.
Padgett, W. G., A. P. Youngblood, and A. H. Winward. 1989. Riparian community type classification of Utah and southeastern Idaho. USDA Forest Service, IM Region. Report R4-ECOL-89-01. Ogden, UT. 191 pp.
Pase, C. P., and A. W. Lindenmuth, Jr. 1971. Effects of prescribed fire on vegetation and sediment in oak-mountain mahogany chaparral. Journal of Forestry 69:800-805.
Paysen, T. E., J. A. Derby, H. Blake, Jr., V. C. Bleich, and J. W. Mincks. 1980. A vegetation classification system applied to southern California. USDA Forest Service General Technical Report PSW-45. USDA Forest Service, Pacific Southwest Research Station, Berkeley, CA.
Peterson, P. M. 1984. Flora and physiognomy of the Cottonwood Mountains, Death Valley National Monument, California. University of Nevada Cooperative National Park Resources Studies Unit Report CPSU/UNLV 022/06. Las Vegas, NV.
Potter, L. D., R. C. Reynolds, Jr., and E. T. Louderbough. 1985. Mancos shale and plant community relationships: Analysis of shale, soil, and vegetation transects. Journal of Arid Environments 9:147-165.
Price, K. P., and J. D. Brotherson. 1987. Habitat and community relationships of cliffrose (*Cowania mexicana* var. *stansburiana*) in central Utah. Great Basin Naturalist 47(1):132-151.
Ream, R. D. 1960. An ordination of the oak communities of the Wasatch Mountains. M.S. thesis, University of Utah, Salt Lake City. 52 pp.
Ream, R. R. 1964. The vegetation of the Wasatch Mountains, Utah and Idaho. Unpublished Ph.D. dissertation, University of Wisconsin, Madison. 190 pp.
Redente, E. F., J. E. Friedlander, and T. McLendon. 1992. Response of early and late semiarid seral species to nitrogen and phosphorus gradients. Plant and Soil 140(1):127-135.
Reid, M. S., K. A. Schulz, P. J. Comer, M. H. Schindel, D. R. Culver, D. A. Sarr, and M. C. Damm. 1999. An alliance level classification of vegetation of the coterminous western United States. Unpublished final report to the University of Idaho Cooperative Fish and Wildlife Research Unit and National Gap Analysis Program, in fulfillment of Cooperative Agreement 1434-HQ-97-AG-01779. The Nature Conservancy, Western Conservation Science Department, Boulder, CO.
Richard, C., G. Kittel, and S. Kettler. 1996. A classification of the riparian vegetation of the San Juan National Forest. Draft 1 report. Colorado Natural Heritage Program, Colorado State University, Fort Collins.
Romme, W. H., K. D. Heil, J. M. Porter, and R. Fleming. 1993. Plant communities of Capitol Reef National Park, Utah. USDI National Park Service, Technical Report NPS/NAUCARE/NRTER-93/02. Cooperative Park Studies Unit, Northern Arizona University. 37 pp.
Rondeau, R. 2001. Ecological system viability specifications for Southern Rocky Mountain ecoregion. First Edition. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO. 181 pp.
Rosgen, D. 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, CO.
Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.
Schultz, L. M., E. E. Neely, and J. S. Tuhy. 1987. Flora of the Orange Cliffs of Utah. Great Basin Naturalist 47:287-298.
Shantz, H. L. 1925. Plant communities in Utah and Nevada. Pages 15-23 in: I. Tidestrom. Flora of Utah and Nevada. Contributions of the U.S. National Herbarium 25, Washington, DC.
Shantz, H. L., and R. L. Piemeisel. 1940. Types of vegetation in Escalante Valley, Utah, as indicators of soil conditions. USDA Technical Bulletin 713. U.S. Department of Agriculture, Washington, DC. 46 pp.
Shaw, R. B., S. L. Anderson, K. A. Schultz, and V. E. Diersing. 1989. Plant communities, ecological checklist, and species list for the U.S. Army Pinon Canyon Maneuver Site, Colorado. Colorado State University, Department of Range Science, Science Series No. 37, Fort Collins. 71 pp.
Shepperd, W. D. 1990. Initial growth, development, and clonal dynamics of regenerated aspen in the Rocky Mountains. USDA Forest Service Research Paper RM-312. RM Forest and Range Experiment Station, Fort Collins, CO. 8 pp.
Shields, L. M., W. H. Rickard, and F. Drouet. 1959. A botanical study of nuclear effects at the Nevada Test Site. 1958 Annual Report, New Mexico Highlands University, to U.S. Atomic Energy Commission.
Shiflet, T. N., editor. 1994. Rangeland cover types of the United States. Soc.for Range Mgmt. Denver, CO. 152 pp.
Shute, D., and N. E. West. 1978. The application of ECOSYM vegetation classifications to rangelands near Price, Utah. Appendix reports 14 and 16 in: J. A. Henderson, L. S. Davis, and E. M. Ryberg, editors. ECOSYM: A

classification and information system for wildland resource management. Utah State University, Logan. 53 pp.
Singh, T., and N. E. West. 1971. Comparison of some multivariate analyses of perennial *Atriplex* vegetation in southeastern Utah. Vegetatio 23(5-6):289-313.
Smith, T. L. 1989. An overview of old-growth forests in Pennsylvania. Natural Areas Journal 9:40-44.
Soil Conservation Service. 1978. Range site descriptions for Colorado. Technical Guide, Section II-E. USDA Soil Conservation Service, Colorado State Office, Denver.
Soil Conservation Service. No date. Range site descriptions of vegetation in Colorado. Unpublished report series MLRA dating from 1975 to 1989. Soil Conservation Service, Colorado Field Office, Denver.
Spence, J. Personal communication. Botanist, National Park Service, Glen Canyon National Recreation Area, UT.
Stevens, R. L., and C. W. Shannon. 1917. Plant life in Oklahoma. In: C. W. Shannon, editor. Animal and plant life of Oklahoma. Oklahoma Geological Survey, Norman.
Steward, L. H. 1982. Desert grassland communities on Otero Mesa, Otero County, New Mexico. Unpublished thesis, New Mexico State University, Las Cruces.
Stewart, G., W. P. Cottam, and S. S. Hutchings. 1940. Influence of unrestricted grazing on northern salt desert plant associations in western Utah. Journal of Agricultural Research 60(5):289-317.
Stuever, M. C., and J. S. Hayden. 1997a. Plant associations of Arizona and New Mexico. Edition 3. Volume 2: Woodlands. USDA Forest Service, Southwestern Region, Habitat Typing Guides. 196 pp.
Szaro, R. C. 1989. Riparian forest and scrubland community types of Arizona and New Mexico. Desert Plants Special Issue 9(3-4):70-139.
Terwilliger, C., Jr., K. Hess, and C. H. Wasser. 1979b. The habitat types of Region II. USDA Forest Service: A preliminary list and description. Unpublished initial progress report for Habitat Type Classification, Region 2, USDA Forest Service.
Terwilliger, C., K. Hess, and C. Wasser. 1979a. Key to the preliminary habitat types of Region 2. Addendum to initial progress report for habitat type classification. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO.
Thatcher, A. P. 1975. The amount of blackbrush in the natural plant community is largely controlled by edaphic conditions. Pages 155-156 in: Proceedings Wildland Shrubs: Symposium and workshop. USDA Forest Service, Provo, UT.
Thilenius, J. F., G. R. Brown, and A. L. Medina. 1995. Vegetation on semi-arid rangelands, Cheyenne River Basin, Wyoming. USDA Forest Service. General Technical Report RM-GTR-263. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 60 pp.
Thompson, W.H., and P.L. Hansen. 2002. Classification and management of riparian and wetland sites of Alberta's Grasslands Natural Region and adjacent subregions. Bitterroot Restoration, Inc., Lethbridge. 416 pp.
Thorne Ecological Institute. 1973a. Environmental setting of the Parachute Creek Valley: An ecological inventory. Unpublished report prepared for Colony Development Operations, Atlantic Richfield Company, by Thorne Ecological Institute, Boulder, CO. [Veg.: pages 36-40, map].
Tuhy, J. S., and J. A. MacMahon. 1988. Vegetation and relict communities of Glen Canyon National Recreation Area. Unpublished final report prepared for USDI National Park Service, Rocky Mountain Region, Lakewood, CO. Utah State University, Logan. 299 pp.
Tuhy, J. S., and S. Jensen. 1982. Riparian classification for the Upper Salmon and Middle Fork Salmon River drainages, Idaho. Unpublished report prepared for the USDA Forest Service, Intermountain Region by White Horse Associates, Smithfield, UT. 183 pp.
Tuhy, J., P. Comer, D. Dorfman, M. Lammert, B. Neely, L. Whitham, S. Silbert, G. Bell, J. Humke, B. Baker, and B. Cholvin. 2002. An ecoregional assessment of the Colorado Plateau. The Nature Conservancy, Moab Project Office. 112 pp. plus maps and appendices.
U.S. Bureau of Reclamation. 1976. Flora and terrestrial vertebrate studies of the Grand Valley, Colorado. Pp. 56-85 and 283-354 in: Final report to the U.S. Bureau of Reclamation by Ecology Consultants, Inc., Fort Collins, CO.
USFS [U.S. Forest Service]. 1937. Range plant handbook. Dover Publications Inc., New York. 816 pp.
USFS [U.S. Forest Service]. 1981a. TES-7, South La Luz grazing allotment. Unpublished report prepared for USDA Forest Service, Southwestern Region, Albuquerque, NM. Various pages, appendices and maps.
USFS [U.S. Forest Service]. 1981b. TES-2, Cuba Ranger District. Unpublished report prepared for USDA Forest Service, Southwestern Region, Albuquerque, NM. Various pages, appendices, and maps.
USFS [U.S. Forest Service]. 1982. TES-9, Heber Ranger District. Unpublished report prepared for USDA Forest Service, Southwestern Region, Albuquerque, NM. Various pages, appendices and maps.
USFS [U.S. Forest Service]. 1983a. TES-4, Coyote Ranger District. Unpublished report prepared for USDA Forest

Service, Southwestern Region, Albuquerque, NM. Various pages, appendices and maps.
USFS [U.S. Forest Service]. 1985c. TES-1, Terrestrial ecosystem survey handbook, appendix B. Unpublished report prepared for USDA Forest Service, SW, Albuquerque, NM. Various pages, appendices and maps.
USFS [U.S. Forest Service]. 1985d. Woodland and forest plant associations (habitat types) south of the Mogollon Rim, Arizona. Unpublished training materials. USDA Forest Service, SW Region, Albuquerque, NM.
USFS [U.S. Forest Service]. 1985e. TES-3, western part Rio Arriba County. Unpublished report prepared for USDA Forest Service, Southwestern Region, Albuquerque, NM. Various pages, appendices and maps.
USFS [U.S. Forest Service]. 1985g. Key to woodland plant associations and plant communities, Lincoln National Forest. Unpublished materials. USDA Forest Service, Southwestern Region, Albuquerque, NM.
Ungar, I. A. 1965. An ecological study of the vegetation of the Big Salt Marsh, Stafford County, Kansas. University of Kansas Science Bulletin 116(1):1-99.
Ungar, I. A. 1968. Species-soil relationships on the Great Salt Plains of northern Oklahoma. The American Midland Naturalist 80(2):392-407.
Ungar, I. A. 1972. The vegetation of inland saline marshes of North America, north of Mexico. Pages 397-411.
Utah Environmental and Agricultural Consultants. 1973. Pages 2-38 in: Environmental setting, impact, mitigation and recommendations for a proposed oil products pipeline between Lisbon Valley, Utah and Parachute Creek, Colorado. Unpublished report for Colony Development Operation, Atlantic Richfield Company, Denver, CO.
Vest, E. D. 1962a. Biotic communities in the Great Salt Lake Desert. Institute of Environmental Biological Research, Ecology and Epizoology Series 73. Division of Biological Science, University of Utah. 122 pp.
Von Loh, J. 2000. Draft local descriptions of the vegetation associations of Ouray National Wildlife Refuge. USGS Bureau of Reclamation, Remote Sensing and GIS Group, Denver Federal Center, Denver.
Von Loh, J., D. Cogan, D. Faber-Langendoen, D. Crawford, and M. Pucherelli. 1999. USGS-NPS Vegetation Mapping Program, Badlands National Park, South Dakota. USDI Bureau of Reclamation. Technical Memorandum No. 8260-99-02. Denver, CO.
Von Loh, J., D. Cogan, K. Schulz, D. Crawford, T. Meyer, J. Pennell, and M. Pucherelli. 2002. USGS-USFWS Vegetation Mapping Program, Ouray National Wildlife Refuge, Utah. USDI Bureau of Reclamation, Remote Sensing and GIS Group, Technical Memorandum 8260-02-03. Denver Federal Center, Denver, CO.
Vories, K. C. 1974. A vegetation inventory and analysis of the Piceance Basin and adjacent drainages. Unpublished thesis. Western State College of Colorado, Gunnison. 243 pp.
Walford, G. M. 1996. Statewide classification of riparian and wetland dominance types and plant communities - Bighorn Basin segment. Report submitted to the Wyoming Department of Environmental Quality, Land Quality Division by the Wyoming Natural Diversity Database. 185 pp.
Walford, G., G. Jones, W. Fertig, S. Mellman-Brown, and K. Houston. 2001. Riparian and wetland plant community types of the Shoshone National Forest. General Technical Report RMRS-GTR-85. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO. 122 pp.
Walford, G., G. Jones, W. Fertig, and K. Houston. 1997. Riparian and wetland plant community types of the Shoshone National Forest. Unpublished report. Wyoming Natural Diversity Database for The Nature Conservancy, and the USDA Forest Service. Wyoming Natural Diversity Database, Laramie. 227 pp.
Ware, G. H., and W. T. Penfound. 1949. The vegetation of the lower levels of the floodplain of the south Canadian River in central Oklahoma. Ecology 30:478-484.
Warren, A. No date. Range site descriptions in Divide Resource Area. Unpublished report prepared for USDI Bureau of Land Management, Great Divide Resource Area, Rawlins, WY.
Warren, P. L., K. L. Reichhardt, D. A. Mouat, B. T. Brown, and R. R. Johnson. 1982. Vegetation of Grand Canyon National Park. Cooperative National Park Resources Studies Unit Technical Report 9. Tucson, AZ. 140 pp.
Weaver, J. E., and F. W. Albertson. 1956. Grasslands of the Great Plains: Their nature and use. Johnsen Publishing Co., Lincoln, NE. 395 pp.
Wells, P. V. 1960. Physiognomic intergradation of vegetation on the Pine Valley Mountains in southwestern Utah. Ecology 41:553-556.
Welsh, S. L. 1957. An ecological survey of the vegetation of the Dinosaur National Monument, Utah. Unpublished thesis, Brigham Young University, Provo, UT. 86 pp.
Welsh, S. L. 1979. Endangered and threatened plants of Utah: A case study. Great Basin Naturalist Memoirs 3:64-80.
Welsh, S. L. 1989. On the distribution of Utah's hanging gardens. Great Basin Naturalist 49(1):1-30.
Welsh, S. L., N. D. Atwood, S. Goodrich, and L. C. Higgins, editors. 1987. A Utah flora. Great Basin Naturalist Memoirs 9. Provo, UT. 894 pp.

Welsh, S. L., N. D. Atwood, S. Goodrich, and L. C. Higgins, editors. 2003. A Utah flora. Third edition revised. Brigham Young University Press, Provo, UT. 912 pp.

Welsh, S. L., and C. A. Toft. 1981. Biotic communities of hanging gardens in southeastern Utah. National Geographic Society Research Reports 13:663-681.

Welsh, S. L., and L. M. Chatterly. 1985. Utah's rare plants. Great Basin Naturalist 45(2):173-236.

West, N. E. 1979. Survival patterns of major perennials in salt desert shrub communities of southwestern Utah. Journal of Range Management 32(6):442-445.

West, N. E. 1982. Approaches to synecological characterization of wildlands in the Intermountain West. Pages 633-643 in: In-place resource inventories: Principles & practices. A national workshop, University of Maine, Orono. Society of American Foresters, McClean, VA. August 9-14, 1981.

West, N.E. 1983a. Great Basin-Colorado Plateau sagebrush semi-desert. Pages 331-349 in: N.E. West, editor. Temperate deserts and semi-deserts. Ecosystems of the world, Vol. 5. Elsevier Publishing Co., Amsterdam.

West, N. E. 1983b. Intermountain salt desert shrublands. Pages 375-397 in: N. E. West, editor. Temperate deserts and semi-deserts. Ecosystems of the world, Vol. 5. Elsevier Publishing Company, Amsterdam.

West, N.E. 1983d. Colorado Plateau-Mohavian blackbrush semi-desert. Pages 399-412 in: N.E. West, editor. Temperate deserts and semi-deserts. Ecosystems of the world, Volume 5. Elsevier Publishing Co., Amsterdam.

West, N. E. 1983e. Southeastern Utah galleta-threeawn shrub steppe. Pages 413-421 in: N. E. West, editor. Temperate deserts and semi-deserts. Ecosystems of the World, Vol.5. Elsevier Publishing Co., Amsterdam.

West, N. E., R. J. Tausch, and P. T. Tueller. 1998. A management-oriented classification of pinyon-juniper woodlands of the Great Basin. USDA Forest Service General Technical Report RMRS-GTR-12. USDA Forest Service, Rocky Mountain Research Station, Ogden, UT. 42 pp.

West, N. E., R. T. Moore, K. A. Valentine, L. W. Law, P. R. Ogden, F. C. Pinkney, P. T. Tueller, and A. A. Beetle. 1972. Galleta: Taxonomy, ecology and management of *Hilaria jamesii* on western rangelands. Utah Agricultural Experiment Station. Bulletin 487. Logan, UT. 38 pp.

West, N. E., and K. I. Ibrahim. 1968. Soil-vegetation relationships in the shadscale zone of southeastern Utah. Ecology 49(3):445-456.

Western Ecology Working Group of NatureServe. No date. International Ecological Classification Standard: International Vegetation Classification. Terrestrial Vegetation. NatureServe, Boulder, CO.

Wright, H. A. 1980. The role and use of fire in the semi-desert grass-shrub type. USDA Forest Service General Technical Report INT-85. Intermountain Forest and Range Experiment Station, Ogden, UT. 23 pp.

Wright, H. A., L. F. Neuenschwander, and C. M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities: A state of the art review. USDA Forest Service General Technical Report INT-58. Intermountain Forest and Range Experiment Station. Ogden, UT.

Young, J. A., R. A. Evans, B. A. Roundy, and J. A. Brown. 1986. Dynamic landforms and plant communities in a pluvial lake basin. Great Basin Naturalist 46(1):1-21.

Young, J. A., and R. A. Evans. 1973. Downy brome-intruder in the plant succession of big sagebrush communities in the Great Basin. Journal of Range Management 26:410-415.

Young, J. A., and R. A. Evans. 1978. Population dynamics after wildfires in sagebrush grasslands. Journal of Range Management 31:283-289.

Youngblood, A. P., W. G. Padgett, and A. H. Winward. 1985a. Riparian community type classification of eastern Idaho-western Wyoming. USDA Forest Service, Intermountain Region. R4-Ecol-85-01. Ogden, UT. 78 pp.

Zimmerman, T. 1978. Skull Creek Study Area Forestry. Unpublished report. USDI Bureau of Land Management, Craig District Office, Craig, CO. 62 pp.

Appendix G

Illustrated Keys to the Plant Associations of Arches National Park

The vegetation of Arches National Park was characterized from field data collected between 2003 and 2006 under the U.S. Geological Survey - National Park Service Vegetation Mapping Program. This key was developed to assist in the accurate field identification of the 75 plant associations, alliances, and park specials described for the Park. The keys are illustrated with images taken during the vegetation sampling and accuracy assessment efforts. Five associations were added to the key and the classification following accuracy assessment:

- *Artemisia tridentata - (Ericameria nauseosa) / Bromus tectorum* Semi-natural Shrubland
- *Juniperus osteosperma / Artemisia tridentata* ssp. *tridentata* Woodland
- *Populus fremontii / Artemisia tridentata* Woodland
- *Sphaeralcea (coccinea, parvifolia)* Herbaceous Vegetation
- *Typha (latifolia, angustifolia)* Western Herbaceous Vegetation

This key is structured to facilitate identification of plant associations using one or more dominant or characteristic species in concert with habitat information. Because of natural variation within plant associations, it is possible that a community can be keyed using more than one of the physiognomic keys. Ecotonal communities (areas where dominant species from several associations mix) may be difficult to key. This guide also allows the user to crosswalk plant associations directly to the Arches National Park vegetation map so that all subsequent research may have a common focal point relative to the baseline years of aerial photography (2001 to 2002) and field data collection (2003 to 2006).

HOW TO USE THE KEY

The key approaches plant association identification at two levels. The first level is physiognomic, allowing the user to determine which major group is being evaluated, e.g., forest, woodland, shrubland or herbaceous. The second level is based on dominant species (sometimes expressed in the key as “characterized by”) and to a lesser extent, habitat and distribution. As an aid to field workers, photographs representing typical situations appear below the association names.

When using this key, you may have difficulty arriving at an association that precisely describes your community. There are several possible reasons for this and each has a solution:

1. You are observing vegetation that you think is an herbaceous or shrubland community, but it has some tree cover. In this case, try keying the vegetation through the woodland key as well as the herbaceous or shrubland key. In general with any layer, if it does not cover at least 8% (tree layer) or 5% (shrub or herbaceous layers), it is ignored. The exception is in very sparse communities (see 4 below)

2. The diagnostic layer consists of woody plants that may appear in either a shrub or a tree form, depending on site conditions and age. These species include *Pinus edulis,*

Juniperus osteosperma, Cercocarpus ledifolius, Quercus gambelii, Fraxinus anomala, and *Tamarix chinensis*. In this key, the first three are ALWAYS considered to be evergreen trees, regardless of their height or growth form, and the rest are considered shrubs, regardless of their height or growth form.

3. You can follow a key to a certain point, but you clearly have something not described in the key. This is to be expected occasionally—very likely you have an association that was not found during the sampling phases of the project.

4. Communities that are sparsely vegetated (e.g., < 10% or 15% total vascular plant cover) should be run through multiple keys. Even though they contain trees or shrubs, they may not fall cleanly into a "woodland "or "shrubland" category. "Sparse" vegetation is defined as having total vascular plant cover of < 10%.

5. Focus on the perennial species in the community, unless the community consists almost entirely of annuals or ephemerals or is highly disturbed or degraded.

Key I: Major Physiognomic Groups

1a Most canopy cover provided by woody plants or plants that appear to be woody: trees, shrubs, or shrub-like herbs **(2)**

1b Most canopy cover provided by non-woody or herbaceous plants: grasses, grass-like herbs (graminoids), and broad-leaf herbs (forbs), that may be tall and coarse. Shrubs may have a few percent cover as long as herbaceous species are clearly dominant; total vegetation cover may range from sparse to dense. Characteristic genera include *Achnatherum*, *Aquilegia*, *Bromus*, *Hesperostipa*, *Leymus*, *Mimulus*, *Pleuraphis*, *Schoenoplectus*, *Sporobolus*, and *Typha* - **Key IV**





2a (1) Forest (predominantly interlocking tree canopies) or woodland (predominantly open, non-interlocking tree canopies) communities; characteristic dominant genera include *Elaeagnus*, *Juniperus*, *Pinus*, *Populus*, *Quercus*, and *Salix* - **Key II**





2b Vegetation dominated by shrub, dwarf shrub, or shrub-like herbs; canopies may interlock, but are more commonly less dense and may be extremely sparse on badland or desert pavement substrates. Characteristic genera include *Allenrolfea*, *Amelanchier*, *Atriplex*, *Artemisia*, *Chrysothamnus*, *Coleogyne*, *Ephedra*, *Ericameria*, *Eriogonum*, *Fendlera*, *Fraxinus*, *Grayia*, *Juniperus*,

Krascheninnikovia, Picrothamnus, Purshia, Poliomintha, Quercus, Rhus, Salix, Sarcobatus, Tamarix, and *Zuckia* - **Key III**





Key II: Forest and Woodland Vegetation

Note: If you have a community with a sparse tree canopy (5 to 8%) and a denser shrub understory, please also try the shrubland vegetation key (Key III)

1a Deciduous woodlands, forests or tall shrublands of streamside or riparian habitats, the canopy dominated by the genera *Elaeagnus*, *Populus*, *Quercus*, *Tamarix* and/or *Salix* trees. Evergreen trees may be present as scattered individuals and the understory is variable **(13)**

1b Upland woodlands and wooded shrublands, usually with an open canopy, the trees sometimes dwarfed, dominated by evergreen *Juniperus osteosperma* with or without *Pinus edulis.* If community is sheltered among Entrada sandstone fins, go to couplet 10 **(2)**

2a (from couplet 1) Sparse woodlands occurring on valley or mesa sides or hogbacks where the substrate consists of narrow ledges or shale slopes covered by coarse colluvium. Total vegetation cover is limited by the amount of rock cover. The shrub layer is diverse. Tree cover is often between 5 and 10% **(3)** (Note: If the total tree cover is 5% or less, please also try **Key III)**

2b Sparse to moderately dense woodlands on relatively level sites on slickrock or in deeper soils, but not in situations where much of the ground surface is covered by colluvial rocks **(4)**

3a (2) Woodlands or wooded shrublands on ledgy or colluvial slopes with an open canopy consisting almost entirely of *Juniperus osteosperma.* The shrub layer is variable, but typical species include *Artemisia bigelovii, Coleogyne ramosissima, Ericameria nauseosa, Ephedra torreyana, Ephedra viridis, Gutierrezia sarothrae,* and *Rhus trilobata;* usually several of these shrubs will be co-dominant - ***Juniperus osteosperma* / Mixed Shrubs Talus Woodland (Utah Juniper / Mixed Shrubs Talus Woodland) [Map Class 30]**





3b Woodlands or wooded shrublands on ledgy or colluvial slopes with a canopy consisting of *Juniperus osteosperma* with nearly equal cover by *Pinus edulis.* The shrub layer is variable, but typical species include *Artemisia bigelovii, Chrysothamnus viscidiflorus* or *Ephedra viridis;* usually several of these shrubs will be co-dominant - ***Pinus edulis* - *Juniperus osteosperma* / Mixed Shrubs Talus Woodland (Pinyon pine – Utah Juniper / Mixed Shrubs Talus Woodland) [Map Class 30]**



4a (2) A very rare woodland type dominated by *Juniperus osteosperma* and occurring on deeper sandy soils or slickrock, where the tree canopy cover is 10% or greater, shrub cover is less than 5%, herbaceous cover is less than 1%, and biological soil crust cover is typically over 10% - ***Juniperus osteosperma* / Sparse Understory Woodland (Utah Juniper / Sparse Understory Woodland) [Stands on dunes or sandsheets = Map Class 25; Stands on slickrock outcrops with large potholes = Map Class 32]**



4b Woodlands or wooded shrublands with more than 5% cover by understory shrub species. In some cases, the understory cover is less than 5%, but in these cases the total vegetation cover is 15% or less because of a lack of rooting sites for woody vegetation in slickrock habitats **(5)**

5a (4) Woodlands or wooded shrublands on fractured Salt Wash, Moab Tongue, Entrada, Kayenta or Navajo sandstone slickrock, where the woody vegetation density is limited by the degree of bedrock fracturing. Shrubs and herbaceous vegetation tend to occupy "pools" of sand or pockets of soil that collect in bedrock depressions and joints. A good deal of sandstone is usually exposed **(6)**

5b Woodlands of deep sandy soils on eolian plains, at the base of sandstone cliffs or monoliths, canyon bottoms, dry washes, or in the slots between sandstone fins. Exposed sandstone is near-vertical and does not provide habitat for vascular plant species **(9)**

6a (5) Woodlands with a mixed shrub understory dominated by *Quercus havardii* var. *tuckeri, Purshia stansburiana,* and/or *Coleogyne ramosissima*; *Amelanchier utahensis* and species of *Cercocarpus* are a minor component or are absent **(7)**

6b Sparse to moderately dense woodlands growing in the joints of fractured slickrock, with a mixed shrub understory dominated or co-dominated by species of *Cercocarpus* **(12)**

7a (6) Woodlands with an open canopy of *Juniperus osteosperma* (*Pinus edulis* is sometimes co-dominant) and an understory dominated by *Coleogyne ramosissima.* Soils are deep relative to the other associations in this part of the key, and the cover of *Coleogyne* may be higher than that of *Pinus edulis* or *Juniperus osteosperma. Quercus havardii* and *Purshia stansburiana* are absent or have no more than two percent cover and few other shrubs are present other than *Fraxinus anomala, Ephedra viridis, Gutierrezia sarothrae,* and *Yucca* spp. Tree cover may be as low as 5% but trees are always regularly scattered throughout area. If trees are present but they contribute a very low percentage of the total vascular cover [e.g., tree cover is less than 2% and *Coleogyne ramosissima* cover exceeds 20%), please go to couplet 37 of Key III - ***Juniperus osteosperma* / *Coleogyne ramosissima* Woodland (Utah Juniper / Blackbrush Woodland) [Map Class 20].** Stands with approximately equal cover by *Pinus edulis* and *Juniperus osteosperma* are assigned to ***Pinus edulis* - *Juniperus osteosperma* / *Coleogyne ramosissima* Woodland (Pinyon Pine -Utah Juniper / Blackbrush Woodland) [Stands on deeper soils = Map Class 20; Stands on fractured/ledgy slickrock alternating with deeper soils = Map Class 33]**





7b Woodlands with a mixed shrub understory dominated by a combination of *Quercus havardii* var. *tuckeri, Purshia stansburiana* and/or *Coleogyne ramosissima*. *Cercocarpus* species may be present in trace amounts **(8)**

8a (7) Woodlands with an open canopy of *Juniperus osteosperma* (*Pinus edulis* is sometimes co-dominant) and a scattered mixed shrub understory dominated by *Purshia stansburiana*. The substrate is often fractured slickrock of the Moab Tongue or the Salt Wash member of the Morrison Formation; *Quercus havardii* and *Coleogyne ramosissima* are absent or have no more than trace cover. Other shrubs are generally present and may include *Amelanchier utahensis, Cercocarpus intricatus, Ephedra viridis, Fraxinus anomala* and *Artemisia bigelovii*. Tree cover may be as low as 5% but is always scattered throughout area - ***Juniperus osteosperma / Purshia stansburiana* Woodland (Utah Juniper / Stansbury Cliffrose Woodland) [Map Class 33].** Stands in which *Pinus* edulis has approximately equal cover with *Juniperus osteosperma* are assigned to ***Pinus edulis - Juniperus osteosperma / Purshia stansburiana* Woodland (Pinyon Pine – Utah Juniper**

/ Stansbury Cliffrose Woodland) [Stands on jointed Moab Tongue slickrock = Map Class 31; Stands on fractured/ledgy slickrock alternating with deeper soils = Map Class 33]





8b Woodlands dominated by *Juniperus osteosperma* (*Pinus edulis* may sometimes be present), occurring where slickrock exposures make up 20-80% of the total ground cover and where soil has developed in pockets or on thin lenses or shelves. *Coleogyne ramosissima* and *Purshia stansburiana* are often roughly co-dominant and *Quercus havardii* var. *tuckeri* may or may not be present to co-dominant - ***Juniperus osteosperma* - (*Pinus edulis*) / *Coleogyne ramosissima* - *Purshia stansburiana* - *Quercus havardii* var. *tuckeri* Wooded Shrubland (Utah Juniper – (Pinyon Pine) / Blackbrush – Stansbury Cliffrose – Tucker Sand Shinnery Oak Wooded Shrubland) [Stands in intermittent washes = Map Class 7; Stands on dunes or sandsheets = Map Class 25; Stands on jointed Moab Tongue slickrock = Map Class 31; Stands on large potholed slickrock = Map Class 32; Stands on fractured/ledgy slickrock alternating with deeper soils = Map Class 33]**





9a (5) Narrow bands of large *Juniperus osteosperma* (sometimes with equally large *Pinus edulis*) that form a ring around the base of sandstone cliffs or monoliths, and are supported by runoff from slickrock expanses above. The understory is dominated by *Artemisia tridentata* ssp. *tridentata*. Other shrubs are generally present and may include *Atriplex canescens, Rhus trilobata, Fraxinus anomala, Mahonia fremontii* and *Quercus* spp. Biological soil crust cover is often high, and these stands are subject to invasion by the exotic *Bromus tectorum* – ***Juniperus osteosperma* / *Artemisia tridentata* ssp. *tridentata* Woodland (Utah Juniper / Basin Big Sagebrush Woodland) [Map Class 7]**





9b Woodlands of deep sandy soils, either on eolian plains, on narrow canyon floors, or in the slots between sandstone fins **(10)**

10a (9) Woodlands or tall shrublands that are a diverse mix of mesic and upland trees, tall shrubs, grasses, and forbs occurring in narrow, sandy slots between Entrada sandstone fins; *Populus fremontii* may be present - **Slickrock Fin Pocket [Map Class 341]**





10b Woodlands on deep, sandy soils on sandsheets, valley floors or canyon bottoms. The shrub layer is generally mixed, but includes species of *Quercus* as understory dominants **(11)**

11a (10) Woodlands in areas of deep soils on sandsheets, between fins, or on valley floors, with an understory dominated by *Quercus havardii* var. *tuckeri*. *Purshia stansburiana, Coleogyne ramosissima* and *Cercocarpus* spp. are absent or have no more than trace cover. Other shrubs are generally present and may include *Amelanchier utahensis, Ephedra viridis, Fraxinus anomala* and *Vanclevea stylosa* - ***Pinus edulis* - *Juniperus osteosperma* / *Quercus havardii* var. *tuckeri* Woodland (Pinyon Pine – Utah Juniper / Tucker Sand Shinnery Oak Woodland) [Stands on intermittent washes = Map Class 7; Stands on sandsheets = Map Class 25; Stands in narrow canyons between large fins = Map Class 341]**





11b Open woodlands of deep soils in canyon bottoms where seepage or shallow slickrock brings water elevates the water table more than usual. The understory is of mixed shrubs, including *Quercus gambelii, Amelanchier utahensis, Ericameria nauseosa,* and *Artemisia tridentata* ssp. *tridentata.* Shrub cover often exceeds tree cover - ***Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland (Pinyon Pine – Juniper / Gambel Oak Woodland) [Map Class 97]**



12a (6) Woodlands dominated by *Pinus edulis* and *Juniperus osteosperma* with a relatively mesic mixed shrub understory in which *Cercocarpus intricatus* is a co-dominant; other shrubs are generally present to codominant, including *Artemisia bigelovii, Amelanchier utahensis, Coleogyne ramosissima, Purshia stansburiana, Fraxinus anomala,* and *Cercocarpus montanus.* Many stands are associated with joint systems within Moab Tongue or Navajo Formation slickrock - ***Pinus edulis* - *Juniperus osteosperma* / *Cercocarpus intricatus* Woodland (Pinyon Pine – Utah Juniper / Littleleaf Mountain Mahogany Woodland) [Stands on jointed Moab Tongue slickrock = Map Class 31; Stands on large potholed slickrock = Map Class 32]**

Note: A few stands lack *Pinus edulis* in the canopy. These belong to ***Juniperus osteosperma* / *Cercocarpus intricatus* Woodland (Utah Juniper / Littleleaf Mountain Mahogany Woodland).** They are otherwise very similar to the community described above and are assigned to the same map classes.





12b Woodlands of *Pinus edulis* and *Juniperus osteosperma* with an understory dominated by *Cercocarpus montanus,* typically occurring on north-facing rims among slabs of sandstone - ***Pinus edulis* - *Juniperus* spp. / *Cercocarpus montanus* – Mixed Shrubs Woodland (Pinyon Pine – Juniper / True Mountain Mahogany – Mixed Shrubs Woodland) [Map Class 33]**





13a (1) Woodlands or forests with a canopy (at least 10% cover) dominated by *Populus fremontii* and occurring on alluvial terraces, the banks of perennial or intermittent streams, or more rarely, the slots between sandstone fins. A subcanopy of *Pinus edulis* or *Juniperus osteosperma* may be present. The shrub and herbaceous layers are variable **(14)**

13b Woodlands, forests or tall shrublands of streamside or riparian habitats, the canopy dominated by the genera *Elaeagnus*, *Quercus*, *Tamarix* and/or *Salix* trees. Evergreen trees and Fremont cottonwood may be present as scattered individuals **(17)**

14a (13) Fremont cottonwood woodlands with an understory of wetland herbaceous species or shrubs, typically occurring on the banks and lowest terraces of perennial streams or the wet sections of intermittent streams **(15)**

14b Fremont cottonwood woodlands with an understory of upland shrub and/or herbaceous species, typically occurring on the higher terraces of perennial or intermittent streams or, more rarely, in narrow, dry sand pockets between sandstone fins **(16)**

15a (14) Fremont cottonwood woodlands in areas that experience frequent flooding, a perennially high water table, and have a shifting, sandy substrate; species of *Equisetum* dominate the understory - ***Populus fremontii* / *Equisetum* spp. Woodland (Fremont Cottonwood / Horsetail Woodland) [Map Class 93]**



15b Fremont cottonwood woodlands (may have an open canopy with as little as 10% cover) with an understory predominantly of *Salix exigua*, occurring where the riparian zone narrows and is poorly developed. This association typically occurs in drainages where there is water available at or near the surface for most of the growing season - ***Populus fremontii* / *Salix exigua* Forest (Fremont Cottonwood / Coyote Willow Forest) [Map Class 93]**



16a (14) Fremont cottonwood woodlands occurring on high, sandy riparian terraces in the larger drainages. A subcanopy of *Pinus edulis* and/or *Juniperus osteosperma* may be present. The understory is dominated by *Ericameria nauseosa* and associated species including *Artemisia tridentata* ssp. *tridentata* and *Bromus tectorum* or *Bromus japonicus* - ***Populus fremontii* / *Ericameria nauseosa* Woodland (Fremont Cottonwood / Rubber Rabbitbrush Woodland) [Map Class 93]**





16b Fremont cottonwood woodlands sometimes co-dominated by *Salix goodingii*, on high, sandy terraces dominated by *Artemisia tridentata* ssp. *tridentata,* often with *Ericameria nauseosa, Sarcobatus vermiculatus, Rhus aromatica,* and *Bromus tectorum* as associates. The wash channel is often dominated by the mesic herbaceous species *Juncus arcticus* and *Equisetum* spp. - ***Populus fremontii* / *Artemisia tridentata* Woodland (Fremont Cottonwood / Big Sagebrush Woodland) [Map Class 93]**





17a (13) Riparian woodlands and tall shrublands with an open to closed canopy dominated by the non-indigenous *Elaeagnus angustifolia* or *Tamarix chinensis.* The understory may be missing or may consist of a combination of native and exotic species. Mature *Populus fremontii* may be scattered through these stands **(18)**

17b Woodlands dominated by trees or tall shrubs of *Quercus* or *Salix,* occurring on riparian terraces, surrounding slickrock tinajas, or in alcoves or pouroff basins **(19)**

18a (17) Mixed riparian woodlands with a canopy that is dominated by *Elaeagnus angustifolia* but which also includes *Populus fremontii* and *Tamarix chinensis* - ***Elaeagnus angustifolia* Semi-natural Woodland (Russian-olive Semi-natural Woodland) [Map Class 93]**



18b Open to closed-canopied riparian tall shrublands or woodlands dominated by *Tamarix chinensis*. There is little vegetation growing in the understory of closed stands - ***Tamarix* spp. Temporarily Flooded Semi-natural Shrubland (Tamarisk Temporarily Flooded Semi-natural Shrubland) [Mature, dense stands on the Colorado River = Map Class 1; Regenerating stands on sand bars or banks of Colorado River = Map Class 2; Stands in tributary drainages = Map Class 9]**





19a (17) Woodlands with a canopy dominated by *Salix gooddingii*, typically in the wetter parts of sandy intermittent washes or bordering deep, water-filled potholes in the slickrock. The understory consists of Salix *exigua*; *Populus fremontii* may be present but is not abundant (<10% cover) - ***Salix gooddingii* / *Salix exigua* Woodland (Goodding Willow / Coyote Willow Woodland) [Map Class 93]**



19b Tall shrublands dominated by *Quercus gambelii* clones; the evenly spaced stems are of similar height and diameter, occurring on sheltered high terraces of the Colorado River or in alcoves or pouroff basins; the understory is composed primarily of oak sprouts - ***Quercus gambelii* / Sparse Understory Shrubland (Gambel Oak Sparse Understory Shrubland) [Stands on the Colorado River = Map Class 4; Stands in mesic alcoves or pouroff basins = Map Class 97]**





Key III: Shrubland Vegetation

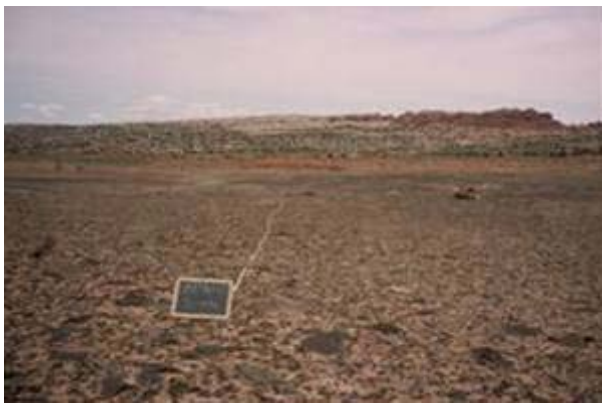
1a Dwarf-shrublands (typically <0.5 m tall), sometimes extremely sparsely vegetated, dominated by *Zuckia brandegeei*, *Atriplex corrugata*, *Atriplex confertifolia*, *Atriplex gardneri*, or *Eriogonum corymbosum* and occurring on badlands or desert pavements derived from the Mancos Shale or the Brushy Basin Member of the Morrison Formation. Stands are usually on low hills or toeslopes **(2)**

1b Short or tall shrublands (typically >0.5 m tall) dominated by species of *Allenrolfea*, *Artemisia*, *Atriplex*, *Chrysothamnus*, *Coleogyne*, *Elaeagnus*, *Ephedra*, *Ericameria*, *Eriogonum*, *Fendlera*, *Grayia*, *Poliomintha*, *Quercus*, *Tamarix*, *Salix*, *Sarcobatus*, or *Suaeda* and occurring on a variety of habitats including the banks of washes, slickrock exposures, talus-covered slopes, sand sheets or other upland habitats. If stands are on badlands, these are derived from the Tidwell Member of the Morrison Formation or gypsum of the Paradox Formation **(8)**

2a (1) Sparsely vegetated dwarf-shrublands dominated by species of the genus *Atriplex* (*corrugata, confertifolia* or *gardneri*) typically occurring on badlands or desert pavements derived from Mancos or Morrison (Brushy Basin) shale **(3)**

2b Dwarf-shrublands, usually sparsely vegetated, dominated by *Zuckia brandegeei* or *Eriogonum corymbosum* and occurring on Mancos or Morrison shale badlands **(7)**

3a (2) Extremely sparse dwarf shrublands of *Atriplex gardneri* and/or *Atriplex confertifolia,* occupying sites where the ground surface is nearly completely covered by a pavement of stained and polished gravel. Other species present include *Enceliopsis, Sphaeralcea, Platyschkuhria* and *Xylorhiza* - ***Atriplex* spp. Desert Pavement Sparse Vegetation (Saltbush Desert Pavement Sparse Vegetation) [Map Class 15]**





3b Dwarf-shrublands dominated by *Atriplex gardneri*, *A. corrugata* and/or *A. confertifolia*, occurring on clay badlands lacking an armor of desert pavement, or the pavement is severely broken up by erosion or other disturbance **(4)**

4a (3) Dwarf shrublands on Mancos or Morrison shale badlands, with a sparse canopy dominated by *Atriplex gardneri* **(5)**

4b Dwarf shrublands on Mancos or Morrison shale badlands, with a sparse canopy dominated by *Atriplex corrugata* or a combination of *Atriplex confertifolia* and *Picrothamnus desertorum* **(6)**

5a (4) Dwarf shrublands, sometimes very sparse, dominated by *Atriplex gardneri* with the short bunchgrass *Pleuraphis jamesii* as the most conspicuous species in a generally sparse herbaceous layer; typically occurs on shale-derived soils of the Morrison Formation (Brushy Basin member) or the basal unit of the Mancos Shale with some cover of gravel and rock - ***Atriplex gardneri* / *Pleuraphis jamesii* Dwarf-shrubland (Gardner Saltbush / James' Galleta Dwarf-shrubland) [Map Class 5]**





5b Dwarf-shrublands dominated by *Atriplex gardneri* and restricted to adobe clay slopes or desert pavements derived from Mancos Shale or the Brushy Basin Member of the Morrison Formation. *Pleuraphis jamesii* is absent, but alkali-tolerant species such as *Platyschkuhria integrifolia* may be present with trace cover - ***Atriplex gardneri* Dwarf-shrubland (Gardner Saltbush Dwarf-shrubland) [Open stands on badlands = Map Class 5; Very sparse stands in Cache Valley on Mancos Shale = Map Class 26]**





6a (4) Sparse dwarf-shrublands dominated by scattered *Atriplex confertifolia* and *Picrothamnus desertorum* and occurring on shale soils of the Morrison Formation - ***Atriplex confertifolia* - *Picrothamnus desertorum* Shrubland (Shadscale – Bud Sage Shrubland) [Map Class 15]**





6b Dwarf-shrublands dominated by *Atriplex corrugata* and occurring on badland exposures of the upper Mancos Shale; total cover rarely exceeds 15%; *Atriplex confertifolia* and *Atriplex gardneri* may be present to co-dominant - ***Atriplex corrugata*** **Dwarf-shrubland (Mat Saltbush Dwarf-shrubland) [Map Class 26]**





7a (2) Short shrublands occurring on badlands of Mancos or Morrison shale and dominated by *Eriogonum corymbosum* - ***Eriogonum corymbosum*** **Badlands Sparse Vegetation (Crispleaf Buckwheat Badlands Sparse Vegetation) [Map Class 5]**





7b Dwarf-shrublands dominated by *Zuckia brandegeei* and occurring in very small patches on Mancos shale hogbacks - ***Zuckia brandegeei*** **Sparse Vegetation (Siltbush Sparse Vegetation) [Map Class 5]**



8a (1) Short shrublands dominated by *Krascheninnikovia lanata, Atriplex canescens* or *Atriplex confertifolia* on deep, alkaline soils of valley floors **(9)**

8b Short or tall shrublands of varying habitats and soils, dominated by other shrub species **(15)**

9a (8) Short shrublands dominated by *Atriplex confertifolia* with a grass- or annual-dominated understory on deep, alkaline soils of valley floors **(10)**

9b Short shrublands dominated by *Krascheninnikovia lanata* or *Atriplex canescens* on deep, alkaline soils of valley floors **(12)**

10a (9) Sparse, short shrublands co-dominated by *Atriplex confertifolia* and *Sarcobatus vermiculatus.* Stands occur on flats and valley bottoms underlain by Mancos or Brushy Basin shale. Cheatgrass or other annuals may have high cover - ***Atriplex confertifolia - Sarcobatus vermiculatus*** **Shrubland (Shadscale – Greasewood Shrubland) [Map Class 15]**



10b Short shrublands dominated by *Atriplex confertifolia* with a native grass-dominated understory on deep, alkaline soils of valley floors **(11)**

11a (10) Short shrublands with a canopy dominated by scattered *Atriplex confertifolia* with a sparse to moderate herbaceous layer dominated by *Pleuraphis jamesii* and occurring on deep soils of valley sides - ***Atriplex confertifolia* / *Pleuraphis jamesii* Shrubland (Shadscale / James' Galleta Shrubland) [Map Class 15]**





11b Short shrublands dominated by a sparse canopy of *Atriplex confertifolia* with a sparse herbaceous layer dominated by *Sporobolus cryptandrus* and occurring on dry sites with saline, gravelly soils - ***Atriplex confertifolia* / *Sporobolus cryptandrus* Shrubland (Shadscale / Sand Dropseed Shrubland) [Map Class 15]**





12a (9) Dwarf shrublands dominated by *Krascheninnikovia lanata* on deep, alkaline valley soils **(13)**

12b Short shrublands characterized by an open canopy of *Atriplex canescens*, with or without a developed grass understory **(14)**

13a (12) Open dwarf shrublands dominated by scattered *Krascheninnikovia lanata* with the short bunchgrass *Pleuraphis jamesii* contributing an herbaceous layer; typically occurring on the floors of the larger valleys - ***Krascheninnikovia lanata* / *Pleuraphis jamesii* Dwarf-shrubland (Winterfat / James' Galleta Dwarf-shrubland) [Map Class 71]**





13b Dwarf-shrublands dominated by *Krascheninnikovia lanata* with little to no cover of *Pleuraphis jamesii*, occurring in disturbed sites on valley floors. The understory typically is sparse or consists of exotic or weedy herbaceous species – ***Krascheninnikovia lanata*** **Dwarf-shrubland (Winterfat Dwarf-shrubland) [Map Class 71]**





14a (12) Short, open shrublands dominated by *Atriplex canescens* with a sparse herbaceous layer dominated by the tall bunchgrass *Sporobolus airoides* and occurring in patches on valley floors - ***Atriplex canescens*** **/** ***Sporobolus airoides*** **Shrubland (Fourwing Saltbush / Alkali Sacaton Shrubland) [Map Class 18]**



14b Short shrublands on dry sites on valley floors or saddles dominated by sparse *Atriplex canescens*, often with a disturbed understory that is either sparse or consists of weedy herbaceous species - ***Atriplex canescens*** **Shrubland (Fourwing Saltbush Shrubland) [Map Class 18]**





15a (8) Short or tall shrublands on valley floors, in desert wash channels or on riparian terraces associated with intermittent or perennial streams; dominant species are *Allenrolfea occidentalis, Chrysothamnus viscidiflorus, Elaeagnus angustifolia, Ericameria nauseosa, Quercus gambelii, Rhus trilobata, Sarcobatus vermiculatus, Salix* spp., *Suaeda* or *Tamarix chinensis* **(16)**

15b Short or tall shrublands associated with upland sites such as sand sheets, gypsum badlands, slickrock, fin slots or colluvial slopes. Dominant species are *Coleogyne ramosissima, Grayia spinosa, Ephedra* spp., *Artemisia bigelovii, Poliomintha incana, Quercus havardii* var. *tuckeri, Artemisia filifolia, Fendlera rupicola* or *Purshia stansburiana* **(29)**

16a (15) Sparse to moderately dense shrublands associated with low terraces, channels and point bars in intermittent washes; dominant species are *Ericameria nauseosa* or *Chrysothamnus viscidiflorus* **(17)**

16b Shrublands in riparian or valley floor positions dominated by other species **(18)**

17a (16) Short shrublands dominated by *Ericameria nauseosa* (may be co-dominant with *Atriplex canescens*), occurring on banks of ephemeral washes and low terraces that flood occasionally - ***Ericameria nauseosa*** **Desert Wash Shrubland (Rubber Rabbitbrush Desert Wash Shrubland) [Map Class 90]**





17b Short shrublands dominated by *Chrysothamnus viscidiflorus* and occurring on terraces or point bars of washes; the herbaceous understory is variable - ***Chrysothamnus viscidiflorus*** **Shrubland Alliance (Green Rabbitbrush Shrubland Alliance) [Map Class 18]**



18a (16) Short shrublands on broad alkaline floodplains dominated by *Sarcobatus vermiculatus, Artemisia tridentata* ssp. *tridentata, Allenrolfea occidentalis,* and/or *Suaeda moquinii* **(19)**

18b Short or tall shrublands of less-alkaline situations, whose dominants include the natives *Salix* spp., *Rhus trilobata,* and *Quercus gambelii* or the exotic tall shrubs *Tamarix chinensis* and *Elaeagnus angustifolia* **(24)**

19a (18) Short shrublands of alkaline sites in the floodplain of Salt Wash downstream of Wolfe Ranch. The community may be very sparse, but the dominants are *Allenrolfea occidentalis* and/or *Suaeda moquinii. Sarcobatus vermiculatus* may be a minor community component **(20)**

19b Short shrublands on valley floors or terraces of drainages and washes and dominated by *Sarcobatus vermiculatus* and/or *Artemisia tridentata* ssp. *tridentata* **(21)**

20a (19) Short shrublands of alkaline sites dominated by *Allenrolfea occidentalis,* usually accompanied by *Sarcobatus vermiculatus* and *Suaeda torreyana* on alkaline or saline flats often adjacent to *Sarcobatus vermiculatus* or *Tamarix chinensis* shrublands. A sparse understory of *Sporobolus spp*.

and/or *Distichlis spicata* may be present - ***Allenrolfea occidentalis*** **Shrubland (Iodinebush Shrubland) [Map Class 6]**





20b Short, very sparse shrublands of extremely alkaline floodplain sites dominated by *Suaeda moquinii* with *Sarcobatus vermiculatus*. *Allenrolfea* is absent - ***Suaeda moquinii*** **Shrubland (Shrubby Seepweed Shrubland) [Map Class 6]**



21a (19) Short shrublands dominated by *Artemisia tridentata* ssp. *tridentata* with *Ericameria nauseosa* and *Atriplex canescens* commonly present, and an understory dominated by *Bromus tectorum*, occurring in small to large patches on valley floors, often on the lowest terrace just above the main wash channel – ***Artemisia tridentata – (Ericameria nauseosa) / Bromus tectorum*** **Semi-natural Shrubland (Big Sagebrush – (Rubber Rabbitbrush) / Cheatgrass Semi-natural Shrubland) [Map Class 8]**





21b Short shrublands occurring on valley floors or terraces of drainages and washes and dominated by *Sarcobatus vermiculatus* and/or *Artemisia tridentata* ssp. *tridentata* **(22)**

22a (21) Short shrublands dominated by *Sarcobatus vermiculatus* and *Artemisia tridentata* (*Ericameria nauseosa* and *Atriplex canescens* may also be present), occurring in narrow bands along smaller drainages or as large patches on valley floors - ***Sarcobatus vermiculatus* / *Artemisia tridentata* Shrubland (Greasewood / Big Sagebrush Shrubland) [Map Class 8]**





22b Short shrublands dominated by *Sarcobatus vermiculatus* with an understory predominantly of grasses, including *Sporobolus airoides* and *Bromus tectorum*, or with a sparse understory **(23)**

23a (22) Short shrublands dominated by relatively dense *Sarcobatus vermiculatus* with an understory dominated by the tall bunchgrass *Sporobolus airoides* (*Hesperostipa comata* may also be present); occurs on high stream terraces in washes - ***Sarcobatus vermiculatus* / *Sporobolus airoides* Shrubland (Greasewood / Alkali Sacaton Shrubland) [Map Class 6]**





23b Short shrublands dominated by *Sarcobatus vermiculatus* with a sparse or variable understory; *Sporobolus airoides* may be present but not over 2% cover - ***Sarcobatus vermiculatus*** **Disturbed Shrubland (Greasewood Disturbed Shrubland) [Map Class 6]**





24a (18) Riparian tall shrublands or woodlands dominated by the exotic species *Tamarix chinensis* and/or *Elaeagnus angustifolia* **(25)**

24b Short or tall riparian shrublands dominated by the native shrubs *Salix* spp., *Rhus trilobata*, and *Quercus gambelii* **(26)**

25a (24) Tall shrublands dominated by the invasive species *Tamarix chinensis* and occurring on banks and terraces of large streams - ***Tamarix*** **spp. Temporarily Flooded Semi-natural Shrubland (Tamarisk Temporarily Flooded Semi-natural Shrubland) [Mature stands on the Colorado River = Map Class 1; Regenerating stands on sand bars or banks of Colorado River = Map Class 2; Stands in tributary drainages = Map Class 9]**

25b Tall shrublands with a mixed canopy of exotic species, among which *Elaeagnus angustifolia* is dominant. The canopy may also include *Tamarix* and *Populus fremontii* – ***Elaeagnus angustifolia*** **Semi-natural Woodland (Russian-olive Semi-natural Woodland) [Map Class 93]**



26a (24) Tall shrublands on high riparian terraces or in alcoves or pouroff basins with a canopy consisting of a near monoculture of either *Quercus gambelii* or *Rhus trilobata* **(27)**

26b Short or tall riparian shrublands dominated by species of *Salix* **(28)**

27a (26) Tall shrublands or woodlands dominated by *Quercus gambelii* clones; the evenly spaced stems are of similar height and diameter; occurs mostly on sheltered high terraces of the Colorado River or in alcoves or mesic pouroff basins; the understory is predominantly composed of Gambel oak sprouts - ***Quercus gambelii*** **/ Sparse Understory Shrubland (Gambel Oak / Sparse Understory Shrubland) [Stands on the Colorado River = Map Class 4; Stands in mesic alcoves or pouroff basins = Map Class 97]**



27b Tall shrublands dominated by dense *Rhus trilobata* and occurring on middle or upper riparian terraces; other shrubs may be present but contribute low cover - ***Rhus trilobata*** **Intermittently Flooded Shrubland (Skunkbush Sumac Intermittently Flooded Shrubland) [Map Class 7]**



28a (26) Tall shrublands dominated by *Salix exigua* with few other species, occurring in riparian and wetland sites on exposed gravel, cobbles, or sand; the understory of a few, scattered forbs and grasses is usually present - ***Salix exigua* / Barren Shrubland (Coyote Willow / Barren Shrubland)) [Dense stands on the Colorado River = Map Class 1; Regenerating stands on sand bars or banks of Colorado River = Map Class 2; Stands in tributary drainages = Map Class 9]**





28b Tall shrublands dominated by *Salix ligulifolia,* typically with an understory of mixed upland and wetland species, occurring around the rims of tinajas - ***Salix ligulifolia* Shrubland (Strapleaf Willow Shrubland) [Map Class 9]**



29a (15) Mixed shrublands, sometimes sparse, on valley or mesa sides or hogbacks where the substrate consists of narrow ledges or shale slopes covered by coarse colluvium. Total vegetation cover is limited by the amount of rock covering the ground surface. The shrub layer is diverse, with up to 15 species present. Characteristic species include *Artemisia bigelovii, Ephedra* spp., *Rhus trilobata, Fendlera rupicola* and *Chrysothamnus stenophyllus.* Cover of pinyon and/or juniper is often between a trace and 5%. If the total tree cover is 5% or greater, please also try **Key II – Forest and Woodland Associations (30)**

29b Shrublands on relatively level uplands not modified by colluvium; either slickrock plateaus, gypsum badlands, fin slots or sandsheets **(32)**

30a (29) Rare shrublands on colluvial slopes where the conspicuous species are the tall shrubs *Fendlera rupicola* and *Atriplex canescens*. Other shrubs present may include *Atriplex confertifolia, Chrysothamnus viscidiflorus,* and *Ephedra torreyana*. The grass *Leymus salinus* may also be present – ***Fendlera rupicola*** **Talus Shrubland (Fendlerbush Talus Shrubland) [Map Class 30]**



30b Mixed shrublands on colluvial slopes lacking *Fendlera rupicola* **(31)**

31a (30) Shrublands, sometimes sparse, on xeric colluvial slopes or sandstone ledges covered by colluvium. The shrubs are diverse, but are generally short or dwarf species among which *Artemisia bigelovii* is dominant or co-dominant and one or both species of *Ephedra* are present. *Rhus trilobata* is absent. Other shrubs present may include A*triplex canescens, Atriplex confertifolia, Chrysothamnus viscidiflorus, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Purshia stansburiana* and *Gutierrezia sarothrae* – ***Artemisia bigelovii – Ephedra (torreyana, viridis)*** **Talus Shrubland (Bigelow Sagebrush – Mormon-tea Talus Shrubland) [Map Class 30]**





31b Shrublands, sometimes sparse, on xeric colluvial slopes. The shrubs are diverse, but *Ephedra viridis* and/or *Ephedra torreyana* are conspicuous, *Artemisia bigelovii* is absent or has no more than trace cover, and *Rhus trilobata* is present with at least trace or greater cover. Other shrubs present may include *Amelanchier utahensis, Brickellia microphylla, Chrysothamnus viscidiflorus, Eriogonum corymbosum, Philadelphus microphyllus* and *Gutierrezia sarothrae* – ***Rhus trilobata – Ephedra (viridis, torreyana)*** **Talus Shrubland (Skunkbush Sumac – Mormon-tea Talus Shrubland) [Map Class 30]**



32a (29) Sparse short shrublands dominated by *Ephedra torreyana,* with or without an herbaceous understory dominated by native grasses **(33)**

32b Short shrublands on upland sites dominated by species other than *Ephedra torreyana;* includes stands of upland or mesic vegetation in slots between sandstone fins **(36)**

33a (32) Short shrublands, usually sparsely to extremely sparsely vegetated, occurring on badlands of Paradox Formation gypsum or Tidwell Shale, dominated by *Ephedra torreyana* and lacking a developed understory of herbaceous species other than spring annuals **(34)**

33b Short shrublands, sometimes sparsely vegetated, occurring on a variety of substrates, dominated by *Ephedra torreyana* and supporting an understory of native grass species **(35)**

34a (33) Sparse shrublands dominated by *Ephedra torreyana* and usually accompanied by *Atriplex canescens* or rarely *Atriplex confertifolia*, occurring on Paradox Formation gypsum. The understory consists predominantly of gypsophilous biological crusts - ***Ephedra torreyana* - (*Atriplex* spp.) / Nonvascular Gypsum Sparse Vegetation (Torrey Joint-fir – (Saltbush) / Nonvascular Gypsum Sparse Vegetation) [Map Class 35]**





34b Shrublands dominated by sparse *Ephedra torreyana* and occurring on hot shale slopes of the Tidwell Member of the Morrison Formation with sparse herbaceous cover - ***Ephedra torreyana* Sparse Vegetation (Torrey Joint-fir Sparse Vegetation) [Map Class 15]**





35a (33) Short shrublands dominated by *Ephedra torreyana* and usually accompanied by *Atriplex gardneri* with the understory dominated by the short bunchgrass *Pleuraphis jamesii*. Stands are on a variety of substrates, including Mancos shale - ***Ephedra torreyana* / *Pleuraphis jamesii* Shrubland (Torrey Joint-fir / James' Galleta Shrubland) [Stands on Paradox Formation gypsum = Map Unit 35; Stands on other substrates = Map Unit 15]**





35b Rare short shrublands dominated by *Ephedra torreyana* and *Achnatherum hymenoides* on higher alluvial terraces of the Colorado River canyon - ***Ephedra torreyana / Achnatherum hymenoides - Pleuraphis jamesii*** **Shrubland (Torrey Joint-fir / Indian Ricegrass – James' Galleta Shrubland) [Map Class 15]**



36a (32) Shrublands of mixed mesic and xeric species, sometimes with scattered *Populus fremontii, Pinus edulis,* or *Juniperus osteosperma*, occurring in the narrow slot canyons between fins of sandstone - **Slickrock Fin Pocket [Map Class 341]**



36b Shrublands and wooded shrublands occurring on upland, riparian or mesic sites but typically not in slots between sandstone fins **(37)**

37a (36) Shrublands occurring on relatively level, deep sands, sandsheets, dunes or sandy soils (rarely on barren red Tidwell shale) dominated by *Coleogyne ramosissima, Quercus havardii* var. *tuckeri, Ephedra* spp., *Grayia spinosa, Poliomintha incana, Vanclevea stylosa* and/or *Artemisia filifolia.* Bedrock exposures are rare and small **(38)**

37b Shrublands on shallow soils over slickrock bedrock, along intermittent wash channels, or on sand dunes. The community is often relatively sparse. Characteristic species are *Purshia stansburiana* and *Coleogyne ramosissima* with roughly equal cover; *Quercus havardii* var. *tuckeri, Ephedra viridis, Fraxinus anomala* are often, but not always, present. Scattered *Pinus edulis* or *Juniperus osteosperma* may be present with less than 5% cover (or at least a very low percentage of the total vascular cover) - ***Coleogyne ramosissima*** **-** ***Purshia stansburiana*** **-** ***Quercus havardii*** **var. *tuckeri* Shrubland (Blackbrush – Stansbury Cliffrose – Tucker Sand Shinnery Oak Shrubland) [Stands on sand dunes or sand sheets = Map Class 11; Stands on intermittent washes = 90]**





38a (37) Common, often homogeneous shrublands, covering extensive areas on stabilized sandy valley floors and plateaus, dominated by *Coleogyne ramosissima. Juniperus osteosperma* trees may be scattered throughout, but tree cover does not exceed 8%. Stands occur on a variety of geologic substrates. Associated shrubs most commonly include *Ephedra viridis, Ephedra torreyana, Atriplex confertifolia,* and/or *Opuntia polyacantha* – ***Coleogyne ramosissima*** **Shrubland (Blackbrush Shrubland) [Dense stands on stable soils = Map Class 10; Stands on sand = Map Class 11; Open stands mixed with *Ephedra* and *Atriplex* spp. on various substrates = Map Class 15]**





A rare variation of this community is dominated by *Grayia spinosa,* often accompanied by *Ephedra viridis* and *Coleogyne ramosissima* and with a sparse *Pleuraphis jamesii* understory - ***Grayia spinosa* Shrubland (Spiny Hopsage Shrubland) [Map Class 10]**



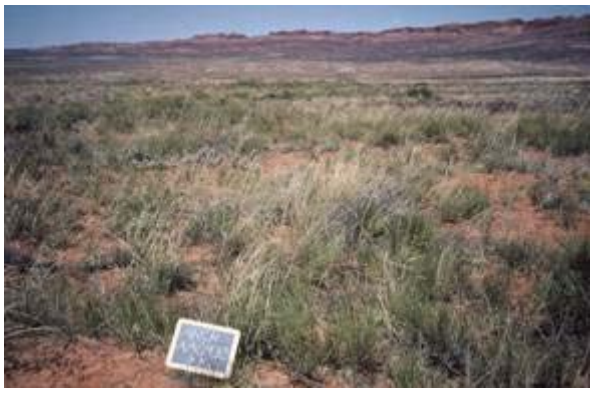
38b Diverse shrublands on unstable sands or occurring as islands of *Ephedra viridis*-dominated communities in a matrix of *Coleogyne ramosissima* shrublands **(39)**

39a (38) Shrublands dominated by *Ephedra viridis*, occurring on sandy soils of valley floors, plateaus and toeslopes, usually as inclusions within a matrix of *Coleogyne ramosissima* shrublands, although extensive stands occur in Salt Valley **(40)**

39b Diverse shrublands occurring on loose sands, dominated by *Quercus havardii* var. *tuckeri*, *Poliomintha incana, Vanclevea stylosa* and/or *Artemisia filifolia* **(41)**

40a (39) Shrublands dominated by *Ephedra viridis* and typically occurring on level or gently sloping sandy sites with an understory predominantly of the tall bunchgrasses *Achnatherum hymenoides* or *Hesperostipa comata* - ***Ephedra viridis* / (*Achnatherum hymenoides* - *Hesperostipa comata*) Shrubland (Mormon-tea / (Indian Ricegrass – Needle-and-Thread Shrubland)) [Stands on sand = Map Class 11; Stands on valley floors = Map Class 14]**





40b *Ephedra viridis* shrublands typically occurring on low spots on sandy benches, with an understory dominated by the short bunchgrass *Pleuraphis jamesii* - ***Ephedra viridis* / *Pleuraphis jamesii* Shrubland (Mormon-tea / James' Galleta Shrubland) [Map Class 14]**





41a (39) Shrublands dominated by *Quercus havardii* var. *tuckeri* (typically with at least 10% cover) and occurring on sand dunes or other sandy substrates. Scattered *Juniperus osteosperma* may be present with 5% or less cover. *Coleogyne ramosissima* and *Purshia stansburiana* are absent or have no more than a few percent relative cover - ***Quercus havardii* var. *tuckeri* Shrubland (Tucker Sand Shinnery Oak Shrubland) [Stands on active dunes = Map Class 13; Stands on intermittent washes = Map Class 90]**





41b Short shrublands dominated by *Poliomintha incana* or *Artemisia filifolia* and occurring on sandy valley floors, benches and plateaus **(42)**

42a (41) Shrublands dominated by *Artemisia filifolia* and occurring on stabilized sand sheets or dunes; if *Poliomintha incana* and *Vanclevea stylosa* are present, they are rare; *Coleogyne ramosissima* may be present with low cover. Herbaceous cover is typically sparse and may include the tall bunchgrasses *Achnatherum hymenoides* and/or *Hesperostipa comata* - ***Artemisia filifolia* Colorado Plateau Shrubland (Sand Sagebrush Colorado Plateau Shrubland) [Stands on sand sheets = Map Class 11; Stands on active dunes = Map Unit 13; Stands on stable, deep soils of valley floors = Map Unit 18]**





42b Shrublands on loose or blowing sands. The vegetation may be sparse, and is dominated by *Poliomintha incana* and/or *Vanclevea stylosa.* If Artemisia *filifolia* is present, it does not have significantly greater cover than either *Poliomintha* or *Vanclevea. Eriogonum leptocladon* may also have measurable cover. The herbaceous layer is typically sparse and may include *Achnatherum hymenoides, Streptanthella longirostris, Rumex hymenosepalus* or other sand-loving species - ***Poliomintha incana* - *Artemisia filifolia* - *Vanclevea stylosa* Shrubland (Hoary Rosemarymint – Sand Sagebrush – Resinbush Shrubland) [Map Class 13]**





Key IV: Herbaceous Vegetation

1a Herbaceous communities dominated by forbs and/or graminoids in cliff, alcove or riparian sites with surface water or moist soils through all or most of the growing season **(2)**

1b Herbaceous vegetation of native or exotic graminoid or forb species occurring in drier sites, mostly on level sites on valley floors or slickrock uplands **(4)**

2a (1) Diverse wet herbaceous communities associated with seeps emerging from cliffs and alcoves, most commonly occurring at the contact between the Moab Tongue and the Entrada Sandstone. Typical species include *Aquilegia micrantha, Mimulus eastwoodiae, Primula specuicola* and *Carex aurea* in the wettest areas; margins may support *Pinus edulis, Juniperus osteosperma,* upland shrubs and mesic herbaceous species such as *Schizachyrium scoparium* and *Toxicodendron rydbergii* - ***Aquilegia micrantha - Mimulus eastwoodiae*** **Herbaceous Vegetation (Mancos Columbine - Eastwood Monkeyflower Herbaceous Vegetation) [Map Class 100]**



2b Tall, mesic graminoid vegetation occupying level, wet sites in drainages and below springs. There is often standing water at the surface during the growing season. Characteristic species include *Typha* spp. and *Schoenoplectus* spp. **(3)**

3a (2) Mesic graminoid communities occurring where intermittent stream channels intercept the water table, creating surface flow for short distances and dominated by *Schoenoplectus pungens*. *Typha domingensis* may be conspicuous to co-dominant - ***Schoenoplectus pungens*** **Herbaceous Vegetation (Common Threesquare Herbaceous Vegetation) [Map Class 92]**

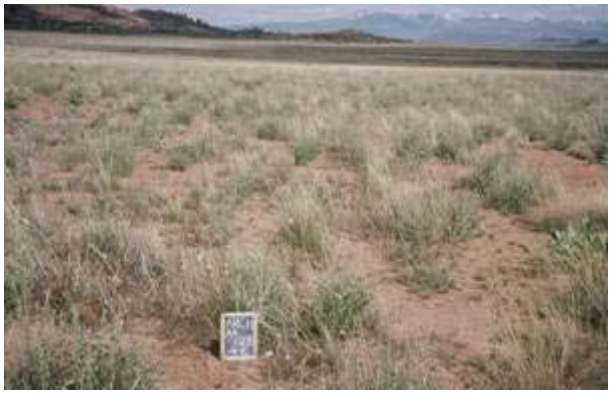


3b Tall mesic graminoid communities dominated by a monoculture of *Typha dominguensis*. The known location is in a ponded marsh in Salt Wash upstream of the Delicate Arch parking area - ***Typha (latifolia, angustifolia)*** **Western Herbaceous Vegetation (Broadleaf, Narrowleaf Cattail Western Herbaceous Vegetation) [Map Class 92]**



4a (1) Forb communities often occurring on valley floors or other heavily disturbed sandy sites and dominated by *Sphaeralcea* spp. Weedy and exotic herbaceous species present may include *Bromus tectorum, Cryptantha crassisepala* var. *elachantha, Oenothera* spp., *Descurainia pinnata,* and *Machaeranthera tanacetifolia*. Sparse remnants of the original native community are generally also present, including *Pleuraphis jamesii, Sporobolus cryptandrus, Krascheninnikovia lanata,* and *Atriplex canescens* – ***Sphaeralcea (coccinea, parvifolia)*** **Herbaceous Vegetation (Scarlet, Narrowleaf Globemallow Herbaceous Vegetation) [Map Class 17]**





4b Herbaceous vegetation of native or exotic graminoid species occurring in drier sites, mostly on level sites on valley floors or slickrock uplands **(5)**

5a (4) Exotic grassland community often occurring on valley floors or other heavily disturbed sites and dominated in all but the driest years by the exotic annual *Bromus tectorum*. Other weedy and exotic herbaceous species present may include *Lappula occidentalis, Cryptantha crassisepala* var. *elachantha, Descurainia pinnata, Halogeton glomeratus, Lepidium lasiocarpum, Salsola pestifer,* and *Plantago patagonica*. Sparse remnants of the original native community are generally also present, including *Pleuraphis jamesii* and *Sphaeralcea* spp. - ***Bromus tectorum* Semi-natural Herbaceous Vegetation (Cheatgrass Semi-natural Herbaceous Vegetation) [Map Class 17]**





5b Grasslands occurring on sandy slickrock plateaus or wash bottoms or shale hogbacks and dominated by native perennial species of *Pleuraphis, Leymus, Sporobolus, Achnatherum,* or *Hesperostipa* **(6)**

6a (5) Sparse to moderately vegetated grasslands occurring on mostly flat areas of deep soils and dominated by the short bunchgrass *Pleuraphis jamesii* with between 5% and 30% cover. Shrubs such as *Atriplex confertifolia, Atriplex canescens, Coleogyne ramosissima, Opuntia polyacantha, Ephedra torreyana, Krascheninnikovia lanata, Sarcobatus vermiculatus, Ericameria nauseosa,* and/or *Gutierrezia sarothrae* may be present with as much as 5% cover as long as *Pleuraphis jamesii* is clearly dominant. Other grasses and herbaceous species are also generally present, but not dominant or co-dominant **(7)**

6b Grasslands occurring on various upland habitats and dominated by the tall bunchgrasses *Achnatherum hymenoides*, *Hesperostipa comata*, *Leymus salinus*, or *Sporobolus* spp. **(8)**

7a (6) Rare grasslands occurring on level valley floors with sandy substrates where the bunchgrasses *Pleuraphis jamesii* and *Sporobolus airoides* are co-dominant; non-vascular cover is usually significant, although not highly developed. Shrubs such as *Ephedra torreyana* and *Coleogyne ramosissima* may have up to 5% cover, but grasses are visually dominant - ***Pleuraphis jamesii* - *Sporobolus airoides* Herbaceous Vegetation (James' Galleta – Alkali Sacaton Herbaceous Vegetation) [Map Class 18]**





7b Common grasslands best developed in Salt Valley; with smaller patches occurring elsewhere in the park on level eolian or alluvial soils (not sand) or gentle slopes of valleys and dominated by *Pleuraphis jamesii*. Shrubs (especially *Atriplex* spp.) are generally present with up to 5% cover but grasses are visually dominant - ***Pleuraphis jamesii* Herbaceous Vegetation (James' Galleta Herbaceous Vegetation) [Stands mixed with low cover of *Ephedra viridis* = Map Class 14; Weedy stands on valley floors = Map Class 17]**





8a (6) Sparse grasslands typically on north-facing shale slopes of the Morrison or (rarely) Chinle shales that have some colluvial rock cover from overlying sandstones; often includes up to 10% cover by shrubs such as *Atriplex confertifolia*, *Chrysothamnus viscidiflorus*, and/or *Artemisia bigelovii*; *Leymus salinus* is visually dominant because of its height - ***Leymus salinus* Shale Sparse Vegetation (Salinas Lyme Grass Shale Sparse Vegetation) [Map Class 27]**





8b Grasslands on sandy habitats or wash bottoms and dominated by *Achnatherum hymenoides*, *Hesperostipa comata*, or *Sporobolus* spp. **(9)**

9a (8) Grasslands dominated by species of the tall bunchgrass genus *Sporobolus* typically occurring on sandy or saline soils on terraces or derived from alluvial deposits **(10)**

9b Grasslands dominated by the tall bunchgrasses *Achnatherum hymenoides* or *Hesperostipa comata* **(11)**

10a (9) Generally sparse grasslands dominated by *Sporobolus airoides*, occurring in large patches or stands on alkaline, fine-textured alluvium. *Pleuraphis jamesii* is generally present, as is the shrub *Atriplex confertifolia* - ***Sporobolus airoides*** **Southern Plains Herbaceous Vegetation (Alkali Sacaton Southern Plains Herbaceous Vegetation) [Map Class 93]**





10b Grasslands dominated by *Sporobolus cryptandrus*, occurring in small patches on terraces or point bars in the larger intermittent washes or in large patches in Salt Valley. *Sporobolus contractus* or *Sporobolus giganteus* may be present, and shrubs such as *Opuntia polyacantha, Krascheninnikovia lanata* or *Ephedra viridis* may have trace cover - ***Sporobolus cryptandrus*** **Great Basin Herbaceous Vegetation (Sand Dropseed Great Basin Herbaceous Vegetation) [Map Class 17]**




11a (9) Grasslands dominated by *Achnatherum hymenoides*, typically occurring on loose, blowing sand and less often on sandy point bars in the larger intermittent washes. *Poliomintha incana* or *Atriplex canescens* may be present with low cover - ***Achnatherum hymenoides* Colorado Plateau Herbaceous Vegetation (Indian Ricegrass Colorado Plateau Herbaceous Vegetation) [Map Class 14]**




11b Grasslands dominated by *Hesperostipa comata*, occurring in small patches on sandy substrates, either on point bars in the major intermittent washes, or more rarely in sand-filled slickrock potholes. Shrubs are generally present with less than 5% total cover - ***Hesperostipa comata* Great Basin Herbaceous Vegetation (Needle-and-Thread Great Basin Herbaceous Vegetation) [Map Class 18]**




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Appendix H

Modified Anderson Land Use/Land Cover Classification

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
1.0 Water	1.1 Open Water	1.11 Stream/river			
		1.12 Canal/ditch	1.121 Lined canal/ditch		
			1.122 Unlined canal/ditch		
		1.13 Lake/pond			
		1.14 Reservoir			
		1.15 Bay/estuary			
		1.16 Sea/ocean			
	1.2 Perennial Ice/Snow	1.21 Snowfield			
		1.22 Glacier			
2.0 Developed	2.1 Residential	2.11 Single-family residential			
		2.12 Multi-family residential			
	2.2 Non-residential Developed	2.21 Commercial/Light Industry	2.211 Major Retail		
			2.212 Mixed/Minor Retail and Services		
			2.213 Office		
			2.214 Light industry		
		2.22 Heavy Industry	2.221 Petro-chemical Refinery		
		2.23 Communications and Utilities			
		2.24 Institutional	2.241 Schools		
			2.242 Cemeteries		
		2.25 Agricultural Business	2.251 Aquiculture		
			2.252 Confined feeding		
		2.26 Transportation	2.261 Airport		
		2.27 Entertainment/ Recreation	2.271 Golf Course		
			2.272 Urban Parks		
	2.3 Mixed Urban				
3.0 Bare	3.1 Transitional				
	3.2 Quarries/Strip mines/Gravel pits				
	3.3 Bare Rock/Sand				
	3.4 Flats				
	3.5 Disposal				

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
4.0 Vegetated	4.1 Woody	4.11 Forested	4.111 Deciduous		
			4.112 Evergreen		
			4.113 Mixed		
		4.12 Shrub land	4.121 Deciduous		
			4.122 Evergreen		
			4.123 Mixed		
			4.124 Desert scrub		
		4.13 Orchards/vineyards/groves	4.131 Irrigated Orchard/ vineyards/groves		
			4.132 Citrus		
			4.133 Non-managed Citrus		
		4.14 Mixed Forest/Shrub			
	4.2 Herbaceous	4.21 Natural Herbaceous	4.211 Natural Grassland		
		4.22 Planted/cultivated	4.221 Fallow/Bare Fields		
			4.222 Small Grains	4.2221 Irrigated small grains	4.22211 Rice Fields
			4.223 Row Crops	4.2231 Irrigated row crops	
				4.2232 Sugar Cane	
			4.224 Planted grasses	4.2241 Pasture/ hay	4.22411 Irrigated Pasture/hay
				4.2242 Other grass	4.22421 Irrigated Other grass
			4.225 Irrigated Planted/ cultivated		
	4.3 Wetlands	4.31 Woody wetlands			
		4.32 Emergent wetlands			

Classification Definitions

1.0 WATER - area covered by water, snow, or ice with less than 25% vegetated or developed cover, unless specifically included in another category.

1.1 Open Water - all areas of open water with less than 25% vegetative or developed cover.

1.11 Stream/river - a natural body of flowing water. Includes streams and rivers that have been channelized in order to control flooding or erosion or to maintain flow for navigation.

1.12 Canal/ditch - a man-made open waterway constructed to transport water, to irrigate or drain land, to connect two or more bodies of water, or to serve as a waterway for water craft. Collection should include the right of ways and associated dikes and levees.

1.121 Lined canal/ditch - a canal or ditch lined with concrete or other impervious material preventing passage of water into underlying strata.

1.122 Unlined canal/ditch - a canal or ditch constructed with dirt or other porous material allowing water to drain.

1.13 Lake/pond - a non-flowing, naturally-existing, body of water. Includes water impounded by natural occurrences and artificially regulated natural lakes. The delineation of a lake is based on the areal extent of water at the time the imagery was acquired.

1.14 Reservoir - any artificial body of water, unless specifically included in another category. It can lie in a natural basin or a man-constructed basin. The delineation of a reservoir is based on the areal extent of water at the time the imagery was acquired. (The water control structures are classified as Communications/Utilities)

1.15 Bay/estuary - the inlets or arms of the sea that extend inland.

1.16 Sea/ocean - an area of the great body of salt water that covers much of the earth.

1.2 Perennial Ice/Snow - areas covered year-round with snow and ice.

1.21 Snowfield - permanent snow not underlain by a glacier .

1.22 Glacier - a body of ice and snow, showing evidence of past or present flow.

2.0 DEVELOPED - Areas of the earth that have been improved by man. Includes all "built-up" and urban areas of the landscape. Does NOT include mining lands, crop lands, or waste-disposal areas (dumps). This land use category takes precedence over a land cover category when the criteria for more than one category are met.

2.1 Residential - lands containing structures used for human habitation.

2.11 Single-family Residential - Lands used for housing residents in single-family dwelling units. Includes trailer parks, mobile home parks, and entire "farmsteads" when there is a home in the complex. (If no home is in the complex, it should be classified as Agricultural Business.) Single-family residential buildings located within another category, such as military family housing, should be identified in this category.

2.12 Multi-family Residential - All lands devoted to housing more than one family on a permanent or semi-permanent basis, group living situations, and their associated grounds. Includes apartments, apartment complexes, duplexes, triplexes, attached row houses, condominiums, retirement homes, nursing homes, and residential hotels. Residential buildings located within another category, such as barracks and dormitories, should be identified in this category when possible, (except residential buildings within convents and monasteries - include these with Institutional).

2.2 Non-residential Developed - Any "developed" area or feature that is used for a purpose other than habitation.

2.21 Commercial/Light Industry - structures and associated grounds used for the sale of products and services, for business, or for light industrial activities. Includes all retail and wholesale operations. Include "industrial parks" and other features that cannot be clearly classified as either a retail service or light industry, such as heavy equipment yards, machinery repair, and junkyards.

2.211 Major Retail - This category includes shopping malls, retail "outlet centers", and "superstores" that draw clientele from a regional area. Consist of extremely large single buildings or a complex of large buildings and their parking lots. Malls usually house one or two major department stores and numerous small retail stores. Includes outlet centers, "superstores", multi-plex movie theaters, and huge warehouse-type stores. The structures themselves are often several acres in size and have extensive parking lots.

2.212 Mixed/Minor Retail and Services - Includes individual stores and services of various sizes and associated grounds and parking. Includes neighborhood strip malls and shopping centers, veterinarian services, small movie theaters, gas stations and auto repair

shops, garden centers, motels, small auto dealerships, public parking lots, lumber yards, art galleries, farm supply stores, flea-markets, bars and restaurants, grocery stores, and commercial "truck stops". Many small office buildings will have no features to distinguish them from retail stores and will fall in this category.

2.213 Office - structures and their associated grounds and parking, which provide financial, professional, administrative, and informational type services. Includes administrative government offices (e.g., IRS and State Motor Vehicles offices) trade schools, professional medical office complexes, research facilities/centers, and banks. Usually only office buildings in office complexes or in downtown areas will be distinguishable as offices. Small, single-story office buildings may blend in with minor retail.

2.214 Light industry - structures and their associated grounds and facilities that are used primarily to produce or process some finished product; or as a wholesale distribution center. Activities include design, assembly, finishing, packaging, warehousing or shipping of products rather than processing raw materials. The materials used in light industry have generally been processed at least once. They are generally "clean" industries that do not produce lots of waste materials. Use this category as a default for those facilities with semi-truck and trailer activity around loading docks, but that cannot be classified as either retail services or heavy industry. Includes electronic firms, clothing and furniture manufacture, grain elevators, printing plants, commercial bakeries, shipping and distribution centers, sand/gravel sorting facilities, secondary buildings associated with a mining or quarrying site, and generic warehouses.

2.22 Heavy Industry - structures and their associated grounds used for heavy fabrication, manufacturing and assembling parts that are, in themselves, large and heavy; or for processing raw materials such as iron ore, timber, and animal products. Accumulated raw materials are subject to treatment by mechanical, chemical, or heat processing to render them suitable for further processing, or to produce materials from which finished products are created. Heavy industries generally require large amounts of energy and raw materials and produce a significant amount of waste products. Indicators of heavy industry may be stockpiles of raw materials, energy producing sources and fuels, waste disposal areas and ponds, transportation facilities capable of handling heavy materials, smokestacks, furnaces, tanks, and extremely large buildings that are complex in outline and roof structure. Include associated waste piles and waste ponds. Heavy industry is usually located away from residential areas. Includes steel mills, paper mills, lumber mills, cotton gins, chemical plants, cement and brick plants, smelters, rock crushing machinery, and ore-processing facilities associated with mining.

2.221 Petro-chemical Refinery - structures and all associated equipment and grounds used for processing petro-chemicals. Include associated waste ponds.

2.23 Communications and Utilities - structures or facilities and associated grounds used for the generation of power and communications, the treatment or storage of drinking water, waste management, flood control, or the distribution and storage of gas and oil not associated with a unique feature. Includes pumping stations (oil, gas, or water), tank farms, power plants, electric substations, sewage treatment facilities and ponds, garbage collection facilities (not the final dumping ground - these are included in Bare), dams, levees, and spillways of appropriate dimensions, filtration plants, and heavy concentrations of antennas or satellite dishes; along with the related operational buildings.

2.24 Institutional - specialized government or private features that meet the educational, religious, medical, governmental, protective, and correctional needs of the public. Parking lots and associated grounds are included with these features. Includes public and private schools (not day care), state capitols, city halls, courthouses, libraries, churches, convents, monasteries, hospitals and training hospitals, post offices, police and fire departments, prisons, and military

bases. Only the military-business areas of a military base are classified here; residential, airport, athletic fields, and vegetated areas are classified in the appropriate category.

2.241 Schools/Universities - public and private schools, seminaries, university campuses, and associated lands. Include the entire "core campus" area, along with athletic fields and vegetated areas. This category does not include day care centers or commercial trade schools, both of which are commercial uses.

2.242 Cemeteries - structures and lands devoted to burial of the dead. Includes mausoleums, service areas, and parking lots.

2.25 Agricultural Business - structures and all associated lands used for raising plants or animals for food or fiber. Includes fish farms and hatcheries, feedlots, poultry farms, dairy farms, temporary shipping and holding pens, animal breeding or training facilities, and greenhouses. (Farmsteads including a dwelling are classified as Residential)

2.251 Aquiculture site - a set of pools of water and related structures used for producing fish, shellfish, or aquatic plants.

2.252 Confined feeding operation - structures and associated pens, storage facilities, waste areas, and ponds that are used for raising meat and dairy cattle, hogs, poultry, or other animals. These features must have a relatively permanent and high animal density. Temporary holding pens and thoroughbred horse farms usually do not qualify.

2.26 Transportation - Roads, railroads, airports, port facilities, and their associated lands. Roads and railroads include the right-of-way, interchanges, and median strips. Category includes railroad stations, railroad yards, bus stations, highway maintenance yards, school bus parking and service yards, and park-and-ride lots. Port facilities include loading and unloading facilities, docks, locks and, temporary storage areas. Associated warehousing and transfer stations for truck or rail are included only if they appear to be an integral part of the airport or port facility. Nearby but separate warehouses will be classified as light industry.

2.261 Airport - Includes the maintained active and overrun areas of the runways, landing strips, and taxiways, with the intervening land; along with the plane tie-down areas, terminals, hangers, related fuel storage facilities, service buildings, parking lots, navigation aids, and airport offices. Rental car lots integrated with the airport should be included with the airport.

2.27 Entertainment and Recreational - areas and structures used predominantly for athletic or artistic events, or for leisure activities, and all associated lands and developed parking areas. Includes outdoor amphitheaters, drive-in theaters, campgrounds, zoos, sports arenas (including indoor arenas), developed parks and playgrounds, community recreation centers, museums, amusement parks, public swimming pools, fairgrounds, and ski complexes (not the ski slopes). Marinas with over 25% of water surface covered by docks and boats are included here.

2.271 Golf Course - structures, associated grounds, driving ranges, and interspersed natural areas used for the game of golf.

2.272 Urban Parks - designated open space in urban settings used for outdoor recreation. Include grass fields and associated structures, parking lots, and facilities. Includes city parks, "green-belt" urban parks, and athletic fields not associated with a school. Does not include undeveloped "open space" on the periphery of urban areas or undeveloped regional, state, or national park areas.

2.3 Mixed Urban - developed areas that have such a mixture of residential and non- residential features where no single feature meets the minimum mapping unit specification. This category is used when more than one-third of the features in an area do not fit into a single category. Often applicable in the central, urban-core area of cities.

3.0 BARE - undeveloped areas of the earth not covered by water that exhibit less than 25% vegetative cover or less than 5% vegetative cover if in an arid area. The earth's surface may be composed of bare soil, rock, sand, gravel, salt deposits, or mud.

3.1 Transitional Bare - areas dynamically changing from one land cover/land use to another, often because of land use activities. Includes all construction areas, areas transitioning between forest and agricultural land, and urban renewal areas that are in a state of transition.

3.2 Quarries/Strip Mines/Gravel Pits - areas of extractive mining activities with significant surface disturbance. Vegetative cover and overburden are removed for the extraction of deposits such as coal, iron ore, limestone, copper, sand and gravel, or building and decorative stone. Current mining activity does not need to be identifiable. Inactive or unreclaimed mines and pits are included in this category until another land cover or land use has been established. Includes strip mines, open-pit mines, quarries, borrow pits, oil and gas drilling sites, and gravel pits with their associated structures, waste dumps, and stockpiles.

3.3 Bare Rock/Sand - includes bare bedrock, natural sand beaches, sand bars, deserts, desert pavement, scarps, talus, slides, lava, and glacial debris.

3.4 Flats - A level landform composed of unconsolidated sediments of mud, sand, gravel, or salt deposits. Includes coastal tidal flats and interior desert basin flats and playas.

3.5 Disposal - designated areas where refuse is dumped or exists, such as hazardous-waste disposal sites, landfills, or dumps. Do not include reclaimed disposal areas or those covered with vegetation.

4.0 VEGETATED - areas having generally 25% or more of the land or water with vegetation. Arid or semi-arid areas may have as little as 5% vegetation cover.

4.1 Woody Vegetation - land with at least 25% tree and (or) shrub canopy cover.

4.11 Forested - land where trees form at least 25% of the canopy cover.

4.111 Deciduous Forest - area dominated by trees where 75% or more of the canopy cover can be determined to be trees that lose their leaves for a specific season of the year.

4.112 Evergreen Forest - area dominated by trees where 75% or more of the canopy cover can be determined to be trees that maintain their leaves all year.

4.113 Mixed Forest - areas dominated by trees where neither deciduous nor evergreen species represent more than 75% of the canopy cover.

4.12 Shrub land - areas where trees have less than 25% cover and the existing vegetation is dominated by plants that have persistent woody stems, a relatively low growth habit, and that generally produce several basal shoots instead of a single shoot. Includes true shrubs, trees that are small or stunted because of environmental conditions, desert scrub, and chaparral. In the eastern US, include former cropland or pasture lands that are now covered by brush to the extent that they are no longer identifiable or usable as cropland or pasture. Clear-cut areas will exhibit a stage of shrub cover during the regrowth cycle. Some common species that would be classified as shrub land are mountain mahogany, sagebrush, and scrub oak.

4.121 Deciduous Shrub land - areas where 75% or more of the land cover can be determined to be shrubs that lose their leaves for a specific season of the year.

4.122 Evergreen Shrub land - areas where 75% or more of the land cover can be determined to be shrubs that keep their leaves year round.

4.123 Mixed Shrub land - areas dominated by shrubs where neither deciduous nor evergreen species represent more than 75% of the land cover.

4.124 Desert Scrub - land areas predominantly in arid and semi-arid portions of the southwestern U.S. Existing vegetation is sparse and often covers only 5-25% of the land. Example species include sagebrush, creosote, saltbush, greasewood, cactus.

4.13 Planted/Cultivated Woody (Orchards/Vineyards/Groves) - areas containing plantings of evenly spaced trees, shrubs, bushes, or other cultivated climbing plants usually supported and arranged evenly in rows. Includes orchards, groves, vineyards, cranberry bogs, berry vines, and

hops. Includes tree plantations planted for the production of fruit, nuts, Christmas tree farms, and commercial tree nurseries. Exclude pine plantations and other lumber or pulp wood plantings that will be classified as Forest.

4.131 Irrigated Planted/Cultivated Woody - orchards, groves, or vineyards where a visible irrigation system is in place to supply water.

4.132 Citrus - trees or shrubs cultivated in orchards or groves that bear edible fruit such as orange, lemon, lime, grapefruit, and pineapple.

4.133 Non-managed Citrus - orchards or groves containing fruit bearing trees or shrubs that are no longer maintained or harvested by humans. Evidence of non-managed citrus includes the growth of non citrus shrubs, trees, and grasses within a orchard or grove.

4.14 Mixed Forest/Shrub – areas dominated by forest and shrub where neither species represent more than 75 % of the canopy cover.

4.2 Herbaceous Vegetation - areas dominated by non-woody plants such as grasses, forbs, ferns and weeds, either native, naturalized, or planted. Trees must account for less than 25% canopy cover while herbaceous plants dominate all existing vegetation.

4.21 Natural Herbaceous - areas dominated by native or naturalized grasses, forbs, ferns and weeds. It can be managed, maintained, or improved for ecological purposes such as weed/brush control or soil erosion. Includes vegetated vacant lots and areas where it cannot be determined whether the vegetation was planted or cultivated such as in areas of dispersed grazing by feral or domesticated animals. Includes landscapes dominated by grass-like plants such as bunch grasses, palouse grass, palmetto prairie areas, and tundra vegetation, as well as true prairie grasses.

4.211 Natural Grasslands - natural areas dominated by true grasses. Includes undisturbed tall-grass and short-grass prairie in the Great Plains of the U.S.

4.22 Planted/Cultivated Herbaceous - areas of herbaceous vegetation planted and/or cultivated by humans for agronomic purposes in developed settings. The majority of vegetation in these areas is planted and/or maintained for the production of food, feed, fiber, pasture, or seed. Temporarily flooded are included in this category. Do not include harvested areas of naturally occurring plants such as wild rice and cattails.

4.221 Fallow/Bare Fields - areas within planted or cultivated regions that have been tilled or plowed and do not exhibit any visible vegetation cover

4.222 Small Grains - areas used for the production of grain crops such as wheat, oats, barley, graham, and rice. Category is difficult to distinguish from cultivated grasses grown for hay and pasture. Indicators of small grains may be a less than 10% slope, annual plowing and seeding, distinctive field patterns and sizes, different timing of green-up and harvest, different harvesting practices, a very “even” texture and tone, or regional variations discovered during field checks.

4.2221 Irrigated Small Grains - areas used for the production of small grain crops where a visible irrigation system is in place to supply water including the flooding of entire fields.

4.22211 Rice Fields - a cereal grass cultivated extensively in warm climates and used as a staple food. Rice is grown on submerged land in coastal plains, tidal deltas, and river basins of tropical, semi-tropical, semi-tropical, and temperate regions of Louisiana, Texas, California, Missouri, Arkansas, and Mississippi. The fields are characterized by a slope of less than 0.5% and have many dikes that meander parallel to the contours of the land surface. The dikes, which are the most significant characteristic of the rice fields, may be small in height and are used to hold water. At times, the rice fields may be covered in water.

4.223 Row Crops - areas used for the production of crops or plants such as corn, soybeans, vegetables, tobacco, flowers and cotton. Fields that exhibit characteristics similar to row crops, but that do not have any other distinguishing features for a more specific category may be included.

4.2231 Irrigated Row Crops - areas used for the production of row crops where a visible irrigation system is in place to supply water.

4.2232 Sugar Cane - a very tall tropical grass up to 15 feet high with thick tough stems that is cultivated as the main source of sugar. It can be found in tropical and sub-tropical areas of the United States such as Florida, Hawaii, and Texas.

4.224 Cultivated grasses - areas of herbaceous vegetation, including perennial grasses, legumes, or grass-legume mixtures that are planted by humans and used for erosion control, for seed or hay crops, for grazing animals, or for landscaping purposes.

4.2241 Pasture/Hay - areas of cultivated perennial grasses and/or legumes (e.g., alfalfa) used for grazing livestock or for seed or hay crops. Pasture lands can have a wide range of cultivation levels. It can be managed by seeding, fertilizing, application of herbicides, plowing, mowing, or baling. Pasture land has often been cleared of trees and shrubs, is generally on steeper slopes than cropland, is intended to graze animals at a higher density than open rangeland, and is often fenced and divided into smaller parcels than rangeland or cropland. Hay fields may be more mottled than small grain fields as they are not plowed annually and may be harvested and baled two or three times a year in some locations.

4.22411 Irrigated Pasture/Hay - areas used as pasture or hay fields where a visible irrigation system is in place to supply water

4.2242 Other planted grasses - areas of other cultivated grass such as turf and sod farms.

4.22421 Irrigated other grasses - areas of other cultivated grasses where a visible irrigation system is in place to supply water.

4.225 Irrigated Planted Herbaceous - land that is growing some indistinguishable crop or grass, but is obviously irrigated.

4.3 Vegetated Wetland - areas where the water table is at, near, or above the land surface for a significant part of most years and vegetation indicative of this covers more than 25% of the land surface. Wetlands can include marshes, swamps situated on the shallow margins of bays, lakes, ponds, streams, or reservoirs; wet meadows or perched bogs in high mountain valleys, or seasonally wet or flooded low spots or basins. Do not include agricultural land that is flooded for cultivation.

4.31 Woody Wetland - areas dominated by woody vegetation. Includes seasonally flooded bottom land, mangrove swamps, shrub swamps, and wooded swamps including those around bogs. Wooded swamps and southern flood plains contain primarily cypress, tupelo, oaks, and red maple. Central and northern flood plains are dominated by cottonwoods, ash, alder, and willow. Flood plains of the Southwest may be dominated by mesquite, saltcedar, seepwillow, and arrowweed. Northern bogs typically contain tamarack or larch, black spruce, and heath shrubs. Shrub swamp vegetation includes alder, willow, and buttonbush.

4.32 Emergent Herbaceous Wetlands - areas dominated by wetland herbaceous vegetation that is present for most of the growing season. Includes fresh-water, brackish-water, and salt-water marshes, tidal marshes, mountain meadows, wet prairies, and open bogs.

Appendix I

Accuracy Assessment Analysis Results

Introduction

This appendix contains the results of the analysis of accuracy assessment (AA) field data. Each of the 784 AA field plots sampled at ARCH in 2006 was compared with the polygon in which it was located. If the field data matched the polygon label, the plot was deemed correct. If it did not, it was marked incorrect and underwent further analysis as to the type and pattern of error, and the best way to resolve the error.

We approached the error analysis with the idea that error can enter a map and into a data set from many sources, most of which are out of the photointerpreter's control. These sources of error include:

- Transcription error by the technician who created the digital mapping database
- Locational error in the field (e.g. canyons or dense forests where GPS doesn't work, OR small or narrow polygons, so sample is taken in a different polygon than was intended)
- Transcription error by persons entering AA data into the relational database
- Transcription error by persons creating the AA contingency table
- Field key is difficult to use (fault may lie with key or with classification)
- Field key does not include all plant associations present within the park
- Field crew error, either by mis-identifying diagnostic species in the field, or by not reading the key carefully, thus resulting in a bad call when the map is actually good
- Point falls within an ecotone, which is impossible to classify but which still has to get mapped as something
- The AA point falls in an inclusion of a different vegetation type that is too small to map as a separate polygon; the mapper had to choose the dominant type to label the polygon
- The photos were flown and/or the plot data collected in a year or season either much drier or much wetter than the year/season in which AA is done

These types of error may affect the accuracy of a map even when the map concepts are good. We therefore felt justified in making post-AA adjustments to the map class definitions, the association-map class crosswalk, field key, and in a few cases, the map polygon labels to account for what we considered to be "false" (i.e., not in control of the mapper) errors.

The initial (uncorrected) accuracy of the ARCH vegetation map was 51.3%. We therefore inspected the original AA plot data, plot photographs, and aerial imagery for approximately 400 plots of accuracy assessment field data to create the table that follows. We identified the patterns of error for every map class that failed to meet the program standard of 80% user's and producer's accuracy and suggested one or more potential solutions in each case. The final step in the process was to present the table in November, 2006 to ARCH natural resources staff and ask for their input for solutions we would apply to the final map. Park staff could choose from our suggestions or offer other solutions. In some cases, staff chose "none of the above" and opted

instead to retain a map class with lower accuracy because it represented a vegetation type that was important to management.

Additional adjustments to map class concepts were made in December, 2008 to make the ARCH map more compatible with the mapping concepts used at Canyonlands National Park. These changes included adding four new map classes to the park that have not been formally accuracy assessed, though all of them have at least one AA point and most have many AA points. The four map classes (4, 8, 71 and 92) were mapped in Canyonlands and also occur in ARCH, although the original photointerpreter had not identified them or pulled them out. We felt that modifying the ARCH map and crosswalk would assist SEUG staff in managing similar types in both parks. In summary, the new map classes are:

- Map Class 4 describes oak patches on the Colorado River that are mostly below MMU (0.5 ha) in size, but have a distinct photo signature that can be easily delineated from neighboring tamarisk shrublands.

- Map Class 8 describes stream terrace communities where basin big sagebrush is the dominant shrub or is co-dominant with greasewood or rabbitbrush.

- Map Class 71 describes winterfat shrublands with or without an herbaceous or weedy understory; almost all polygons of this type are in Salt Valley.

- Map Class 92 describes mesic herbaceous vegetation, characterized by *Typha* and *Schoenoplectus*, along tributary drainages and was only mapped where known to occur in the park.

Other changes made in December, 2008 included renaming and renumbering map classes to make them compatible with those in Canyonlands. All of these changes are noted in the last column of the table below, and in the final map class number and final map class name columns.

Original Map Class	Final Map Class	Original Map Class Name	Final Map Class Name	Map Class Concept	Problem	Proposed Solution	Decision 11/06/06 and 12/08 Revision
1	**1**	Tamarisk – Gambel Oak River Corridor Altered Woodland Mosaic	Tamarisk River Corridor Shrubland	MC intended only for Colorado River canyon. Patchy and disturbed; tamarisk dominant with Gambel oak or Rhus. Sandbar willow on bars & banks	Crews found it more often than Gerald mapped it. Errors are for sites away from Colorado River	Amend field key to restrict this map unit to stands on the Colorado River	Accept proposed solution. Only one polygon in park. **12/08:** Mapped oak clones separately even if <MMU, as MC4, to match CANY MC concept
2	**1**	Tamarisk Temporarily Flooded Shrubland	Tamarisk River Corridor Shrubland	Stands of pure, mature tamarisk on floodplains, mostly in the Moab suburbs	The two incorrect plots are transcription errors: should have been labeled 7, not 2. Otherwise, no issues	Gerald should review all polygons mapped as 2 to make sure there aren't more transcription errors from Mylar to digital form	Accept proposed solution. **12/08:** Combined with MC1 to match CANY map class concept
3	**93**	Fremont Cottonwood Woodland Alliance	Tributary Woodland	Open woodlands on Courthouse Wash & upper Salt Wash with other mesic to hydric vegetation; lacks tamarisk	Significant confusion with MC6	Combine MC 3, 4, 5	Accept proposed solution. Rename "Fremont Cottonwood - Tamarisk Woodland" **12/08:** Combined MC3, 4, and 5 and renumbered MC93. Used “m” modifier for stands with mesic herbaceous understory
4	**93**	Fremont Cottonwood/ Tamarisk Understory Woodland	Tributary Woodland	Open woodlands on Courthouse Wash & upper Salt Wash with tamarisk understory or mosaicked with tamarisk	Significant confusion with MC3	Combine MC 3, 4, 5	Accept proposed solution. **12/08:** Used "x" modifier for stands with a TAMCHI understory
5	**93**	Disturbed bottoms (Tamarisk treatments)	Tributary Woodland	Open woodlands on Courthouse Wash & upper Salt Wash with visible disturbance related to tamarisk or other weed removal	Significant confusion with MC3. Ephemeral concept anyway with ongoing TAMCHI removal program	Combine MC 3, 4, 5	Accept proposed solution **12/08:** Used "x" modifier for stands with a TAMCHI understory
N/A	**4**	N/A	Gambel Oak Terrace Shrubland	Small patches along Colorado River canyon found just inland of TAMCHI thickets	N/A – created post AA	N/A	**12/08:** Map class concept developed & interpreted post-AA analysis; true accuracy of this map class is unknown

Original Map Class	Final Map Class	Original Map Class Name	Final Map Class Name	Map Class Concept	Problem	Proposed Solution	Decision 11/06/06 and 12/08 Revision
6	**6**	Greasewood Intermittently Flooded Shrubland Alliance	Greasewood Flats	SARVER terraces on upper Courthouse Wash & Salt Wash / tributaries with SARVER, with or without herbaceous layer. A few areas have some ARTRT also	No issues	Absorb MC91	None needed. **12/08:** Absorbed polygons of MC91 and gave these a cover density value of E. Mapped big sagebrush separately, as MC8
7	**7**	Pinyon - Juniper intermittently flooded Woodland Alliance	Pinyon - Juniper Intermittently Flooded Woodlands	Ephemeral drainages with junipers and mesic tall shrub understory. Includes “bathtub rings” around the base of large SS outcrops. Identified by large tree crowns and landscape position	Minor confusion with slickrock map units that include PJ/ tall shrubs	Add PJ/tall shrub assns. to crosswalk for MC7. Modify key to specify that slickrock stands go to MC 31, etc, while wash bottom stands go to MC7	Accept proposed solution
8	**100**	Hanging Gardens Complex	Hanging Gardens	Hanging gardens. Point data only	Not accuracy assessed	None needed	None needed
N/A	**8**	N/A	Basin Big Sagebrush Terrace Shrubland	Terraces on upper Courthouse Wash & Salt Wash / tributaries with ARTTRI co-dominant or dominant	N/A – created post AA	N/A	**12/08:** Map class concept developed & interpreted post-AA analysis; true accuracy of this map class is unknown
9	**9**	Floodplain Mixed Shrubland Mosaic	Tributary Tamarisk and Salix Shrubland Mosaic	Greasewood-dominated terraces now degraded & invaded by tamarisk in Salt Wash & upper Courthouse Wash	No issues	None needed	None needed. **12/08:** Pulled out stands of short shrubs on terraces from TAMCHI mosaic, as either MC6 or 18, to match CANY mapping concepts
10	**10**	Blackbrush Shrubland	Blackbrush Shrublands	Blackbrush-dominated stands with or without an herbaceous layer. Settings are plateaus and benches on sand sheets and shallow shale soils	Minor confusion with MC20 (PJ/COLRAM). Field crews should have gone both ways when tree cover approached 10%	Amend field key to allow to go to shrubland when tree cover < 10% as long as the entire community isn't sparse	Accept proposed solution

Original Map Class	Final Map Class	Original Map Class Name	Final Map Class Name	Map Class Concept	Problem	Proposed Solution	Decision 11/06/06 and 12/08 Revision
11	**11**	Sand Sage - Blackbrush Sandsheet Shrubland Mosaic	Sandsheet Shrublands	Blackbrush / sand sagebrush mosaic with or without a herbaceous layer. Occurs on sand sheets or low dunes	Minor confusion with MC12, otherwise ok	None needed	None needed
12	**25**	Sand Dune Woodland and Shrubland Mosaic	Sand Dune Woodlands	Mosaic of sand-loving shrublands & sparse juniper woodlands. Trees mostly in the swales between dunes	Minor confusion with MC20 (PJ/COLRAM)	None needed	Keep separate from MC13. **12/08:** Renumber to MC25 to match same MC concept at CANY
13	**13**	Dune Complex	Dune Complex	Mapped on the "brightest" / least vegetated dunes. Smaller areas of this type are included in the dune woodland mosaic	Major confusion with MC12	If QUHAVT shrubland is added to MC13 crosswalk, accuracy is 73%	Keep separate from MC12/25. Accept proposed solution. **12/08:** Added QUHAVT Shrubland to MC13 crosswalk
14	**14**	Green Mormon Tea - Xeric Grasses Dwarf-shrub Herbaceous Vegetation Complex	Mormon Tea - Mixed Grass Shrublands	Nearly level plateaus or larger benches. Complex of mot form of EPHVIR with HILJAM, STIHYM, & STICOM. MC has unclear boundaries with weedy degraded areas (MC17)	No issues	None needed	None needed
15	**15**	Red Barrens Shrub and Herbaceous Complex	Shale Barrens Desert Scrub	Sparse veg on Tidwell, Cutler, Moenkopi. Veg includes mixed stands of COLRAM, ATRCON, & EPHTOR & patchy HILJAM	Confused with MC 12, 17. Stands of sparse anything can look like this MC, so it is difficult to distinguish consistently	Don't have a good solution; the only option is to fold 15 into 12, which will drag the accuracy of 12 below 80%	Accept lower accuracy. Note that primary confusion with MC involves polygons mapped as 15t (wooded shrublands)

Original Map Class	Final Map Class	Original Map Class Name	Final Map Class Name	Map Class Concept	Problem	Proposed Solution	Decision 11/06/06 and 12/08 Revision
16	**5**	Mancos Shale Badlands Sparse Vegetation Complex	Badlands Sparse Vegetation	Sparse mat saltbush vegetation on Mancos shale	Minor confusion with MC6, which goes away if upland SARVER stands are included in MC16. Major confusion is with MC 10 (really, sparse MC15)	(1) Fix field key to allow upland SARVER stands to represent MC16. (2) Fold 16 into 15. (3) Re-map all the Mancos shale south of Fiery Furnace outside of Cache Valley as MC15. (4) Retain MC16 & restrict to upper Mancos outcrops on the floor of Cache Valley	Accept solution 3 and remap other polys of 16 as MC15. **12/08:** Renumbered most polys of MC16 outside Cache Valley as MC5 (not 15), and defined this map class as characterized by ATRGAR (see next line, also)
16	**26**	Mancos Shale Badlands Sparse Vegetation Complex	Mat Saltbush Sparse Vegetation	Sparse mat saltbush vegetation on Mancos shale	Minor confusion with MC6, which goes away if upland SARVER stands are included in MC16. Major confusion is with MC 10 (really, sparse MC15)	(1) Fix field key to allow upland SARVER stands to represent MC16. (2) Fold 16 into 15. (3) Re-map all the Mancos shale south of Fiery Furnace outside of Cache Valley as MC15. (4) Retain MC16 & restrict to upper Mancos outcrops on the floor of Cache Valley	Accept solution (4): Retain MC & narrow concept to include only upper Mancos on the floor of Cache Valley. **12/08:** Mapped polys in Cache Valley as MC26, and defined this map class as characterized by ATRCOR. Mapped only where known to occur from plots and AA points and on identical adj. habitats
17	**17**	Salt Valley Weedy and Mixed Herbaceous Complex	Weedy Herbaceous Vegetation	Degraded grasslands on older alluvium. Nearly solid cheatgrass outside the park in Salt Valley. Cheatgrass not separated from other weedy types	Minor confusion with MC18, which is the undegraded form of the same communities	None needed	None needed. **12/08:** Mapped winterfat shrublands separately, as MC71, to match similar concept mapped at CANY
18	**18**	Courthouse Wash Terrace Special Shrub and Herbaceous Complex	High Terrace Shrub Herbaceous Complex	Complex of shrub and herbaceous veg on deep, sandy soils of high terraces in Courthouse Wash and similar areas. ARTFIL and ATRCAN are dominant with good cover of grasses including SPOAIR and HILJAM	Landform mapping is good, but veg is more diverse than originally modeled. Major confusion is with MC6. Can't get >65% accuracy without stretching this MC to include COLRAM shrublands	If kept as a veg map class, accuracy will have to be less than 80%. (1) Convert to a geomorphologic unit and remove from AA. (2) Combine with MC6; will dilute both the accuracy and concept of MC6 by adding high terraces to a low terrace map class	Change to geomorph type. Describe assns and effects of surface age, grazing history, substrate, water table, etc. Remove from AA. **12/08:** Retained MC as a veg class. Pulled out stands of greasewood (MC6) and defined this map class by other terrace species (ARTFIL, ATRCAN, ERINAU, grass)

Original Map Class	Final Map Class	Original Map Class Name	Final Map Class Name	Map Class Concept	Problem	Proposed Solution	Decision 11/06/06 and 12/08 Revision
19	**27**	Saline Wildrye - Shale Sparse Vegetation	Salina Lyme Grass Sparse Vegetation	Mapped on north-facing slopes of the Mancos, Morrison, and Cutler group shales where no tree cover present	Confused with a number of other map units	Narrow the concept of this map unit to ONLY steep, north-facing Brushy Basin, talus covered slopes. Remaining polys should be folded into MC15	Retain as a separate map unit. Accept proposed solution. **12/08:** Mapped only where known to occur from plots and AA points and on identical adjacent habitats
20	**20**	Utah Juniper - Pinyon / Blackbrush and Mixed Shrub Complex	Pinyon – Juniper / Blackbrush Woodlands	Limited to higher and denser woodlands at the north end. Blackbrush understory not apparent with higher tree cover	Minor confusion with related map units. One bad field call corrected	Once PJ/PUST added to crosswalk (fits concept), there are no remaining issues. Add parts of MC30 polys and absorb MC33	Accept proposed solution. **12/08:** Did **not** add PJ/PUST to crosswalk. Remapped to include only PJ / blackbrush on deep soils and remapped polys in areas with more bedrock exposed as MC33
30	**30**	Steep Canyonsides and Escarpments Mixed Sparse Shrubland and Woodland Mosaic	Talus Sparse Vegetation Complex	Steep slopes of the CO River and Salt Wash canyons below Wingate cliffs and the south side of Salt Valley. Mixed veg with many shrubs. Sparse trees on some slopes. Other slopes are sparely vegetated	Confusion with MC12 and 20. Plots on colluvial slopes keyed to other assns were also called wrong. This MC is based on very steep slopes; the most representative areas masked out of the AA	Revise map unit concept to exclude Kayenta ledges and include only the stuff below: Wingate (if shattered) and Chinle/Moenkopi colluvial slopes. Revise relevant couplets in key to allow stands on steep colluvial slopes to represent MC30	Accept proposed solution. Flatter, ledgy sites of Kayenta will be remapped as MC33
31	**31**	Moab Tongue Fm "pattern jointed" slickrock Complex	Moab Tongue Slickrock Woodlands	This map unit is a special complex to describe the Moab Tongue with deep joints supporting sparse woodland and shrub vegetation	Major confusion with the other sandstone units, primarily because of missing crosswalk associations	Add PJ/PUST and PJ/CEIN to crosswalk; they are common. If MC31& 34 remain separate map classes, revise field key to account for geology, since most associations overlap	Accept proposed solution. **12/08:** Added these associations to crosswalk. Absorbed polygons of MC131 and gave these pattern attribute 4

Original Map Class	Final Map Class	Original Map Class Name	Final Map Class Name	Map Class Concept	Problem	Proposed Solution	Decision 11/06/06 and 12/08 Revision
32	**32**	Navajo Fm hard buff SS Slickrock Vegetation Complex	Pothole and Jointed Sandstone Woodlands	This map unit describes the pattern of Navajo slickrock with sparse vegetation growing in cracks and small potholes	Major confusion with MC12, because crosswalk didn't include PJ/ mesic tall shrubs woodland or mesic tall shrubland	Add these associations to the crosswalk (both common associations on Navajo), and the issue goes away	Accept proposed solution. **12/08:** Did not add mesic tall shrubland to the crosswalk because this MC is a sparse woodland type
33	**33**	Kayenta and Morrison Salt Wash Member Formation Hard SS Slickrock - Sparse Vegetation Complex	Sandstone Ledges Woodland	Similar to other slickrock-sparse types but specific to the Salt Wash SS, with some Kayenta exposures included because they seemed similar	Low accuracy. Major confusion with MC20 in vegetation and substrate; main difference is veg density	Add PJ/tall shrubs assns to crosswalk, combine MC20 and 33, revise name. Retain linework to preserve differences in veg density. Also add parts of MC30 polys that are on Kayenta	Accept proposed solution. **12/08:** Did not combine MC33 & MC20; relabeled many polys of MC20 to MC33, when they had some bedrock exposed. Added assns to crosswalk. Remapped Kayenta ledgy sites in polys of MC30 and labeled these as MC33
34	**130**	Entrada Fm Hard Buff Slickrock Vegetation Complex	Entrada Sandstone	This is largely a bedrock unit with small areas of pothole vegetation. Hanging gardens may occur below overhangs	Bare slickrock wasn't part of the key; crews tried to cram 98% bedrock plots into veg types	Any plot described as "mostly bare slickrock", was changed to correct. Once this correction was made, no issues remain	**12/08:** Changed to a geologic map class where 99% bare slickrock and removed from AA. Remapped the few vegetated areas as MC31 or 32
35	**35**	Gypsum with cryptobiotic soil crust - Sparse Vegetation Complex	Gypsum Badlands Sparse Vegetation	Paradox Fm badlands stabilized by heavy gypsiferous soil crusts. Community is restricted to gypsum exposures	Veg is more diverse than just EPHTOR / lichen. Any sand encourages PLEJAM to join the community	Add EPHTOR/PLEJAM to crosswalk. This raises accuracy to 81%	Accept proposed solution
36	**136**	Wingate Sandstone	Wingate Sandstone Bluffs	Largely unvegetated bluffs. A few areas may have hanging gardens	None. Not accuracy assessed	None needed	None needed

Original Map Class	Final Map Class	Original Map Class Name	Final Map Class Name	Map Class Concept	Problem	Proposed Solution	Decision 11/06/06 and 12/08 Revision
N/A	**71**	N/A	Winterfat Shrublands	Winterfat shrublands in a mosaic with MC17 & 14 in Salt Valley, with or without an herbaceous understory	N/A – created post AA	N/A	**12/08:** Map class concept developed & interpreted post-AA analysis; true accuracy of this map class is unknown
90	**90**	Dry Wash Complex	Dry Wash Shrublands	Floodplains and low terraces of intermittent or ephemeral streams.	Maps well as a landform, but the vegetation is variable depending on the veg of adjacent terraces	(1) Crosswalk to many assns. & restrict MC to wash bottoms with <15% cover. (2) re-map as a geologic class and eliminate as a map unit, remove from AA	Eliminate as a map unit, remap polygons as surrounding types. **12/08:** Retained MC. Reviewed mapping errors. Accepted lower accuracy because map class is rare
91	**6**	Salt Flat Complex	Greasewood Flats	Small areas on Salt Wash & upper tributaries with a salt crust and little vegetation.	Ephemeral Salt Wash flats probably altered by Oct. 2006 floods. No point in keeping this MC	Fold MC91 into MC6, or retain as either a subset of greasewood associations or as a geologic type	Fold polys into MC6 but retain linework and apply a modifier to the former MC91 polygons. **12/08:** Used an "AO" modifier for polygons where ALLOCC was documented by a plot or AA pt
N/A	**92**	N/A	Tributary Mesic Herbaceous Complex	Sections of streams with surface water present in growing season; supports mixed, mesic herbaceous species	Mapped only where known to occur, so may be more extensive in the park. Not accuracy-assessed	N/A	**12/08:** Two polygons in park mapped where known to occur from a plot and AA point.
97	**97**	Cliff & Alcove Mesic Woodland & Shrubland Complex	Cliff and Alcove Complex	Mesic shrubs with juniper and pinyon in sheltered alcoves below rims	Not accuracy assessed	None needed	None needed
99	**2**	Riverine Sandbar - Sandbar Willow Mosaic	Riverine Sandbar Sparse Willow Shrubland	Colonizing sandbar willow on active flood plains	With the crosswalk corrected, no issues	None needed	None needed

Original Map Class	Final Map Class	Original Map Class Name	Final Map Class Name	Map Class Concept	Problem	Proposed Solution	Decision 11/06/06 and 12/08 Revision
131	**31**	Juniper - Pinyon / Blackbrush and Mixed Shrub and Moab Tongue Slickrock Mosaic	Moab Tongue Slickrock Woodlands	Similar to MC31; for areas with more vegetation and less slickrock, esp. with denser woodlands	No issues	None needed	None needed. **12/08:** Combined with MC31 and added pattern attribute 4 to former MC131 polys
341	**341**	Entrada Fin and Woodland Swale Mosaic	Entrada Fin / Swale Woodland Mosaic	Related to MC34; is for areas where the bedrock cannot be separated from narrow bands of vegetation between sandstone fins.	No issues, as this is basically a geologic unit that can include a broad range of associations	Revise field key to guide readers directly to slickrock fin pocket type if they are in fins, regardless of vegetation	Broaden field key to include more of the mesic PJ types. **12/08:** Added P-J/CEMO assn to crosswalk and called other associations correct if landform was “fins”

Appendix J

Map Class Descriptions for Arches National Park

Introduction

This document provides a visual guide and description of the vegetation map classes for the Arches National Park Vegetation Mapping Project. Thirty-one map classes are described in this guide. Two unvegetated geologic map classes and twelve land use classes are not included.

Each of the map classes included in this guide is documented by:

- ground photographs (if available)
- a list of component NVC associations and ecological systems
- common plant species
- examples of each map class signature taken from the ortho imagery with delineated polygons
- descriptions of the photo signature
- a description of the ecology and distribution of the map class within the mapping area
- a graphic showing distribution of the map class throughout the mapping area
- polygon statistics report (polygon number, size, and area)
- accuracy assessment results for each map class

This guide does not attempt to show all variations within each vegetation map class; only the most common or significant representations are included. These should be sufficient to give the user an understanding of the relationships among the vegetation classification, the imagery, and mapping concepts.

VEGETATED MAP CLASSES OF ARCHES NATIONAL PARK

UPLAND FOREST AND WOODLAND 461
Pinyon - Juniper Intermittently Flooded Woodlands (W-PJIF) 461
Pinyon - Juniper / Blackbrush Woodlands (W-PJBB) 463
Sand Dune Woodlands (W-PJSD) 465
Moab Tongue Slickrock Woodlands (W-MTSW) 467
Pothole and Jointed Sandstone Woodlands (W-PJSW) 469
Sandstone Ledges Woodlands (W-LEDG) 471
Entrada Fin / Swale Woodland Mosaic (C-FINS) 473
UPLAND SHRUBLANDS 475
Badlands Sparse Vegetation (C-BADS) 475
Greasewood Flats (S-SAVE) 477
Basin Big Sagebrush Terrace Shrubland (S-ARTR) 480
Blackbrush Shrublands (S-BLAC) 482
Sandsheet Shrublands (S-SAND) 484
Dune Complex (S-DUNE) 486
Mormon Tea - Mixed Grass Shrublands (C-EVGR) 488
Shale Barrens Desert Scrub (S-SBDS) 490
High Terrace Shrub Herbaceous Complex (C-TERR) 492
Mat Saltbush Sparse Vegetation (C-MATS) 494
Talus Sparse Vegetation Complex (C-TALS) 496
Gypsum Badlands Sparse Vegetation (S-GYPS) 499
Winterfat Shrublands (S-WINT) 501
Dry Wash Shrublands (S-WASH) 503
UPLAND HERBACEOUS COMMUNITIES 505
Weedy Herbaceous Vegetation (H-WEED) 505
Salina Lyme Grass Sparse Vegetation (H-LESA) 507
RIPARIAN / WETLAND WOODLANDS AND SHRUBLANDS 509
Tamarisk River Corridor Shrubland (S-TARC) 509
Riverine Sandbar Sparse Willow Shrublands (S-RSSW) 511
Gambel Oak Terrace Shrubland (S-GOTS) 513
Tributary Tamarisk and Salix Shrubland Mosaic (S-TTSS) 515
Tributary Woodland (W-POFR) 517
Cliff and Alcove Complex (C-ALCO) 519
Hanging Gardens (H-HANG) 521
Tributary Mesic Herbaceous Complex (H-TMHC) 523

Upland Forest and Woodland

Map Class 7
Pinyon - Juniper Intermittently Flooded Woodlands (W-PJIF)





Photo credits: NPS

Associations

Pinus edulis – Juniperus osteosperma / Quercus havardii var. *tuckeri* Woodland [CEGL002497]
Juniperus osteosperma / Artemisia tridentata ssp. *tridentata* Woodland [CEGL002360]
Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii Wooded Shrubland [CEGL003774]
Rhus trilobata Intermittently Flooded Shrubland [CEGL001121]

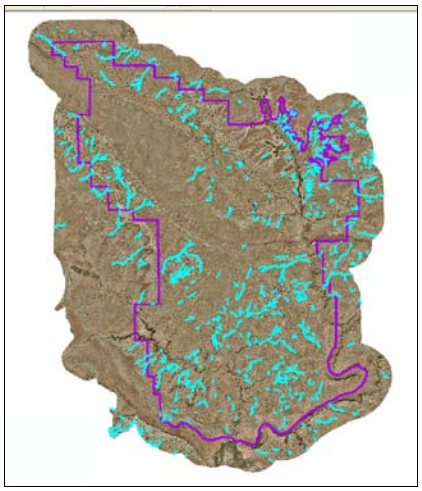
Common species

- *Pinus edulis*
- *Juniperus osteosperma*
- *Quercus havardii* var. *tuckeri*
- *Artemisia tridentata* ssp. *tridentata*
- *Purshia stansburiana*
- *Coleogyne ramosissima*
- *Fraxinus anomala*
- *Mahonia fremontii*
- *Ephedra viridis*
- *Rhus trilobata*

W-PJIF Map Class Statistics

Type:	Complex of multiple associations
Frequency:	543 total polygons
	384 polygons in ARCH
	159 polygons in the environs
Total project area:	667 hectares / 1,648 acres (1.3 %)
	461 hectares / 1,140 acres in ARCH
	206 hectares / 508 acres in the environs
Average Polygon Size:	1.2 hectares / 3 acres
Producer's accuracy:	93% ± 8%
User's accuracy:	93% ± 8%

Distribution in Mapping Area

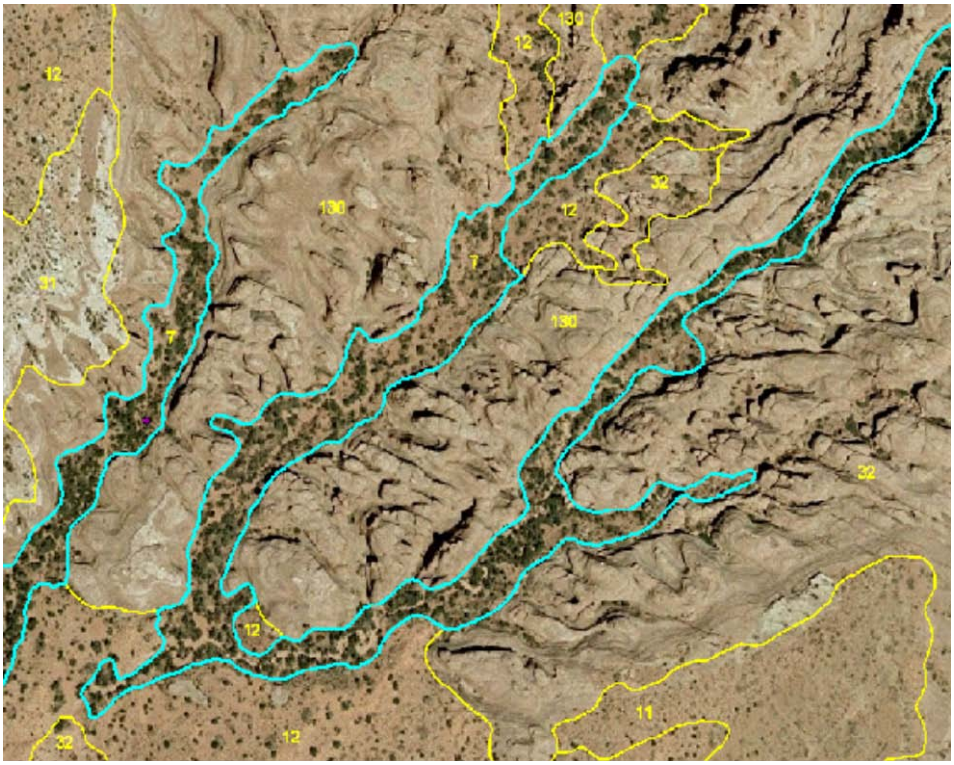


Distribution/Ecology/Composition

Map class 7 describes open pinyon-juniper stands growing along ephemeral washes and at the base of large sandstone outcrops. These communities have larger, more robust trees and mesic understories because of the increased runoff from drainage channels and the funneling of rainwater off the slickrock. The shrub understory is often diverse and provides moderate cover, with Stansbury cliffrose and Tucker oak hugging the drainages. Taller shrubs such as singleleaf ash, Fremont barberry and skunkbush are often present. Soils are usually deep and sandy, although some slickrock outcrops may be present. Litter is concentrated under the trees and oak clones.

Interpretation

Polygons of map class 7 narrow and often elongated, following wash bottoms or hugging the base of large sandstone outcrops. Tree crowns are smaller and darker green than cottonwood crowns would be, and trees are shorter. Trees appear as scattered dark dots along the washes, with an understory that ranges in pattern from sparse to clumpy, and sometimes with conspicuous irregular patches of Tucker oak. Adjacent polygons are often mapped as bare Entrada or Navajo slickrock (e.g., map classes 130, 131).



Example of photo signature for map class W-PJIF (#7).

Map Class 20
Pinyon - Juniper / Blackbrush Woodlands (W-PJBB)




Photo credits: NPS

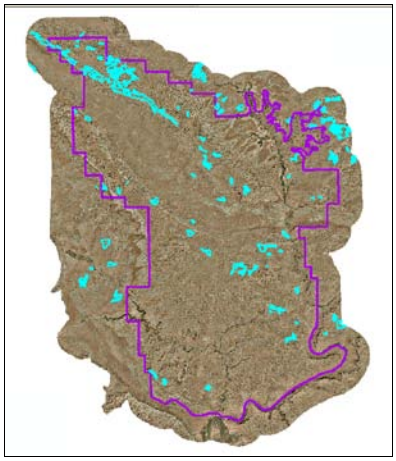
Associations
Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima Woodland [CEGL000781]
Juniperus osteosperma / Coleogyne ramosissima Woodland [CEGL002909]

Common species
- *Juniperus osteosperma*
- *Coleogyne ramosissima*
- *Fraxinus anomala*
- *Pinus edulis*
- *Ephedra viridis*
- *Streptanthella longirostris*

W-PJBB Map Class Statistics

Type:	Alliance
Frequency:	121 total polygons
	78 polygons in ARCH
	43 polygons in the environs
Total project area:	829 hectares / 2,049 acres (1.6 %)
	500 hectares / 1,236 acres in ARCH
	329 hectares / 813 acres in the environs
Average Polygon Size:	6.9 hectares / 16.9 acres
Producer's accuracy:	92% ± 16%
User's accuracy:	60% ± 21%

Distribution in Mapping Area

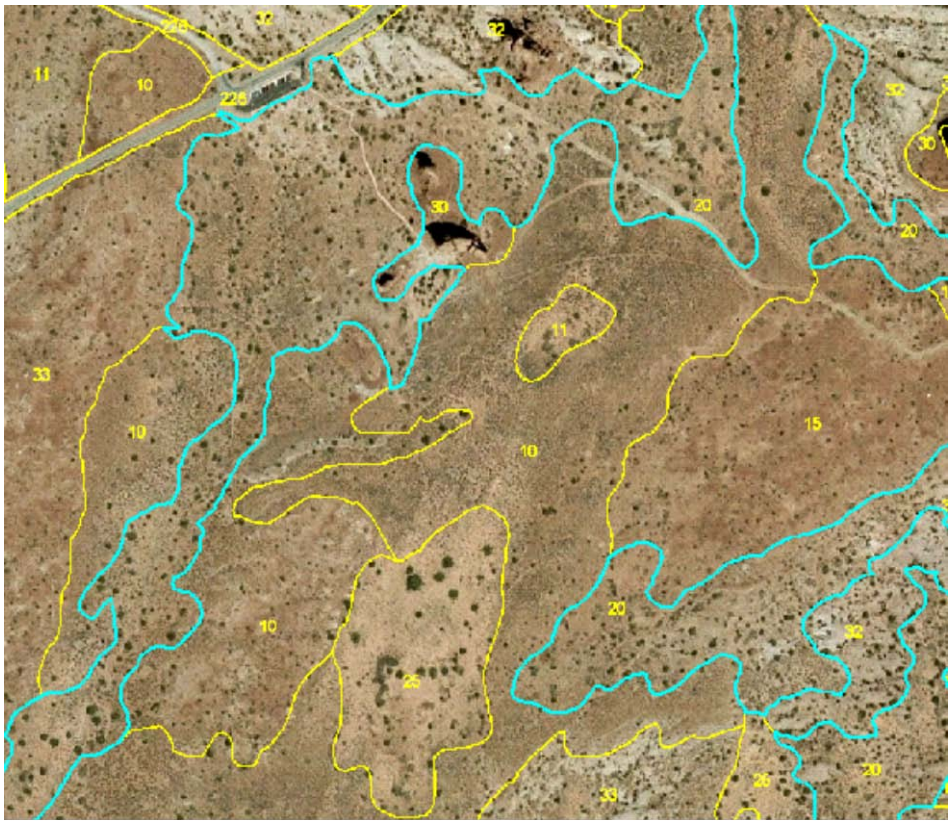


Distribution/Ecology/Composition
Map class 20 represents areas with consistent cover of juniper and pinyon pine (generally greater than 8% tree cover) with a visible understory of blackbrush. This type is best developed on benches and ledges of Entrada, Navajo, and Dewey Bridge Formations with shallow to moderately deep soils that cover most of the underlying bedrock. Sandstone exposures support inclusions of sparse pinyon-juniper woodlands (often <10% canopy closure), whereas residual shale soils or slope wash support blackbrush shrublands. This type also can occur on stabilized eolian sands. Stands of map class 20 are not common in the park

but are distributed throughout the mapping area. Gravel can provide up to 80% ground cover, while litter is concentrated under the tree crowns. Biological soil crusts are common in stands with sandy soils.

Interpretation

Map class 20 lacks the bright sand signature of map class 25. Tree canopies are clearly visible as rounded dark green dots and blackbrush cover is indicated by regularly-spaced, tiny black specks. Background substrate color is generally a tan or light brown color where soil is exposed. Adjacent polygons vary, but map class 33 (Ledge Sandstone Woodland) is most common.



Example of photo signature for map class W-PJBB (#20).

Map Class 25
Sand Dune Woodlands (W-PJSD)




Photo credits: NPS

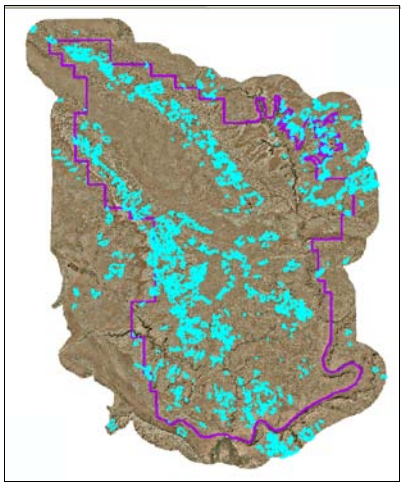
Associations
Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii Wooded Shrubland [CEGL003774]
Pinus edulis – Juniperus osteosperma / Quercus havardii var. *tuckeri* Woodland [CEGL002497]
Juniperus osteosperma / Sparse Understory Woodland [CEGL000732]

Common species
- *Juniperus osteosperma*
- *Coleogyne ramosissima*
- *Quercus havardii* var. *tuckeri*
- *Ephedra viridis*
- *Sphaeralcea* spp.
- *Pinus edulis*
- *Purshia stansburiana*
- *Gutierrezia sarothrae*
- *Opuntia polyacantha*
- *Achnatherum hymenoides*

W-PJSD Map Class Statistics

Type:	Alliance
Frequency:	709 total polygons
	512 polygons in ARCH
	197 polygons in the environs
Total project area:	2,737 hectares / 6,764 acres (5.2 %)
	2,092 hectares / 5,169 acres in ARCH
	645 hectares / 1,595 acres in the environs
Average Polygon Size:	3.9 hectares / 9.5 acres
Producer's accuracy:	81% ± 12%
User's accuracy:	100%

Distribution in Mapping Area

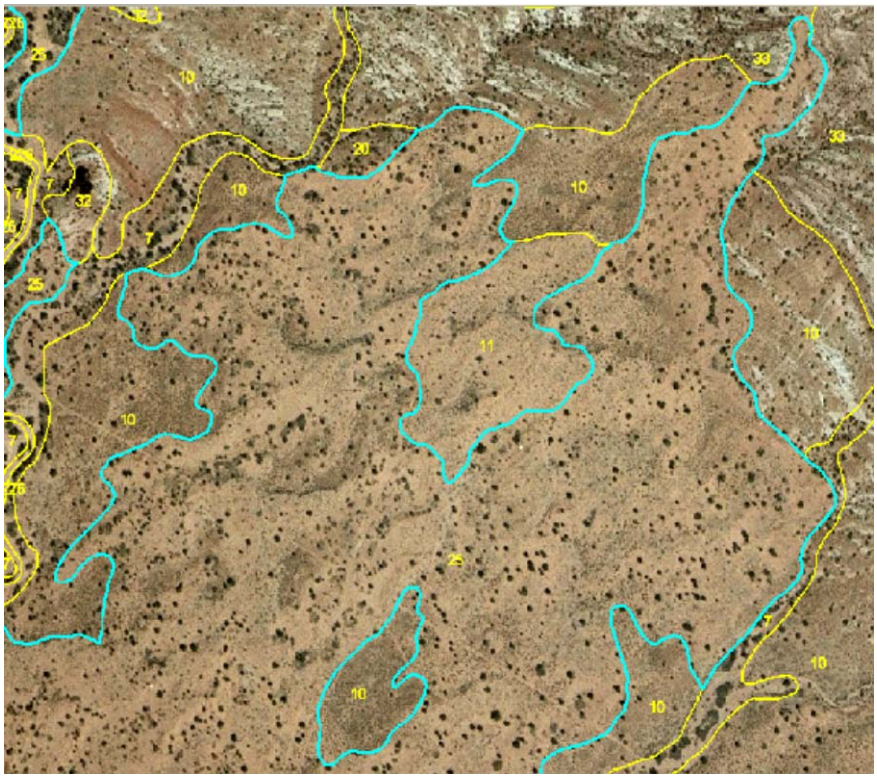


Distribution/Ecology/Composition
Map class 25 is common and widely distributed on sand-covered plateaus and benches throughout ARCH. It is characterized by a mosaic of sand-loving shrublands and sparse pinyon-juniper woodlands on

undulating sand dunes. Trees are concentrated in the swales between dunes where bedrock is sometimes exposed, and clonal forms of green Mormon-tea and Tucker oak perch atop the dunes. Blackbrush is often the dominant shrub in these communities, but sand sagebrush is rare to absent (see map class 11 – Sandsheet Shrubland). Herbaceous species present are usually those that do well in loose sand such as Indian ricegrass, sand muhly, globemallow, and sand verbena. Soils are stabilized in some areas with light biological and physical crusts, while other areas are actively blowing dunes.

Interpretation

Polygons are small to medium-sized, irregularly shaped. The characteristic signature combines the bright sand signature (as in map classes 11 and 13) and large, rounded dark green tree crowns of pinyon and juniper. Small strips of sandstone bedrock are sometimes visible, and the dunes often occupy the space between large sandstone outcrops. High magnification reveals a speckling of understory shrubs or blotchy light green areas of grass cover. Mot forms of green Mormon-tea and Tucker oak are visible as pimply-looking olive green spots that may be larger than the tree crowns. Blackbrush (appearing as very dark, regular specks) is the most common shrub in this community, which accounts for the confusion with map class 20 in the field. However, map class 25 is sandier and supports sand-loving species, whereas map class 20 is characterized by more homogenous blackbrush cover on variable (even rocky) substrates. Adjacent polygons tend to be mapped as the treeless dune communities (map classes 11 and 13), Blackbrush Shrublands (map class 10), and sandstone outcrop woodlands (map classes 31, 32, and 33).



Example of photo signature for map class W-PJSD (#25).

Map Class 31
Moab Tongue Slickrock Woodlands (W-MTSW)





Photo credits: NPS

Associations

Juniperus osteosperma / Cercocarpus intricatus Woodland [CEGL000733]
Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii Wooded Shrubland [CEGL003774]
Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus Woodland [CEGL000779]
Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland [CEGL000782]

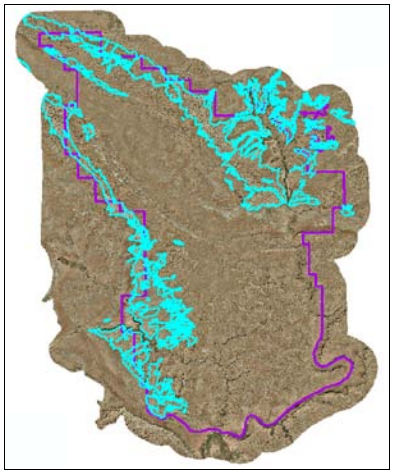
Common species

- *Juniperus osteosperma*
- *Cercocarpus intricatus*
- *Rhus trilobata*
- *Fraxinus anomala*
- *Coleogyne ramosissima*
- *Achnatherum speciosum*
- *Pinus edulis*
- *Amelanchier utahensis*
- *Quercus havardii* var. *tuckeri*
- *Purshia stansburiana*
- *Ephedra viridis*
- *Streptanthella longirostris*

W-MTSW Map Class Statistics

Type:	Alliance
Frequency:	247 total polygons
	160 polygons in ARCH
	87 polygons in the environs
Total project area:	6,486 hectares / 16,026 acres (12.3 %)
	4,396 hectares / 10,862 acres in ARCH
	2,090 hectares / 5,165 acres in the environs
Average Polygon Size:	26.3 hectares / 64.9 acres
Producer's accuracy:	89% ± 7%
User's accuracy:	98% ± 4%

Distribution in Mapping Area



Distribution/Ecology/Composition

Map class 31 represents the parallel-fissured slickrock of the Moab Tongue (Curtis Formation) and the patchy vegetation that is concentrated in the joints and linear potholes of this geologic type. This map unit is common throughout the mapping area wherever Moab Tongue slickrock is exposed, mostly in the northern and western portions of the park. Slickrock is a major component of this map unit, comprising at least 80% cover in most polygons. Runoff from the bedrock surfaces concentrates in the joints and fractures, enabling the vegetation growing there to survive. Utah Juniper / Blackbrush – Stansbury Cliffrose – Tucker oak Wooded Shrubland is the most common association in this map unit, sometimes with an element of littleleaf mountain mahogany. The vegetation is characterized by an open canopy of stunted (typically 1 to 2m tall) juniper and/or pinyon trees and a mix of tall and short shrubs which vary in dominance from site to site. Trees typically have 5-15% cover, and total shrub cover is usually less than 10%. Cliffrose, blackbrush, and singleleaf ash are the major understory shrubs, but other shrubs such as Utah serviceberry, littleleaf mountain mahogany, Tucker oak and skunkbush are usually minor components of the community. The herbaceous understory is usually sparse. Biological soil crusts are often well developed on what little soil is exposed.

Interpretation

This map class describes the unique woodland community occurring in the deep joints cutting the Moab Tongue sandstone. Polygons vary in size and shape, closely following the light gray exposures of Moab Tongue slickrock. The majority of each polygon is slickrock, with dots of shrubs and rounded tree crowns only visible in the parallel cracks and joints characteristic of this geologic formation. Map class 31 is distinguished from other slickrock-based vegetation map classes (32, 33) by geologic characteristics and the distribution of vegetation rather than differences in the community composition. Adjacent polygons are often mapped as Shale Barrens Desert Scrub (map class 15), Blackbrush Shrublands (map class 10) Sandsheet Shrublands (map class 11), and Sand Dune Woodlands (map class 25).



Example of photo signature for map class W-MTSW (#31).

Map Class 32
Pothole and Jointed Sandstone Woodlands (W-PJSW)




Photo credits: NPS

Associations

Juniperus osteosperma / Cercocarpus intricatus Woodland [CEGL000733]
Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii Wooded Shrubland [CEGL003774]
Juniperus osteosperma / Sparse Understory Woodland [CEGL000732]
Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus Woodland [CEGL000779]
Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland [CEGL000782]

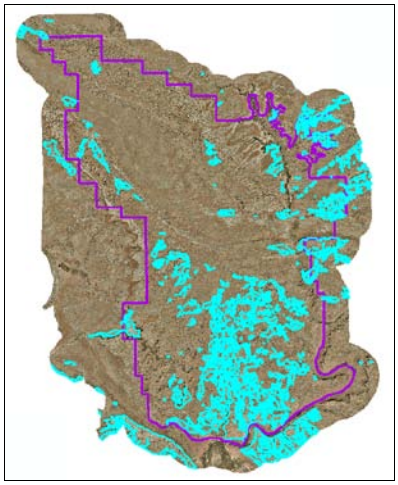
Common species

- *Pinus edulis*
- *Cercocarpus intricatus*
- *Coleogyne ramosissima*
- *Quercus havardii* var. *tuckeri*
- *Artemisia bigelovii*
- *Yucca harrimaniae*
- *Hesperostipa comata*
- *Lepidium montanum*
- *Juniperus osteosperma*
- *Cercocarpus montanus*
- *Purshia stansburiana*
- *Ephedra viridis*
- *Fraxinus anomala*
- *Gutierrezia sarothrae*
- *Achnatherum hymenoides*

W-PJSW Map Class Statistics

Type:	Alliance
Frequency:	393 total polygons
	263 polygons in ARCH
	130 polygons in the environs
Total project area:	5,674 hectares / 14,022 acres (10.8 %)
	3,776 hectares / 9,332 acres in ARCH
	1,898 hectares / 4,690 acres in the environs
Average Polygon Size:	14.4 hectares / 35.7 acres
Producer's accuracy:	94% ± 7%
User's accuracy:	88% ± 8%

Distribution in Mapping Area

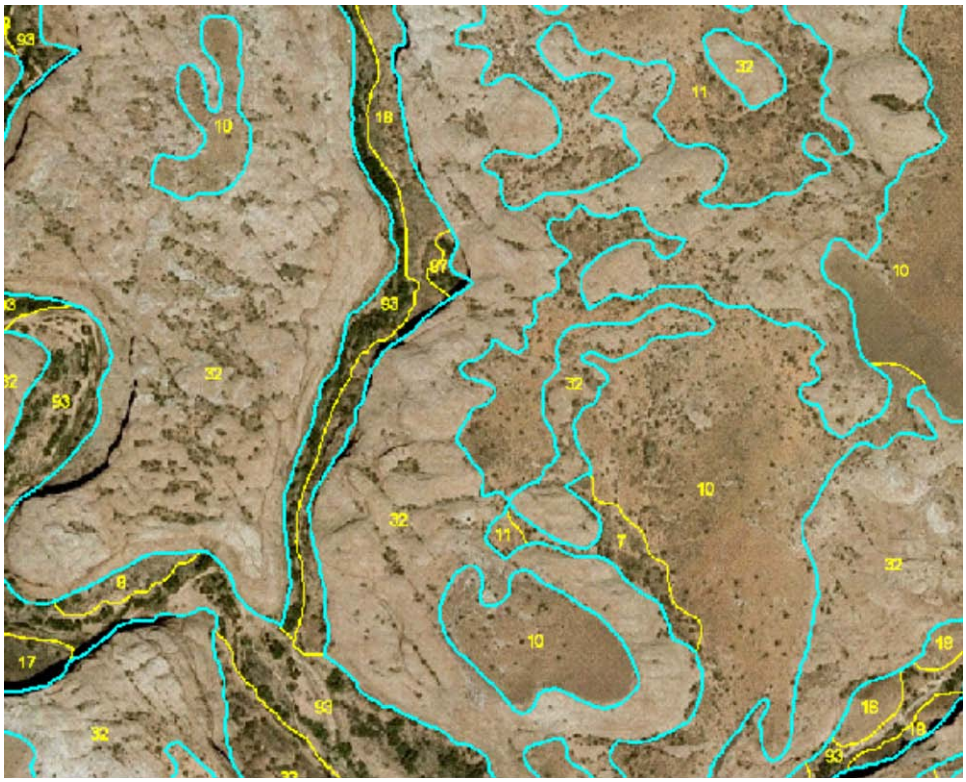


Distribution/Ecology/Composition

This map class represents woodland communities growing in small, closed drainage potholes formed in unjointed Entrada and Navajo sandstone slickrock. It is very common in ARCH and distributed throughout the park, but most of it is concentrated in the southern and central portions of the park where there are extensive exposures of Navajo sandstone. Barren slickrock is a major component of this map unit often comprising 80% or more of the ground surface. The scattered pockets of vegetation depend on runoff from the surrounding expanses of slickrock. These sparse communities are characterized by an open canopy of dwarf (typically <2m tall) juniper and/or pinyon trees with 1 to 5% cover. Shrubs may have as much or more cover than the trees; littleleaf mountain mahogany is the most characteristic species of this map class, but this list in any particular pothole can vary.

Interpretation

Polygons are generally large and sinuous, following the exposures of rolling slickrock of the Navajo and Entrada formations. Most of each polygon is slickrock, so the photo signature is largely the light tan or gray of the rock. Shrubs appear as grayish dots (curl-leaf and mountain mahogany) and black dots (blackbrush), and scattered pinyon or juniper crowns are visible as large dark green dots. This map class is distinguished from the other slickrock map classes (31 and 33) based on the character of the geology and patterns of vegetation distribution. Vegetation grows in potholes and joints; the joints in Navajo sandstone are wider, shallower, and less regular than joints in the Moab Tongue. Adjacent polygons are most often mapped as Blackbrush Shrublands (map class 10), Sandsheet Shrublands (map class 11), Sand Dune Woodlands (map class 25), other sandstone-dominated map units (map class 31 or 33), and bare slickrock (map class 130).



Example of photo signature for map class W-PJSW (#32).

Map Class 33
Sandstone Ledges Woodlands (W-LEDG)




Photo credits: NPS

Associations

Juniperus osteosperma / Purshia stansburiana Woodland [Park Special]
Juniperus osteosperma - (Pinus edulis) / Coleogyne ramosissima - Purshia stansburiana - Quercus havardii Wooded Shrubland [CEGL003774]
Pinus edulis - Juniperus osteosperma / Cercocarpus montanus – Mixed Shrub Woodland [CEGL000780]
Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima Woodland [CEGL000781]
Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland [CEGL000782]

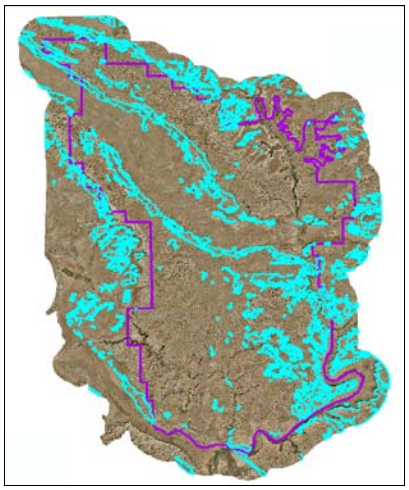
Common species

- *Pinus edulis*
- *Coleogyne ramosissima*
- *Purshia stansburiana*
- *Ephedra viridis*
- *Yucca harrimaniae*
- *Achnatherum hymenoides*
- *Juniperus osteosperma*
- *Quercus havardii* var. *tuckeri*
- *Artemisia bigelovii*
- *Fraxinus anomala*
- *Gutierrezia sarothrae*

W-LEDG Map Class Statistics

Type:	Alliance
Frequency:	497 total polygons
	226 polygons in ARCH
	271 polygons in the environs
Total project area:	6,006 hectares / 14,842 acres (11.4 %)
	3,056 hectares / 7,551 acres in ARCH
	2,950 hectares / 7,290 acres in the environs
Average Polygon Size:	12.1 hectares / 29.9 acres
Producer's accuracy:	92% ± 6%
User's accuracy:	85% ± 8%

Distribution in Mapping Area

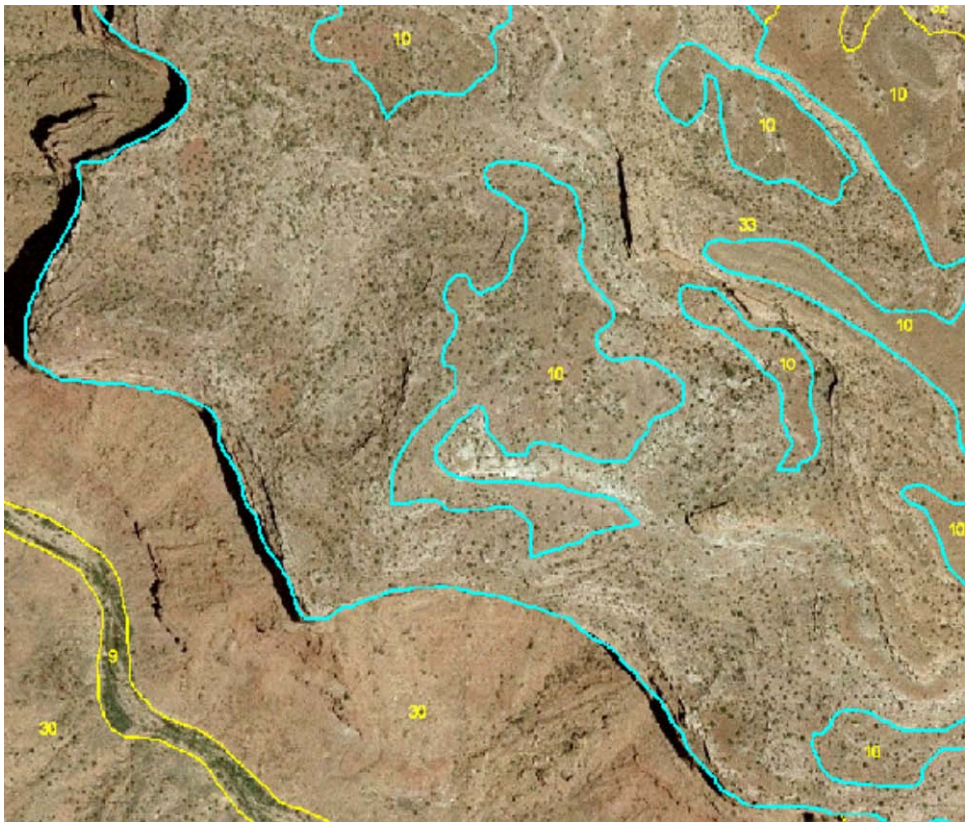


Distribution/Ecology/Composition

Map class 33 represents the extensive transitional areas that link areas of deeper soils supporting Pinyon – Juniper / Blackbrush Woodlands and expanses of slickrock where vegetation is limited to cracks, joints, and potholes. This very common map class is distributed throughout ARCH and occurs on a variety of geologic formations, including the Navajo, Kayenta, Entrada, and Morrison (Salt Wash member) Formations. Bedrock cover ranges from 20-60% and generally is exposed as long linear shelves, ledges or scattered flat outcrops. Vegetation is transitional, ranging from Pinyon – Juniper / Blackbrush woodlands where soils are more developed to Pinyon – Juniper / Mountain Mahogany woodlands where slickrock dominates. Stansbury cliffrose is one of the most common understory species and is characteristic of transitional areas and drainages where bedrock is exposed but not dominant.

Interpretation

Polygons of map class 33 look like a hybrid between map classes 20 and 32: there is too much bedrock exposed to fit map class 20 and there is too much developed soil and too much vegetation cover to fit map class 32. Polygons are generally large and sinuous, following the broken or ledgy sandstone exposures of several geologic formations. Shrubs appear as grayish dots (curl-leaf and mountain mahogany) and black specks (blackbrush and cliffrose); tree crowns are visible as large, scattered, dark green dots. Map class 33 has denser vegetation cover and less bedrock exposed than do map classes 31 and 32 (20 to 60% instead of >80%). Vegetation grows in large potholes and in shallow pools or low hills of soil atop bedrock steps and ledges. Adjacent polygons are commonly mapped as **B**lackbrush Shrublands (map class 10), Sandsheet Shrublands (map class 11), Sand Dune Woodlands (map class 25), other sandstone-dominated map classes (31 or 32), and sparsely vegetated talus slopes (map class 30).



Example of photo signature for map class W-LEDG (#33).

Map Class 341
Entrada Fin / Swale Woodland Mosaic (C-FINS)




Photo credits: NPS

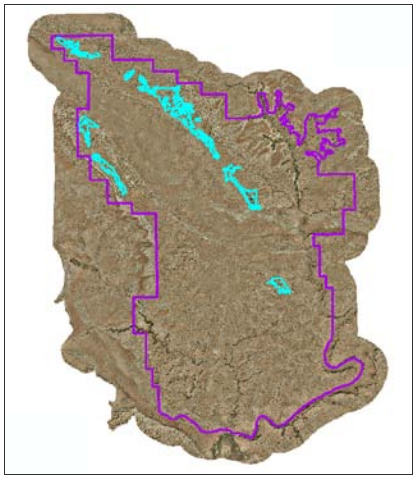
Associations
Slickrock Fin Pocket [Park Special]
Pinus edulis - Juniperus osteosperma / Cercocarpus montanus – Mixed Shrub Woodland [CEGL000780]
Pinus edulis - Juniperus osteosperma / Quercus havardii var. *tuckeri* Woodland [CEGL002497]

Common species
- *Pinus edulis*
- *Juniperus osteosperma*
- *Quercus havardii* var. *tuckeri*
- *Rhus trilobata*
- *Cercocarpus montanus*
- *Purshia stansburiana*
- *Fraxinus anomala*
- *Amelanchier utahensis*
- *Heterotheca villosa*
- *Yucca harrimaniae*

C-FINS Map Class Statistics

Type:	Alliance
Frequency:	27 total polygons
	27 polygons in ARCH
	None in the environs
Total project area:	803 hectares / 1,985 acres (1.5 %)
	803 hectares / 1,985 acres in ARCH
	None in the environs
Average Polygon Size:	29.8 hectares / 73.5 acres
Producer's accuracy:	90% ± 11%
User's accuracy:	90% ± 11%

Distribution in Mapping Area

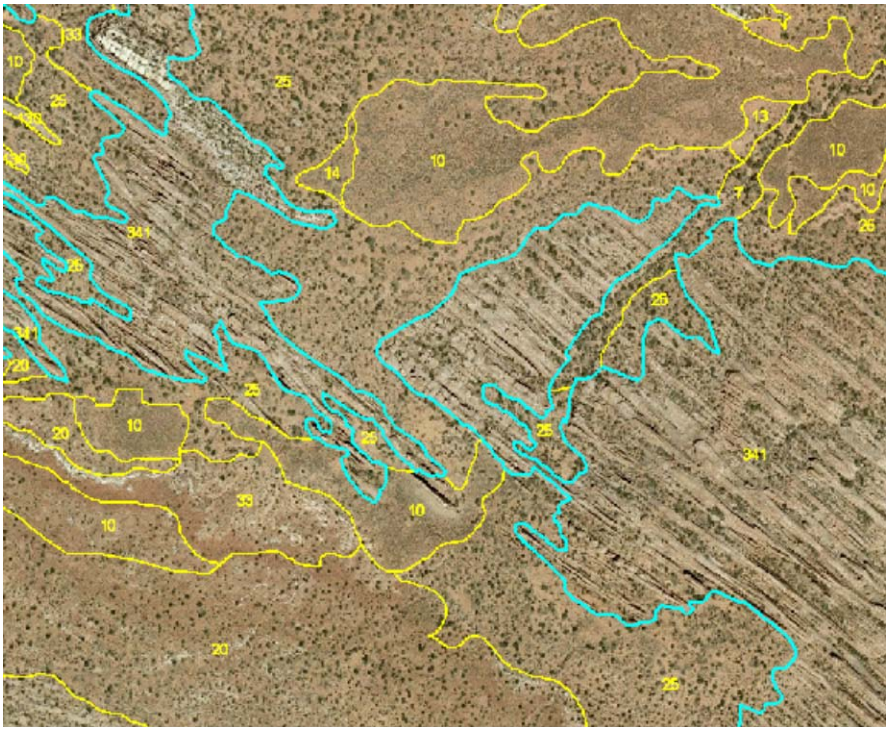


Distribution/Ecology/Composition
This map class represents the mosaic of Entrada sandstone fins and intervening vegetated "pockets" or swales. Some areas encompass slot canyons (typical of the Fiery Furnace) with series of potholes and pour-offs that are subject to periodic flooding. Soils between fins are deep and sandy, often with small dunes present. Biological soil crusts are usually sparse or absent. Plants benefit from the sheltered nature

of these pockets and the concentrated runoff from surrounding slickrock. Vegetation communities are variable, even within one swale, since some species are better adapted to the sandy dune openings while other species may thrive at the base of slickrock outcrops. This makes fin-and-swale communities difficult to classify, as they may contain elements of many plant associations in a small area, as well as a few Fremont cottonwood trees in a particularly wet spot.

Interpretation

This map class is restricted to the fin formations of Entrada sandstone located in the northern portion of the park, on both margins of Salt Valley. Polygons vary in size and are irregular in shape, often with trailing fingers that follow the longest fins. The light brown, parallel fins of sandstone are clearly visible in the photo signature, as are the brighter sandy soils in the swales. Scattered pinyon and juniper tree crowns appear as dark green dots, and shrubs are smaller, grayish green irregular dots under higher magnification. Large clumps of mesic shrubs (Gambel oak, skunkbush, singleleaf ash) are occasionally present and appear as bright green, irregular dots that are larger than the pinyon / juniper canopies. Neighboring polygons are commonly mapped as Sand Dune Woodlands (Map Class 25) or other sandstone-dominated communities (map classes 31 and 32).



Example of photo signature for map class C-FINS (#341).

Upland Shrublands

Map Class 5
Badlands Sparse Vegetation (C-BADS)





Photo credits: NPS

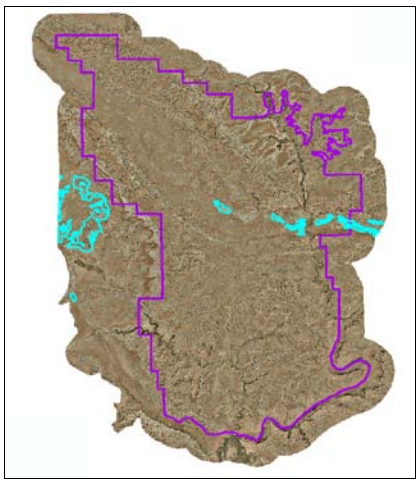
Associations
Atriplex gardneri / Pleuraphis jamesii Dwarf-shrubland [CEGL001441]
Atriplex gardneri Dwarf-shrubland [CEGL001438]
Eriogonum corymbosum Badlands Sparse Vegetation [CEGL002979]
Zuckia brandegeei Dwarf-Shrubland [CEGL002493]

Common species
- *Atriplex confertifolia*
- *Atriplex gardneri*
- *Zuckia brandegeei*
- *Eriogonum corymbosum*
- *Sarcobatus vermiculatus*
- *Tetradymia spinosa*
- *Pleuraphis jamesii*
- *Eriogonum inflatum*

C-BADS Map Class Statistics

Type:	Complex of multiple associations
Frequency:	35 total polygons
	16 polygons in ARCH
	19 polygons in the environs
Total project area:	729 hectares / 1,800 acres (1.4 %)
	134 hectares / 332 acres in ARCH
	594 hectares / 1,469 acres in the environs
Average Polygon Size:	20.8 hectares / 51.4 acres
Producer's accuracy:	74% ± 19%
User's accuracy:	100%

Distribution in Mapping Area

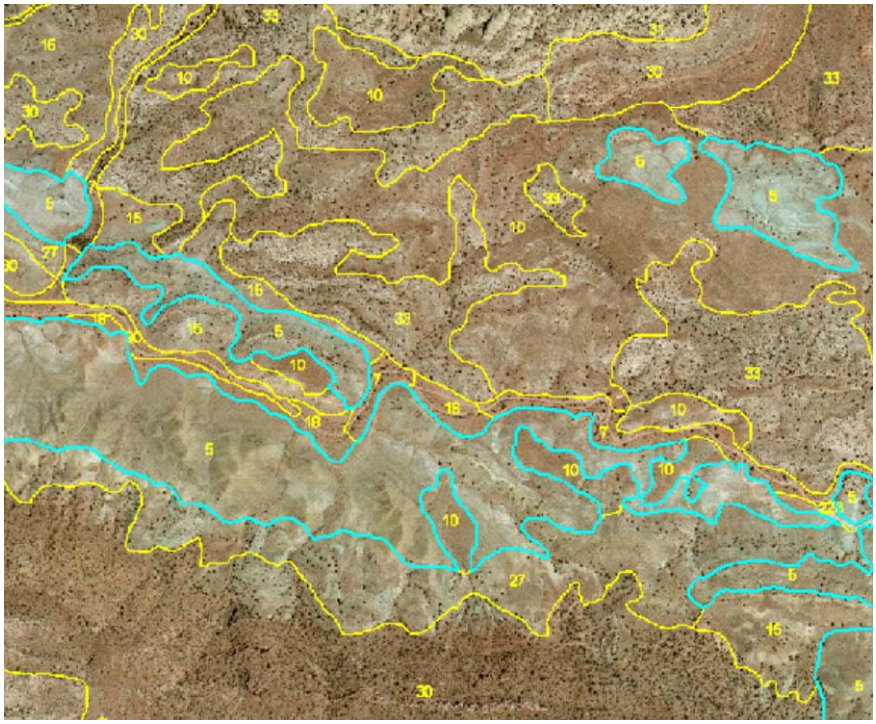


Distribution/Ecology/Composition

Map class 5 describes the sparse dwarf shrublands that occur on the rolling hills and badlands of alkaline, gray clay soils derived from the Mancos and Morrison formation shale. This type occurs primarily on low hills and ridges on the margins of Cache Valley, Salt Valley within ARCH, as well as the Little Valley area in the environs. Small drainages and gullies bisect this landscape, where the occasional stunted juniper may be found. Litter is nearly absent from the surface cover, and bentonite within the soil can give the surface a popcorn-like texture. These are extremely sparse communities, with total vegetation cover usually less than 8%. Gardner saltbush associations are the most prevalent in this map unit, often with a sparse understory of galleta grass. Crispleaf buckwheat and siltbush associations are extremely rare in the mapping area, with siltbush only known from one hogback in Cache Valley. While they are desert-adapted, prolonged drought and disturbance-related erosion of shale soils can degrade these already sparse communities.

Interpretation

This map class represents the mottled gray clay shales of the lower Mancos and Morrison formation at ARCH. Vegetation on this substrate is so sparse that it is difficult to see shrubs even under high magnification. Adjacent polygons are usually identified as map class 15 (which has similar, but denser, vegetation and is mainly on red shales derived from the Tidwell Member of the Morrison Formation), map class 11 (Sandsheet Shrublands), and map class 30 (talus slopes ringing Cache Valley).



Example of photo signature for map class C-BADS (#5)

Map Class 6
Greasewood Flats (S-SAVE)





Photo credits: NPS

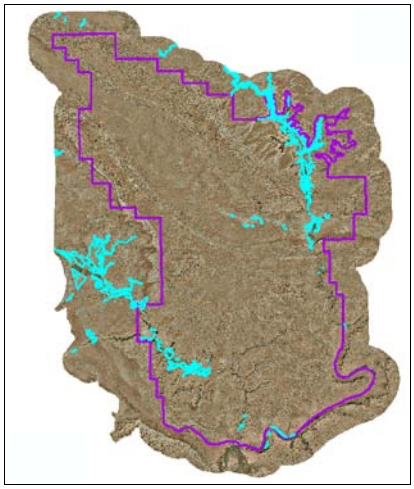
Associations
Allenrolfea occidentalis Shrubland [CEGL000988]
Sarcobatus vermiculatus Disturbed Shrubland [CEGL001357]
Sarcobatus vermiculatus / Sporobolus airoides Sparse Vegetation [CEGL001368]
Suaeda moquinii Shrubland [CEGL001991]

Common species
- *Sarcobatus vermiculatus*
- *Ericameria nauseosa*
- *Atriplex confertifolia*
- *Allenrolfea occidentalis*
- *Sporobolus airoides*
- *Bromus tectorum*

S-SAVE Map Class Statistics

Type:	Complex of multiple associations
Frequency:	217 total polygons
	138 polygons in ARCH
	79 polygons in the environs
Total project area:	972 hectares / 2,402 acres (1.8 %)
	457 hectares / 1,129 acres in ARCH
	515 hectares / 1,273 acres in the environs
Average Polygon Size:	4.5 hectares / 11.1 acres
Producer's accuracy:	94% ± 7%
User's accuracy:	100%

Distribution in Mapping Area

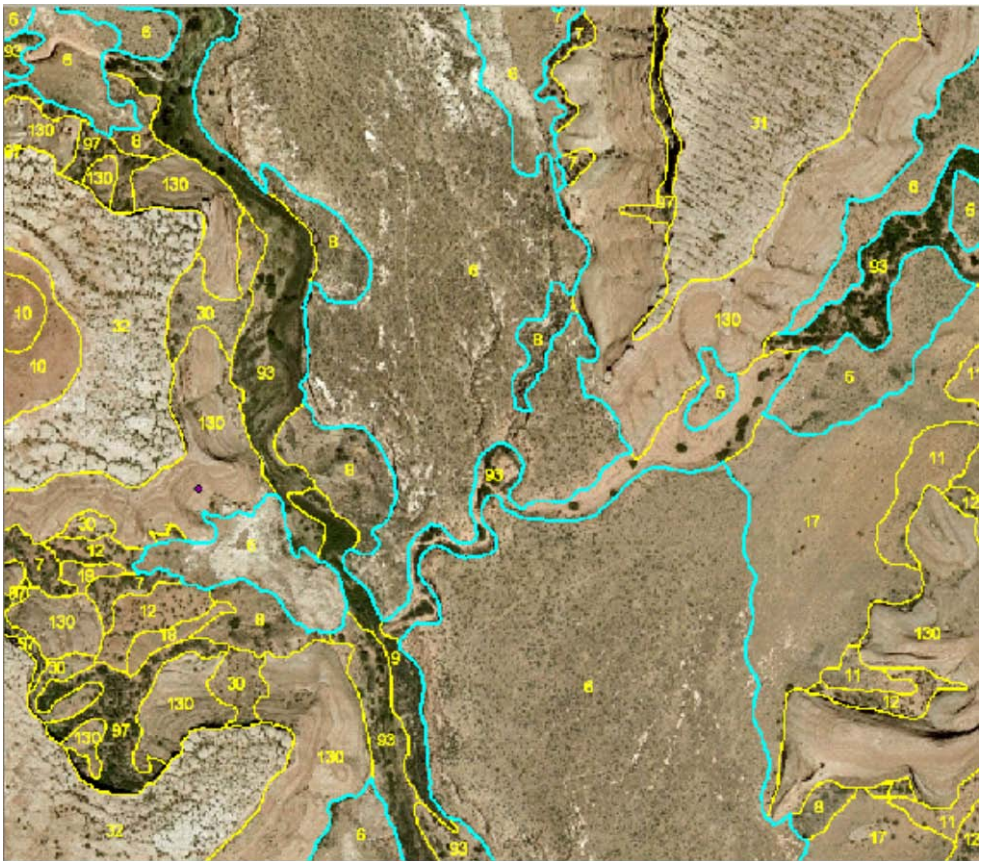


Distribution/Ecology/Composition
Greasewood communities (map class 6) in ARCH occur mainly on the broad alluvial terraces of upper Courthouse Wash and upper Salt Wash, with a few polygons scattered along the Colorado River corridor and in lower Salt Valley. They are located on terraces high enough above the main channel (usually at least 2 to 5 feet above) that they are not subject to any regular flooding. Soils are fine textured, sandy, and

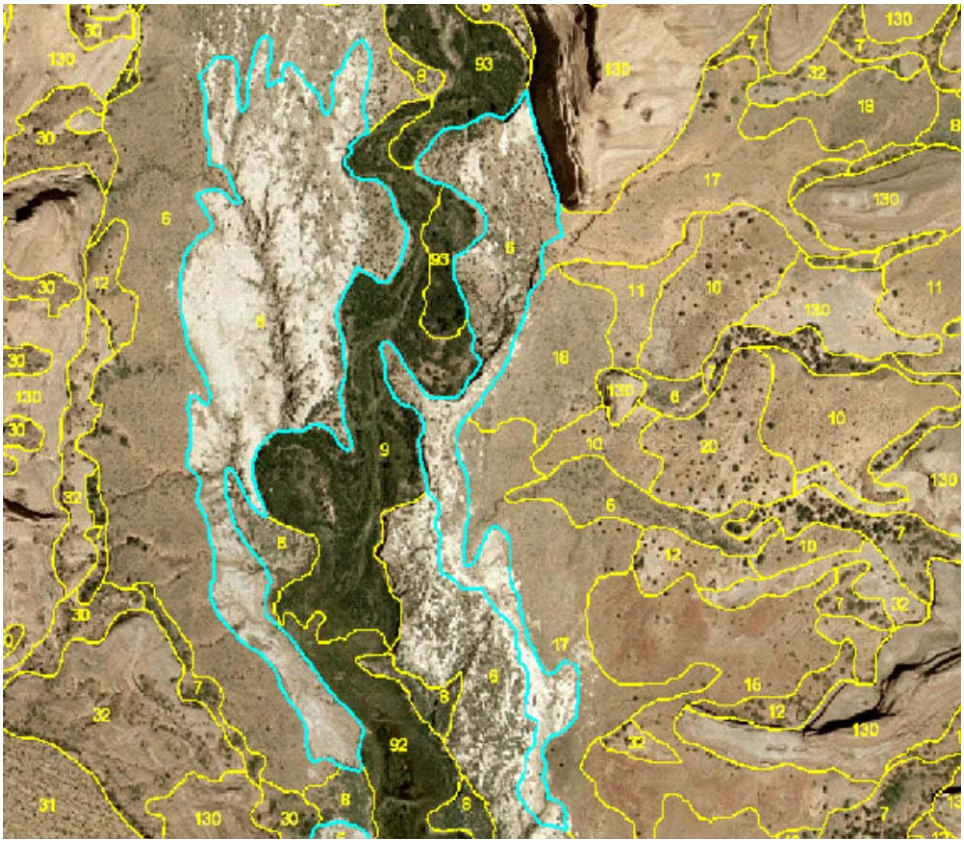
often alkaline. Understories vary from moderate cover of alkali sacaton, galleta, or saltgrass to no understory at all, and moss cover may be relatively high. Depending on rainfall, cover of exotic annuals such as cheatgrass, *Vulpia octoflora*, and Russian thistle may be low to high. Some stands have a few scattered basin big sagebrush shrubs among the greasewood. A few areas are classified as alkali salt flats that support only sparse cover of iodine bush *(Allenrolfea occidentalis)* with the occasional scattered greasewood shrub. These polygons are given an "AO" modifier where *Allenrolfea* has been documented. Most stands were heavily influenced by past grazing practices.

Interpretation

Polygons are irregularly-shaped, and are located on broad, flat terraces above polygons of cottonwood woodlands (map class 93) and tamarisk shrublands (map class 9) following the active wash channels. Other terrace communities, including High Terrace Shrub Herbaceous Complex (map class 18), Basin Big Sagebrush Shrubland (map class 8), and Weedy Herbaceous Vegetation (map class 17), are common neighbors of this map class. The vegetation photo signature is a mottled, olive-green texture with darker dots visible. The background color of polygons is tan from the sandy alluvium, dark gray/brown from well-developed cryptobiotic soil, or white from alkali salt flats.



Example of photo signature for map class S-SAVE (#6) with dense shrub cover.



Example of photo signature for map class S-SAVE (#6) with sparse shrub cover.

Map Class 8
Basin Big Sagebrush Terrace Shrubland (S-ARTR)




Photo credits: NPS

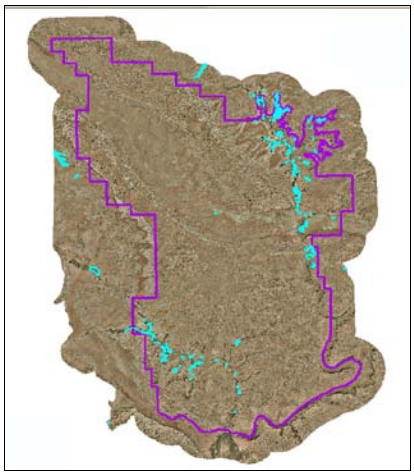
Associations
Artemisia tridentata – (Ericameria nauseosa) / Bromus tectorum Semi-natural Shrubland [CEGL002699]
Sarcobatus vermiculatus / Artemisia tridentata Shrubland [CEGL001359]

Common species
- *Artemisia tridentata* spp. *tridentata*
- *Sarcobatus vermiculatus*
- *Atriplex canescens*
- *Ericameria nauseosa*
- *Artemisia filifolia*
- *Bromus tectorum*
- *Opuntia polyacantha*

S-ARTR Map Class Statistics

Type:	Complex of multiple associations
Frequency:	166 total polygons
	143 polygons in ARCH
	23 polygons in the environs
Total project area:	199 hectares / 491 acres (0.4 %)
	145 hectares / 359 acres in ARCH
	53 hectares / 132 acres in the environs
Average Polygon Size:	1.2 hectares / 3 acres
Producer's accuracy:	87% ± 18%
User's accuracy:	93% ± 15%

Distribution in Mapping Area

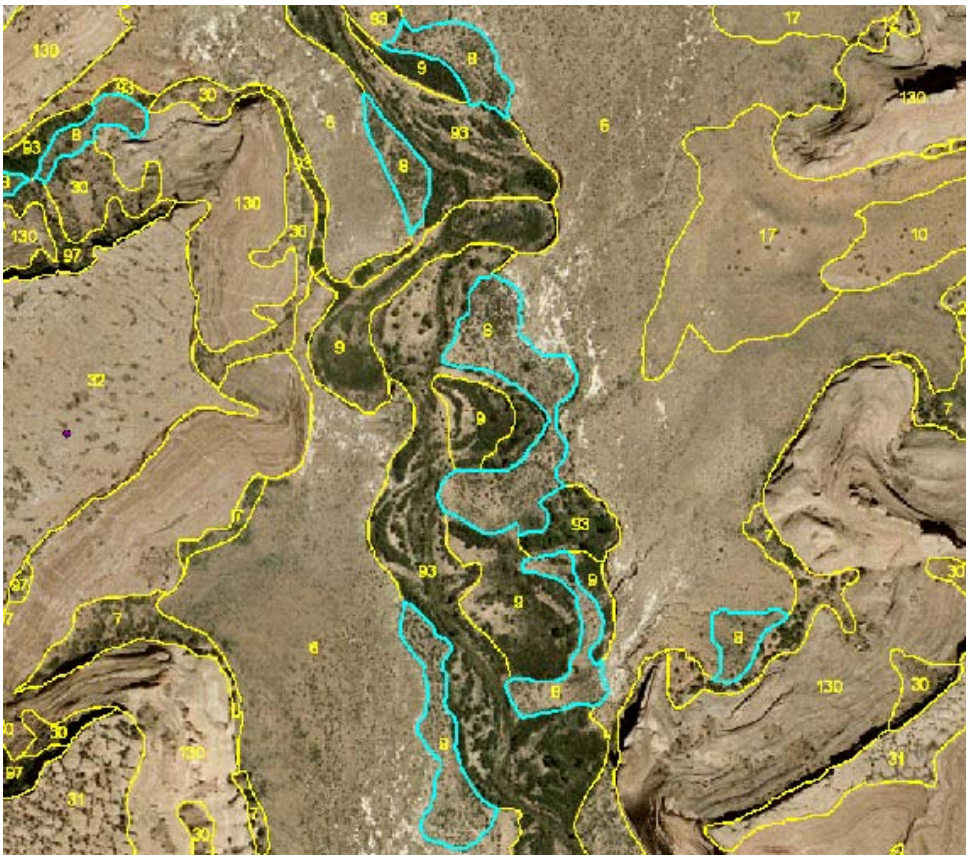


Distribution/Ecology/Composition
Basin big sagebrush communities (map class 8) are uncommon in the mapping area and occur mainly on the low terraces close to the main channels of lower Sevenmile Canyon, Courthouse Wash, and upper Salt Wash. Terraces on which basin big sagebrush is dominant generally have less alkaline soils and are better drained than the adjacent terraces dominated by greasewood and/or saltbush, and are high enough above the main wash channel that they are rarely subject to flooding. These terraces are susceptible to drought however, and many of the shrubs and grasses show dieback from recent dry years. Basin big sagebrush,

greasewood, and salt bush are often co-dominants in the shrub canopy layer. Most stands have cheatgrass and other weedy vegetation in the understory, probably as a result of past grazing practices. Scattered Utah juniper occur in the oldest stands, especially those which occur at the base of sandstone cliffs. Biological soil crust development varies widely from one terrace to another, with cover ranging from 0 to 30%. Moss is usually a prominent component of the cryptobiotic community.

Interpretation

Map class 8 was developed and interpreted after the accuracy assessment was complete, in order for the ARCH vegetation map to be as consistent as possible with CANY mapping concepts. Polygons of this map class are generally small and follow the sandy terraces of the canyon bottoms in ARCH. Stands are commonly on lower terraces than Greasewood Flats (map class 6) and High Terrace Shrub Herbaceous Complex (map class 18) and occasionally abut the main wash channel (map classes 93, 9, or 7). Polygons of map class 8 also occur in deep depressions along higher terraces, in ravines, and on narrow high terraces in protected and mesic sites close to high sandstone walls (map class 97). The vegetation photo signature is a speckling of dots that are generally darker and larger than those of neighboring fourwing saltbush or greasewood shrublands. A grass understory, visible as a smooth light green color, may or may not be present. The background color of map class 8 polygons is the tan color of the sandy soil, with some darkening in areas with good biological soil crust development.



Example of photo signature for map class S-ARTR (#8).

Map Class 10
Blackbrush Shrublands (S-BLAC)





Photo credits: NPS

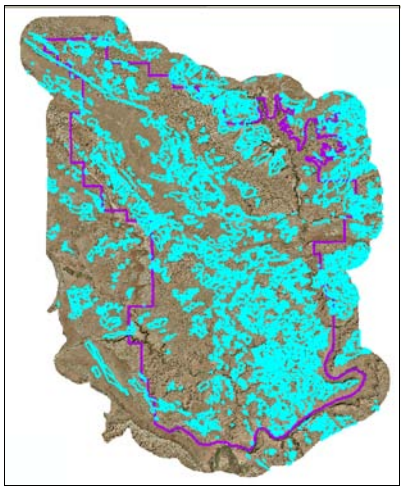
Associations
Coleogyne ramosissima Shrubland [CEGL001332]
Grayia spinosa Shrubland [CEGL002358] - rare

Common species
- *Coleogyne ramosissima*
- *Grayia spinosa*
- *Ephedra torreyana*
- *Pleuraphis jamesii*
- *Opuntia polyacantha*
- *Gutierrezia sarothrae*
- *Phacelia crenulata*
- *Juniperus osteosperma*

S-BLAC Map Class Statistics

Type:	Association
Frequency:	1,457 total polygons
	993 polygons in ARCH
	464 polygons in the environs
Total project area:	9,074 hectares / 22,421 acres (17.3 %)
	5,989 hectares / 14,798 acres in ARCH
	3,085 hectares / 7,623 acres in the environs
Average Polygon Size:	6.2 hectares / 15.4 acres
Producer's accuracy:	85% ± 7%
User's accuracy:	93% ± 5%

Distribution in Mapping Area

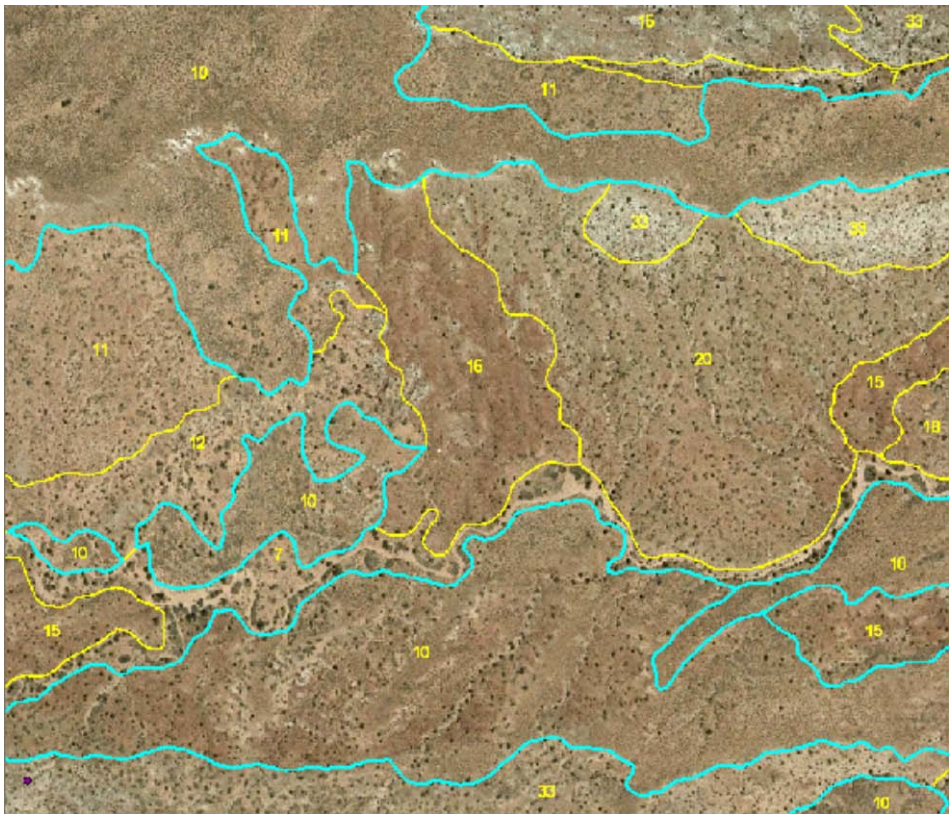


Distribution/Ecology/Composition
Map class 10 represents one of the most widespread and common vegetation types at ARCH. The community is typically a near-monoculture of blackbrush shrubs with cover between 10 and 35%. Blackbrush shrublands occur in nearly every upland habitat with enough soil to support them, including alluvial fans, gullies, colluvial slopes, valley sides, benches, dunes, hills, ridges, canyon rims, valleys and plateaus. Herbaceous understory is generally less than 10%; the perennial grasses galleta grass and Indian

ricegrass are the most common species. In a wet spring, *Phacelia crenulata* may be conspicuous, and cheatgrass and *Vulpia octoflora* are common. Stands on sandy substrates have up to 55% cover by biological soil crusts. Stands on Tidwell Shale may have a chert gravel veneer, which limits species diversity and cover. Scattered juniper trees (up to 8% cover) are often present, especially in areas where soils are shallow or there are exposures of jointed and potholed bedrock that can support juniper.

Interpretation

This map class has a distinctly speckled photo signature of fairly dense and uniformly-spaced dark dots. Polygons are extremely variable in both size and shape. Map class 10 can be distinguished from map class 11, which also contains blackbrush shrublands, by the background color of the polygons. Map class 10 polygons are a dark tan color because of either higher rock cover, darker soils, or greater soil crust development. Map class 11 polygons have a brighter photo signature due to the sandy substrate. Polygons of map class 15 often have a similar background color to map class 10, but are usually a darker red color and always have much sparser vegetation (blackbrush cover generally less than 10%). Because of the ubiquitous nature of blackbrush communities in ARCH, polygons adjacent to map class 10 may be mapped as many other classes. However, map class 15 and map class 11, both of which also have blackbrush shrubland components, are the most common neighbors. A “t” modifier was applied to map class 10 in polygons with scattered Utah juniper trees (typically less than 5% cover).



Example of photo signature for map class S-BLAC (#10), showing polygons of 10 (top) and 10t (bottom). The dark specks in 10t are Utah juniper trees.

Map Class 11
Sandsheet Shrublands (S-SAND)





Photo credits: NPS

Associations

Artemisia filifolia Colorado Plateau Shrubland [CEGL002697]
Coleogyne ramosissima Shrubland [CEGL001332]
Coleogyne ramosissima – Purshia stansburiana – Quercus havardii var. *tuckeri* Shrubland [CEGL002348]
Ephedra viridis / (Achnatherum hymenoides – Hesperostipa comata) Shrubland [CEGL002354]

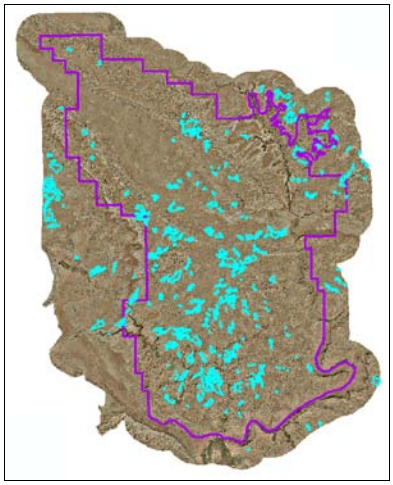
Common species

- *Artemisia filifolia*
- *Coleogyne ramosissima*
- *Quercus havardii* var. *tuckeri*
- *Purshia stansburiana*
- *Atriplex canescens*
- *Ephedra viridis*
- *Gutierrezia sarothrae*
- *Sphaeralcea* spp.
- *Pleuraphis jamesii*
- *Achnatherum hymenoides*

S-SAND Map Class Statistics

Type:	Complex of multiple associations
Frequency:	324 total polygons
	251 polygons in ARCH
	73 polygons in the environs
Total project area:	1,376 hectares / 3,400 acres (2.6 %)
	1,023 hectares / 2,529 acres in ARCH
	353 hectares / 871 acres in the environs
Average Polygon Size:	4.2 hectares / 10.5 acres
Producer's accuracy:	90% ± 14%
User's accuracy:	75% ± 17%

Distribution in Mapping Area

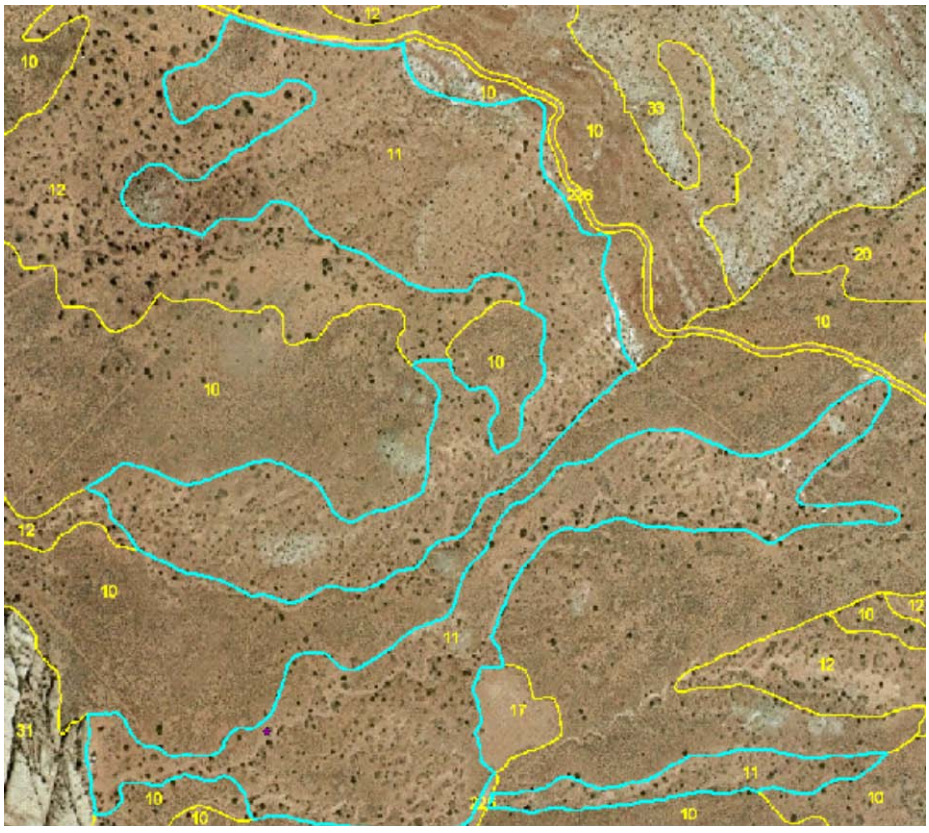


Distribution/Ecology/Composition

Map class 11 is common and widespread throughout the mapping area on sand sheets and low, stabilized dunes. This map class represents a mosaic of sand sagebrush with patches of blackbrush, or a mix of blackbrush with Mormon-tea or Tucker oak. An herbaceous layer consisting of Indian ricegrass, globemallow, and *Plantago patagonica* is often present. Soils are deep and sandy, and stabilized with light cryptobiotic and physical crusts (although patches of well-developed cryptogams may be present). Scattered Utah junipers may be present, particularly where bedrock exposures concentrate rain runoff to their roots. In comparison with map class 13, which is loose, blowing dunes, this map unit is on sand sheets to very low dunes with greater vegetation cover and generally higher degree of soil stabilization. More generalist species, such as blackbrush, are common in map class 11, whereas map class 13 is characterized by sand-loving species such as frosted mint, sand buckwheat, and false gumweed.

Interpretation

Polygons of map class 11 are often large and irregularly shaped, with a distinctive bright sand matrix photo signature (lighter tan than surrounding areas). Shrubs appear as dark speckles and dots, similar to map class 10, but are more scattered and patchy (map class 10 tends to be regularly spaced). Surrounding polygons are often other communities that contain blackbrush (map classes 10 or 15), Sand Dune Woodlands (map class 25), or Mormon Tea - Mixed Grass Shrublands (map class 14).



Example of photo signature for map class S-SAND (#11).

Map Class 13
Dune Complex (S-DUNE)




Photo credits: NPS

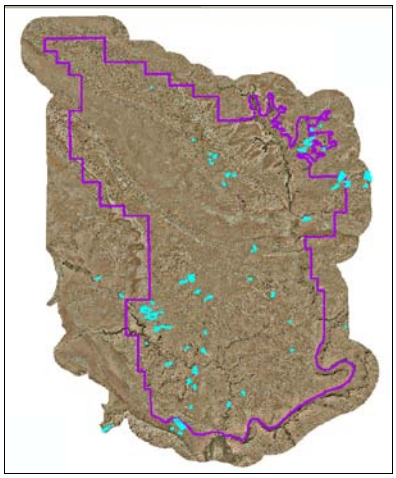
Associations
Poliomintha incana - Artemisia filifolia - Vanclevea stylosa Shrubland [CEGL002418]
Artemisia filifolia Colorado Plateau Shrubland [CEGL002697]
Quercus havardii var. *tuckeri* Shrubland [CEGL002486]

Common species
- *Artemisia filifolia*
- *Vanclevea stylosa*
- *Poliomintha incana*
- *Quercus havardii* var. *tuckeri*
- *Eriogonum leptocladon*
- *Achnatherum hymenoides*
- *Muhlenbergia pungens*
- *Yucca harrimaniae*
- *Oenothera pallida*
- *Abronia fragrans*

S-DUNE Map Class Statistics

Type:	Complex of multiple associations
Frequency:	72 total polygons
	54 polygons in ARCH
	18 polygons in the environs
Total project area:	186 hectares / 460 acres (0.4 %)
	131 hectares / 325 acres in ARCH
	55 hectares / 135 acres in the environs
Average Polygon Size:	2.6 hectares / 6.4 acres
Producer's accuracy:	94% ± 12%
User's accuracy:	76% ± 18%

Distribution in Mapping Area

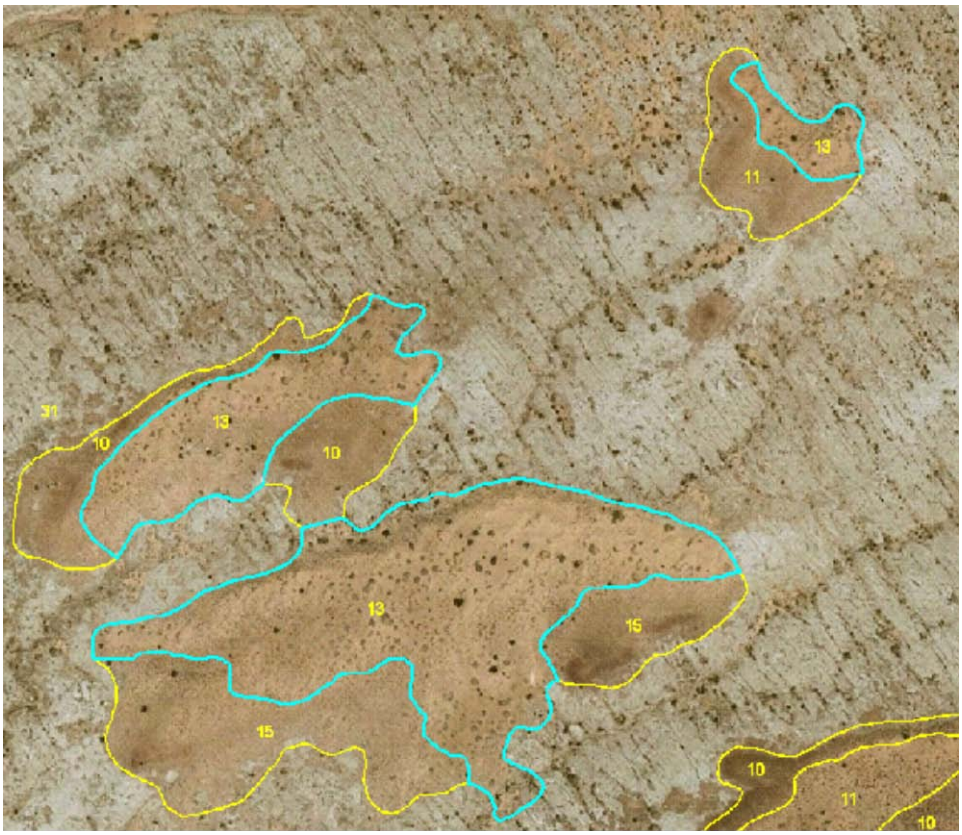


Distribution/Ecology/Composition
Map class 13 represents communities growing on loose sands and active dune systems. These communities are scattered throughout the mapping area. The dunes support a sparse cover of sand-loving species such as frosted mint, sand buckwheat, sand sage, pillar false gumweed, and Tucker oak. The understory is generally sparse and consists of sand loving grasses and forbs such as sand muhly, Indian

ricegrass, and sand verbena. Scattered pinyon or juniper may be present, but with low enough cover not to be confused with map class 25. Patches of cryptobiotic soil may occur, but the overall ground surface is characterized by loose sand. Burrows created by rodents are common. In contrast to this map class, map class 11 is characterized by sand sheets to very low dunes supporting more generalist species, such as blackbrush, and with a higher degree of soil stabilization.

Interpretation

This map class is mapped on "blowout" dunes. Polygons are generally small and isolated, or appear as inclusions within the Sand Dune Woodland mosaic (map class 25). Polygons of map class 13 are scattered throughout the park, and can be recognized by the bright, light tan color of loose sand. A speckling of shrubs is visible under higher magnification, and widely scattered pinyon and juniper may also be present. Adjacent polygons are often mapped as other sand dune types (map classes 11 or 25), blackbrush communities (map classes 10 or 15), or sandstone communities (map classes 31, 32, and 33).



Example of photo signature for map class S-DUNE (#13).

Map Class 14
Mormon Tea - Mixed Grass Shrublands (C-EVGR)




Photo credits: NPS

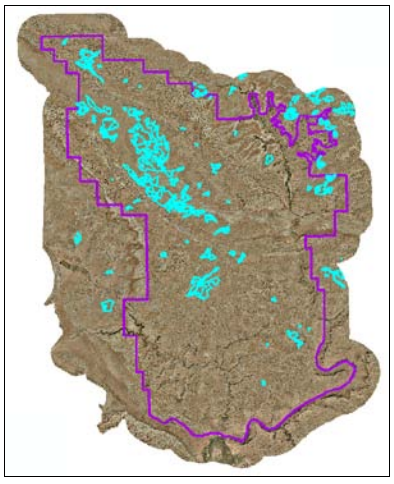
Associations
Achnatherum hymenoides Colorado Plateau Herbaceous Vegetation [CEGL002343]
Ephedra viridis / (Achnatherum hymenoides - Hesperostipa comata) Shrubland [CEGL002354]
Ephedra viridis / Pleuraphis jamesii Shrubland [CEGL002356]
Pleuraphis jamesii Herbaceous Vegetation [CEGL001777]

Common species
- *Ephedra viridis*
- *Pleuraphis jamesii*
- *Hesperostipa comata*
- *Opuntia polyacantha*
- *Achnatherum hymenoides*
- *Sporobolus cryptandrus*
- *Bromus tectorum*
- *Sphaeralcea parvifolia*

C-EVGR Map Class Statistics

Type:	Complex of multiple associations
Frequency:	155 total polygons
	109 polygons in ARCH
	46 polygons in the environs
Total project area:	1,563 hectares / 3,863 acres (3 %)
	1,278 hectares / 3,157 acres in ARCH
	286 hectares / 706 acres in the environs
Average Polygon Size:	10.1 hectares / 24.9 acres
Producer's accuracy:	97% ± 7%
User's accuracy:	100%

Distribution in Mapping Area

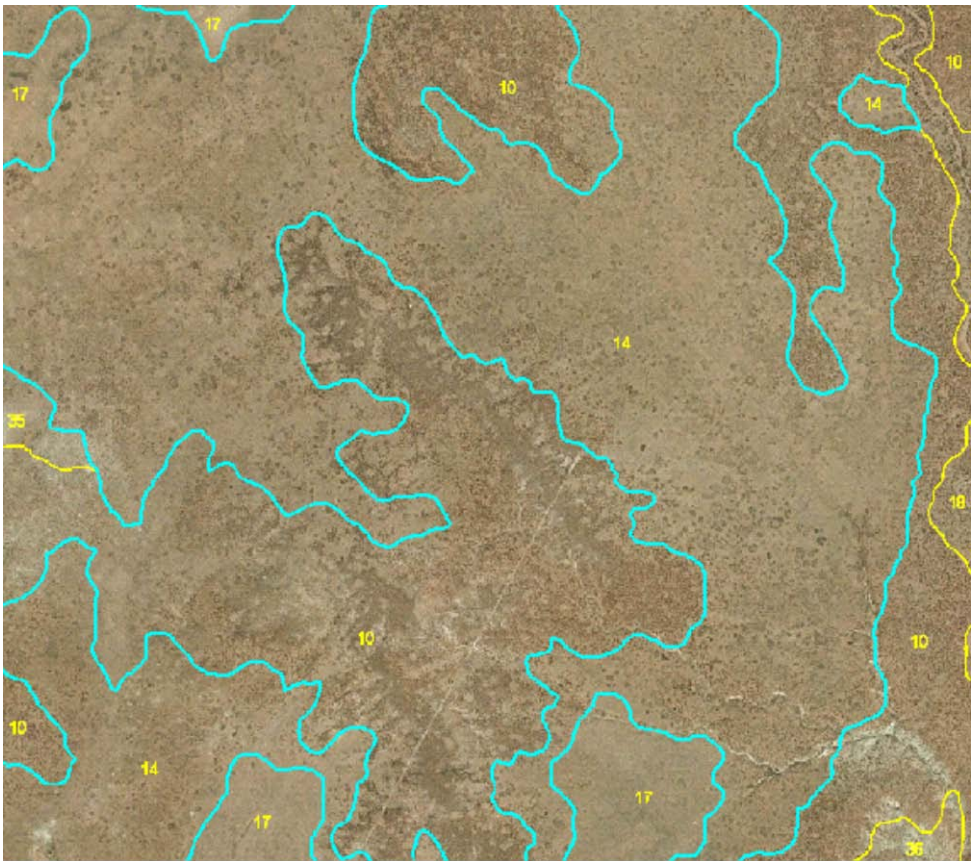


Distribution/Ecology/Composition
This map class occurs on nearly level plateaus and high valley floors It is generally associated with older alluvial deposits and deep and finer-textured soils stabilized by light biological or physical crusts. Most polygons were mapped in Salt Valley, with a few sites in Willow Flat and the northeast environs near The Highlands. Map class 14 is a complex of green Mormon-tea shrubs in their grass-like "mot" form

interspersed with grassy openings dominated by the perennial grasses galleta, Indian ricegrass, and needle-and-thread. The map class often occurs as isolated patches within extensive blackbrush stands, occupying slight depressions and flats, whereas the blackbrush will dominate the surrounding low hills and slopes. The green Mormon-tea / needle-and-thread grass association is at the sandier end of the communities included in this map class. Green Mormon-tea with galleta grass is abundant on the floor of Salt Valley on fine sands and silts. Degraded stands contain significant understory cover by cheatgrass, stickseed, and Russian thistle. Some polygons of map class 14 may have scattered juniper trees, and rodent burrows are common.

Interpretation

In this map class, green Mormon-tea grows in a grass-like "mot" form. These mots provide the characteristic photo signature of this map unit. They appear as irregular, pimply-looking, light olive green spots which are usually as large or larger than pinyon or juniper tree crowns. The herbaceous understory varies in cover, but when present it appears as a smooth-textured, light green color. The background color of these polygons is the light tan of the sandy substrate. Adjacent polygons are often Weedy Herbaceous Vegetation (map class 17), Winterfat Shrublands (map class 71), Blackbrush Shrublands (map class 10), and sand dune communities (map class 11 and 12).



Example of photo signature for map class C-EVGR (#14).

Map Class 15
Shale Barrens Desert Scrub (S-SBDS)





Photo credits: NPS

Associations

Atriplex confertifolia / Pleuraphis jamesii Shrubland [CEGL001304]
Atriplex confertifolia / Sporobolus cryptandrus Shrubland [Provisional] [CEGL003762]
Atriplex confertifolia – Picrothamnus desertorum Shrubland [CEGL001295]
Atriplex confertifolia - Sarcobatus vermiculatus Shrubland [CEGL001313]
Atriplex spp. Desert Pavement Sparse Vegetation [CEGL003767]
Coleogyne ramosissima Shrubland [CEGL001332]
Ephedra torreyana Sparse Vegetation [CEGL002353]
Ephedra torreyana / Pleuraphis jamesii Shrubland [CEGL003772]
Ephedra torreyana / Achnatherum hymenoides – Pleuraphis jamesii Shrubland [CEGL002352]

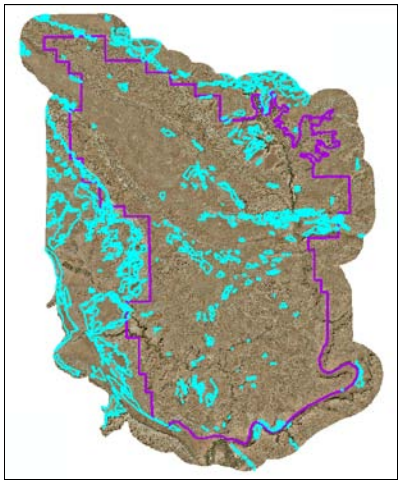
Common species

- *Coleogyne ramosissima*
- *Ephedra torreyana*
- *Picrothamnus desertorum*
- *Achnatherum hymenoides*
- *Atriplex confertifolia*
- *Atriplex gardneri*
- *Pleuraphis jamesii*
- *Eriogonum inflatum*

S-SBDS Map Class Statistics

Type:	Complex of multiple associations
Frequency:	387 total polygons
	197 polygons in ARCH
	190 polygons in the environs
Total project area:	4,202 hectares / 10,384 acres (8 %)
	1,217 hectares / 3,008 acres in ARCH
	2,985 hectares / 7,376 acres in the environs
Average Polygon Size:	10.9 hectares / 26.8 acres
Producer's accuracy:	52% ± 20%
User's accuracy:	79% ± 21%

Distribution in Mapping Area



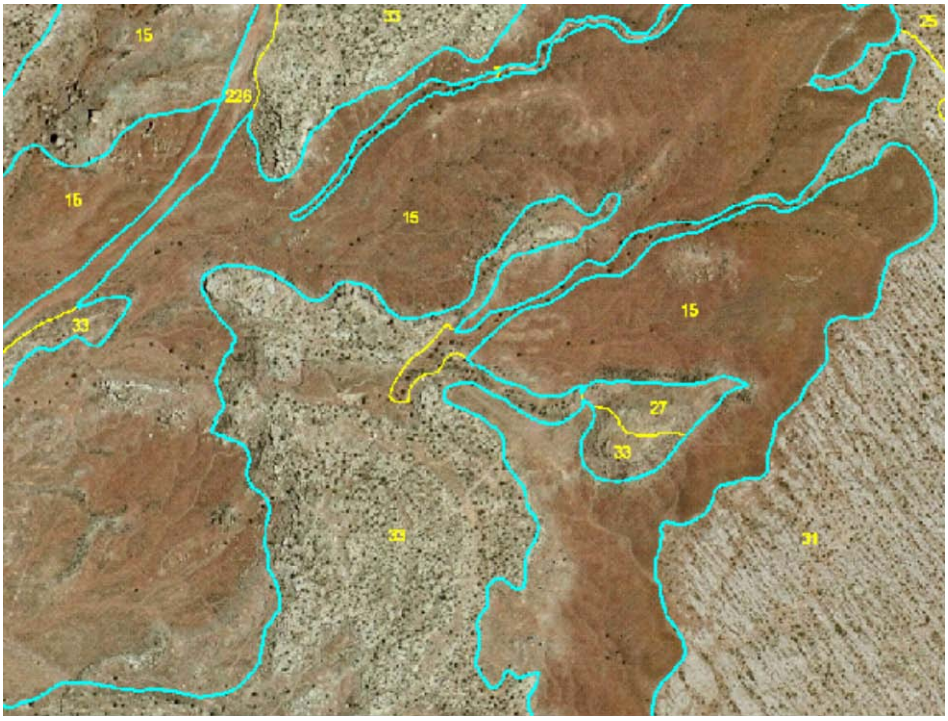
Distribution/Ecology/Composition

Polygons of map class 15 are landscapes of generally sparse vegetation on mostly red or sometimes gray shales. The map class is common and widely distributed throughout ARCH and the environs. Polygons of map class 15 occur on a variety of geologic substrates, including Mancos Shale, Brushy Basin, Salt Wash, and Tidwell members of the Morrison Formation, Moab Tongue, Dewey Bridge, and the Cutler Formation. The landscape usually consists of rolling, badland-like hills and valley sides. Many small drainages and gullies bisect the landscape, and may contain scattered juniper trees. A surface veneer of small platey rocks is often present, and there is typically very little biological soil crust development. Bentonite layers within the Mancos and Morrison formations in Cache Valley give the soils there a popcorn-like texture. Elsewhere, soils are typically alkaline and have a high clay component. Litter is nearly absent in these communities, and total vegetation cover is often between 1 and 5%.

Typical vegetation in map class 15 consists of sparse, mixed stands of blackbrush, shadscale, and Torrey joint-fir with patchy cover of James' galleta. The shadscale / galleta shrubland and sparse blackbrush shrubland are the most common associations in this map unit, occupying low elevation areas of ARCH with alkaline, gravel-covered soils. The Torrey joint-fir sparse shrubland association occupies the same habitat as the others in this map class, but is quite rare. All these associations are adapted to desert conditions, but show dieback due to drought stress over the last 10 years.

Interpretation

This common map class is distributed throughout ARCH and is defined by the dark red color of the shale substrate. A few polygons have a mottled dark gray color characteristic of the clay shales that support Gardner saltbush sparse communities. Shrubs are rarely visible in the photo signature, but occasionally scattered dark speckles of blackbrush and Torrey joint-fir may be visible under magnification. Adjacent polygons are usually denser Blackbrush Shrublands (map class 10), Sandsheet Shrublands (map class 11), badland communities (map classes 5 and 16), and sandstone slickrock communities (map classes 31, 32 and 33).



Example of photo signature for map class S-SBDS (#15).

Map Class 18
High Terrace Shrub Herbaceous Complex (C-TERR)





Photo credits: NPS

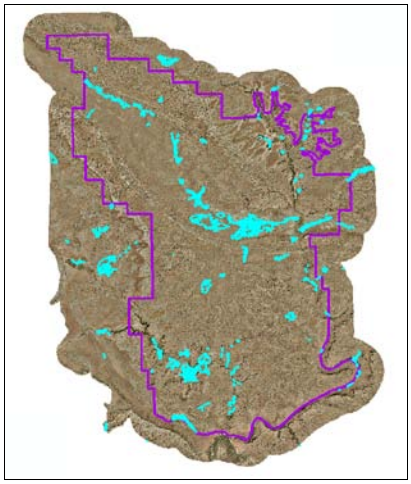
Associations
Artemisia filifolia Colorado Plateau Shrubland [CEGL002697]
Atriplex canescens / Sporobolus airoides Shrubland [CEGL001291]
Atriplex canescens Shrubland [CEGL001281]
Chrysothamnus viscidiflorus Shrubland Alliance [A.2651]
Hesperostipa comata Great Basin Herbaceous Vegetation [CEGL001705]
Pleuraphis jamesii - Sporobolus airoides Herbaceous Vegetation [CEGL001778]

Common species
- *Artemisia filifolia*
- *Ericameria nauseosa*
- *Pleuraphis jamesii*
- *Achnatherum hymenoides*
- *Bromus tectorum*
- *Gutierrezia sarothrae*
- *Atriplex canescens*
- *Sarcobatus vermiculatus*
- *Sporobolus airoides*
- *Hesperostipa comata*
- *Salsola tragus*
- *Opuntia polyacantha*

C-TERR Map Class Statistics

Type:	Complex of multiple associations
Frequency:	244 total polygons
	183 polygons in ARCH
	61 polygons in the environs
Total project area:	930 hectares / 2,298 acres (1.8 %)
	722 hectares / 1,784 acres in ARCH
	208 hectares / 513 acres in the environs
Average Polygon Size:	3.8 hectares / 9.4 acres
Producer's accuracy:	96% ± 9%
User's accuracy:	88% ± 12%

Distribution in Mapping Area



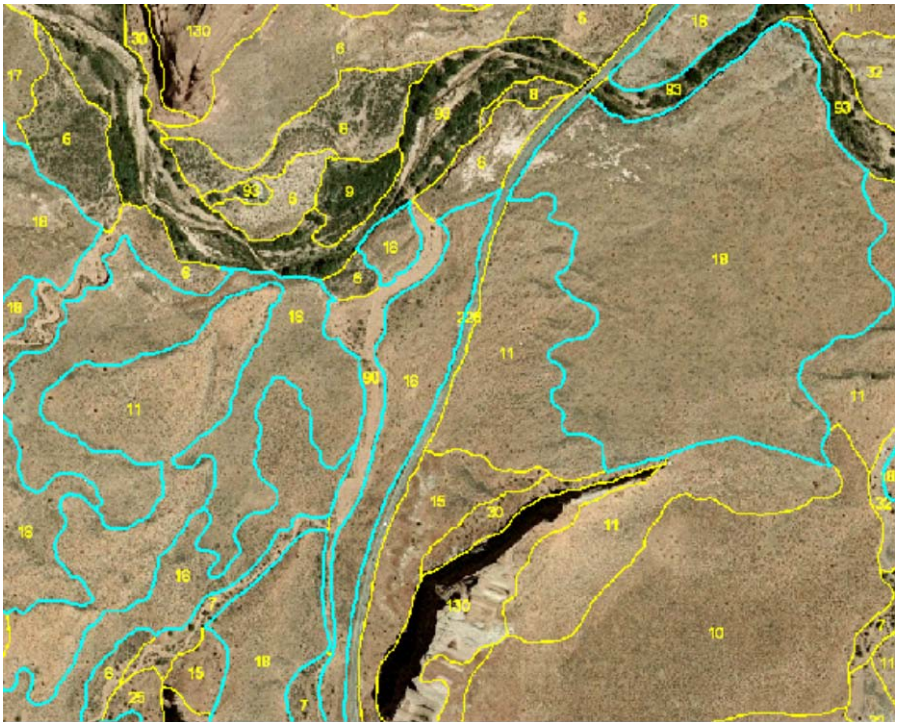
Distribution/Ecology/Composition

This map class describes the complex of shrubland and herbaceous vegetation found on deep, sandy soils of the oldest eolian-influenced alluvial terraces in Courthouse Wash, Salt Wash, and Salt Valley. Sand sagebrush and fourwing saltbush are the dominant shrubs with variable and patchy cover of grasses including alkali sacaton and James' galleta. Some stands include moderate to high cover of cheatgrass and other weedy vegetation, probably as a result of past grazing or other disturbance. Soils are rapidly drained and are generally sandy. Biological soil crust development varies widely among stands, but moss is usually a prominent crust component.

The terraces of map class 18 are high enough above the main wash channel that they are rarely subject to flooding and are relatively stable. They are susceptible to drought stress however, and many of the shrubs and grasses show dieback from recent dry years. Some stands include scattered Utah juniper. The presence of alkali sacaton indicates terraces with greater soil alkalinity and less disturbance. Polygons where needle-and-thread is the dominant understory species include an "HS" modifier.

Interpretation

Polygons of map class 18 are uncommon in ARCH and follow the sandy high terraces lining canyon bottoms. These terraces are commonly higher than the Greasewood Flats (map class 6) and Basin Big Sagebrush Terrace Shrubland (map class 8), but occasionally adjacent to the main wash channel (map classes 93, 9, or 90). Other common neighbors, especially in lower Salt Valley, are Weedy Herbaceous Vegetation (map class 17), Mormon Tea - Mixed Grass Shrublands (map class 14), Sandsheet Shrublands (map class 11), and Blackbrush Shrublands (map class 10). The vegetation photo signature varies with the vegetation; in most cases a speckling of medium-dark shrubs (fourwing saltbush and sand sagebrush) is visible. A grass understory, visible as a smooth light green color, may or may not be present. The background color of map class 18 polygons is the tan color of the sandy soil, with some darkening in areas with good biological soil crust development.



Example of photo signature for map class C-TERR (#18).

Map Class 26
Mat Saltbush Sparse Vegetation (C-MATS)



Photo credits: NPS

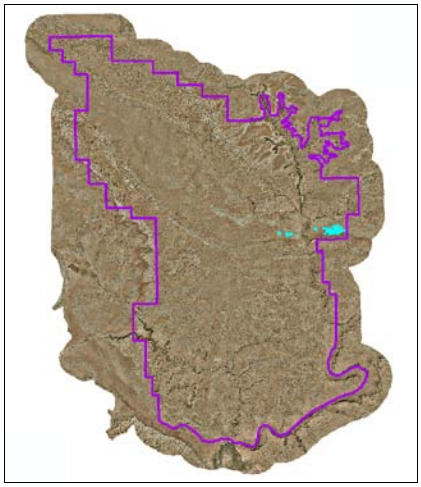
Associations
Atriplex corrugata Dwarf-shrubland [CEGL001437]
Atriplex gardneri Dwarf-shrubland [CEGL001438]

Common species
- *Atriplex corrugata*
- *Atriplex gardneri*

C-MATS Map Class Statistics

Type:	Complex of multiple associations
Frequency:	24 total polygons
	24 polygons in ARCH
	None in the environs
Total project area:	27 hectares / 67 acres (0.1 %)
	27 hectares / 67 acres in ARCH
	None in the environs
Average Polygon Size:	1.1 hectares / 2.8 acres
Producer's accuracy:	100%
User's accuracy:	100%

Distribution in Mapping Area

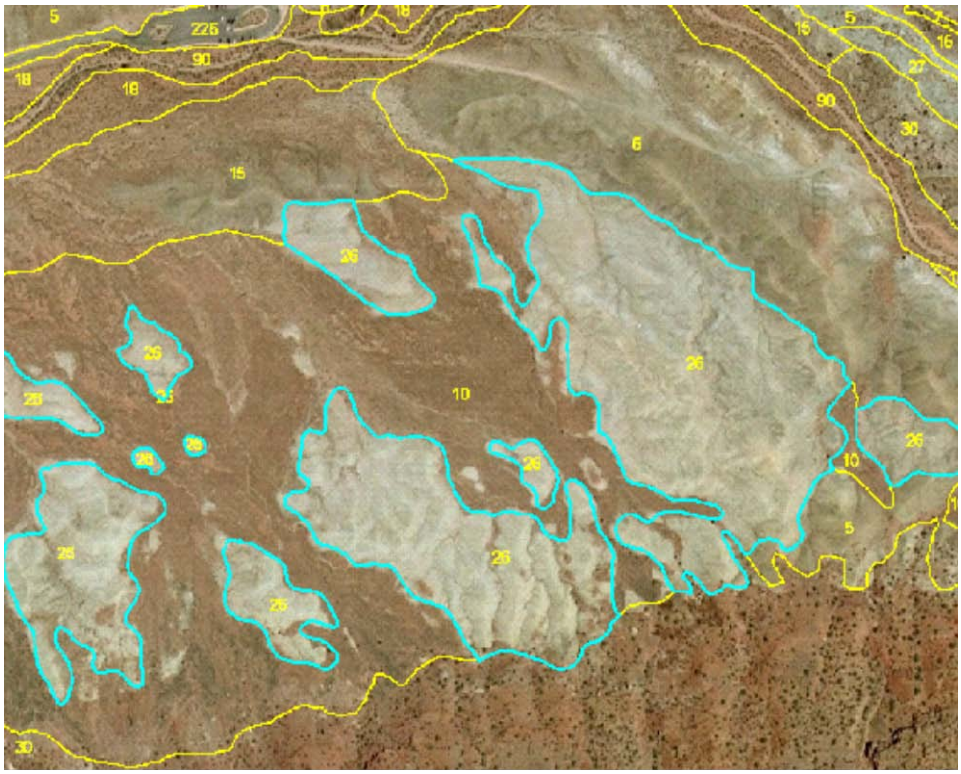


Distribution/Ecology/Composition

Map class 26 is rare in ARCH and is restricted to Cache Valley. It describes the sparse dwarf shrublands that occur on the rolling hills and badlands of alkaline, gray clay soil derived from the upper layers of the Mancos Shale. Litter is nearly absent from the surface cover, and bentonite within the parent shale gives the soil a popcorn-like texture. These are extremely sparse communities; total vegetation cover is usually less than 15%. Mat saltbush associations dominate this map class. Although they are desert-adapted, prolonged drought and erosion of shale soils resulting from anthropogenic disturbance can degrade these already sparse communities.

Interpretation

This map class represents the mottled-gray clay shales of the Mancos Formation at ARCH. Vegetation on this substrate is so sparse that it is difficult to see shrubs even under high magnification. It was only mapped where known to occur from plots and AA points or on identical habitats nearby and is restricted to exposures of the upper Mancos Shale in Cache Valley. Adjacent polygons are usually map classes 15 or 5 (which have similar but denser vegetation and are mainly on dark grey or red shales derived from the Morrison Formation), map class 10 (Blackbrush Shrublands), map class 11 (Sandsheet Shrublands), and map class 30 (Talus Sparse Vegetation Complex).



Example of photo signature for map class C-MATS (#26).

Map Class 30
Talus Sparse Vegetation Complex (C-TALS)




Photo credits: NPS

Associations

Artemisia bigelovii - Ephedra spp. Talus Shrubland [CEGL003755]
Rhus trilobata – Ephedra (viridis, torreyana) Talus Shrubland [CEGL003776]
Pinus edulis-Juniperus osteosperma / Mixed Shrub Talus Woodland [CEGL002328]
Fendlera rupicola Talus Shrubland [CEGL002765]
Juniperus osteosperma / Mixed Shrubs Talus Woodland [CEGL002266]

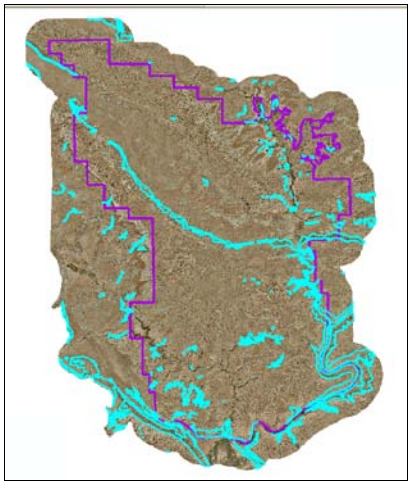
Common species

- *Artemisia bigelovii*
- *Juniperus osteosperma*
- *Chrysothamnus viscidiflorus*
- *Coleogyne ramosissima*
- *Gutierrezia sarothrae*
- *Amelanchier utahensis*
- *Achnatherum hymenoides*
- *Ephedra* spp.
- *Rhus aromatica*
- *Atriplex confertifolia*
- *Ericameria nauseosa*
- *Fendlera rupicola*
- *Fraxinus anomala*
- *Pleuraphis jamesii*

C-TALS Map Class Statistics

Type:	Complex of multiple associations
Frequency:	277 total polygons
	157 polygons in ARCH
	120 polygons in the environs
Total project area:	3,262 hectares / 8,060 acres (6.2 %)
	1,385 hectares / 3,423 acres in ARCH
	1,877 hectares / 4,637 acres in the environs
Average Polygon Size:	11.8 hectares / 29.1 acres
Producer's accuracy:	96% ± 9%
User's accuracy:	79% ± 14%

Distribution in Mapping Area



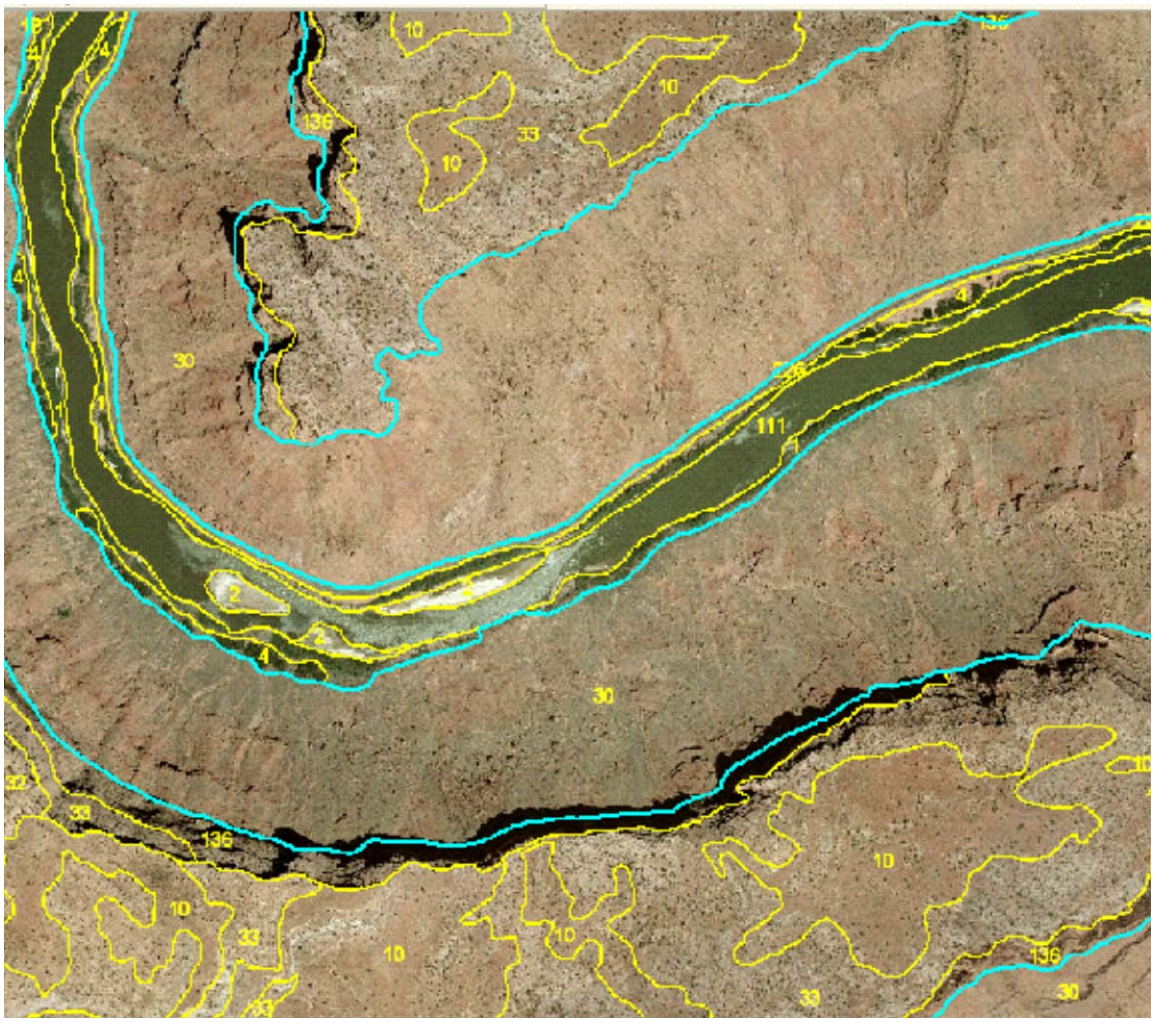
Distribution/Ecology/Composition

This map class describes the steep colluvial slopes of the Colorado River canyon below Wingate cliffs, the steep canyon sides of Salt Wash, and the scarp forming the south side of Salt Valley. Vegetation is variable, with diverse desert shrublands on hotter, drier exposures and sparse woodlands and taller shrublands on protected slopes. James' galleta or cheatgrass form an understory on the drier slopes. The unvegetated surface has moderate to high cover of large and small rocks that are talus derived from the Wingate, Chinle, and Morrison Formations. Constant soil movement, rill erosion, and rockfall limit vegetation development; rocks and soil collect on the upslope sides of trees and shrubs.

The most consistent species in this map class is Bigelow sagebrush, but shrub diversity is always high and may include fourwing saltbush, Torrey joint-fir, green Mormon-tea, viscid rabbitbrush, blackbrush, shadscale, skunkbush, crispleaf buckwheat, Utah serviceberry, and mountain mahogany. Sampled plots in this map class had an average of 10 shrub species per plot, but total vegetation cover usually did not exceed 15%. Aspect and degree of sheltering were the greatest influences on species dominance, with north-facing or distinctly concave slopes supporting more mesic species such as Utah serviceberry, skunkbush, fendlerbush, singleleaf ash, pinyon pine and Utah juniper.

Interpretation

This map class represents the diverse but sparse communities growing on steep colluvial slopes. Polygons are usually elongated, since they primarily occupy canyon walls. The matrix is usually the dark red color of the underlying Chinle shale or Wingate sandstone colluvium, and slopes usually exceed 20°. Otherwise, the photo signature varies depending on aspect and vegetation. Hot, south- and west-facing slopes may appear devoid of vegetation but most usually have a very sparse shrub community of Torrey joint-fir, Bigelow sagebrush, blackbrush and shadscale. North- and east-facing slopes often have scattered pinyon and/or juniper trees with their dark, round crowns obvious in the photo signature. Other shrubs such as skunkbush, single-leaf ash, and fendlerbush may appear as small gray speckles on these cooler slopes. Adjacent polygons are often riparian and terrace map classes that occur at the base of the canyon walls (map classes 1, 2, 3, 4, 6, and 18), valley floor communities (map classes 10, 11, 14, 17), and Kayenta sandstone communities above the Wingate cliffs (map class 33).



Example of photo signature for map class C-TALS (#30).

Map Class 35
Gypsum Badlands Sparse Vegetation (S-GYPS)




Photo credits: NPS

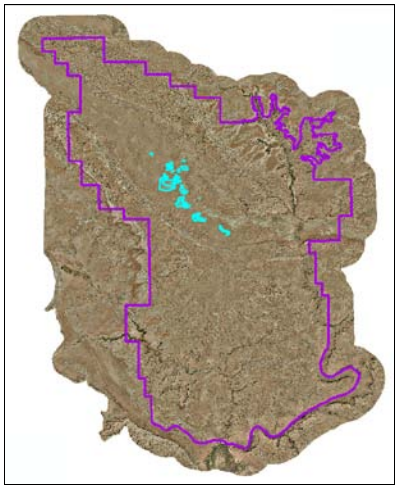
Associations
Ephedra torreyana - *(Atriplex* spp.*) /* Nonvascular Gypsum Sparse Vegetation [CEGL002349]
Ephedra torreyana / Pleuraphis jamesii Shrubland [CEGL003772]

Common species
- *Ephedra torreyana*
- *Opuntia polyacantha*
- *Atriplex canescens*
- *Pleuraphis jamesii*

S-GYPS Map Class Statistics

Type:	Complex of multiple associations
Frequency:	20 total polygons
	20 polygons in ARCH
	None in the environs
Total project area:	164 hectares / 404 acres (0.3 %)
	164 hectares / 404 acres in ARCH
	None in the environs
Average Polygon Size:	8.2 hectares / 20.2 acres
Producer's accuracy:	96% ± 8%
User's accuracy:	96% ± 8%

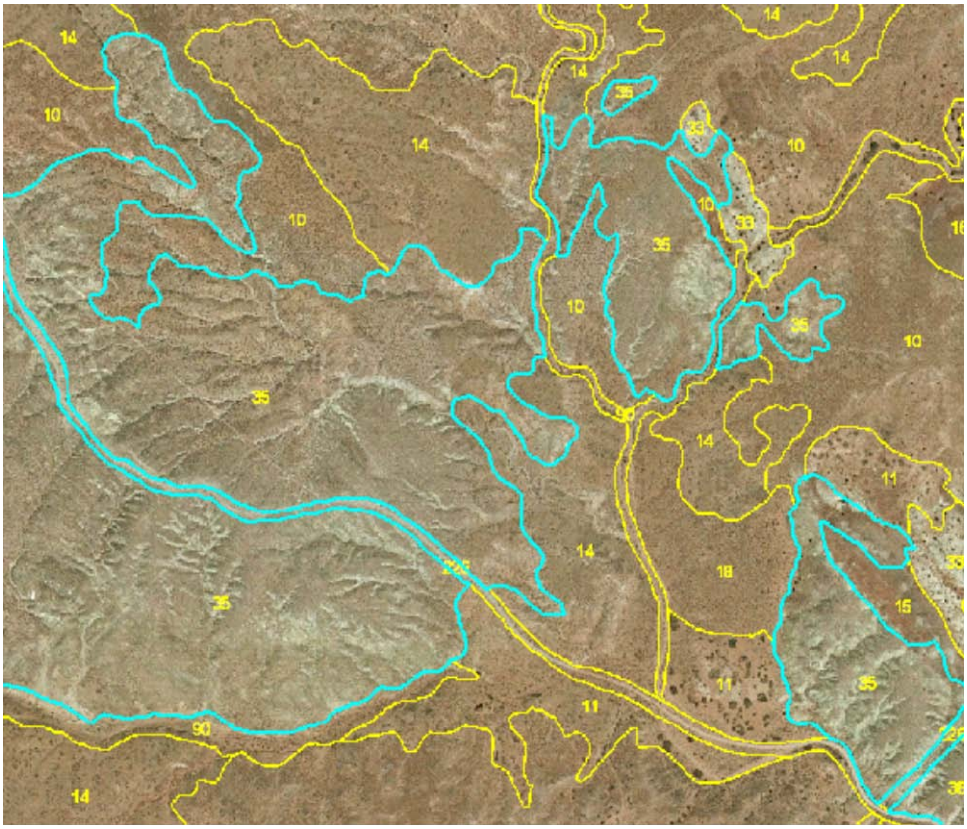
Distribution in Mapping Area



Distribution/Ecology/Composition
This map class represents badlands associated with Paradox Formation gypsum located in the central and lower southern sections of Salt Valley. The soft gypsum evaporite is stabilized by well developed soil crusts with exceptionally high gypsiferous lichen cover. The sparse Torrey joint-fir community is tied to the gypsum. On areas with thin eolian sands, James' galleta replaces the biological soil crust. Shale gravel may be scattered across the surface in some sites.

Interpretation

This very rare type occurs in small, irregularly shaped polygons on the Paradox Formation and is restricted to Salt Valley. Vegetation is so sparse that it is difficult to see shrubs in the photo signature; however, the gypsiferous cryptobiotic crust gives the photo signature a grayer color than the surrounding polygons. Adjacent polygons represent the common map units in Salt Valley, especially Blackbrush Shrubland (map class 10), Sandsheet Shrublands (map class 11), Mormon Tea - Mixed Grass Shrublands (map class 14), and Weedy Herbaceous Vegetation (map class 17).



Example of photo signature for map class S-GYPS (#35).

Map Class 71
Winterfat Shrublands (S-WINT)





Photo credits: NPS

Associations

Krascheninnikovia lanata Dwarf-shrubland [CEGL001320]
Krascheninnikovia lanata / Pleuraphis jamesii Dwarf-shrubland [CEGL001322]

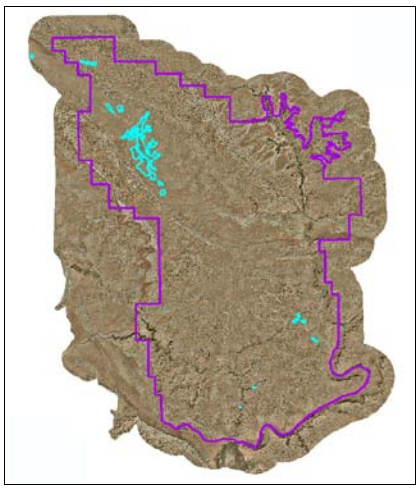
Common species

- *Krascheninnikovia lanata*
- *Coleogyne ramosissima*
- *Sporobolus cryptandrus*
- *Bromus tectorum*
- *Salsola tragus*
- *Lepidium montanum*
- *Ephedra* spp.
- *Pleuraphis jamesii*
- *Achnatherum hymenoides*
- *Sphaeralcea* spp.
- *Plantago patagonica*

S-WINT Map Class Statistics

Type:	Complex of multiple associations
Frequency:	24 total polygons
	23 polygons in ARCH
	1 polygons in the environs
Total project area:	338 hectares / 834 acres (0.6 %)
	335 hectares / 828 acres in ARCH
	2 hectares / 6 acres in the environs
Average Polygon Size:	14.1 hectares / 34.8 acres
Producer's accuracy:	92% ± 17%
User's accuracy:	85% ± 20%

Distribution in Mapping Area



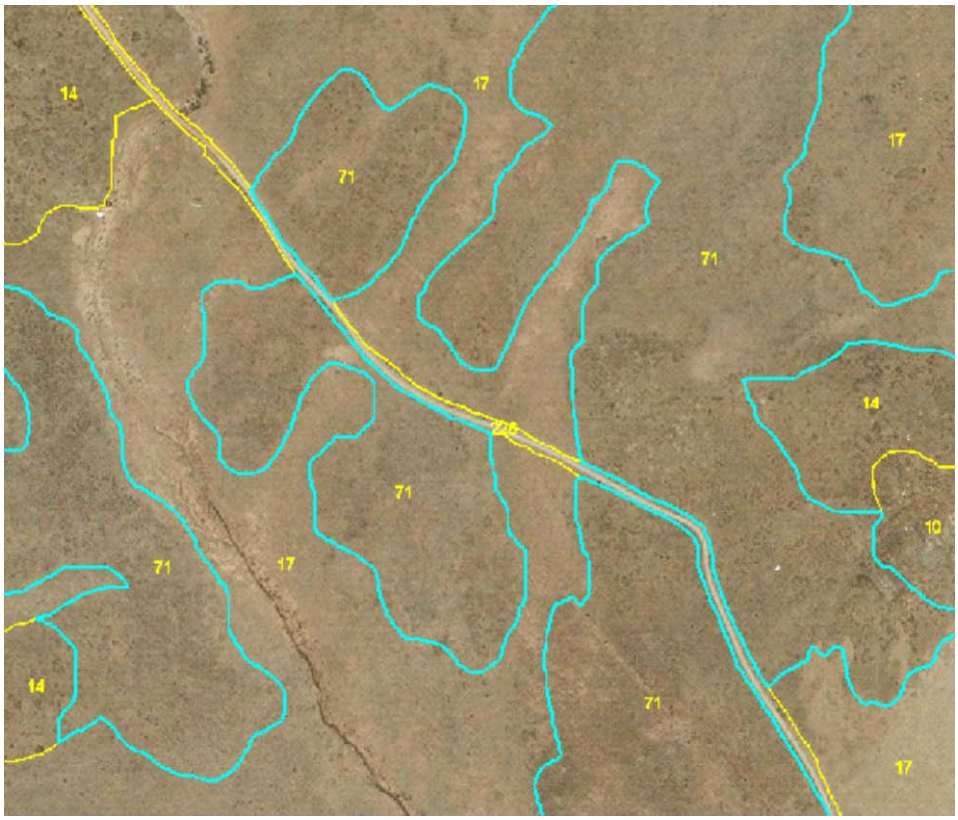
Distribution/Ecology/Composition

Map class 71 is uncommon in ARCH. It describes a mix of winterfat shrublands and native or weedy herbaceous communities growing on older alluvium. This map class occurs primarily in Salt Valley, as well as in the area north of the Colorado River, south of The Windows, and west of the Salt Wash canyon.

Shrub cover ranges from 4 to 25% and herbaceous cover, dominated by James' galleta, sand dropseed, and cheatgrass, ranges from 3 to 65%. Bare soil exposure is generally high, with slight biological and physical soil crust development stabilizing the surface. Soils are rapidly drained sandy or silty loams.

Interpretation

This map class was developed and interpreted after accuracy assessment field work and analysis were complete. It was based on the large number of AA points assigned to winterfat shrublands, which helped with keying in on the subtleties of the photo signature. Polygons of map class 71 are generally large and follow the extent of old alluvium that is deposited across the floor of Salt Valley. The photo signature is a smooth, muted, greenish-brown color, only slightly darker than neighboring polygons of Weedy Herbaceous Vegetation (map class 17). Under magnification, the tiny dark speckles of winterfat shrubs can usually be seen. Rare, small inclusions of blackbrush and green Mormon-tea mots are easy to see. Adjacent polygons are often mapped as Mormon Tea - Mixed Grass Shrublands (map class 14), Blackbrush Shrublands (map class 10), and Weedy Herbaceous Vegetation (map class 17).



Example of photo signature for map class S-WINT (#71).

Map Class 90
Dry Wash Shrublands (S-WASH)




Photo credits: NPS

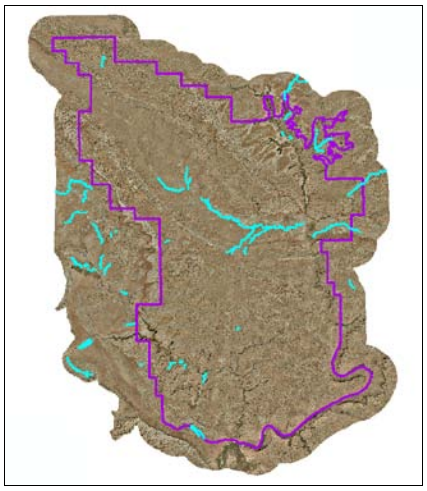
Associations
Coleogyne ramosissima – Purshia stansburiana – Quercus havardii var. *tuckeri* Shrubland [CEGL002348]
Ericameria nauseosa Desert Wash Shrubland [CEGL002261]
Quercus havardii var. *tuckeri* Shrubland [CEGL002486]

Common species
- *Ericameria nauseosa*
- *Purshia stansburiana*
- *Atriplex canescens*
- *Achnatherum hymenoides*
- *Bromus tectorum*
- *Quercus havardii* var. *tuckeri*
- *Artemisia filifolia*
- *Rumex venosus*
- *Sporobolus cryptandrus*
- *Artemisia dracunculus*

S-WASH Class Statistics

Type:	Complex of multiple associations
Frequency:	53 total polygons
	29 polygons in ARCH
	24 polygons in the environs
Total project area:	175 hectares / 432 acres (0.3 %)
	91 hectares / 225 acres in ARCH
	84 hectares / 206 acres in the environs
Average Polygon Size:	3.3 hectares / 8.1 acres
Producer's accuracy:	82% ± 24%
User's accuracy:	69% ± 25%

Distribution in Mapping Area

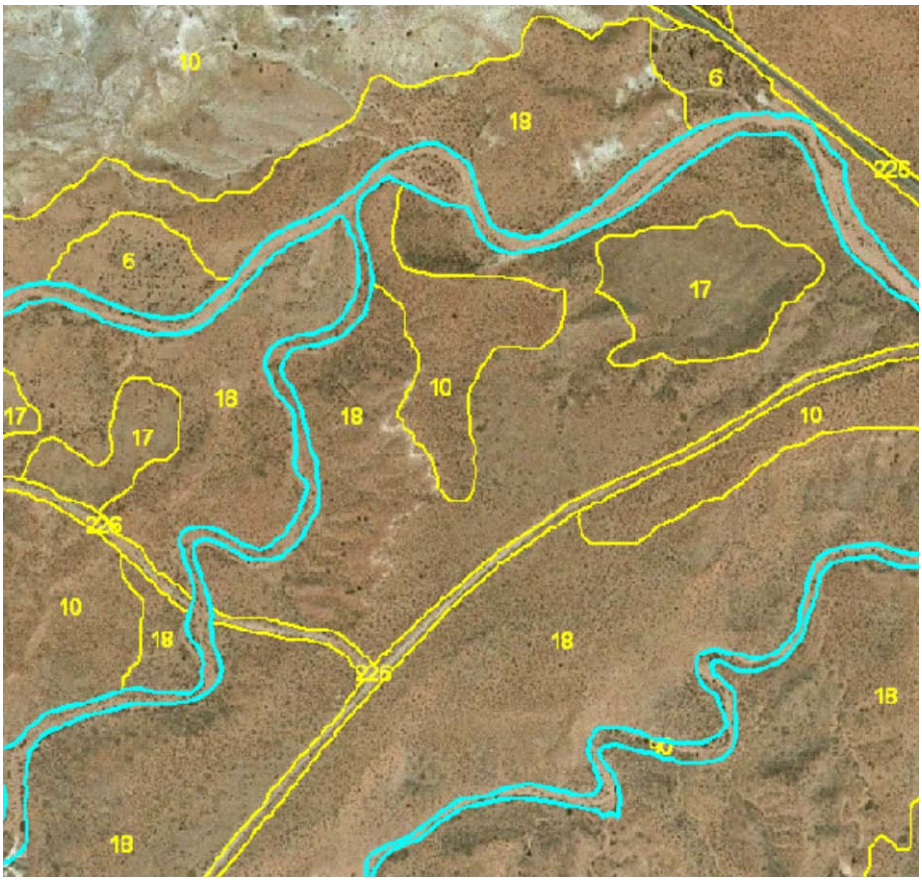


Distribution/Ecology/Composition
This uncommon map class represents the sparse shrub or herbaceous vegetation growing in or on the banks of intermittent or ephemeral wash channels. Occurrences are widely distributed throughout ARCH

and its environs. Some polygons have very low cover of Utah juniper and rare, scattered Fremont cottonwood trees. The disturbed banks of washes support a sparse, mixed shrub community, of which *Ericameria nauseosa* is the most consistent element. Depending on the texture of the substrate and the frequency of disturbance, other shrubs present may include sand sagebrush, Stansbury cliffrose, skunkbush, and Tucker oak.

Interpretation

Polygons of map class 90 follow sandy wash channels that are large enough to support a unique mix of shrubs along their course and banks. Polygons of map class 90 are long, sinuous, very narrow and have the distinct light tan of sand lining wash channels as their matrix color. A speckling of medium-dark shrubs can often be seen along the edges of the wash and occasionally as small islands of vegetation within the channel. Because wash channels run through or dissect nearly every vegetation community in ARCH, adjacent polygons may be mapped as almost any other map class. However, Greasewood Flats (map class 6) and High Terrace Shrub Herbaceous Complex (map class 18) are most common.



Example of photo signature for map class S-WASH (#90).

Upland Herbaceous Communities

Map Class 17
Weedy Herbaceous Vegetation (H-WEED)





Photo credits: NPS

Associations

Bromus tectorum Semi-natural Herbaceous Vegetation [CEGL003019]
Pleuraphis jamesii Herbaceous Vegetation [CEGL001777]
Sphaeralcea (coccinea, parvifolia) Herbaceous Vegetation [CEGL005366]
Sporobolus cryptandrus Great Basin Herbaceous Vegetation [CEGL002691]

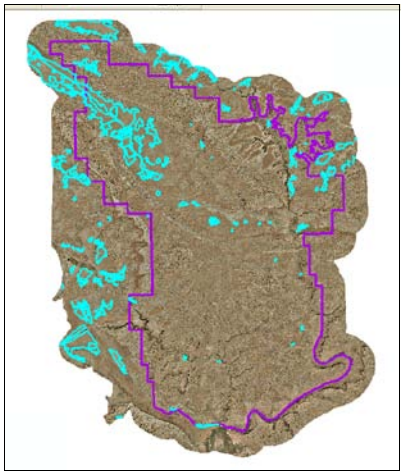
Common species

- *Pleuraphis jamesii*
- *Bromus tectorum*
- *Salsola tragus*
- *Descurainia pinnata*
- *Krascheninnikovia lanata*
- *Sporobolus cryptandrus*
- *Sphaeralcea* spp.
- *Lappula occidentalis*
- *Opuntia polyacantha*
- *Cryptantha crassisepala*

H-WEED Map Class Statistics

Type:	Complex of multiple associations
Frequency:	165 total polygons
	71 polygons in ARCH
	94 polygons in the environs
Total project area:	2,740 hectares / 6,770 acres (5.2 %)
	908 hectares / 2,245 acres in ARCH
	1,831 hectares / 4,525 acres in the environs
Average Polygon Size:	16.6 hectares / 41 acres
Producer's accuracy:	91% ± 12%
User's accuracy:	91% ± 12%

Distribution in Mapping Area



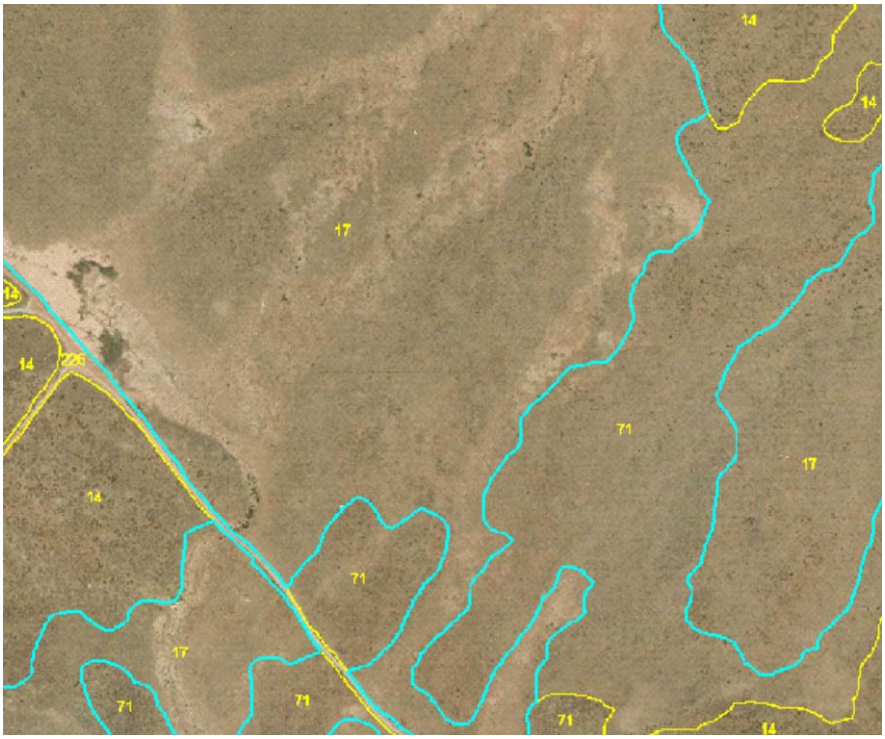
Distribution/Ecology/Composition

Map class 17 describes a mix of weedy herbaceous communities that represent degraded grasslands on old alluvium. Most polygons of this map class occur at the northwest end of Salt Valley, but some occur in the environs, especially Little Valley, Long Valley, Yellow Cat Flat, and the large alluvial terraces above upper Courthouse Wash and Sevenmile Canyon. Outside the park boundary in Salt Valley, this map unit is nearly solid cheatgrass. A combination of domestic livestock grazing history, extended droughts, and soil conditions that favor spring annual species are the driving factors for this map class. Small inclusions of native grass and winterfat communities are common in polygons of map class 17.

Vegetation in these stands varies from 8 to 75% total cover. Cover and species composition are strongly influenced by late winter rainfall affecting the growth of spring annual plant species. Cheatgrass cover may be as high as 65% in a wet spring. Bare soil exposure is high, with slight cryptobiotic soil development and physical crust providing minimal surface stabilization.

Interpretation

Polygons of map class 17 are generally large match areas of older alluvium deposited on the floor of Salt Valley and similar graben settings. The characteristic photo signature of this map class is a smooth, muted, greenish-brown color with the tan color of bare soil in the background. Vegetation is very hard to see in the aerial imagery, even under magnification. Patchy blackbrush and green Mormon-tea mots are rare and easy to see, but sparse winterfat and globemallow communities that are characteristic of this map class are nearly indistinguishable. Polygons of this map class were modeled by extrapolating the photo signature associated with sample plots of the constituent associations to extent of older alluvial deposits in these valleys (taken from the geology map for ARCH). Adjacent polygons are most often mapped as Shale Barrens Desert Scrub (map class 15), Sandsheet Shrublands (map class 11), Winterfat Shrublands (map class 71), Mormon Tea - Mixed Grass Shrublands (map class 14), and Blackbrush Shrublands (map class 10).



Example of photo signature for map class H-WEED (#17).

Map Class 27
Salina Lyme Grass Sparse Vegetation (H-LESA)





Photo credits: NPS

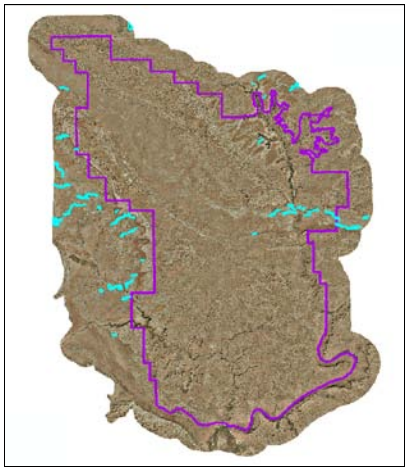
Associations
Leymus salinus Shale Sparse Vegetation [CEGL002745]

Common species
- *Leymus salinus*
- *Pleuraphis jamesii*
- *Artemisia bigelovii*
- *Atriplex confertifolia*
- *Poa secunda*

H-LESA Map Class Statistics

Type:	Association
Frequency:	47 total polygons
	15 polygons in ARCH
	32 polygons in the environs
Total project area:	190 hectares / 469 acres (0.4 %)
	34 hectares / 85 acres in ARCH
	155 hectares / 384 acres in the environs
Average Polygon Size:	4 hectares / 10 acres
Producer's accuracy:	100%
User's accuracy:	100%

Distribution in Mapping Area

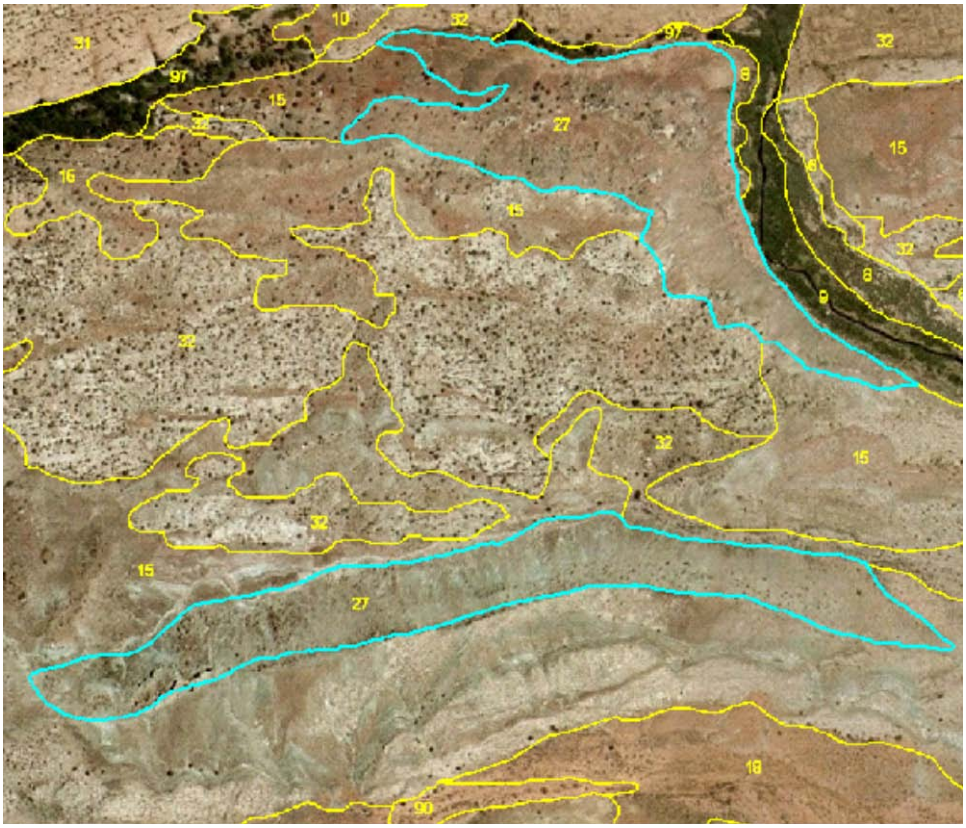


Distribution/Ecology/Composition
Map class 27 describes sparse communities of Salinas lyme grass and shrubs that are restricted to moderately steep to steep, north-facing, usually rocky slopes. Soils are derived from the Cedar Mountain Formation and the Brushy Basin and Salt Wash members of the Morrison Formation. Soils tend to have a clay to loam texture and poor biological soil crust development. Stands are affected by slope movement; the large bunchgrasses collect soil on their upslope side. Erosion occurs primarily during and after precipitation events.

The Salinas Lyme Grass Sparse Vegetation association is uncommon in the mapping area, occurring only on north-facing, rocky shale slopes. Most polygons are around the margins of Salt and Cache valleys, with a few scattered occurrences in the northern and western environs. Total vegetation cover ranges from 3 to 55%, with Salinas lyme grass accounting for 1 to 35% cover. Scattered juniper trees are present in some stands. Over time, this association may become invaded sufficiently by shadscale to be classified as a shrubland type. Conversely, the constant downslope soil movement and rockfall may tend to favor the survival of grasses over woody plants.

Interpretation

This rare type occurs in long, narrow, relatively small polygons that mainly run west to east along steep, north-facing, rocky shale slopes. It was only mapped where known to occur plot and AA point data and on identical habitats near known locations. Scattered shrubs (dark speckles) and occasional trees (larger, darker green dots) may be seen, but it is difficult to discern the photo signature of the saline wildrye on these slopes. Adjacent polygons are usually mapped as Badlands Sparse Vegetation (map class 5), Shale Barrens Desert Scrub (map class 15), and Sandstone Ledges Woodlands (map class 33).



Example of photo signature for map class H-LESA (#27).

Riparian / Wetland Woodlands and Shrublands

Map Class 1
Tamarisk River Corridor Shrubland (S-TARC)





Photo credits: NPS

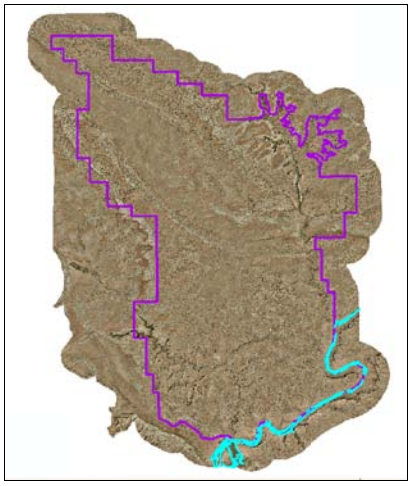
Associations
Tamarix spp. Temporarily Flooded Shrubland [CEGL003114]

Common species
- *Tamarix ramosissima*
- *Salix exigua*
- *Quercus gambelii*
- *Rhus trilobata*
- *Ericameria nauseosa*
- *Distichlis spicata*

S-TARC Map Class Statistics

Type:	Association
Frequency:	95 total polygons
	14 polygons in ARCH
	81 polygons in the environs
Total project area:	170 hectares / 421 acres (0.3 %)
	34 hectares / 85 acres in ARCH
	136 hectares / 336 acres in the environs
Average Polygon Size:	1.8 hectares / 4.4 acres
Producer's accuracy:	100%
User's accuracy:	60% ± 46%

Distribution in Mapping Area

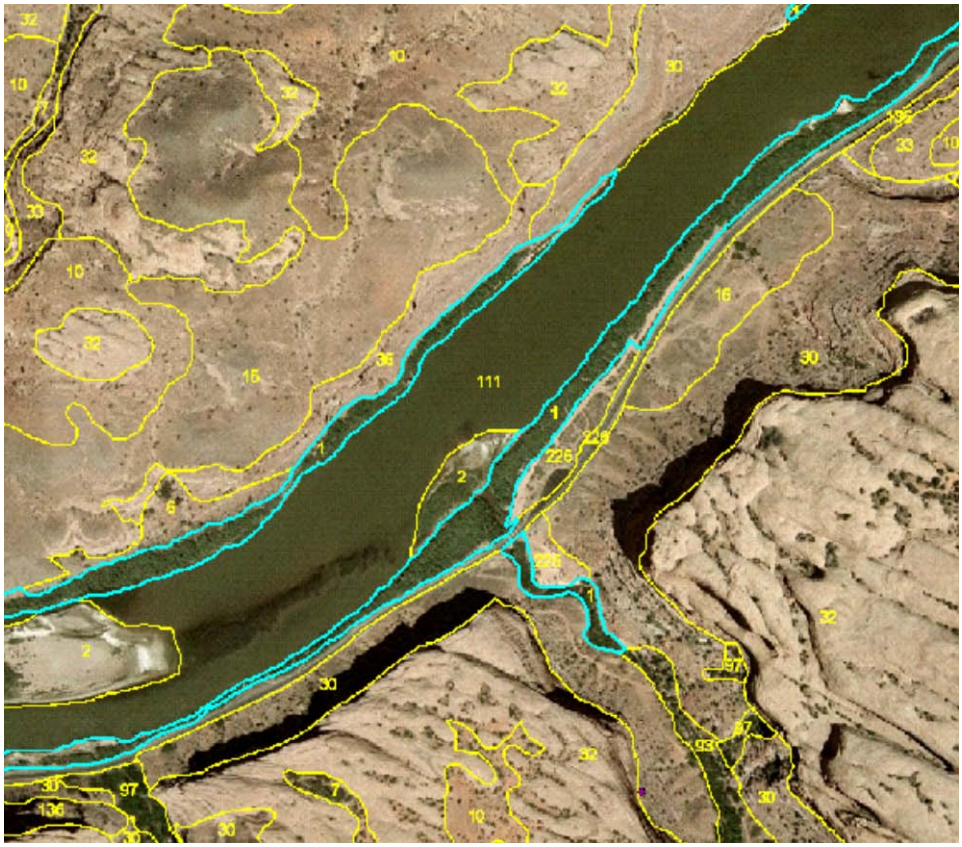


Distribution/Ecology/Composition
Map class 1 is not common or widely distributed in ARCH, occurring only in a narrow corridor along the Colorado River on the park boundary. It represents dense, mature stands of tamarisk and coyote willow, with little to no understory, growing on the river terraces and broad floodplains and backwaters of the Colorado River, mostly in the environs south of the park boundary. This map unit is a patchy mosaic of tall shrubs, with narrow bands of coyote willow at the water's edge and tamarisk generally dominating the

rest of the riverbank. Small, rare patches of skunkbush and Gambel oak occur in a mosaic with the tamarisk and willow. Soils are the deep, silty or sandy alluvium of the riverbank that are subject to frequent flooding. The amount of leaf litter present depends on flood activity. Some of these stands have been recently burned in an effort to suppress the tamarisk, and tamarisk leaf beetles have also been released in the area.

Interpretation

Map class 1 consists of long, narrow, sinuous polygons which follow the Colorado River's edge as well as polygons on the widest parts of the river floodplain in the mapping area. The matrix photo signature is a rough-textured pattern indicating the generally dense canopy of tamarisk and ranges from the solid dark green of dense tamarisk thickets to grainy-looking, sparser stands with a paler olive-green color. Small inclusions of greasewood shrublands (map class 6) may be present away from the river's edge; these appear as patches of speckled olive green. Polygons adjacent to map class 1 are usually mapped as Riverine Sandbar Sparse Willow Shrubland (map class 2), Gambel Oak Terrace Shrubland (map class 4), higher terrace shrublands (map classes 6 and 18), Talus Sparse Vegetation Complex (map class 30), the Colorado River (map class 111), or various land use categories (map classes 330, 212, 221, and 226).



Example of photo signature for map class S-TARC (#1).

Map Class 2
Riverine Sandbar Sparse Willow Shrublands (S-RSSW)



Photo credit: NPS

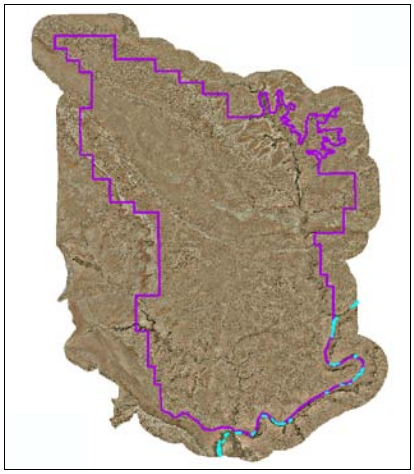
Associations
Salix exigua / Barren Shrubland [CEGL001200]

Common species
- *Salix exigua*
- *Tamarix chinensis*

S-RSSW Map Class Statistics

Type:	Association
Frequency:	51 total polygons
	15 polygons in ARCH
	36 polygons in the environs
Total project area:	26 hectares / 65 acres (0.1 %)
	6 hectares / 16 acres in ARCH
	20 hectares / 49 acres in the environs
Average Polygon Size:	0.5 hectares / 1.3 acres
Producer's accuracy:	75% ± 48%
User's accuracy:	100%

Distribution in Mapping Area

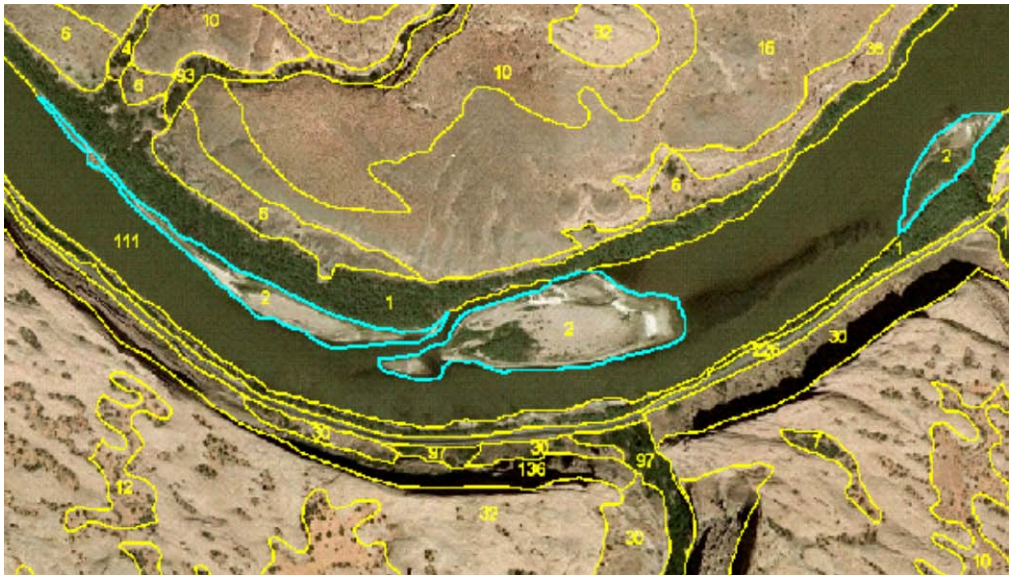


Distribution/Ecology/Composition
Map class 2 represents the lowest floodplain of the Colorado River and actively shifting sand bar islands that are inundated during high water levels. The vegetation consists of colonizing coyote willow and tamarisk with variable cover; stands range from 5 to 75% cover. Coyote willow usually occurs in a narrow belt on the water's edge, hemmed in by tamarisk behind it. Because these sites flood annually,

there is no understory or accumulation of leaf litter, and both deposition and erosion of sand and silt are constant processes.

Interpretation

This rare map class occurs mostly in the environs south of the park boundary and only on the banks of the Colorado River closest to the water's edge or on islands in the river that are submerged at high water. Polygons are small and narrow, with a bright matrix color of light tan sand. Some polygons appear devoid of vegetation, while others exhibit thick dark green patches of dense coyote willow or young tamarisk. This map class is the most dynamic type in the park and is subject to change dramatically from one year to the next, with fluctuations in river flow and flood events. The accuracy of photo interpretation is complicated by this fact. Adjacent polygons are generally mapped as Tamarisk River Corridor Shrubland (map class 1), Talus Sparse Vegetation Complex (map class 30), or the Colorado River (map class 111).



Example of photo signature for map class S-RSSW (#2).

Map Class 4
Gambel Oak Terrace Shrubland (S-GOTS)





Photo credits: NPS

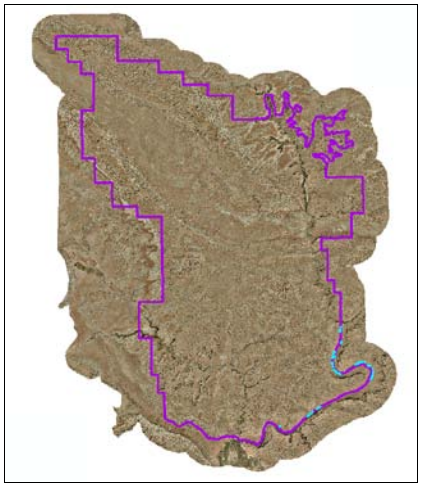
Associations
Quercus gambelii / Sparse Understory Shrubland [CEGL002337]

Common species
- *Quercus gambelii*
- *Tamarix ramosissima*
- *Salix exigua*
- *Ericameria nauseosa*
- *Sarcobatus vermiculatus*
- *Bromus tectorum*

S-GOTS Map Class Statistics

Type:	Association
Frequency:	21 total polygons
	9 polygons in ARCH
	12 polygons in the environs
Total project area:	11 hectares / 27 acres (0.02 %)
	5 hectares / 13 acres in ARCH
	5 hectares / 13 acres in the environs
Average Polygon Size:	0.5 hectares / 1.3 acres
Producer's accuracy:	100%
User's accuracy:	100%

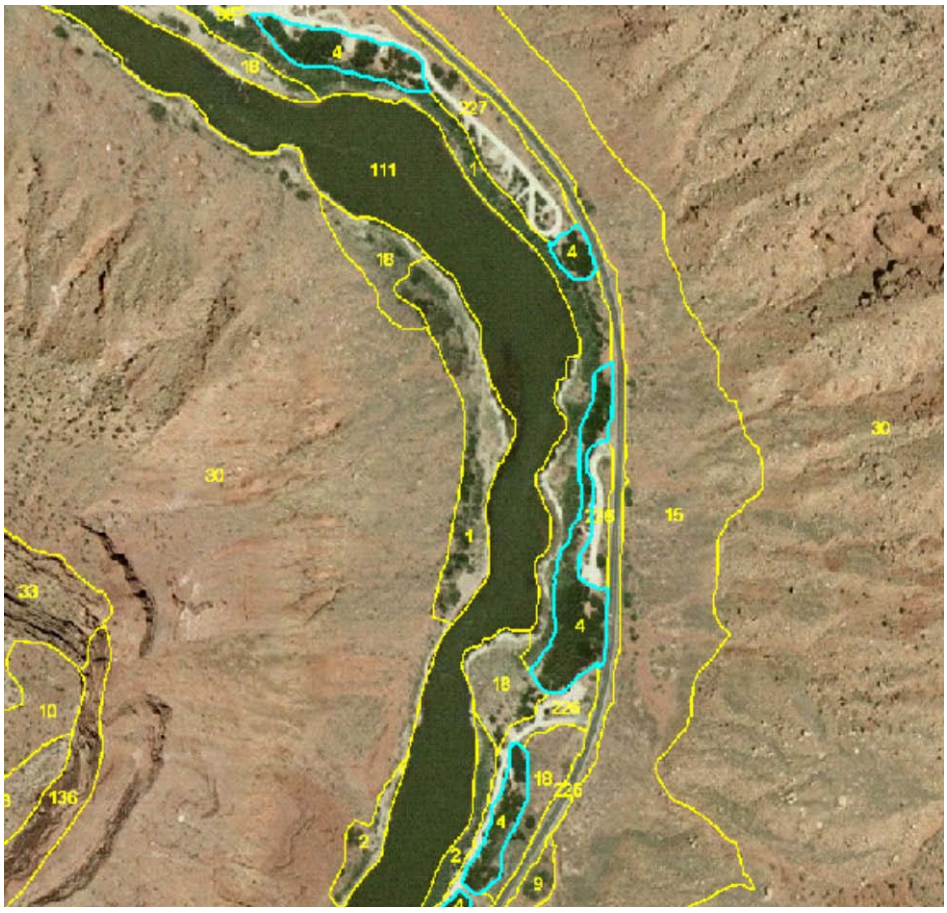
Distribution in Mapping Area



Distribution/Ecology/Composition
Map class 4 is rare and restricted in its distribution at ARCH, occurring only in a narrow corridor along the Colorado River on or just outside of the park boundary. This map unit represents the dense, mature stands of Gambel oak with little to no understory growing on high terraces of the Colorado River. Soils are deep, silty or sandy alluvium within the high flood zone but rarely flooded. Leaf litter cover is high, ranging from 50-93%, and can be more than an inch thick.

Interpretation

Map class 4 was developed and interpreted after the map accuracy assessment analysis was complete. It consists of short, narrow polygons that follow the Colorado River and occur as bands or small clumps on the inland edge of adjacent bands of tamarisk and/or coyote willow. The vegetation photo signature is a very dark green, lumpy texture indicating the generally dense, but clumpy Gambel oak canopy; oak stands are a darker green color than neighboring thickets of tamarisk and/or willow. Polygons adjacent to Map class 4 are most often mapped as Riverine Sandbar Sparse Willow Shrubland (map class 2), Tamarisk River Corridor Shrubland (map class 1), High Terrace Shrub Herbaceous Complex (map class 18), Talus Sparse Vegetation Complex (map class 30), and the Colorado River (map class 111).



Example of photo signature for map class S-GOTS (#4).

Map Class 9
Tributary Tamarisk and Salix Shrubland Mosaic (S-TTSS)





Photo credits: NPS

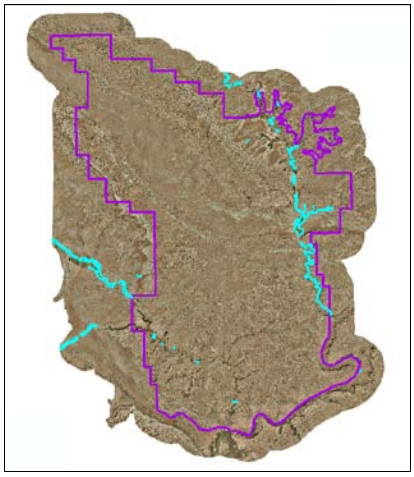
Associations
Salix exigua / Barren Shrubland [CEGL001200]
Salix ligulifolia Shrubland [CEGL001218]
Tamarix spp. *Temporarily Flooded* Shrubland [CEGL003114]

Common species
- *Tamarix ramosissima*
- *Salix exigua*
- *Salix ligulifolia*
- *Ericameria nauseosa*
- *Distichlis spicata*
- *Sporobolus airoides*

S-TTSS Map Class Statistics

Type:	Complex of multiple associations
Frequency:	54 total polygons
	32 polygons in ARCH
	22 polygons in the environs
Total project area:	268 hectares / 662 acres (0.5 %)
	130 hectares / 320 acres in ARCH
	138 hectares / 342 acres in the environs
Average Polygon Size:	5 hectares / 12.3 acres
Producer's accuracy:	100%
User's accuracy:	91% ± 12%

Distribution in Mapping Area



Distribution/Ecology/Composition
This map class occurs adjacent to the main channels of Courthouse Wash, especially outside the park boundary, and Salt Wash, where tamarisk and/or willow shrubs are dominant. Communities are subject to periodic flooding in addition to deposition of sediments and debris following major precipitation events. Due to landscape position, the sites along drainage channels could be eliminated by scour as drainages meander across the landscape. Some stands are being treated to remove tamarisk.

Interpretation

These polygons are long and narrow, following wash bottoms and low terraces. The photo signature is a blotchy mosaic of dense, bright green (wetter areas) to scattered dark green shrubs or clumps of shrubs with a high cover of tan sandy soil showing through. Adjacent polygons are most often mapped as Greasewood Flats (map class 6) or High Terrace Shrub Herbaceous Complex (map class 18), Weedy Herbaceous Vegetation (map class 17), or Talus Sparse Vegetation Complex (map class 30).



Example of photo signature for map class S- TTSS (#9).

Map Class 93
Tributary Woodland (W-POFR)





Photo credits: NPS

Associations

Elaeagnus angustifolia Semi-natural Woodland [CEGL005269]
Populus fremontii / Artemisia tridentata Woodland [CEGL005365]
Populus fremontii / Equisetum spp. Woodland [CEGL003775]
Populus fremontii / Ericameria nauseosa Woodland [CEGL002465]
Populus fremontii / Salix exigua Forest [CEGL000666]
Salix gooddingii / Salix exigua Woodland [CEGL003778]
Sporobolus airoides Southern Plains Herbaceous Vegetation [CEGL001685]

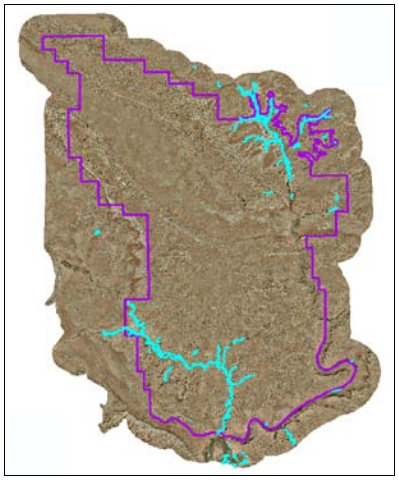
Common species

- *Populus fremontii*
- *Salix gooddingii*
- *Artemisia tridentata* ssp. *tridentata*
- *Tamarix ramosissima*
- *Equisetum* spp.
- *Phragmites australis*
- *Heterotheca villosa*
- *Salix exigua*
- *Elaeagnus angustifolia*
- *Ericameria nauseosa*
- *Rhus trilobata*
- *Juncus balticus*
- *Medicago sativa*
- *Sporobolus airoides*

W-POFR Map Class Statistics

Type:	Complex of multiple associations
Frequency:	91 total polygons
	74 polygons in ARCH
	17 polygons in the environs
Total project area:	324 hectares / 800 acres (0.6 %)
	284 hectares / 702 acres in ARCH
	40 hectares / 98 acres in the environs
Average Polygon Size:	3.6 hectares / 8.8 acres
Producer's accuracy:	98% ± 4%
User's accuracy:	95% ± 6%

Distribution in Mapping Area

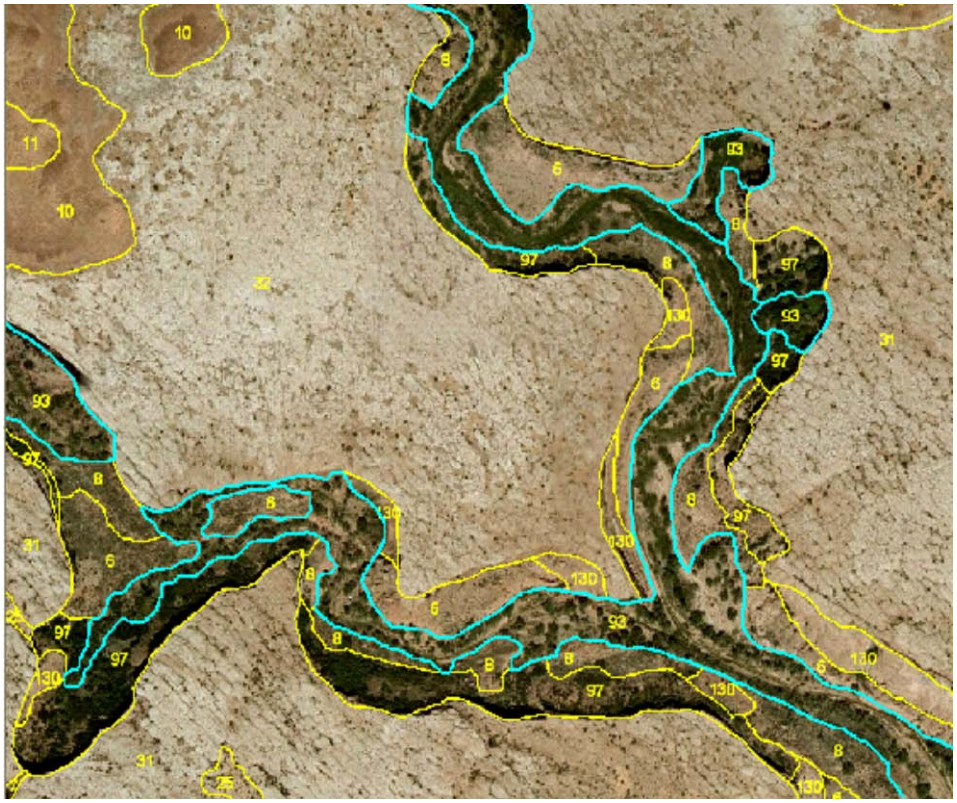


Distribution/Ecology/Composition

Map class 93 represents the Fremont cottonwood-dominated (and more rarely Gooding willow- or Russian-olive-dominated) communities in the mapping area, with small inclusions of other mesic and wetland shrub or herbaceous types that are too small to delineate separately. Polygons of this map class occur in the park along Courthouse Wash, Sevenmile Canyon, upper Salt Wash drainage and Lost Spring Canyon. There are a few scattered polygons in the southern environs of the park, including the Matheson Wetlands Preserve and Negro Bill Canyon. Cottonwood canopies range from large, decadent trees to young saplings emerging from thick coyote willow or tamarisk shrublands. Understories are generally dense (35 to 75% cover), and may be shrub or herbaceous-dominated. Some stands have high cover by the invasive species tamarisk, Russian-olive, or alfalfa. Stands occupy terraces with a high percentage of litter covering the sandy soil. Flood regimes vary, but most sites are subject to flash floods after storm events.

Interpretation

Map class 93 is characterized by long, narrow polygons in canyon bottoms and on wash terraces. Stands vary in density and degree of clumping, but the characteristic large, rounded tree crowns of the Fremont cottonwoods appear much taller than the surrounding vegetation when viewed in stereo. Dark green tamarisk shrubs fill in the spaces between scattered cottonwood crowns in some polygons (denoted with an “X” modifier). Others stands have rabbitbrush, greasewood, or big sagebrush shrubs visible as gray dots when viewed with magnification. Occasionally, cottonwood stands will have a smooth green signature in the understory indicating a thick herbaceous layer of horsetail or sedges (denoted with an “M” modifier). Surrounding polygons are usually mapped as other terrace map classes, such as Basin Big Sagebrush Terrace Shrubland (map class 8), Greasewood Flats (map class 6), High Terrace Shrub Herbaceous Complex (map class 18) or Tributary Tamarisk and Salix Shrubland Mosaic (map class 9).



Example of photo signature for map class W-POFR (#93).

Map Class 97
Cliff and Alcove Complex (C-ALCO)




Photo credits: NPS

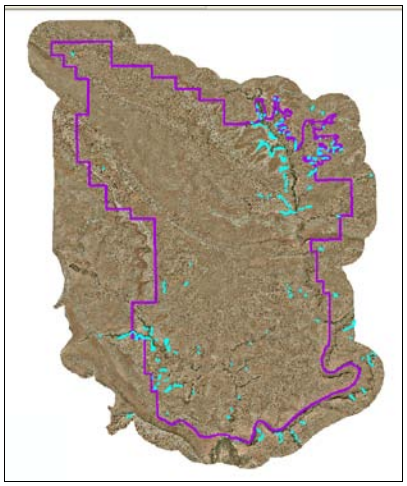
Associations
Quercus gambelii / Sparse Understory Woodland (Shrubland) [CEGL002337]
Pinus edulis – Juniperus spp. / *Quercus gambelii* Woodland [CEGL000791]

Common species
- *Pinus edulis*
- *Juniperus osteosperma*
- *Quercus gambelii*
- *Rhus trilobata*
- *Cornus sericea*
- *Celtis laevigata* var. *reticulata*
- *Mahonia fremontii*
- *Toxicodendron rydbergii*

C-ALCO Map Class Statistics

Type:	Complex of multiple associations
Frequency:	191 total polygons
	135 polygons in ARCH
	56 polygons in the environs
Total project area:	116 hectares / 287 acres (0.2 %)
	87 hectares / 214 acres in ARCH
	29 hectares / 73 acres in the environs
Average Polygon Size:	0.6 hectares / 1.5 acres
Producer's accuracy:	N/A
User's accuracy:	N/A

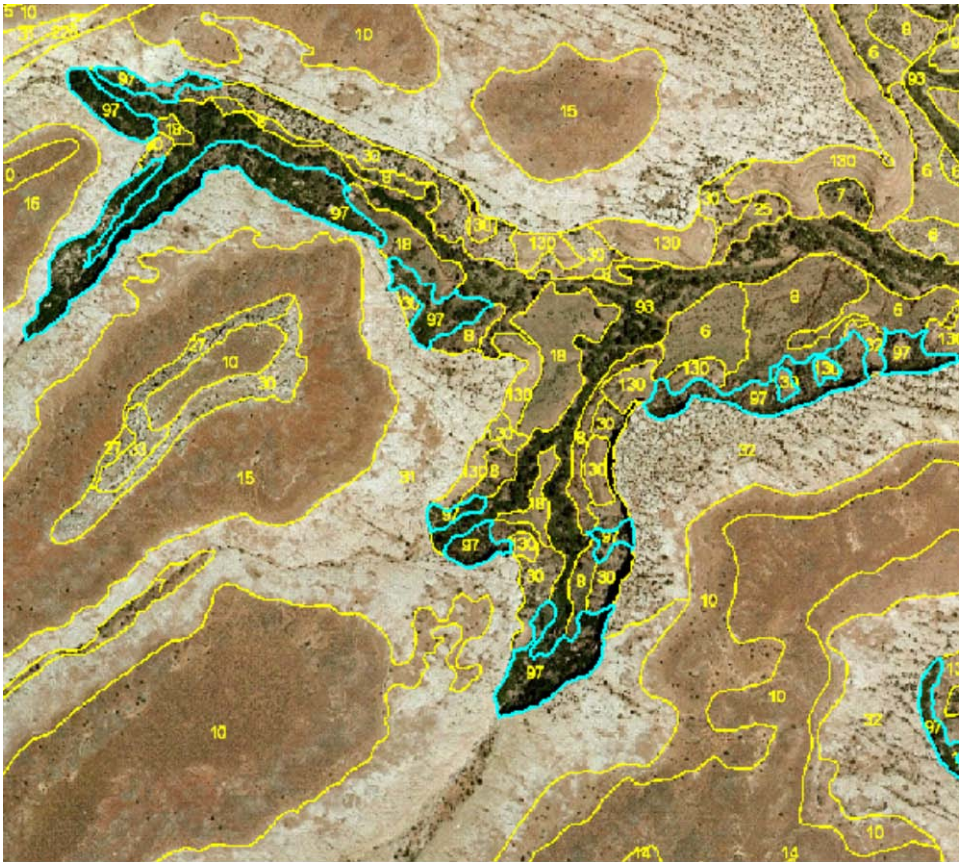
Distribution in Mapping Area



Distribution/Ecology/Composition
Map class 97 is a relatively common mesic map unit, with polygons widely distributed throughout the park. Occurrences are located beneath the rims of many canyons on moist, sheltered slopes or in pouroff basins or on the slopes below alcoves. Communities are composed of a mix of mesic tall shrubs, in some cases with juniper and pinyon trees. Vegetation is dense; with total cover (including understory cover) may exceed 100%, and leaf litter cover is generally high.

Interpretation

Polygons of map class 97 are generally small and narrow, and hug the cliff walls and alcoves of Moab Tongue and Navajo sandstones. The photo signature varies depending on how much bedrock is exposed and how much moisture is seeping through the cliffs to support the vegetation. Dark green, rounded tree or oak crowns are usually visible and are larger than the smaller, gray-green dots of mixed mesic shrubs. Some polygons have a continuous thick dark green photo signature, which are probably Gambel oak thickets. Adjacent polygons are usually mapped as sandstone-dominated communities (map classes 31 or 32), Talus Sparse Vegetation Complex (map class 30), or Tributary Woodland (map class 93).



Example of photo signature for map class C-ALCO (#97).

Riparian / Wetland Herbaceous Communities

Map Class 100
Hanging Gardens (H-HANG)



Photo credit: NPS

Associations

Aquilegia micrantha - Mimulus eastwoodiae Herbaceous Vegetation [CEGL002729]

Common species

- *Aquilegia micrantha*
- *Mimulus eastwoodiae*
- *Panicum acuminatum*
- *Schizachyrium scoparium*
- *Cirsium rydbergii*
- *Adiantum capillus-veneris*
- *Juncus ensifolius*
- *Toxicodendron rydbergii*

H-HANG Map Class Statistics

Type:	Association
Frequency:	N/A
Total project area:	N/A
Average Polygon Size:	N/A
Producer's accuracy:	N/A
User's accuracy:	N/A

Feature mapped as points, not polygons; data are incomplete and therefore not shown

Distribution/Ecology/Composition

Hanging gardens develop where groundwater moving through porous sandstone intercepts impermeable layers, forcing the water to emerge from canyon walls with a steady, year-round flow. Over time, alcoves form as water dissolves the calcareous cement holding the sandstone together. Well-developed hanging gardens are found in these alcoves and smaller gardens are sometimes found along seeping horizontal cracks on cliff faces at the junctions of geologic layers. At ARCH, many of the hanging gardens, and most of the best-developed ones, emerge from the contact of the Moab Tongue and the Entrada

Sandstone. The availability of water from a seep and the gradual building of soil caught and held by the moist rock surface are keys to the survival of hanging garden vegetation; these communities are vulnerable to changes and fluctuations in water availability due to drought.

Hanging gardens support a unique assemblage of plants within the alcove and in the saturated soils and talus downslope. Many species (such as alcove death camas) are endemic to the Colorado Plateau and are found rarely outside of hanging gardens. Although vegetation is dense within the gardens, examples are usually long and narrow; they may extend for more than 100m along a horizontal crack, but may be no more than 1 or 2m wide. Species that often surround the hanging gardens on moist, sheltered slopes below include poison ivy, Utah serviceberry, Gambel oak, chokecherry, and large pinyon or juniper trees.

Interpretation

This type was not interpreted because it occurs on near-vertical cliff faces or beneath cliff overhangs; occurrences are not visible on the aerial imagery. Instead, this type is documented by point data derived from the plots database and from observations in the field that field crew members marked/drew on copies of the aerial imagery. There are hundreds of separate hanging gardens at ARCH; this mapping project located only a few of them.

Map Class 92
Tributary Mesic Herbaceous Complex (H-TMHC)





Photo credits: NPS

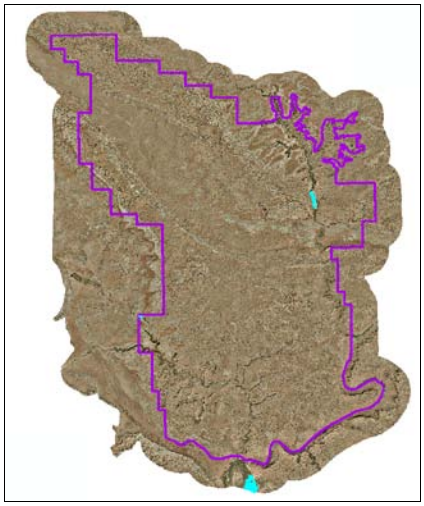
Associations
Schoenoplectus pungens Herbaceous Vegetation [CEGL001587]
Typha(latifolia, angustifolia) Western Herbaceous Vegetation [CEGL002010]

Common species
- *Typha latifolia*
- *Juncus arcticus*
- *Schoenoplectus pungens*
- *Muhlenbergia asperifolia*

H-TMHC Map Class Statistics

Type:	Complex of multiple associations
Frequency:	2 total polygons
	2 polygons in ARCH
	None in the environs
Total project area:	9 hectares / 21 acres (0 %)
	9 hectares / 21 acres in ARCH
	None in the environs
Average Polygon Size:	4.3 hectares / 10.6 acres
Producer's accuracy:	100%
User's accuracy:	100%

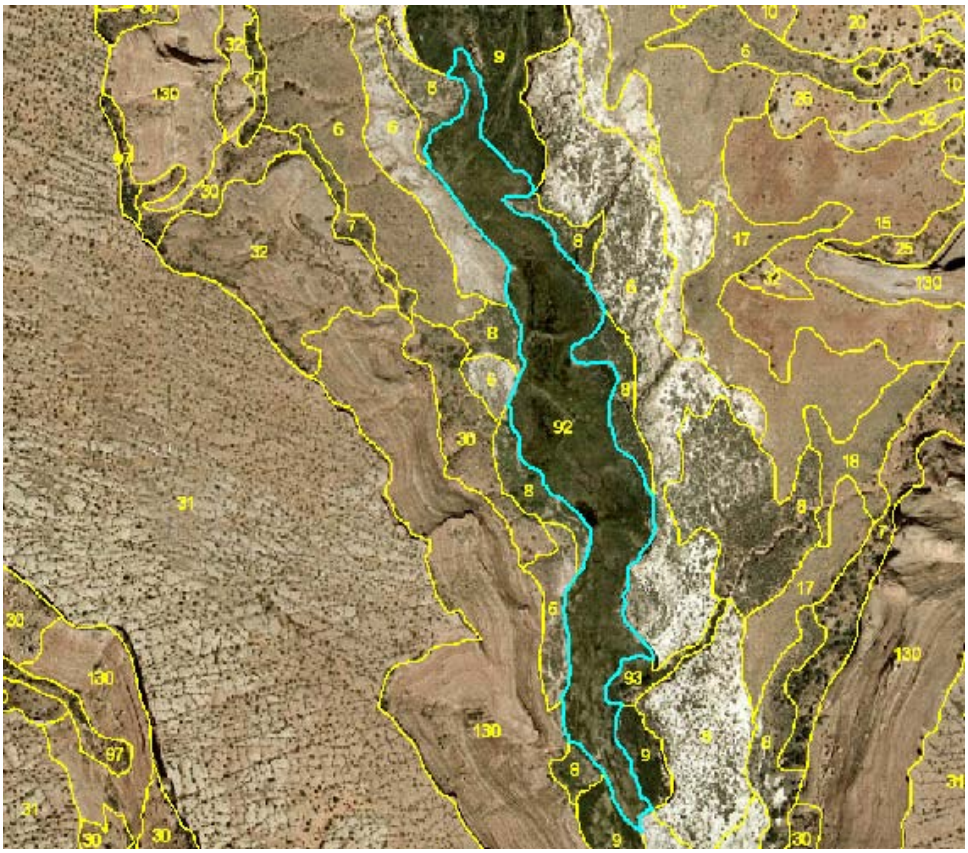
Distribution in Mapping Area



Distribution/Ecology/Composition
There are only two polygons of map class 92 in ARCH: one is a large beaver swamp just north of Wolfe Ranch in Salt Wash, the other is a tiny polygon at the very upper end of Courthouse Wash just inside the park boundary. Other small stands of mesic herbaceous vegetation may occur in the park but are too small to map separately. The remaining polygons of map class 92 all occur in the environs of the Matheson Wetlands Preserve northwest of Moab. Since no plots or AA points were sampled in this area, the vegetation occurring there has not been described, but is most likely dominated by Bulrush (*Scirpus* spp.)

Interpretation

This map class was only mapped in the park where known to occur (one plot and one AA point), and mapped in a few areas of the environs where it was thought to occur. The photo signature is a smooth mossy green color with pools of standing water appearing as black or light brown spots interrupting the otherwise pure green color of the polygon. The scattered dark green spots of shrubs or trees, such as tamarisk and cottonwood, can be seen around the margins of the community.



Example of photo signature for map class H-TMHC (#92).

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 138/100533, October 2009

National Park Service
U.S. Department of the Interior



Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov