National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Vegetation Classification and Mapping Project Report, Hovenweep National Monument

Natural Resource Technical Report NPS/NCPN/NRTR—2008/092

ON THE COVER
Cutthroat Castle ruin, Hovenweep National Monument (Photograph courtesy of the National Park Service)

Vegetation Classification and Mapping Project Report, Hovenweep National Monument

Natural Resource Report NPS/NCPN/NRTR—2008/092

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

Gery Wakefield and Aneth Wight
Southeast Utah Group / Northern Colorado Plateau Network
National Park Service
Moab, UT

Angie Evenden
Northern Colorado Plateau Network
National Park Service
Moab, Utah

Janet Coles
Northern Colorado Plateau Network
National Park Service
Moab, Utah

April, 2008

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

The Natural Resource Publication series addresses natural resource topics that are of interest and applicability to a broad readership in the National Park Service and to others in the management of natural resources, including the scientific community, the public, and the NPS conservation and environmental constituencies. Manuscripts are peer-reviewed to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and is designed and published in a professional manner.

The Natural Resource Technical Report series is used to disseminate the peer-reviewed results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service's mission. The reports provide contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations. Current examples of such reports include the results of research that addresses natural resource management issues; natural resource inventory and monitoring activities; resource assessment reports; scientific literature reviews; and peer reviewed proceedings of technical workshops, conferences, or symposia.

Views, statements, findings, conclusions, recommendations and data in this report are solely those of the authors and do not necessarily reflect policies of the U.S. Department of the Interior, NPS. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

Printed copies of reports in these series may be produced in a limited quantity and they are only available as long as the supply lasts. This report is available from the Northern Colorado Plateau I&M Network website (http://www.nature.nps.gov/im/units/NCPN) or the Natural Resource Publications Management Web site (http://www.nature.nps.gov/publications/NRPM) on the Internet.

Please cite this publication as:

Von Loh, J., G. Wakefield, A. Wight, A. Evenden, and J. Coles. 2008. Vegetation Classification and Mapping Project Report, Hovenweep National Monument. Natural Resource Technical Report NPS/NCPN/NRTR—2008/092. National Park Service, Fort Collins, Colorado.

NPS D-40, April 2008

Contents

SUMMARY ..... **xi**

ACKNOWLEDGEMENTS ..... **xiii**

INTRODUCTION **1**

Vegetation Classification and Mapping Project, Hovenweep National Monument *1*

The USGS-NPS Vegetation Mapping Program *1*

Northern Colorado Plateau Network Inventory and Monitoring Program *1*

Vegetation Mapping Program Standards *2*

National Vegetation Classification Standard *2*

Other Standards *4*

PROJECT AREA DESCRIPTION **5**

Location and Setting *5*

Topography *7*

Climate *8*

Geology and Vegetation *8*

Vegetation Change *12*

Soils *13*

Biological Soil Crusts *13*

Hydrology and Water Resources *14*

Land Use *14*

Previous Vegetation Studies *15*

PROJECT OVERVIEW **16**

General Approach and Timeline *16*

Primary Partners and Project Roles *17*

Aerial Photography *18*

Scoping Meeting *18*

Project Boundary and Map Extent *18*

Minimum Mapping Unit *20*

Ecological System Classification *20*

VEGETATION CLASSIFICATION AND DESCRIPTION **21**

Pre-Field Methods *21*

Preliminary Classification List 21
Legacy Data Review 21

Field Methods *21*

Field Sampling Approach 21

Plot Data Collection 22
Data Processing and Analysis....25
Observation Points....25

Classification Data Analysis....*26*

Shadscale / Herbaceous Group 28
Sagebrush Group 29
Dwarf-shrub or Herbaceous Group 30
Cheatgrass-invaded Group 30
Pinyon-Juniper Group....30

Classification Results....*31*

Plant Community Descriptions *35*

Woodland Associations 35
Shrubland Associations 36
Herbaceous Associations....37
Riparian Associations....38

Field Key Preparation *38*

FUELS DATA COLLECTION 39

VEGETATION MAPPING 40

Methods....*40*

Field Reconnaissance, Sampling, and Initial Mapping....40
Map Class and Polygon Attribute Development 40
Park Specials 42
Mapping....42
Spatial Database Development....43
Map Classes....43

Results....*43*

Map Class Descriptions....47
Map Polygons....48
Discussion 48

ACCURACY ASSESSMENT....53

REFERENCES....54

APPENDIX A: ECOLOGICAL SYSTEMS OF HOVENWEEP NATIONAL MONUMENT....59

APPENDIX B: PLOT AND OBSERVATION POINT INSTRUCTIONS AND DATA FORMS....66

Appendix B.1. Plot and Observation Point Field Sampling Manual....*67*

Appendix B.2. Example of a Vegetation Plot Data Form....*96*

Appendix B.3. Example of an Observation Point Data Form *100*

APPENDIX C 102

C.1. Plots Database Documentation *102*

C.2. Geodatabase Documentation *113*

APPENDIX D: PLANT SPECIES LIST AND CROSSWALK 121

APPENDIX E: FIELD PLOT CROSSWALK TO NVC ASSOCIATIONS 125

APPENDIX F: PLANT ASSOCIATION DESCRIPTIONS FOR HOVENWEEP NATIONAL MONUMENT 129

APPENDIX G: ILLUSTRATED KEYS TO THE PLANT ASSOCIATIONS OF HOVENWEEP NATIONAL MONUMENT 215

KEY I - A KEY TO THE MAJOR PHYSIOGNOMIC GROUPS OF HOVENWEEP NATIONAL MONUMENT *216*

KEY II - A KEY TO THE FOREST AND WOODLAND ASSOCIATIONS OF HOVENWEEP NATIONAL MONUMENT *218*

KEY III - A KEY TO THE SHRUBLAND AND WOODED SHRUBLAND ASSOCIATIONS OF HOVENWEEP NATIONAL MONUMENT *226*

KEY IV- A KEY TO THE HERBACEOUS ASSOCIATIONS OF HOVENWEEP NATIONAL MONUMENT *234*

APPENDIX H: MODIFIED ANDERSON LAND USE-LAND COVER CLASSIFICATION 240

APPENDIX J: MAP CLASS DESCRIPTIONS FOR HOVENWEEP NATIONAL MONUMENT 249

Figures

Figure 1. Location of HOVE within the Northern Colorado Plateau Inventory and Monitoring Network (shaded area 5
Figure 2. Map of the HOVE vegetation mapping project area, showing the locations of the six Monument parcels and adjacent land ownership 6
Figure 3. Location of Hovenweep National Monument relative to major Colorado Plateau physiographic features. Light gray signifies the extent of the Colorado Plateau. Dark gray and black areas represent uplifts and mountains (Thornberry-Erlich 2004)..... 7
Figure 4. Climate data for HOVE (Western Regional Climate Center 2007) 8
Figure 5. Geologic map of HOVE and vicinity..... 9
Figure 6a. Vegetation typical of Jurassic Morrison Formation exposures: Shadscale shrubland (L) and James' galleta grassland (R, foreground)..... 10
Figure 6b. Vegetation typical of Cretaceous Dakota Sandstone exposures shrub understory .. 10
Figure 6c. Vegetation typical of Cretaceous Mancos Shale exposures: Shadscale shrubland with James' galleta understory (foreground) 11
Figure 6d. Vegetation typical of the Jurassic Morrison Formation: Bottomland big sagebrush shrubland (L) and mesa top eolian deposits of Wyoming big sagebrush shrubland (R) 11
Figure 7. Vegetation surrounding the Holly House ruin changed significantly between 1919 (top) and 2007 (bottom). Juniper density on the canyon rim is much higher in the later photo. Holly House is the upper-left ruin in both photographs 12
Figure 8. Intact (L) and recovering (R) biological soil crusts typical of the Colorado Plateau. The ruler in the center of the right-hand photograph is 15 cm (6 in) long..... 14
Figure 9. Example of an ortho-rectified aerial photograph used as the base image for the HOVE Vegetation Classification and Mapping Project. This image contains the Square Tower Unit 19
Figure 10. Locations of sample plots (vegetation plots and observation points) in each of the six HOVE management units..... 24
Figure 11. Cluster analysis dendrogram of HOVE plot data showing five clusters defined using the Sorensen distance measure and Flexible Beta group linkage method. The clusters were interpreted as (1) Shadscale or herbaceous, (2) Sagebrush, (3) Dwarf-shrub or herbaceous, (4) Cheatgrass-invaded areas, and (5) Pinyon-juniper..... 28
Figure 12. Detrended Correspondence Analysis ordination of the shadscale / herbaceous group displayed two interpretable clusters and two outlier plots, which were identified as Bigelow sagebrush and Shadscale / mixed shrubs, respectively..... 29
Figure 13. Bray-Curtis polar ordination of sagebrush group within HOVE shows gradient of big sagebrush abundance from higher (blue, 20-50%) to lower (red, 6-20%) canopy cover 29
Figure 14. Detrended Correspondence Analysis ordination of dwarf-shrub or herbaceous group revealed four clusters, including Smooth Brome vegetation (red), Western Wheatgrass (blue), and two different types of Woodlands (black). The fourth cluster (green) was identified based on species composition and abundance 30
Figure 15. Detrended Correspondence Analysis ordination of the Pinyon-Juniper group at HOVE. The three groups represent a gradient of pinyon pine density..... 31
Figure 16. Structure of the HOVE geodatabase 44
Figure 17. The HOVE vegetation map based on the final map classes 52

Tables

Table 1. National Vegetation Classification System hierarchy for terrestrial vegetation 3
Table 2. Project timeline for HOVE vegetation mapping project tasks: 2002 – 2007 16
Table 3. Size of the six management units that comprise HOVE 19
Table 4. Plot sizes used for vegetation classification sampling at HOVE 22
Table 5. General plot data categories and specific data components collected at each vegetation classification plot 23
Table 6. Vegetation cover and height classes used in the HOVE vegetation mapping project . 25
Table 7. Distribution of vegetation plots and observation points in each of the six HOVE management units 26
Table 8. Plant associations identified within the HOVE vegetation mapping project area *..... 32
Table 9. Physiognomic attributes assigned to polygons during mapping. When appropriate, these attributes were assigned to individual polygons. Otherwise they were assigned to an entire map class 41
Table 10. Modifiers used to provide additional information for map polygons in the HOVE vegetation mapping project area 42
Table 11. Map classes used in the HOVE vegetation map, with map class number, code and name, crosswalk to NVC association, and the relationship of map class to plant associations. HOVE vegetation map classes are arranged by NatureServe ecological systems. Vegetation associations and alliances marked with an asterisk (*) were documented in field notes but were not sampled 45
Table 12. Summary statistics for polygons of each map class developed for the HOVE vegetation mapping project 49

Acronyms and Abbreviations

AA	Accuracy Assessment
BLM	United States Bureau of Land Management
CANM	Canyons of the Ancients National Monument
CEGL	Community Element Code
DBH	Diameter At Breast Height (4.5 feet)
DEM	Digital Elevation Model
DOQQ	Digital Orthophotograph Quarter Quadrangle
DRC	Diameter At Root Crown
e^2M	engineering-environmental Management, Incorporated
ES	Ecological System
ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
GIS	Geographic Information System
GPS	Global Positioning System
HOVE	Hovenweep National Monument
I&M	Inventory and Monitoring Program
ITIS	Integrated Taxonomic Information System
LC/LU	Land Cover/Land Use
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
TSN	Taxonomic Serial Number
UNESCO	United Nations Education, Science, and Cultural Organization
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 worked with the support of the U.S. Geological Survey - National Park Service Vegetation Mapping Program to describe and map vegetation at Hovenweep National Monument (HOVE). This collaborative effort involved many project partners, particularly engineering-environmental Management, Inc. (e2M), the Western Region office of NatureServe, and their cooperators.

The mapping area is 326 hectares (805 acres), encompassing the six management units of the Monument. Mapping extended only to the boundaries of each HOVE unit. Ecologists, botanists, and photointerpreters worked together to identify plant associations for HOVE and determine how best to map them using 1:12,000-scale color aerial photography. The team collected vegetation and environmental data from 27 vegetation classification plots and 32 observation points. No supplemental fuels data were collected during the project. Fieldwork and mapping were completed between 2003 and 2007.

Analysis of the plot data revealed 29 National Vegetation Classification plant associations or park special vegetation types within the Monument. An additional five vegetation associations and alliances were documented in field notes and formed the basis of map classes, but were not sampled.

Vegetation and land use were interpreted to the most detailed level possible using high-resolution, 1:12,000-scale color aerial photography that had been digitally scanned and orthorectified. Most of the interpretation was based on site visit information, because virtually every part of the Monument is accessible on foot. Polygons representing vegetation or land use map classes were delineated on the stereo photographs and transferred to a spatial database. Because the individual Monument parcels are so small, the standard minimum mapping unit of 0.5 ha was discarded and polygons were delineated to approximately 0.1 ha (0.3 acres).

A total of 338 map polygons representing 29 natural and semi-natural vegetation map classes were developed for the HOVE mapping project. Two geologic map classes describe 57 additional polygons and two land use map classes describe 13 polygons. Average polygon size across all map classes is 0.8 ha (2.0 acres). The most frequent vegetation mapping unit is Wyoming Sagebrush Disturbed Shrubland (Map Class # 23) with 54 polygons covering 77.6 ha (24%) of the mapped area.

Because each polygon was visited and delineated in the field, we chose not to conduct a thematic accuracy assessment of the vegetated map classes. A thorough field verification of map polygons was employed instead. Results of this verification trip are available in a separate report.

Products resulting from the HOVE 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 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]:

- report describing the results of the field verification of the vegetation map
- geodatabase containing map polygon attribute, land use, plot data and Monument and project boundaries
- ground photographs of vegetation plots and observation points in hard copy and digital formats
- all field data (plot and observation 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 Monument.

Acknowledgements

This project was completed through the contributions and dedication of numerous individuals and organizations. Angela Evenden (NPS-NCPN), Mike Story and Tammy Hamer (NPS-WASO), Karl Brown (USGS/NPS) and Mike Mulligan (USGS) provided project oversight and coordination. Funding for this project was provided through the USGS-NPS National Vegetation Mapping Program, NPS Fire Program, and the Northern Colorado Plateau Inventory and Monitoring Network.

Several individuals collected plot and observation point field data. We especially appreciate the hard work of Jim Von Loh and Sarah Boyes of e^2M.

Travis Belote of e^2M prepared the preliminary vegetation classification; final association names were assigned by Marion Reid of NatureServe. Marion also created and supplied a local association description template and worked with Janet Coles to prepare global association descriptions. Janet also developed a method to test and improve the field key, as well as edited the final report. Travis Belote helped organize information and produce interim reports and other products.

Database management support and development were skillfully performed by Margaret Beer, Helen Thomas (NPS) and Jack Doria (e^2M). Their preparation of a new MS Access database for plot and observation point data simplified entry and analysis. Margaret and Jack provided assistance to database users to allow analyses to proceed on schedule. Helen Thomas supervised the QC of plot and photo data and oversaw the management of the photo database.

Aneth Wight and Gery Wakefield coordinated the management of GIS data. Gery created the base orthophotography from standard stereo aerial photographs. Aneth created the final geodatabase.

Special thanks to James Jacobs (jqjacobs.net) for permission to use his Holly ruins photograph that helps to illustrate vegetation change at HOVE over the past century (Figure 7).

The staff of Hovenweep National Monument made us welcome whenever we visited to check the map or collect field data, and provided helpful advice on how to best access different parts of the Monument. Special thanks to Chris Nickel of HOVE.

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

Introduction

Vegetation Classification and Mapping Project, Hovenweep National Monument

The Hovenweep National Monument (HOVE) Vegetation Mapping Project was organized and coordinated by the Northern Colorado Plateau Network (NCPN) Inventory and Monitoring (I&M) Program between 2001 and 2007, with assistance from several project cooperators. The purpose of this project was to describe and map existing plant associations on 326 hectares (805 acres) within HOVE, and to provide this information in written, tabular, digital, and spatial formats useful to Monument resource managers, the NCPN I&M Program, and others. The basic project components consist of vegetation classification, description, and spatial database development. No formal accuracy assessment was conducted for this project.

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 Northern Colorado Plateau Network. The HOVE Vegetation Classification and Mapping Project was initiated by the NCPN with assistance from engineering-environmental Management, Incorporated (e2M), and NatureServe. Vegetation plot and observation point data collection occurred in 2003 and map verification trips occurred in 2004 and 2007.

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 HOVE project area. Later sections document the methods and results for each of the major steps in the project: scoping, vegetation classification and description, and vegetation mapping.

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 to 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 HOVE. 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 park 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 include 12 basic data sets needed by park staff to guide resource management. Vegetation classification and mapping together 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 HOVE vegetation mapping project is the third 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) – not used in the HOVE mapping project
- 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 International Vegetation Classification Standard (IVCS) 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 IVCS is based in part on earlier vegetation classification produced by the United Nations Educational, Cultural, and Scientific Organization (UNESCO 1973, Driscoll et al. 1984). Use of a standardized classification system helps ensure data compatibility throughout the National Park Service and other agencies. The FGDC Vegetation Subcommittee works to keep this standard current and relevant (http://biology.usgs.gov/fgdc.veg/standards/vegstd.htm).

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 variability 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 strata 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 ESRI 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.

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

Level	Criteria Delineating Level	Example
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.

NPS photo

Photo credit: Jim Von Loh

Project Area Description

Location and Setting

"Hovenweep" means "deserted valley" in the Paiute language. Hovenweep National Monument (HOVE) was established in 1923 by presidential proclamation to protect the ruins of five Ancestral Puebloan-era villages in the canyons of southwestern Colorado and adjacent Utah (NPS 2005; Figure 1). Multi-story towers perched on canyon rims and balanced on boulders comprise some of the Monument's unique structures. Subsequent boundary adjustments expanded HOVE to its current 326 ha (805 acres).

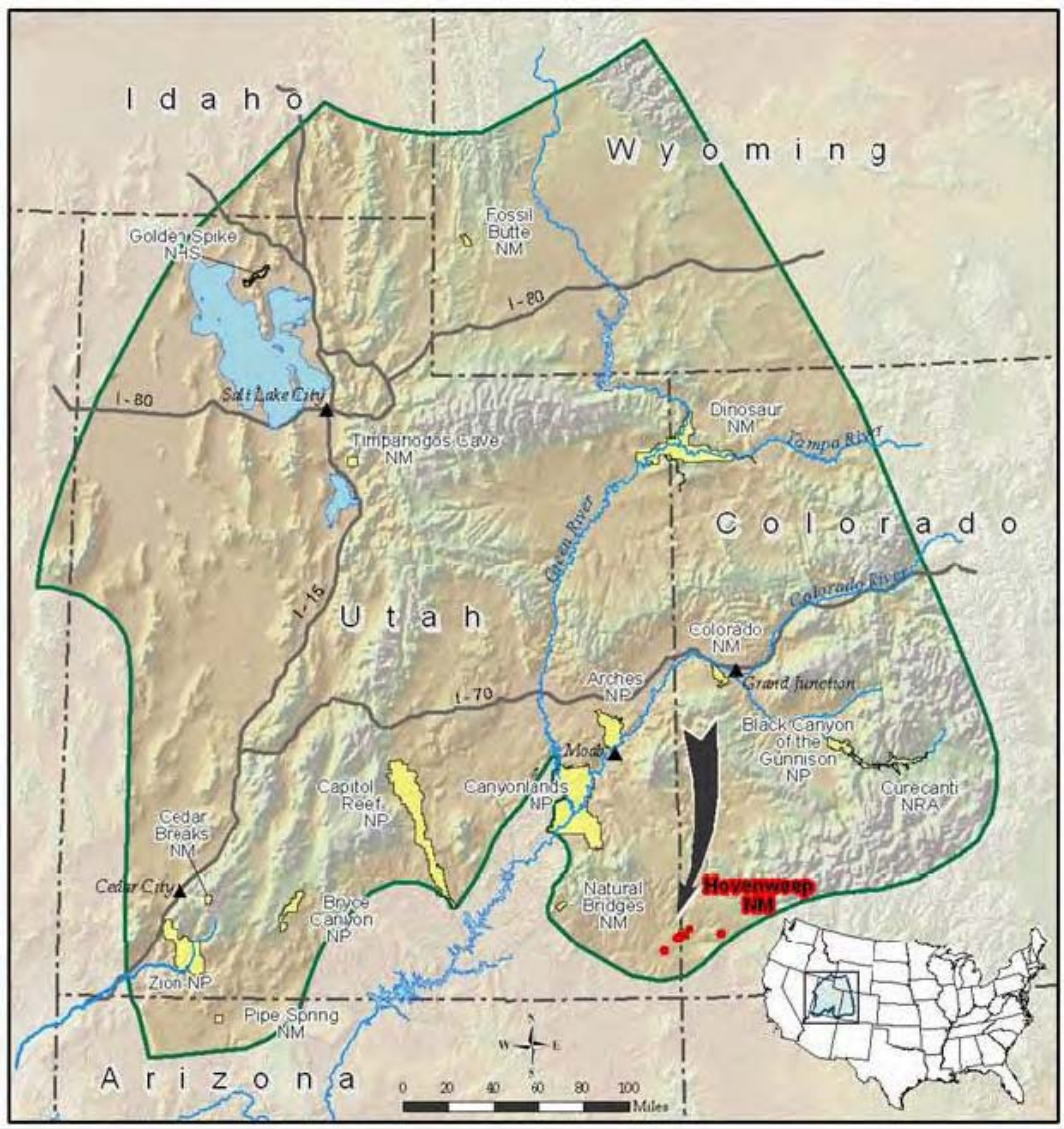


Figure 1. Location of HOVE within the Northern Colorado Plateau Inventory and Monitoring Network (shaded area).

Three Monument units in Colorado (Hackberry/Horseshoe, Holly, and Cutthroat Castle) are surrounded by Canyons of the Ancients National Monument (CANM), administered by the Bureau of Land Management (Figure 2). CANM was established in 2000 to protect cultural anatural resources and is managed under the National Landscape Conservation System (BLM 2007). A fourth Colorado unit, Goodman Point, is surrounded by private land. The Monument's Cajon Unit is surrounded by the Navajo Nation, while the Square Tower Unit abuts BLM and State of Utah lands.

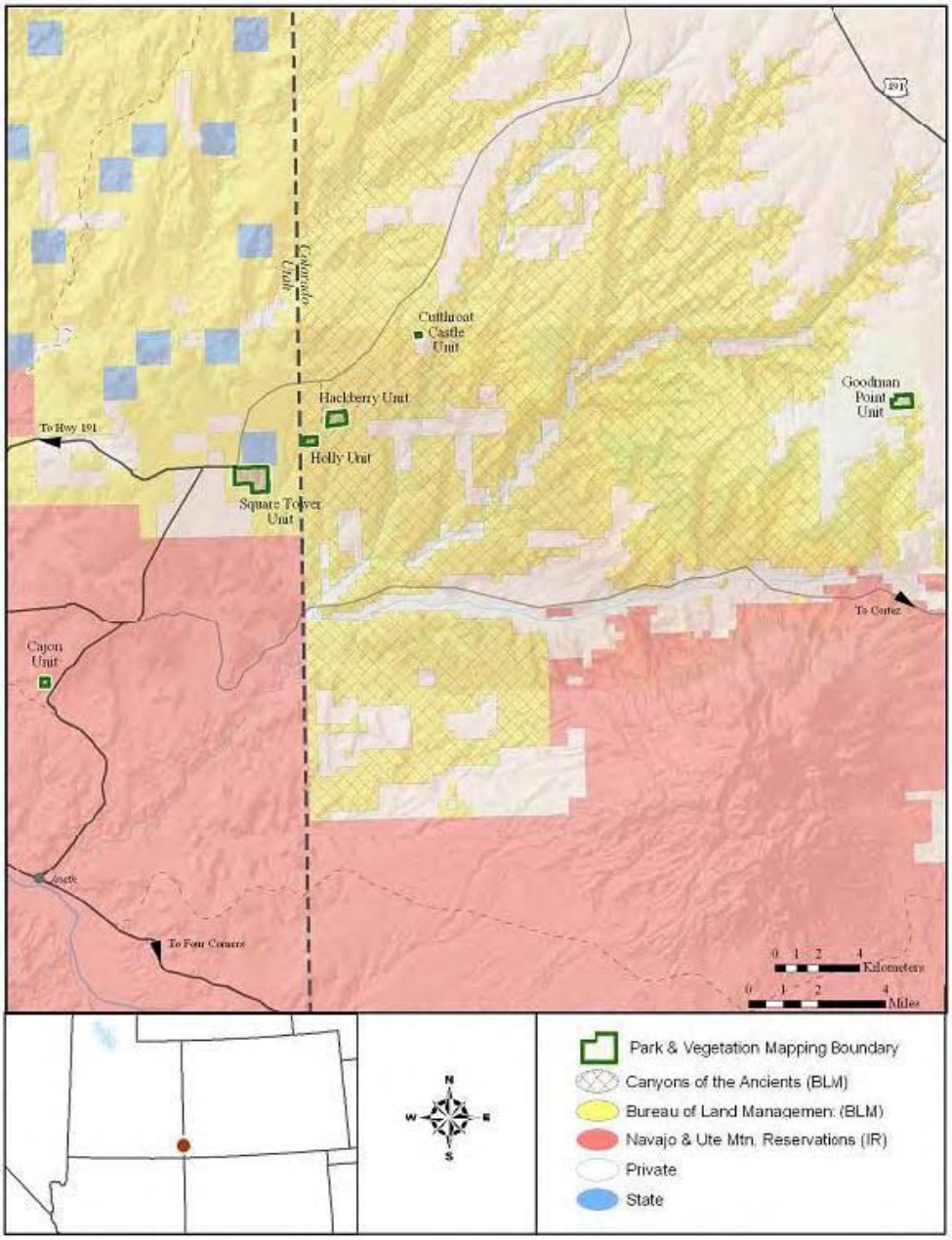


Figure 2. Map of the HOVE vegetation mapping project area, showing the locations of the six Monument parcels and adjacent land ownership.

Topography

The six management units of Hovenweep National Monument are located within the Canyon Lands section of the Colorado Plateaus physiographic region (Fenneman and Johnson 1946). The Colorado Plateau is a 336,700 km2 (130,000 mi2) basin ringed by highlands, subdivided into canyons and plateaus and drained by the Colorado River (Figure 3). HOVE management unitsoccupy a highland known as Cajon Mesa. The HOVE landscape is characterized by a rolling plateau dissected by numerous steep-walled canyons and ringed by the peaks of island ranges such as the Sleeping Ute and the Carrizo Mountains. Elevation increases steadily from west to east across the Monument. The lowest elevation in the Cajon Unit is 1,550 m (5,080 ft.). The highest elevations in the other units, from west to east, are 1,610 m (5,280 ft.) at Square Tower1,645 m (5,400 ft.) at Holly, 1,695 m (5,560 ft.) at Hackberry, 1,800 m (5,900 ft.) at Cutthroat Castle), and 2,055 m (6,750 ft.) at Goodman Point.

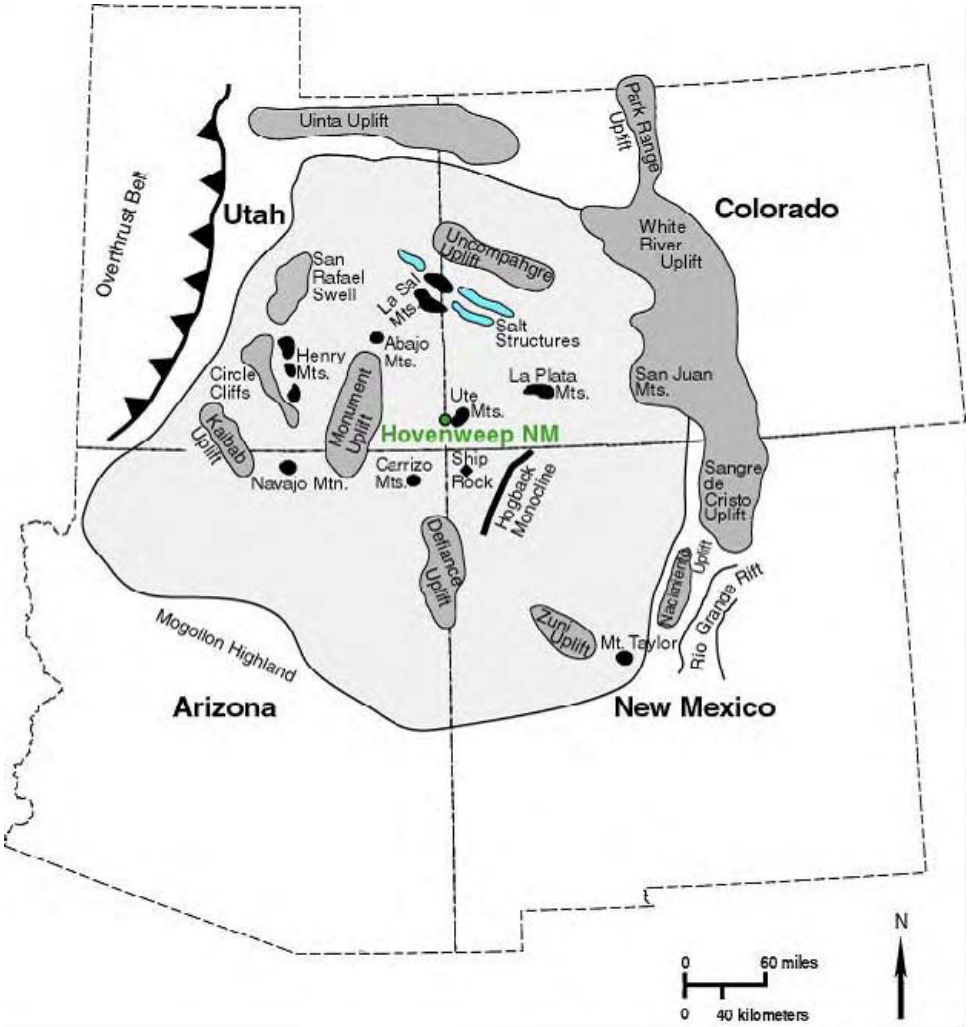


Figure 3. Location of Hovenweep National Monument relative to major Colorado Plateau physiographic features. Light gray signifies the extent of the Colorado Plateau. Dark gray and black areas represent uplifts and mountains (Thornberry-Erlich 2004).

Climate

Even with the broad spatial extent of HOVE, there are only minor differences in precipitation, soils, and plant associations among the six units. The Visitor Center at the Square Tower Unit records an average of 34 cm (13.4 in) of precipitation annually; average annual precipitation at Cortez, near the Goodman Point Unit, is 33 cm (12.95 in). Precipitation peaks in the late summer and fall (Figure 4); early summer is very dry. July-August precipitation results from Sonoran monsoon patterns, while winter-spring precipitation is the result of Pacific storms.

Annual temperature variability at HOVE is typical of high deserts; extremes range from -23 C (-10 °F) in winter to summertime highs of 41 C (105 °F). The mean annual temperature is 11 C (52 °F). Evaporation potential in this region is 114 cm (45 in) per year. During winter, however, evaporation is low and moisture is able to penetrate into the soil, becoming available to plants during the high drought-stress period of late spring and early summer (Schelz 2002).

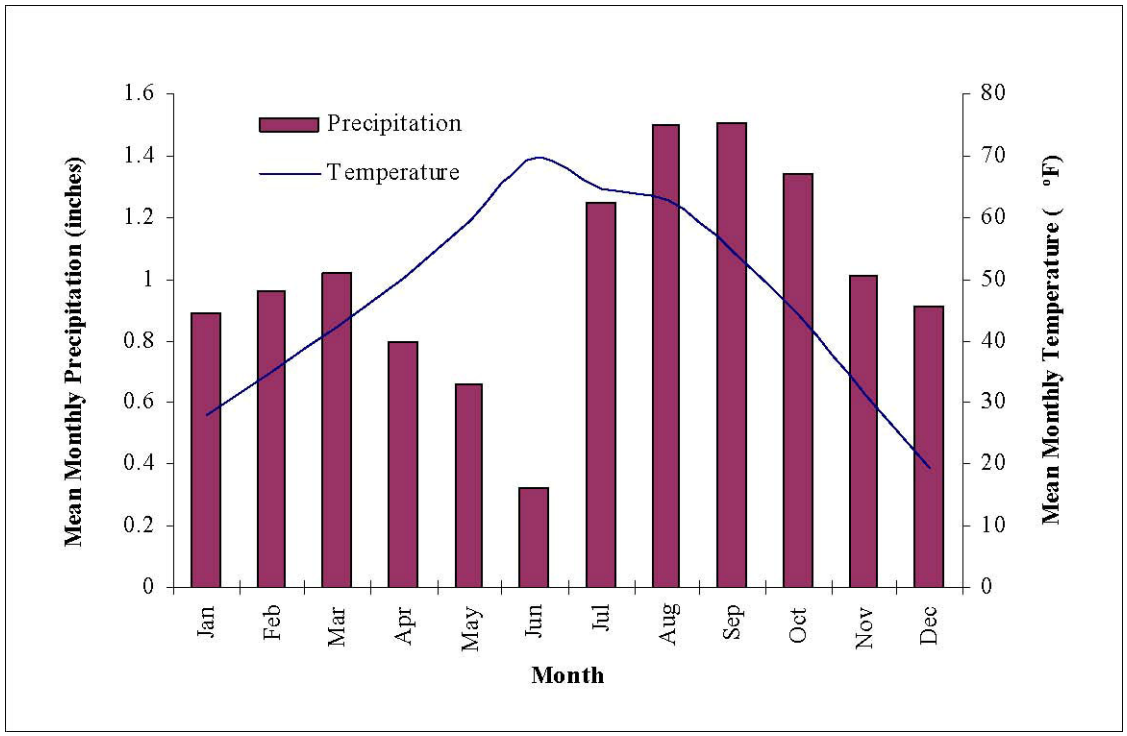


Figure 4. Climate data for HOVE (Western Regional Climate Center 2007).

Geology and Vegetation

Geology, soils, and aspect are the main factors controlling the distribution of vegetation within the mapping project area. HOVE lies in the Dry Domain, Tropical/Subtropical Steppe Division of the Colorado Plateau Semidesert Province (Bailey 2001). The Monument supports vegetation broadly classified as semi-desert (West 1988) on moderately rugged topography. Woodlands of two-needle pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) dominate at higher elevations and in canyons. Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) and saltbush (*Atriplex* spp.) shrublands occupy deeper soils at lower elevations.

Geologic processes created the plateaus and canyons of HOVE over a period of about 100 million years. The formations exposed at HOVE were deposited during the late Jurassic (Morrison Formation) and early Cretaceous by braided streams flowing across a coastal plain (Burro Canyon Formation) and associated river deltas (Dakota Sandstone) (Thompson 1993). These deposits were deeply buried but were brought to the surface by regional uplift and erosion that began about 10 million years ago. Rocks within the Monument are flat-lying and relatively undeformed (Figure 5).

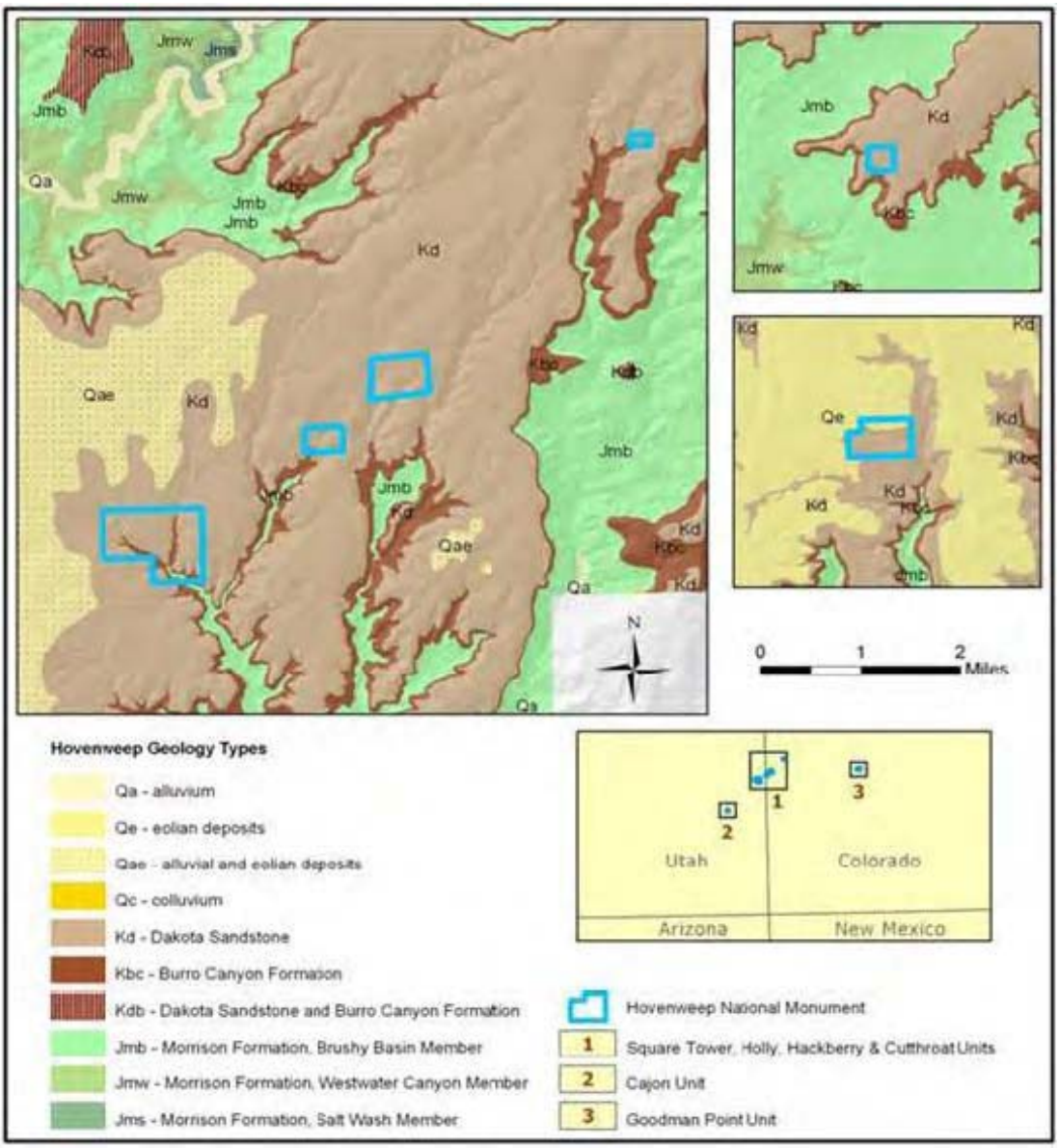


Figure 5. Geologic map of HOVE and vicinity.

Exposures of the Morrison Formation occur only on the Cajon and Square Tower Units. This formation takes the form of slopes of gray, pale-green, red-brown, or purple bentonitic mudstone with lenses of distinctive green and red chert-pebble conglomerate. Plant communities occurring

on the Morrison Formation exposures include shadscale (Atriplex confertifolia) and four-wing saltbush (*Atriplex canescens*) shrublands and James' galleta (*Pleuraphis jamesii*) grasslands (Figure 6a).

Photo credit: NCPN

Figure 6a. Figure 6a. Vegetation typical of Jurassic Morrison Formation exposures: Shadscale shrubland (L) and James' galleta grassland (R, foreground).

Cretaceous Dakota Sandstone underlies the mesa top in all HOVE units. Pinyon-juniper woodlands are the dominant vegetation, interrupted by sagebrush shrublands on the deepest soils. The mesas are dissected by canyons, whose walls generally support open woodlands with montane shrubs in the understory (Figure 6b.) Within the canyons, water absorbed by the Dakota Sandstone emerges below the caprock when it intercepts underlying impermeable Burro Canyon Shale. These seeps and springs provide habitat for small stands of netleaf hackberry (*Celtis laevigata* var. *reticulata*) and Rio Grande cottonwood (*Populus deltoides* ssp. *wislizeni*).

Photo credit: NCPN

Figure 6b. Vegetation typical of Cretaceous Dakota Sandstone exposures shrub understory.

Upper Cretaceous Mancos Shale is exposed on a few ridges and slopes, mostly in the Square Tower and Hackberry Units. It is characterized by a gray soft marine shale. Plant communities

that have become established on Mancos Shale include sparse grasslands of James' galleta or Salinas wildrye (*Leymus salinus*), Wyoming big sagebrush – shadscale shrublands, and shadscale - four-wing saltbush shrublands with a James' galleta understory (Figure 6c).

Photo credit: NCPN

Figure 6c. Vegetation typical of Cretaceous Mancos Shale exposures: Shadscale shrubland with James' galleta understory.

Recent (Holocene) deposits are present in all HOVE units and include wind-deposited loess or sand supporting pinyon-juniper woodlands and Wyoming big sagebrush shrublands. Recent alluvial deposits support fourwing saltbush and black greasewood (*Sarcobatus vermiculatus*) shrublands or weedy herbaceous communities of cheatgrass (*Bromus tectorum*) or annual forbs. (Figure 6d).

Photo credit: NCPN

Figure 6d. Vegetation typical of recent deposits: Basin big sagebrush shrubland on valley fill (L) and mesa top eolian deposits supporting Wyoming big sagebrush shrubland (R).

Vegetation Change

The general vegetation of the Four Corners region that includes Hovenweep NM area has remained roughly stable for the past 2,000 years (Hall 1988). The dominant vegetation types include pinyon-juniper woodland, sagebrush steppe, and bunchgrass grasslands. However, there is evidence of significant community changes within the Monument within the past 100 years. Photographs accompanying an early 20th-century report on the pre-Puebloan ruins of southwestern Colorado (Fewkes 1919) show a lower density of shrubs and juniper trees in units at the west end of HOVE than is present today (Figure 7).

Photo credit: NCPN

Photo credit: J.Q. Jacobs

Figure 7. Vegetation surrounding the Holly House ruin changed significantly between 1919 (top) and 2007 (bottom). Juniper density on the canyon rim is much higher in the later photo. Holly House is the upper-left ruin in both photographs.

West (1988) analyzed fossil pollen to study the effects of climate and human activities on vegetation of the Intermountain West between the prehistoric period of human settlement (around 7,000 BC) and the early 1970s. He concluded that no major climatic changes had occurred in the area since the prehistoric period, and that human activities were the major drivers of vegetation change during the period of study.

More recent studies have modified this view. Juniper species have been expanding their range and density across the interior western United States since the latter stages of the Little Ice Age, around 500 years before present (Miller and Wigand 1994). At that time, the climate shifted toward winter-dominated precipitation, which favors woodlands over shrub- or grass-dominated systems. The pace of juniper spread increased exponentially beginning around the time of European settlement (1850). The advent of milder winters and higher average precipitation combined with removal of fire-carrying grasses by grazing livestock are both thought to have contributed to the increase in juniper density and distribution (Betancourt et al. 1993).

Soils

HOVE soils are derived from local sandstones and shales and may be residual, alluvial, or eolian in origin. In general, shallow to deep eolian soils are found on the mesa tops, with shallow colluvium on canyon slopes and deep alluvium in the canyon bottoms. Thirteen soils types have been described for the six units of HOVE and all are typically well drained. Soil textures range from sandy loam to clay loam. The descriptions that follow are derived from USDA-NRCS soil surveys (2003, 1993, 1980).

The Cajon Unit is capped by Whit Very Fine Sandy Loam, an alkaline soil on gentle slopes that supports shadscale shrublands. Cutthroat Castle Unit soils typically are Romberg-Crosscan-Rock Outcrop Complex soils on very steep slopes supporting pinyon-juniper woodlands. Hackberry Unit soils include Rizno-Gapmesa Complex on gentle slopes and Romberg-Crosscan-Rock Outcrop Complex soils on very steep slopes. Both types support pinyon-juniper stands. The Holly Unit is characterized by Typic Torriorthents-Rock Outcrop Complex and Claysprings Very Stony Clay Loam soils on moderate to steep slopes. The latter typically supports pinyon-juniper woodlands.

The Goodman Point Unit contains the widest range of soils. The Romberg-Crosscan Complex occupies moderately steep canyons, hills and alluvial fans. Wetherhill Loam, Gladel-Pulpit Complex, and Cahona-Pulpit Complex soils formed from eolian deposits occupy gently sloping hills and mesas. These soils support Wyoming big sagebrush shrublands and pinyon-juniper woodlands. Square Tower Unit soils are characterized by Ruinpoint-Cahona Association and Rizno-Ruinpoint-Rock Outcrop Complex on mesa tops that support Wyoming big sagebrush stands. Little Ruin Canyon contains deposits of Littlenan-Moenkopie-Recapture Complex soils on structural benches and alluvial terraces that support basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), rubber rabbitbrush (*Ericameria nauseosa*), and mixed canyon wall shrubland

Biological Soil Crusts

Biological soil 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 services provided by biological soil crusts include fixing atmospheric nitrogen, building soil organic matter (Eldridge and Green 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).

Biological soil crusts are well developed within parts of HOVE, particularly where thin sandy soils overlie slickrock (Figure 8) and in the nutrient-poor openings between tree canopies and clumps of vascular plants. Soil crusts were destroyed within most of HOVE by intensive sand cattle grazing between 1900 and 1950 (O'Dell et al. 2005).

Photo credits: NPS

Figure 8. Intact (L) and recovering (R) biological soil crusts typical of the Colorado Plateau. The ruler in the center of the right-hand photograph is 15 cm (6 in) long.

Hydrology and Water Resources

The Monument contains limited water resources in the form of intermittent streams, ephemerally wet bedrock potholes (tinajas), seeps, and springs. Tinajas are concentrated on sandstone caprock exposures and seeps in the heads of canyons. Water is trapped in potholes or flows in washes after precipitation events. Debris lines and channel scour indicate flooding can occur, resulting in removal of some vegetation, eroding and redepositing boulders and sediments, and causing drainage incision.

Permanent water sources are limited in HOVE, consisting of a few springs and seeps located in canyon heads. They provide sufficient water for localized, ephemeral surface flows and moist to saturated soils where they emerge from contact zones between porous Dakota Sandstone, which caps the mesas, and underlying impervious Burro Canyon Shale. Eight to ten springs are located within Monument boundaries. The springs are important sources of early summer moisture that maintain mesic plant species until the late summer monsoon rains begin.

Land Use

The vegetation and landscape of the Four Corners region has been managed and disturbed for at least 3,000 years. Ancestral Puebloan influence is evident in the form of water diversion and holding structures, areas of tilled soil for crop production, and many trees that were cut to provide structural timbers and firewood. Crop plants grown by aboriginal peoples included corn,

beans, squash, and cotton. The crops were grown using dry farming techniques as well as irrigation water stored in check dams, ditches, and ponds. From the late 1800s through the 1940s, all of Hovenweep was subjected to sheep grazing intense enough to eliminate much of the vegetation and biological soil crusts. Exposed soils were subsequently lost to wind and water erosion. Today, soils tend to be thin and the plant species composition is considered depauperate relative to what undisturbed sites with similar soils could support (Schelz and Moran 2002).

In general, land uses imposed by indigenous peoples had an influence on vegetation that persists to the present (Schelz and Moran 2002). Prehistoric and historic indigenous peoples used local native plants for food, medicine, tool making, heating, and shelter. Some native plants used and possibly grown as crops include milkweed (*Asclepias* spp.), Rocky Mountain beeplant (*Cleome serrulata*), and wolfberry (*Lycium* spp.). In addition, rabbitbrush (*Chrysothamnus* spp. And *Ericameria* spp.), cliffrose (*Purshia stansburiana*), Mormon tea (*Ephedra* spp.), yucca (*Yucca* spp.), and serviceberry (*Amelanchier utahensis*) were important plants to the Ancestral Puebloans. The netleaf hackberry (*Celtis laevigata* var. *reticulata*) trees that grow around some seeps and springs may have been introduced by prehistoric settlers to provide shade for water sources and fruit for tribal members (Schelz and Moran 2002).

A variety of modern land uses are ongoing within the vegetation classification and mapping project area including roads, NPS facilities, water and electrical lines, and recreational foot trails. All land uses have an influence on vegetation distribution and development at HOVE. In the northwestern corner of the Square Tower Unit, older NPS facilities and access roads were removed and the sites are being reclaimed using native plant species.

Previous Vegetation Studies

The recorded vascular flora for HOVE is relatively diverse for such a small area, consisting of approximately 64 families, 318 genera, and 350 species. There have been more than a dozen formal and informal botanic and vegetation studies involving HOVE since 1870 (Schelz and Moran 2002). The most recent work prior to this project was a floristic survey of the Monument between 2001 and 2003 by Monument staff (Schelz 2004). The objectives of that study were to:

- obtain an inventory of 90% of plant species in the Monument
- collect and preserve at least one specimen for each species within the Monument
- determine plant community types and map them on aerial photos
- compile plant community type and species lists for each of the six Monument units
- document vegetation conditions by establishing permanent photo points in every unit

Schelz (2004) classified and mapped 71 plant associations within HOVE. In general, Schelz's associations represent a level of classification somewhat finer than the National Vegetation Classification. The map classes used in Schelz's 2004 report correlate to plant associations.

Other notable vegetation work at HOVE includes exotic plant inventories completed by Schelz and Budalier (2000) and Dewey and Anderson (2005).

Project Overview

General Approach and Timeline

The goals of this project were to inventory, describe, and map the existing vegetation of HOVE. The project is part of an effort undertaken by the NCPN to classify and map vegetation in all network parks. As part of this broader, coordinated program, the NCPN developed standardized databases, mapping and reporting standards, and naming conventions to ensure that data across parks can be collated and compared.

The NCPN vegetation classification and mapping project 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 to complete vegetation maps for all network parks (Evenden 2001). NCPN contracted with engineering-environmental Management, Inc. (e2M) to undertake most of the work needed to complete the HOVE vegetation mapping project. Table 2 is a timeline for completion of the major project tasks.

Table 2. Project timeline for HOVE vegetation mapping project tasks: 2002 - 2007.

TASK DESCRIPTION	2002	2003	2004	2005	2006/2007
Planning and Scoping	■				
Preliminary Plant Associations		■			
Field Data Collection		■			
Photointerpretation		■	■		■
Vegetation Classification			■		
Local & Global Descriptions			■	■	
Spatial Database			■	■	
Field Key to Plant Associations				■	
Final Report and Products					■

The field sampling strategy was developed by the e^2M senior biologist following a review of the preliminary list of plant associations. Field data were collected in 2003 and entered into an MSAccess database developed by e^2M and NCPN. Data were analyzed in 2004 and NatureServe developed the final plant association classification. e^2M ecologists prepared local plant association descriptions, while global plant association descriptions were completed by NatureServe ecologists in 2005. An illustrated field key to HOVE plant associations was developed in 2005.

NPS Southeast Utah Group (SEUG), NCPN, and e2M staff cooperated in interpreting the aerial imagery and developing the spatial database for the HOVE vegetation map during 2004 and 2005. Map classes were initially defined for the project on a 1:1 basis; e.g., one plant association / map class. Polygon attribution followed standards developed by NCPN for all park mapping projects (Evenden 2004).

A draft map and associated spatial database were completed in 2004. Final revisions were made to the vegetation classification, map and spatial database during 2006 and early 2007. All geospatial products associated with this project are in the UTM projection, Zone 12, using the NAD83 datum.

Primary Partners and Project Roles

Several agencies and organizations were involved in completing the Hovenweep National Monument Vegetation Mapping Project. The roles of each individual are described below.

engineering-environmental Management, Inc.

- *Jim Von Loh, Senior Biologist* – managed plot and observation point field data collection and entry, created the field key to plant associations, prepared local descriptions, interpreted aerial photography to plant association level, conducted an aerial photo signature verification trip, lead author on final report, integrally involved with every component of the project
- *Sarah Boyes, Field Technician* – assisted with plot and observation point data collection, data entry, and provided GIS support
- *Travis Belote, Staff Ecologist* – conducted preliminary classification of field data to plant associations, assisted with field key preparation, and assisted with draft report production
- *Anne Beuchling, Staff Ecologist* – assisted with draft report production
- *Jack Doria, Database Programmer* – programming assistance for projects MS Access database
- *Janet Coles, Consulting Ecologist* – collected vegetation plot and observation point field data, provided training for field data collection, and provided photointerpretation notes

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, report writing, final product completion, data management
- *Margaret Beer, Data Manager* – project database development and data management support, final product completion
- *Gery Wakefield, GIS Team Leader* – scan and transfer to digital product the interpreted line work, database development in GIS, and final report
- *Aneth Wight, GIS Technician* – project boundary coverage, final report, database support
- *Janet Coles, Vegetation Ecologist* – technical editor for the final report and appendices, conducted final map verification trip, organized final product completion

NatureServe

- *Marion Reid, Senior Regional Ecologist* – project manager for NatureServe, provided final classification to association
- *Janet Coles, Ecologist* – reviewed draft local descriptions and prepared global descriptions
- *Mary Russo, Ecology Data Manager* – Entered HOVE local and global descriptions into

NatureServe's Biotics database, formatted descriptions, completed plant species crosswalk

- *Kristin Snow, Assistant Ecologist/Ecological Information Manager* – Developed reporting 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

Because of budget limitations, the NCPN decided to use existing imagery rather than fly new stereo and orthophotography for the small, scattered parcels that constitute HOVE. NCPN staff evaluated the black and white orthophotographs available through USGS and determined that they lacked the resolution and contrast needed to discern subtle differences in vegetation. Instead, true color 1:12,000 aerial photographs flown by USDA in August 1996 were used as the base imagery (Figure 9). These photographs were scanned to digital format and the images warped to fit control points on each photograph using ERDAS Imagine 8.7 software.

Logistical and budget considerations also forced the vegetation mapping project boundary to be limited to the boundary of each HOVE unit. No environs were mapped by this project.

Scoping Meeting

Two project scoping meetings were held by the NCPN vegetation mapping program manager during 2001 and 2002, in which the HOVE project was discussed. Plans were made to acquire vegetation plot data during 2003, delineate vegetation polygons on photocopies of existing aerial photographs, and prepare the database using SEUG GIS managers and technicians.

Project Boundary and Map Extent

HOVE was sampled, interpreted, and mapped to the legal (fenced) boundaries of each unit. The total mapping area is approximately 326 ha (805 acres; Table 3). The environs surrounding HOVE consist primarily of lands owned and/or managed by the Navajo Nation, the State of Utah, and BLM. The Goodman Point Unit is surrounded by private land (Figure 2).

Figure 9. Example of an ortho-rectified aerial photograph used asVegetation Classification and Mapping P the base image for the HOVE roject. This image contains the Square Tower Unit.

Table 3. Size of the six management units that comprise HOVE.

HOVE Unit	Hectares	Acres
Square Tower	161.2	398.4
Hackberry	59.5	147.0
Goodman Point	57.4	141.8
Holly	26.0	64.1
Cajon	16.1	39.8
Cutthroat Castle	5.8	14.3
Total	**326**	**805.4**

Minimum Mapping Unit

The standard 0.5 ha (1.2 acre) minimum mapping unit (MMU) was not used in the HOVE vegetation mapping project, because the individual management units are relatively small and the loss of detail created by an artificial mapping unit size would have reduced the detail and utility of the map. Using 1:12,000 scale photographs, it is possible to identify distinct features as small as 0.1 ha (0.25 acres). During the scoping phase of this project, NCPN managers expressed interest in identifying and mapping several features that occur in patches smaller than the MMU: hanging gardens, springs and seeps, invasive species (especially tamarisk), and heavy concentrations of drought and beetle-killed timber. Of these, only seeps and springs were observed in the field; these were mapped as polygons of the riparian and wetland plant communities they support.

Ecological System Classification

The network 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 for HOVE. An ES is 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 Colorado and Utah contain more than 80 ecological systems (NatureServe Explorer 2006). This approach complements the NVC where the finer-scale association units provide a basis for interpreting ES patterns and concepts. A description of each ES unit appears in Appendix A.

The ecological system classification addresses natural landscapes. Land-use categories used to organize developed areas are described elsewhere in this report. Ten Ecological System units are being used for the HOVE vegetation mapping project (with their NatureServe identifying codes):

- Colorado Plateau Pinyon-Juniper Woodland (CES304.767)
- Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)
- Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.777)
- Colorado Plateau Mixed Low Sagebrush Shrubland (CES304.762)
- Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784)
- Inter-Mountain Basins Greasewood Flat (CES304.780)
- Inter-Mountain Basins Shale Badland (CES304.789)
- Inter-Mountain Basins Semi-Desert Grassland (CES304.787)
- Southern Rocky Mountain Montane-Subalpine Grassland (CES306.824)
- Rocky Mountain Lower Montane Riparian Woodland and Shrubland (CES306.821)

Vegetation Classification and Description

Pre-Field Methods

Preliminary Classification List

A preliminary list of vegetation associations and alliances for HOVE was compiled during the planning and scoping phase. e^2M developed this list by selecting from NVC plant associations and alliances (NatureServe Explorer 2006) known to occur in the Northern Canyon Lands section of the Intermountain Semi-Desert and Desert Province (Bailey 2001). Previous vegetation classification work, floristic information for HOVE and expert local knowledge were used to refine the list. This list was used to plan field work and assign provisional association names to vegetation plots and observation points.

Legacy Data Review

Existing vegetation data for HOVE were reviewed for possible use in the classification. This legacy data is documented in Schelz and Moran (2002). It was determined that existing data did not meet the standards for classification analysis. The final vegetation classification was derived from new field data collected specifically for the HOVE vegetation mapping project.

Field Methods

The primary purpose of classification plot data was to derive quantitative information documenting the composition and structure of HOVE's vegetation and associated environmental conditions. These data became the basis for classifying the vegetation at the Monument. Field methods used in the HOVE vegetation mapping project followed national program standards (e.g., TNC and ESRI 1994a, 1994b). The methods for conducting classification plot (also known as relevé) sampling are widely used by ecologists. Data gathered during this project contributed To understanding vegetation relationships across broader landscapes beyond the boundaries of the Monument. The plot dataset was enhanced by collecting observation point data, whose primary purpose was to support photointerpretation.

In addition to the basic vegetation data collected at each plot, the NCPN defined additional data fields to meet needs of network managers. Plot forms and individual data field descriptions appear in Appendix B. This section is a summary of the vegetation plot methods used at HOVE.

Field Sampling Approach

The sampling area included the entire Monument, which is broken into six management units (Cajon, Cutthroat Castle, Goodman Point, Hackberry/Horseshoe, Holly, and Square Tower). Given the very small project area and relative ease of accessibility, ecologists visited most potential map polygons in the field and collected vegetation plot data, observation point data, and/or field notes on photocopies of aerial photographs.

The list of 70 potential plant associations prepared by Schelz (2002) guided field sampling efforts. The sampling strategy was to collect at least three plots for every common vegetation type within HOVE. However, rare types were sampled less often and sometimes with observation points rather than vegetation plots because of their small size. An effort was made to distribute plots across the HOVE landscape to capture the diversity of each association, and to avoid over-sampling relative to its abundance. Sampling locations were determined by using aerial photographs, preliminary maps created by Schelz (2002), and field reconnaissance. Field investigators made a special effort to focus on homogenous aerial photograph and landscape signatures when selecting representative vegetation stands for sampling. Field crews for the HOVE vegetation project were led by investigators with experience in sampling plant communities of national parks and other landscapes. The sampling was completed during April

The sampling was completed during April and May, 2003. This time period allowed for efficient sampling during the cooler season. A field data collection period of eight-days duration was implemented by two teams researchers. A total of 27 vegetation plots and 32 observation points were sampled and field notes recorded during the 2003 field season (Figure 10).

Plot Data Collection

Field crews located classification plots subjectively 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 at least 0.5 hectares. Plots were generally located in stands exceeding the minimum mapping unit (0.5 ha). A few plots were sampled in smaller vegetation patches of distinctive or rare species aggregations, such as hanging gardens and riparian plant communities. Plot size and shape requirements 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). HOVE plots were typically circular, but plot shape was adjusted as needed to sample linear bands of vegetation in drainage bottoms. Plot size and shape were recorded for all HOVE plots.

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

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

Location and Plot Identifiers. The bounds of each plot were marked using measuring tapes. The Universal Transverse Mercator (UTM) XY coordinates at the center of each plot were recorded (Zone 12, NAD83) on 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 appendixes B and C

HOVE staff requested that the vegetation plot locations not be permanently marked. Locations were recorded on topographic maps and aerial photographs during each field trip to avoid duplication of effort and ensure that the Monument was adequately sampled.

Within each plot, researchers estimated and recorded an array of vegetation and environmental data using the field forms in Appendix B and data definitions in Appendix C. Three categories of data were collected for vegetation plots (Table 5):

- location and plot identifiers
- environmental description
- vegetation description

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

Environmental Description. The physical characteristics of each plot were documented in both categorical and narrative fields (Table 5; Appendix B, Appendix C). These included topographic 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.

An effort was made to document biological soil crusts because they are of significant concern across the Colorado Plateau. Field crews were trained in the identification of soil crust components (cyanobacteria, lichens, and mosses), made notes on soil crust distribution and characterization, and took a representative photograph of the soil crust in five plots where some crust development was evident. Because biological soil crust are fragile, all field crew members were instructed on how to avoid damaging them to the extent possible during sampling.

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.

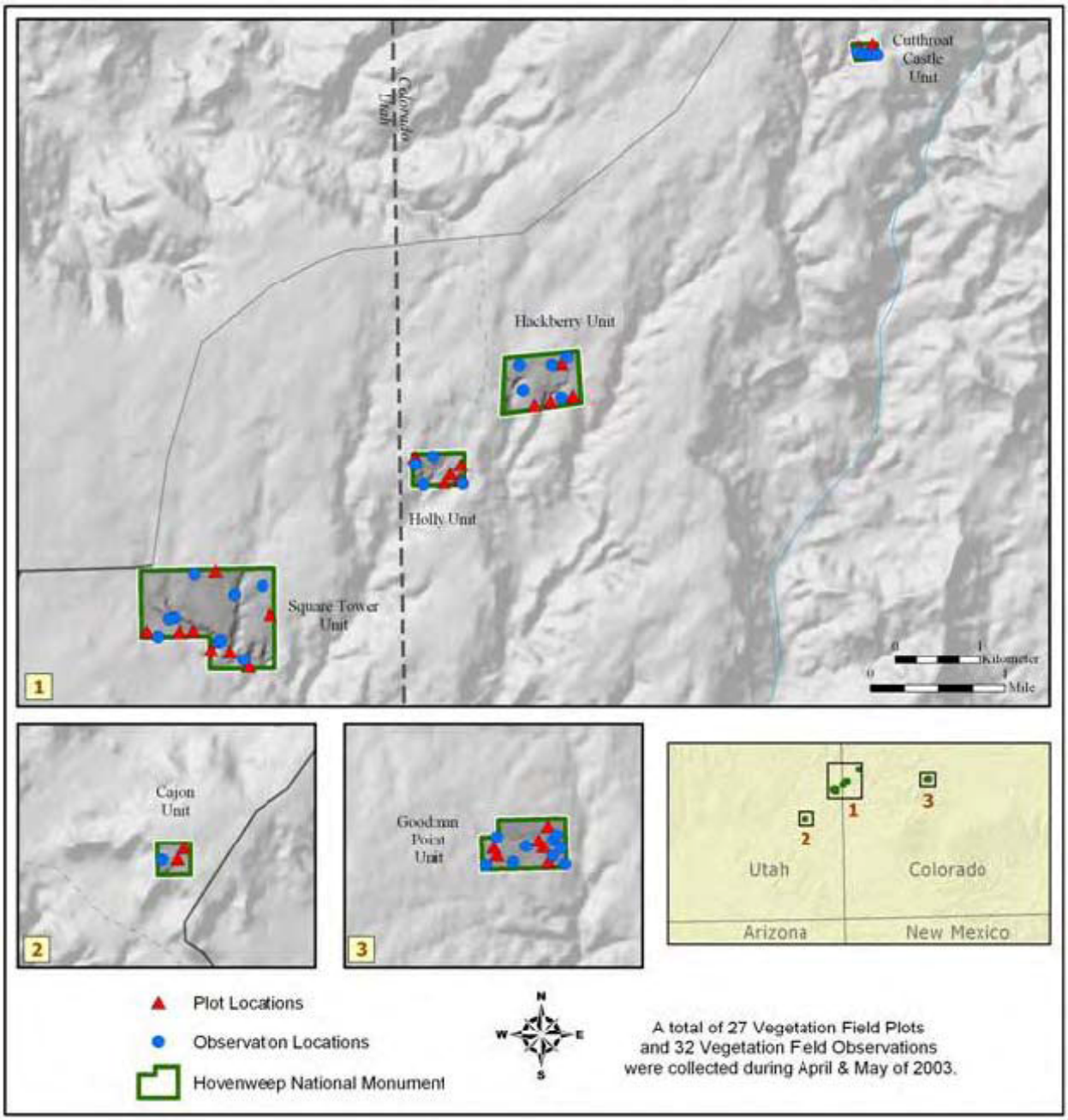


Figure 10. Locations of sample plots (vegetation plots and observation points) in each of the six HOVE management units.

Table 6. Vegetation cover and height classes used in the HOVE 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%				

Descriptive 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, and site disturbance history. The overall character of the vegetation and features of each plot were recorded in two 35 mm color slide photographs. In five plots, a third photograph was taken to document soil crusts.

Data Processing and Analysis

Twenty-seven vegetation classification plots were sampled within the mapping project area during the 2003 field season (Table 7). Plot data were manually entered into the HOVE Vegetation Mapping Project Database. 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 HOVE database offers NCPN greater flexibility in overall data management. The NCPN database was designed to accommodate all project data including plots, observation points, and fuels data. Data standards were established by NCPN for all network vegetation mapping projects, allowing compatibility of data across network park units. Fields associated with the HOVE plots database are described in Appendix C.

Each of the 35-mm slides associated with the project was scanned into digital format and stored in a photograph database. Ninety-five photographs were taken; of these, five photographs document soil crust conditions. A unique identifier allows each photograph to be linked with the plots and spatial databases.

Observation Points

In addition to classification plots, field crews collected vegetation and environmental data at 32 observation points (Table 7). Data collected at observation points reflected the vegetation of an undefined area around the point rather than a measured plot, and were less detailed (Appendix B). These data were intended primarily to support 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:

- the vegetation was highly disturbed, ecotonal, or otherwise anomalous
- cartographers requested documentation of a specific photo signature or area
- they wished to document special features or vegetation occurring in stands smaller than 0.5 ha (1.24 acres).

Table 7. Distribution of vegetation plots and observation points in each of the six HOVE management units.

Unit	# of Vegetation Plots	# of Observation Points
Cajon	2	1
Cutthroat Castle	2	4
Goodman Point	6	9
Hackberry/Horseshoe	4	5
Holly	5	4
Square Tower	8	9

A thorough quality assessment and quality check (QA/QC) was performed on all plot and observation point data following entry to the MSAccess 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 HOVE 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 feature class (point data) was developed to store sample plot information.

Classification Data Analysis

Vegetation classification was accomplished through a multivariate analysis of plot data augmented by observation point information. Species cover data were exported into a

spreadsheet and arranged into a plot x species data matrix. Midpoints of canopy cover classes were used in all data analyses. Exploratory multivariate statistical analyses were used with the objectives of summarizing the compositional and structural characteristics of the plant communities and assessing possible spatial patterns related to environmental gradients.

After outlier plots were identified and removed from the data set, a cluster analysis was performed using the Sorenson distance measure and Flexible Beta group linkage method (McCune and Mefford 1999). Clustering revealed five groups (Figure 11): weedy / herbaceous types, shadscale / galleta grass, dwarf shrub or herbaceous types, pinyon pine – Utah juniper woodlands, and sagebrush shrublands. Indicator species analysis, cluster analyses, and ordinations revealed a few subgroups within each group. Beyond that, tabular analysis was used to compare species presence within groups and determine relationships among plots to differentiate vegetation associations or groups of closely related associations (Mueller-Dombois and Ellenberg 1974). Plots that clearly were included in the concept of an established NVC association were assigned to that association. Plots that did not fit established association concepts were given provisional names that reflected the diagnostic floristic elements. Each of the five groups is discussed below.

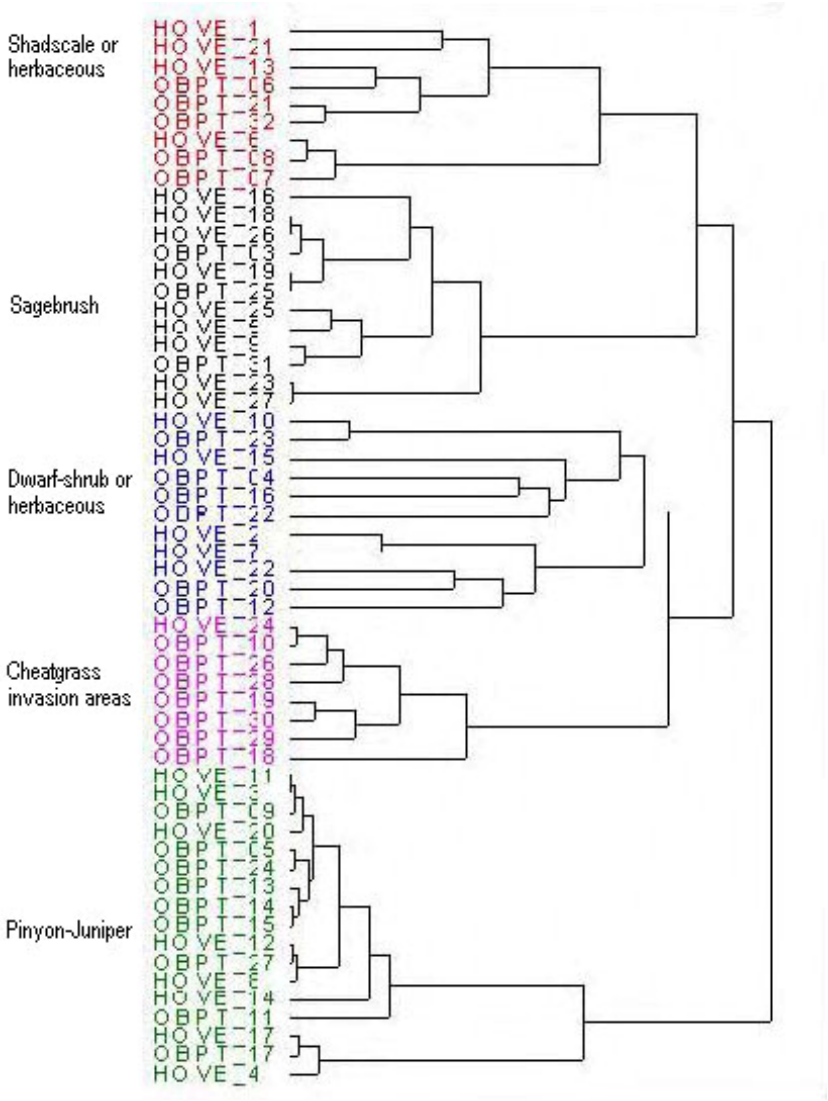


Figure 11. Cluster analysis dendrogram of HOVE plot data showing five clusters defined using the Sorensen distance measure and Flexible Beta group linkage method. The clusters were interpreted as (1) Shadscale or herbaceous, (2) Sagebrush, (3) Dwarf-shrub or herbaceous, (4) Cheatgrass-invaded areas, and (5) Pinyon-juniper.

Shadscale / Herbaceous Group

Cluster analysis and Indicator Species Analysis (ISA) indicated two interpretable clusters of vegetation dominated by shadscale and James' galleta grass, respectively. Two outlying samples were interpreted as Bigelow sagebrush (Artemisia bigelovii) and a shadscale / mixed shrub community, based on species composition and abundance (Figure 12).

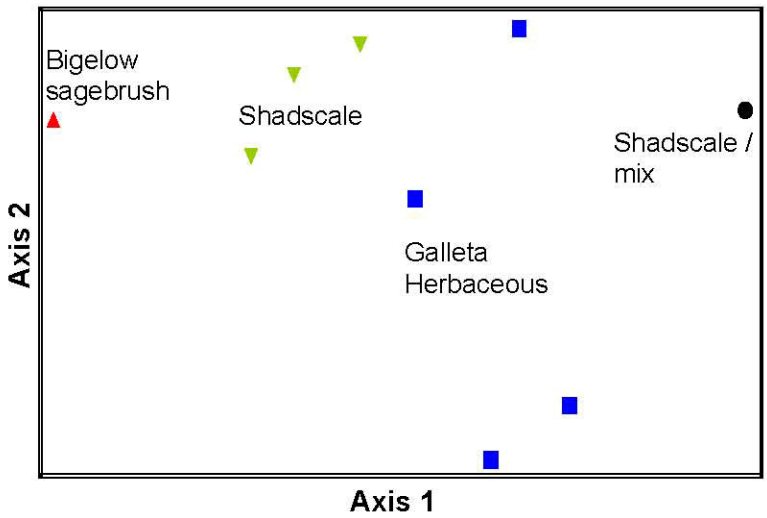


Figure 12. Detrended Correspondence Analysis ordination of the shadscale / herbaceous group displayed two interpretable clusters and two outlier plots, which were identified as Bigelow sagebrush and shadscale / mixed shrubs, respectively.

Sagebrush Group

Using cluster analysis and ISA, three clusters were determined to be most appropriate for this group. A variety of ordination techniques revealed that a gradient of big sagebrush cover existed in the data (Figure 13), but that the clusters were difficult to interpret as NVC associations. Samples were classified using either ordination scores or species composition and abundance.

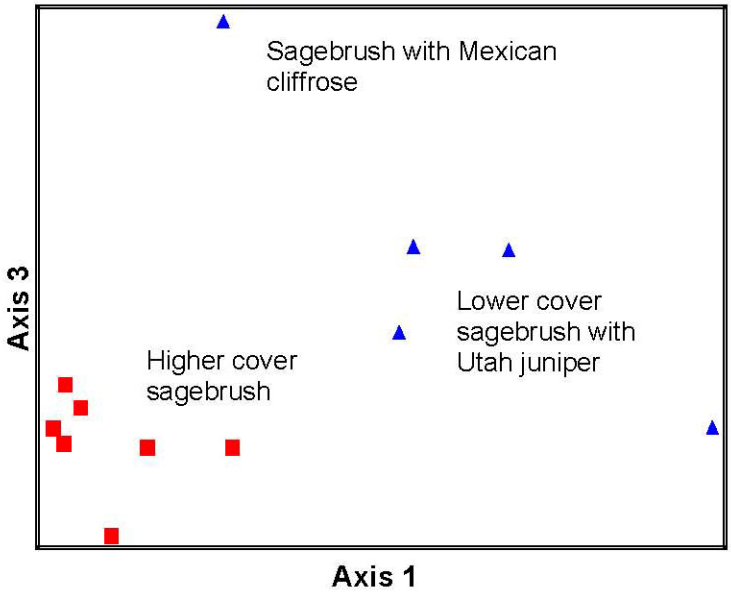


Figure 13. Bray-Curtis polar ordination of sagebrush group within HOVE shows gradient of big sagebrush abundance from higher (blue, 20-50%) to lower (red, 6-20%) canopy cover.

Dwarf-shrub or Herbaceous Group

Cluster analysis and ISA indicated four interpretable clusters in the dwarf-shrub and herbaceous group (Figure 14). Two clusters were easily interpreted as smooth brome (*Bromus inermis*)-dominated plots and Western wheatgrass (*Pascopyrum smithii*)-dominated plots, respectively. One cluster was interpreted as either Gambel Oak Woodland (*Quercus gambelii*) or Rio Grande Cottonwood Woodland (*Populus deltoides* ssp. *wislizeni*) based on the tallest stratum and species composition. The remaining cluster was difficult to interpret due to the fact that many plots were linked by high cover values of herbaceous or weedy species. These plots were subjectively classified based upon dominant species composition and abundance.

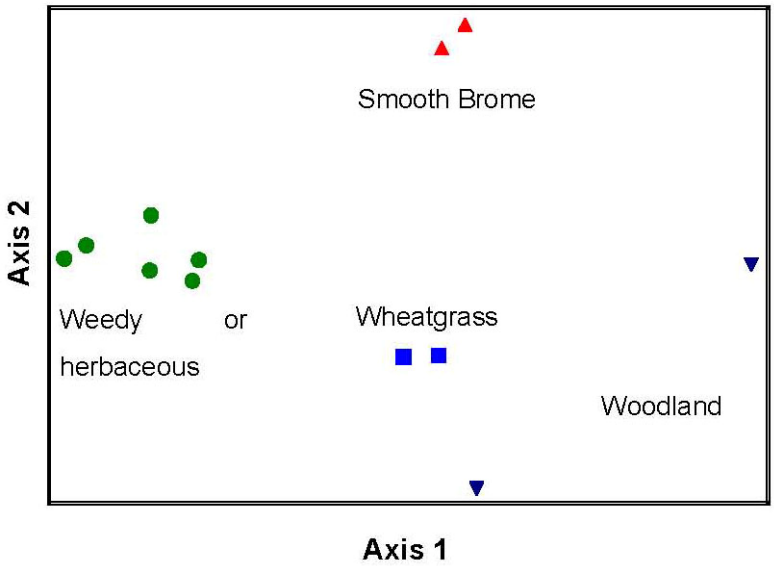


Figure 14. Detrended Correspondence Analysis ordination of dwarf-shrub or herbaceous group revealed four clusters, including Smooth Brome vegetation (red), Western Wheatgrass (blue), and two different types of Woodlands (black). The fourth cluster (green) was identified based on species composition and abundance.

Cheatgrass-invaded Group

This group was difficult to analyze because the abundance of cheatgrass (*Bromus tectorum*) linked plots with otherwise dissimilar dominant strata (ordination not shown). We therefore classified plots within this group based on dominant strata and species abundance and composition.

Pinyon-Juniper Group

Cluster analysis and ISA indicated up to three possible clusters in the pinyon-juniper group. These were interpreted as revealing a gradient of pinyon pine (Figure 15). A Utah juniper / cliffrose shrub subgroup overlapped in the ordination with a cluster of Utah juniper with sparse two-needle pinyon pine. A third subgroup of two-needle pinyon pine with sparse Utah juniper also appeared in the cluster analysis and DCA ordination.

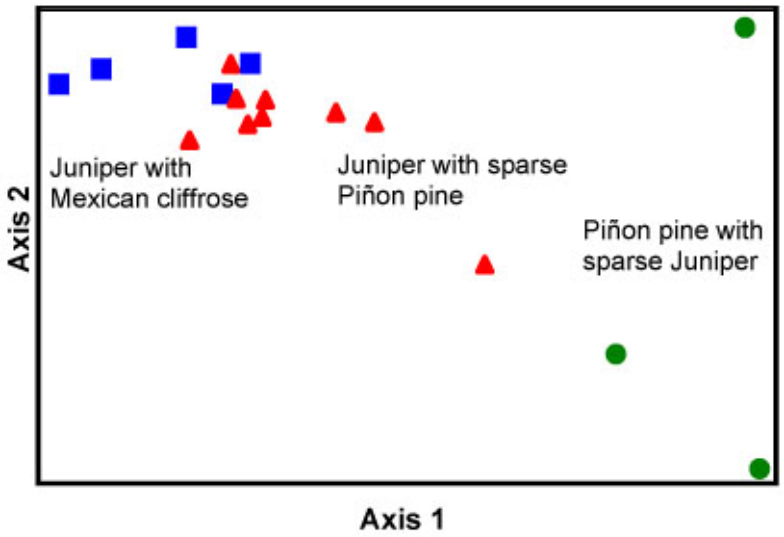


Figure 15. Detrended Correspondence Analysis ordination of the Pinyon-Juniper group at HOVE. The three groups represent a gradient of pinyon pine density.

Following the preliminary assignment of plots to established or provisional associations, the analysis and results were submitted to NatureServe for review. NatureServe ecologists gave particular attention to the provisional name assignments. Plots were compared with data available from other NCPN parks, and with the literature. In some cases, the concept of existing associations could be expanded to include some of the provisional vegetation types. In other cases, plots appeared to represent new ecological types that were likely to be found in other parts of the Colorado Plateau. New NVC associations were created for these plots. A few plots appeared to represent types that are unique to HOVE or anomalous situations, such as burns. These plots were given “park special” status and were not incorporated into the NVC. The classification for HOVE was finalized in February 2004.

Classification Results

The vegetation of the HOVE mapping project area was classified into 34 types, including 31 NVC plant associations representing 19 NVC alliances and 10 ecological systems (Table 8). Three types were described at the alliance level only. One of the types (Mixed Riparian Shrubland) was described as a ‘park special’ because it occurred in small patches and appears to be unique to the Monument. The vegetation includes 13 woodland and 14 shrubland associations, (including one riparian), and six herbaceous associations. Three associations are dominated by exotic herbaceous species; the others describe predominantly native vegetation. Five types were described from field notes only; no quantitative plot data were collected for these types.

Table 8. Plant associations identified within the HOVE vegetation mapping project area*.

NVC Association	Common Name	CEGL Code†
UPLAND ASSOCIATIONS		
WOODLANDS		
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)		
Juniperus osteosperma / Artemisia tridentate ssp. wyomingensis Woodland	Utah juniper / Wyoming Big Sagebrush Woodland	CEGL000730
Juniperus osteosperma / Sparse Understory Woodland	Utah juniper / Sparse Understory Woodland	CEGL000732
Pinus edulis - Juniperus osteosperma / Artemisia bigelovii Woodland	Two-needle Pinyon - Utah Juniper / Bigelow Sagebrush Woodland	CEGL002118
Pinus edulis – Juniperus osteosperma / Arctostaphylos patula Woodland	Two-needle Pinyon – Utah juniper / Greenleaf Manzanita Woodland	CEGL002939
Pinus edulis – Juniperus spp. / Artemisia tridentata (ssp. wyomingensis, ssp. vaseyana) Woodland	Two-needle Pinyon – Juniper / Sagebrush Woodland	CEGL000776
¥Pinus edulis – Juniperus osteosperma / Atriplex spp. Woodland	Two-needle Pinyon – Utah Juniper / Saltbush Woodland	CEGL002366
Pinus edulis – Juniperus spp. / Cercocarpus montanus – Mixed Shrub Woodland	Two-needle Pinyon – Juniper / Mountain Mahogany – Mixed Shrub Woodland	CEGL000780
¥Pinus edulis - Juniperus osteosperma / Pleuraphis jamesii Woodland	Two-needle Pinyon - Utah Juniper / James' Galleta Woodland	CEGL002379
Pinus edulis – Juniperus osteosperma / Purshia stansburiana Woodland	Two-needle Pinyon – Juniper / Stansbury Cliffrose Woodland	CEGL000782
Pinus edulis – Juniperus spp. / Quercus gambelii Woodland	Two-needle Pinyon – Juniper / Gambel Oak Woodland	CEGL000791
Pinus edulis – Juniperus osteosperma / Sparse Understory Woodland	Two-needle Pinyon – Utah juniper / Sparse Understory	CEGL002148
SHRUBLANDS		
Colorado Plateau Mixed Low Sagebrush Shrubland (CES304.762)		
Artemisia bigelovii Shrubland	Bigelow Sagebrush Shrubland	CEGL000276
Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)		
Artemisia tridentata ssp. wyomingensis / Atriplex confertifolia Shrubland	Wyoming Big Sagebrush – Shadscale Shrubland	CEGL001040
Artemisia tridentata ssp. wyomingensis / Disturbed Understory Semi-natural Shrubland	Wyoming Big Sagebrush / Disturbed Understory Semi-natural Shrubland	CEGL002083

Table 8. Plant associations identified within the HOVE vegetation mapping project area*.

NVC Association	Common Name	CEGL Code†
Artemisia tridentata ssp. wyomingensis / Pleuraphis jamesii Shrubland	Wyoming Big Sagebrush / James' Galleta Shrubland	CEGL002084
Artemisia tridentata ssp. wyomingensis / Poa fendleriana Shrubland	Wyoming Big Sagebrush / Muttongrass Shrubland	CEGL002775
Artemisia tridentata ssp. wyomingensis / Sparse Understory Shrubland	Wyoming Big Sagebrush / Sparse Understory Shrubland	CEGL002768
Sarcobatus vermiculatus / Artemisia tridentata Shrubland	Black Greasewood / Big Sagebrush Shrubland	CEGL001359
Inter-Mountain Basins Semi-Desert Shrub-Steppe Shrubland (CES304.788)		
Artemisia tridentata - (Ericameria nauseosa) / Bromus tectorum Semi-natural Shrubland	Big Sagebrush – (Rubber Rabbitbrush) / Cheatgrass Semi-natural Shrubland	CEGL002699
Inter-Mountain Basins Greasewood Flat (CES304.780)		
Sarcobatus vermiculatus Disturbed Shrubland	Black Greasewood Disturbed Shrubland	CEGL001357
¥Sporobolus airoides Herbaceous Alliance	Alkali Sacaton Herbaceous Alliance	A.1267
Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)		
Amelanchier utahensis Shrubland	Utah Serviceberrry Shrubland	CEGL001067
¥Quercus gambelii Shrubland Alliance	Gambel Oak Shrubland Alliance	A.920
Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784)		
Atriplex canescens / Pleuraphis jamesii Shrubland	Fourwing Saltbush / James' Galleta Shrubland	CEGL001288
Atriplex confertifolia / Pleuraphis jamesii Shrubland	Shadscale / James' Galleta Shrubland	CEGL001304
GRASSLANDS		
Inter-Mountain Basins Semi-Desert Grassland (CES304.787)		
Bromus tectorum Herbaceous Vegetation	Cheatgrass Herbaceous Vegetation	CEGL003019
Pleuraphis jamesii Herbaceous Vegetation	James' Galleta Herbaceous Vegetation	CEGL001777
Erodium cicutarium Semi-natural Annual Herbaceous Vegetation	Crane's-bill Semi-natural Annual Herbaceous Vegetation	CEGL002085
Southern Rocky Mountain Montane-Subalpine Grassland (CES306.824)		

Table 8. Plant associations identified within the HOVE vegetation mapping project area*.

NVC Association	Common Name	CEGL Code†
Bromus inermis - (Pascopyrum smithii) Semi-natural Herbaceous Vegetation	Smooth Brome – (Western Wheatgrass) Semi-natural Herbaceous Vegetation	CEGL005264
Pascopyrum smithii Herbaceous Vegetation	Western Wheatgrass Herbaceous Vegetation	CEGL001577
Inter-Mountain Basins Shale Badland (CES304.789)		
Leymus salinus Shale Sparse Vegetation	Salinas Wildrye Shale Sparse Vegetation	CEGL002745
RIPARIAN, WETLAND AND MESIC ASSOCIATIONS		
Rocky Mountain Lower Montane Riparian Woodland and Shrubland (CES306.821)		
¥Celtis laevigata var. reticulate Woodland Alliance	Netleaf Hackberry Woodland Alliance	A.632
Mixed Riparian Shrubland	Mixed Riparian Shrubland	Park Special
Populus deltoides (ssp. wislizeni, ssp. monilifera / Artemisia tridentate Woodland	Cottonwood / Basin Big Sagebrush Woodland	CEGL005966
Populus deltoides (ssp. wislizeni, ssp. monilifera / Salix exigua Woodland	Cottonwood / Coyote Willow Woodland	CEGL002685

* Plant associations determined from the vegetation plot and observation point data. Associations are ordered by physiognomy and grouped by ES. Identification codes are provided for plant associations and ecological systems.

† The CEGL code is assigned by NatureServe 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.

¥ These vegetation types were documented from field notes and observations, but were not sampled.

Plant Community Descriptions

This section provides a summary of HOVE vegetation by physiognomic group. Appendix F contains detailed local and global descriptions of the 29 plant associations, alliances and park special vegetation types sampled within the Monument. Five additional types documented from field notes but not sampled are not included in Appendix F. Local descriptions are based on plot and observation point data from the Monument. Global descriptions characterize the association across its range and are based primarily on published and unpublished literature.

Most of the plant associations at HOVE fit into defined NVC concepts. A few associations represent local variations of NVC types, and one (Mixed Riparian Shrubland) is not classified within the NVC but instead is described as a Park Special. Five vegetation types were described from field notes but lack plot data. These are marked with asterick (*) in the text below.

Woodland Associations

Hovenweep woodland associations have become established on canyon sides, canyon rims, slopes, and hills. The coniferous woodlands reflect the elevation and precipitation gradient that exists between the Cajon Unit and the Goodman Point Unit, e.g., there are a few scattered Utah juniper trees on the low-elevation Cajon Unit, whereas the high-elevation Goodman Point Unit has well-established two-needle pinyon pine and Utah juniper woodlands. Woodlands also increase in importance with soil depth; bedrock exposures and thin soils support fewer, dwarfed trees, whereas deeper eolian deposits support relatively dense stands and large trees. In the Square Tower and Goodman Point units, Utah juniper are becoming established in Wyoming big sagebrush stands, resulting in a broad ecotone that ranges from woodland to wooded shrubland in terms of community structure. The woodland associations at HOVE include:

- *Juniperus osteosperma / Artemisia tridentata* ssp. *wyomingensis* Woodland
- *Juniperus osteosperma* / Sparse Understory Woodland
- *Pinus edulis - Juniperus osteosperma / Artemisia bigelovii* Woodland
- *Pinus edulis - Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland
- **Pinus edulis - Juniperus osteosperma / Atriplex* spp. Woodland
- *Pinus edulis - Juniperus* spp. / *Cercocarpus montanus* - Mixed Shrub Woodland
- **Pinus edulis - Juniperus osteosperma / Pleuraphis jamesii* Woodland
- *Pinus edulis - Juniperus osteosperma / Purshia stansburiana* Woodland
- *Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland
- *Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland

Deep soils support open to moderately closed pinyon-juniper woodlands of trees with large crowns. The most common type has Wyoming big sagebrush dominating the understory, although this association also occurs on a few talus slopes where Wyoming big sagebrush from the canyon bottom mixes with sparse Utah juniper trees. Some stands on the deepest soils have very little growing in the understory other than biological soil crusts; a few have a sparse understory dominated by James' galleta.

Thinner soils near canyon rims support a diversity of pinyon-juniper woodland types. The trees

tend to be dwarfed relative to those on deeper soils. Most stands have a mixed shrub understory; depending on location, the dominant shrub may be Bigelow sagebrush *Artemisia bigelovii*), Stansbury cliffrose (*Purshia stansburiana*), Utah serviceberry (*Amelanchier utahensis*), or mountain mahogany (*Cercocarpus montanus*). Sheltered slopes at higher elevations may support a pinyon-juniper woodland with a Gambel oak (*Quercus gambelii*) understory.

Shrubland Associations

Shrublands within the six management units of Hovenweep are influenced by precipitation, landscape position, soil depth and alkalinity/salinity. At the Cajon Unit, annual precipitation is low and the soils are alkaline, resulting a predominance of salt- and drought-tolerant shrubs such as saltbush and black greasewood. At the Goodman Point Unit, the higher elevation and annual precipitation results in extensive stands of Wyoming big sagebrush on slopes and hills and mesic shrubs established in the main drainage. Bigelow sagebrush occurs on bedrock exposures with thin soil cover. The shrubland associations at HOVE include:

- *Artemisia bigelovii* Shrubland
- *Artemisia tridentata* ssp. *wyomingensis* - *Atriplex confertifolia* Shrubland
- *Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland
- *Artemisia tridentata* ssp. *wyomingensis / Pleuraphis jamesii* Shrubland
- *Artemisia tridentata* ssp. *wyomingensis / Poa fendleriana* Shrubland
- *Artemisia tridentata* ssp. *wyomingensis* / Sparse Understory Shrubland
- *Sarcobatus vermiculatus / Artemisia tridentata* Shrubland
- *Sarcobatus vermiculatus* Disturbed Shrubland
- *Atriplex canescens / Pleuraphis jamesii* Shrubland
- *Atriplex confertifolia / Pleuraphis jamesii* Shrubland
- *Artemisia tridentata* - *(Ericameria nauseosa) / Bromus tectorum* Semi-natural Shrubland
- *Amelanchier utahensis* Shrubland
- **Quercus gambelii* Shrubland Alliance

Basin big sagebrush stands are relatively rare within HOVE, occurring only on canyon floors with developed alluvial terraces. The largest stand occupies the canyon floor and upper canyon walls in the Square Tower Unit. Rubber rabbitbrush is a common species in the shrub layer. These sites have disturbed understories in which cheatgrass forms a relatively dense and continuous herbaceous layer.

Wyoming big sagebrush-dominated stands are the most widely distributed shrublands in HOVE. Shadscale is a co-dominant on thin, shale-derived soils, but on deeper, sandier soils, Wyoming big sagebrush is the overwhelming dominant. Most stands show evidence of disturbance, either through the presence of exotic species such as cheatgrass, or by diminished cover of perennial native species such as James' galleta or muttongrass (*Poa fendleriana*). Wyoming big sagebrush communities that have become established on prehistoric ruins or that have reinvaded historic burns have dense understories of cheatgrass.

Bigelow sagebrush shrublands are restricted to thin soil pockets overlying Dakota Sandstone bedrock within the Cajon Unit. Associated woody species include sparse Stansbury cliffrose,

Mormon-tea (*Ephedra* spp.), and Utah juniper. Biological soil crusts and rock outcrop account for most of the ground cover.

Fourwing saltbush shrublands are known only from shallow eolian deposits in the Cajon Unit. The stands are sparse and typically include spiny hopsage (*Grayia spinosa*) in the canopy. The understory generally has James' galleta in addition to exotic herbaceous species such as cranesbill. Utah juniper trees have become established in the last century (Figure 7). The drought of 2002 killed many of the saltbush shrubs, leaving a sparse grassland of James' galleta.

Black greasewood shrublands occur in small patches on dry terraces in the Square Tower Unit. Wyoming big sagebrush is co-dominant on sites where at least 0.5m of sand overlies alkaline soils. The understory of these stands is overwhelmingly dominated by cheatgrass.

A shrubland dominated by Utah serviceberry was documented on a steep, rocky canyon slope in the Square Tower Unit. Deeper soils on the same slope support Wyoming big sagebrush. The northern exposure provides a cooler, mesic environment and likely traps winter snow for additional moisture. Fire would eliminate Wyoming big sagebrush in this stand. Small stands of Gambel oak occur within the pinyon-juniper woodlands at the Goodman Point Unit. Depending on the size of the sampling unit, these stands may be characterized as shrublands or as pinyon-juniper woodlands with a Gambel oak understory.

Herbaceous Associations

Herbaceous plant communities are a relatively minor component of the vegetation at HOVE. Many types have become established due to disturbance, such as soil movement, fire, and livestock grazing. Herbaceous plant associations at HOVE include:

- *Erodium cicutarium* Semi-natural Annual Herbaceous Vegetation
- *Bromus tectorum* Semi-natural Herbaceous Vegetation
- *Pleuraphis jamesii* Herbaceous Vegetation
- *Leymus salinus* Shale Sparse Vegetation
- *Bromus inermis - (Pascopyrum smithii)* Semi-natural Herbaceous Vegetation
- *Pascopyrum smithii* Herbaceous Vegetation
- **Sporobolus airoides* Herbaceous Alliance

Naturally-occurring herbaceous vegetation is rare within HOVE. Small grasslands dominated by alkali sacaton (*Sporobolus airoides*), Salinas wildrye, or James' galleta were documented during field reconnaissance and sampling. Burned woodlands and shrublands are now monocultures of cheatgrass or crane's-bill (*Erodium cicutarium*) or were planted to western wheatgrass (*Pascopyrum smithii*). Smooth brome (*Bromus inermis*) was introduced in swales to provide grass hay for livestock and possibly to stabilize archaeological sites. With the exceptions of passive recreation, archaeological activity and fire, HOVE is now free from most forms of disturbance. Because of this, the areas currently dominated by exotic herbaceous species may eventually recover to native shrublands or woodlands.

Riparian Associations

Riparian vegetation is rare within HOVE. There are no perennial streams within the Monument, and many of the springs and seeps have diminished flows. Pockets of riparian vegetation have developed around plunge pools and seeps. Where seeps have dried, these stands are relict and will shift to upland species within a few decades. All stands are extremely small and have only a few trees of netleaf hackberry or Rio Grande cottonwood (*Populus deltoides* ssp. *wislizeni*) and an understory of mesic shrubs and herbaceous species. Riparian and wetland plant associations within HOVE include:

- Mixed Riparian Shrubland
- **Celtis laevigata* var. *reticulata* Woodland Alliance
- *Populus deltoides* (ssp. *wislizeni*, ssp. *monilifera*) / *Artemisia tridentata* Woodland
- *Populus deltoides* (ssp. *wislizeni*, ssp. *monilifera*) / *Salix exigua* Woodland

One stand of mixed mesic shrubs was documented within the Goodman Point Unit. It is supported by a combination of groundwater seepage and low evapotranspiration (on a north-facing slope). Wild crabapple (*Peraphyllum ramosissimum*) and coyote willow (*Salix exigua*) are the dominant shrub species. Small clusters of Rio Grande cottonwood occupy small seeps and springs in canyon bottoms, in alcoves, and under pour-offs. Stands may be affected by scouring during flash floods and minor channel erosion, but many are protected by boulders that have fallen from adjacent cliffs and slopes. Because of declining water tables and spring flows, stands are unlikely to increase in extent; they can only persist by root sprouts where sufficient soil moisture persists. Netleaf hackberry woodlands are commonly associated with archaeological sites in the Four Corners region; at HOVE, a few trees persist in mesic, sheltered canyon bottoms. Tamarisk (*Tamarix* spp.) are scattered in areas where moisture is close to the surface.

Field Key Preparation

An illustrated dichotomous field key to plant associations of the HOVE mapping area was developed for this project. The key is designed to assist 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., woodland, tall shrubland, shrubland, or herbaceous. The second level focuses on the dominant species' canopy cover. Brief environmental descriptions are included with the floristic information to assist in identifying plant associations. To increase the utility of the key, individual plant associations are cross-referenced to map classes.

The field key was constructed from data collected specifically for this mapping project. Because the key is based on a sample of the vegetation, it does not include all associations occurring within the Monument, nor does it describe the full range of variation available in the Monument.

The field key was tested by NatureServe using HOVE vegetation plot data. A NatureServe ecologist selected random plots of 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. This process identified areas where the key was confusing or incomplete. Appendix G is the revised version of the field key.

Fuels Data Collection

Fuels data were not analyzed as part of this project and data pertinent only to fuels and fire predictive modeling were not collected. The plot photographs and some of the data collected for vegetation classification may be useful for fuels management.

Data collected in the vegetation plots at HOVE that are potentially useful for fuels modeling include stem diameter at root crown for pinyon and juniper trees and stem diameter at breast height for Gambel oak, and cottonwood. Sampled pinyon-juniper stands were assigned to one of four age-class categories: old-growth, mature, young, or invasive.

Vegetation Mapping

Methods

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

- Field reconnaissance
- Map class and attribute development
- Mapping
- Spatial database development

Field reconnaissance was intended to familiarize the photointerpreter with the Monument, patterns of vegetation distribution, and environmental factors useful for developing mapping models and map class concepts. Photointerpretation drew on field notes and sample plots to delineate consistent, homogenous polygons on the base photography and attribute them. Because HOVE is a small park, some of the steps were more integrated than is the case in larger parks. For example, reconnaissance, plot data collection, polygon delineation and initial map class concept development occurred concurrently.

Field Reconnaissance, Sampling, and Initial Mapping

Field reconnaissance occurred immediately prior to vegetation plot and observation point data collection during the spring of 2003. The photointerpreter visited the Monument to assign plant communities or complexes to distinct signatures on the orthophotographs. Reconnaissance sessions focused on comparing on-the-ground vegetation conditions with signatures on the project aerial photography. Initial hypotheses of which environmental drivers most influenced the vegetation were also developed at this time. Field notes and interpretive line work were hand-written directly onto color photocopies of the aerial photographs. These field photos were used to guide later office-based interpretation and mapping.

Following the initial reconnaissance, vegetation plot and observation point data collection training was conducted at the Cajon Unit by the consulting ecologist. After the training was complete, the sampling team met to examine and delineate distinct aerial photo signatures for the Cajon Unit to guide sampling. Each of the other five HOVE management units was approached in a similar, systematic fashion to develop vegetation plot, observation point, and map class polygon information. During the plot and observation point sampling phase, field crew members visited as much of each management unit as possible and wrote detailed notes on photocopies of the aerial imagery.

Map Class and Polygon Attribute Development

The goal of mapping was to identify meaningful units to represent existing vegetation and land uses within HOVE. Map classes specific to this project were developed to characterize vegetation types within the Monument. Standard land-use map classes (Anderson et al. 2002) were used to map unvegetated managed areas such as Monument facilities and roads.

Interpretation and delineation of vegetation map classes addressed all types observed within HOVE regardless of size. Several map classes occur in polygons smaller than the 0.5-hectare MMU; the purpose of this level of delineation was to retain the maximum amount of detail in the vegetation map.

The current standard for the USGS-NPS Vegetation Mapping Program projects is to map 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 HOVE, most map classes represent single NVC associations; a few represent groups of similar plant associations because they could not be distinguished consistently even in the field. Map class definitions and concepts were adjusted throughout the project as new information became available.

In order to facilitate use of vegetation maps and mapping data across multiple parks, the NCPN developed a map class coding system. Photointerpreters typically use a numeric map class coding system as a form of shorthand. Although these numeric codes have been retained within the spatial database and map class guide (Appendix J), a complementary, five-letter alphacode system for map classes was created for 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 and N = nonvascular). The subsequent four letters generally abbreviate the map class name. For example, the Pinyon-Juniper / Mixed Shrub Woodland map class is represented by the alphacode “W-PJSH”. 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. Complexes of vegetation that include several physiognomic types are prefaced by “C”; geologic exposures are given the prefix G (for “geology”) and developed sites the prefix L (for “land cover/land use”).

Photointerpretation, 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 other attributes to characterize vegetation structure (density, pattern, height; Table 9), and disturbance. All map polygons were assigned to a land cover / land use type (Anderson et al. 2002; Appendix H). In addition, all vegetation polygons were assigned to higher levels of the NVC hierarchy (alliance and formation). Non-vegetated map classes were coded as ‘unclassified’ or ‘unvegetated’ in the NVC columns.

Table 9. Physiognomic attributes assigned to polygons during mapping. When appropriate, 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 2 3 4 5	Clumped/Bunched Linear Gradational/Transitional Regularly Alternating Homogenous
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 define a suite of polygon modifiers to describe altered vegetation, landforms, transportation and utilities, and other situations (Evenden 2004). Table 10 is a list of the modifiers used in the HOVE project.

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

Category	Code	Name	Description
Vegetation Modifiers	a	Altered	Applies when some alteration is evident, but the type is visually indistinguishable from unaltered stands
Transportation Modifiers	t	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

Park Specials

During the NCPN project planning phase, an effort was made to identify features of particular interest to resource managers. HOVE park specials included locations of springs, seeps, and significant populations of non-native plants. In most cases, stands of non-native plant species in HOVE were mapped as vegetation polygons, e.g., *Bromus inermis, Bromus tectorum, Erodium cicutarium,* and *Pascopyrum smithii* (introduced). Springs and seeps were documented as small polygons of vegetation dominated by the riparian trees Populus deltoides ssp. wislizeni or *Celtis laevigata* var. *reticulata*. These small vegetation patches typically represent plant associations or alliances described in the NVC.

Mapping

The mapping component of the HOVE project used a combination of methods to interpret and

delineate vegetation polygons. Before going into the field, a trained photointerpreter visually examined the aerial photographs in stereo to identify distinct polygons. Polygons were drawn on photocopies of these photographs. These were carried into the field and during the reconnaissance/sampling phase, polygons were attributed with vegetation or land use map classes and the boundaries modified as needed. After field work was complete, the field photos were digitized using vector editing in ArcGIS. Each vegetation and land use polygon so produced was given density, pattern, and other descriptive attributes. Copies of electronic plot and observation point data and plot photographs were available to the project lead ecologist for reference during final development of the map classes and polygons.

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 converted to a geodatabase format, the general structure of which is illustrated in Figure 16. This format allows text and image information to be incorporated and linked to spatial coordinates. A more detailed description of the geodatabase is provided in Appendix C.

Map Classes

Thirty-three map classes were developed to describe the HOVE vegetation mapping project area (Table 11). Of these, 29 are vegetation map classes and four are non-vegetated geologic or land-use map classes. Most of the vegetation map classes represent a single plant association or alliance; no map class represents more than two associations.

Results

Table 11 shows the relationship of vegetation map classes to NatureServe-defined ecological systems. Appendix A provides a brief description of each ecological system. The geologic and Anderson land use map classes could not be placed within the ecological system classification.

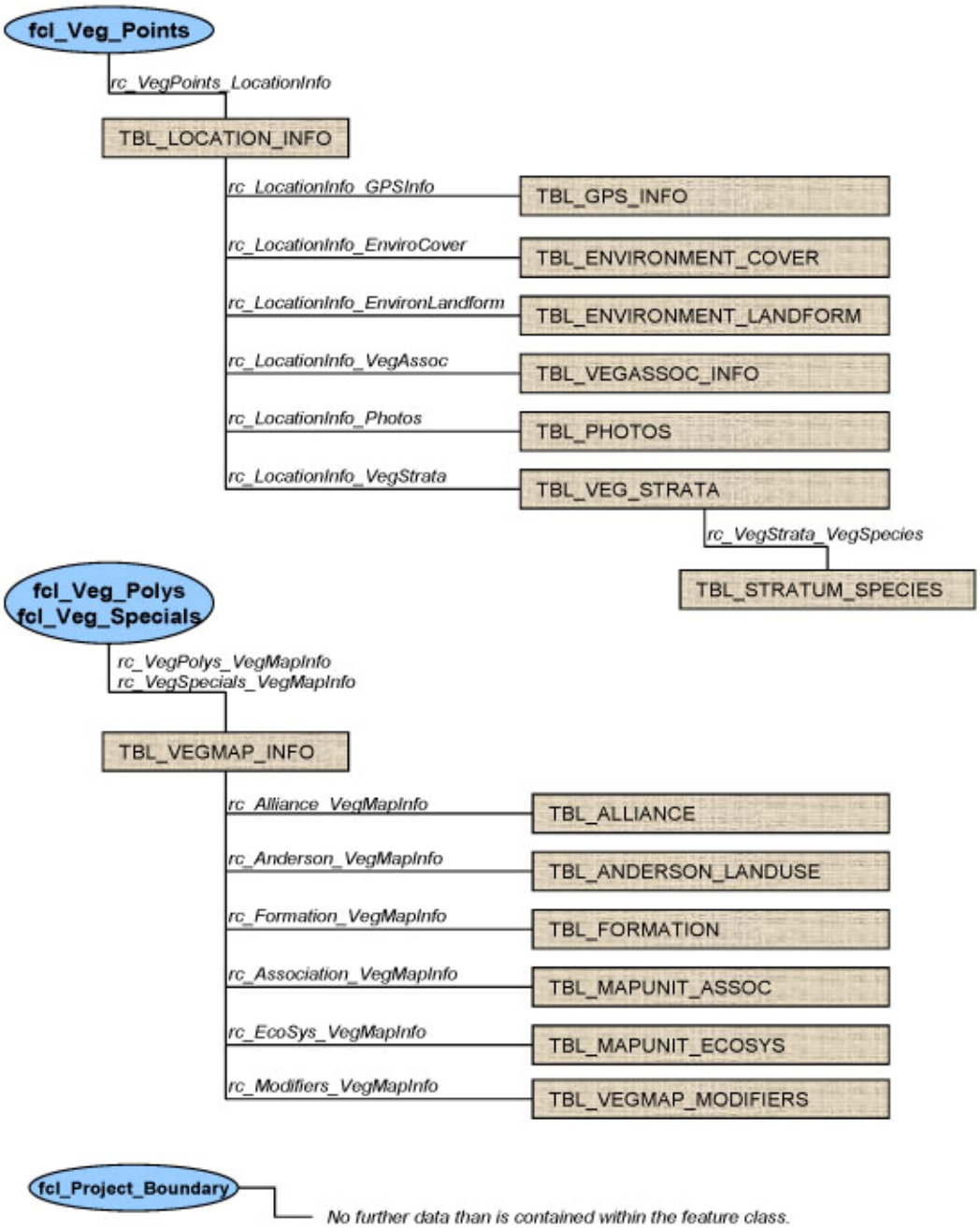


Figure 16. Structure of the HOVE geodatabase.

Table 11. Map classes used in the HOVE vegetation map, with map class number, code and name, crosswalk to NVC association, and the relationship of map class to plant associations. HOVE vegetation map classes are arranged by NatureServe ecological systems. Vegetation associations and alliances marked with an asterisk (*) were documented in field notes but were not sampled.

Map Class #	Map Class Code	Map Class Name	Associations Assigned to Map Class	Relation
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)				
41	W-JUOS	Juniper Woodland	*Juniperus osteosperma / Artemisia tridentata* ssp. *wyomingensis* Woodland *Juniperus osteosperma* / Sparse Understory Woodland	1 : many
42	W-PJQG	Pinyon-Juniper / Gambel Oak Woodland	*Pinus edulis – Juniperus spp. / Quercus gambelii* Woodland	1 : 1
43	W-PJAT	Pinyon-Juniper / Saltbush Woodland	**Pinus edulis - Juniperus osteosperma / Atriplex* spp. Woodland	1 : 1
44	W-PJBG	Pinyon-Juniper / Grasses Woodland	**Pinus edulis - Juniperus osteosperma / Pleuraphis jamesii* Woodland	1 : 1
45	W-PJWS	Pinyon-Juniper / Wyoming Sagebrush Woodland	*Pinus edulis - Juniperus spp. / Artemisia tridentata (ssp. wyomingensis, ssp. vaseyana) Woodland*	1 : 1
46	W-PJMM	Pinyon-Juniper / Mountain Mahogany Woodland	*Pinus edulis - Juniperus* spp. / *Cercocarpus montanus* - Mixed Shrub Woodland	1 : 1
47	W-PJSP	Pinyon-Juniper / Sparse Understory Woodland	*Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland	1 : 1
48	W-PJPS	Pinyon-Juniper / Bitterbrush Woodland	*Pinus edulis - Juniperus osteosperma / Purshia stansburiana* Woodland	1 : 1
49	W-PJAB	Pinyon-Juniper / Bigelow Sagebrush Woodland	*Pinus edulis - Juniperus osteosperma / Artemisia bigelovii* Woodland	1 : 1
Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)				
31	S-MONT	Montane Deciduous Shrubland	*Amelanchier utahensis* Shrubland **Quercus gambelii* Shrubland Alliance	1 : many
Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)				
20	S-SBCG	Basin Big Sagebrush Shrubland	*Artemisia tridentata - (Ericameria nauseosa) / Bromus tectorum* Semi-natural Shrubland *Sarcobatus vermiculatus / Artemisia tridentata* Shrubland	1 : many
22	S-SBSS	Wyoming Sagebrush – Shadscale Shrubland	*Artemisia tridentata* ssp. *wyomingensis - Atriplex confertifolia* Shrubland	1 : 1
23	S-SBDI	Wyoming Sagebrush Disturbed Shrubland	*Artemisia tridentata ssp. wyomingensis* / Disturbed Understory Semi-natural Shrubland	1 : 1

Table 11. Map classes used in the HOVE vegetation map, with map class number, code and name, crosswalk to NVC association, and the relationship of map class to plant associations. HOVE vegetation map classes are arranged by NatureServe ecological systems. Vegetation associations and alliances marked with an asterisk (*) were documented in field notes but were not sampled.

Map Class #	Map Class Code	Map Class Name	Associations Assigned to Map Class	Relation
24	S-SBNG	Wyoming Sagebrush / Native Grass Shrubland	*Artemisia tridentata* ssp. *wyomingensis / Poa fendleriana* Shrubland *Artemisia tridentata* ssp. *wyomingensis / Pleuraphis jamesii* Shrubland	1 : many
25	S-SBSP	Wyoming Sagebrush / Sparse Understory Shrubland	*Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland *Artemisia tridentata* ssp. *wyomingensis / Pleuraphis jamesii* Shrubland	1 : many
Colorado Plateau Mixed Low Sagebrush Shrubland (CES304.762)				
26	S-ARBI	Bigelow Sagebrush Shrubland	*Artemisia bigelovii* Shrubland	1 : 1
Inter-Mountain Basins Greasewood Flat (CES304.780)				
8	H-SPAI	Alkali Sacaton Grassland	**Sporobolus airoides* Herbaceous Alliance	1 : 1
33	S-SAVE	Greasewood Shrubland	*Sarcobatus vermiculatus* Disturbed Shrubland	1 : 1
Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784)				
27	S-FWGA	Fourwing Saltbush / Galleta Shrubland	*Atriplex canescens / Pleuraphis jamesii* Shrubland	1 : 1
28	S-SSGA	Shadscale / Galleta Shrubland	*Atriplex confertifolia / Pleuraphis jamesii* Shrubland	1 : 1
Inter-Mountain Basins Semi-Desert Grassland (CES304.787)				
10	H-GRAS	Mixed Short Grassland	*Pleuraphis jamesii* Herbaceous Vegetation *Erodium cicutarium* Semi-natural Annual Herbaceous Vegetation	1 : many
13	H-BRTE	Cheatgrass Grassland	*Bromus tectorum* Semi-natural Herbaceous Vegetation	1 : 1
Southern Rocky Mountain Montane-Subalpine Grassland (CES306.824)				
11	H-PASM	Western Wheatgrass Grassland	*Pascopyrum smithii* Herbaceous Vegetation	1 : 1
12	H-BRIN	Smooth Brome Shrubland	*Bromus inermis - (Pascopyrum smithii)* Semi-natural Herbaceous Vegetation	1 : 1
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)				
34	C-RIPA	Mixed Riparian Shrubland	Mixed Riparian Shrubland [Park Special]	1 : 1

Table 11. Map classes used in the HOVE vegetation map, with map class number, code and name, crosswalk to NVC association, and the relationship of map class to plant associations. HOVE vegetation map classes are arranged by NatureServe ecological systems. Vegetation associations and alliances marked with an asterisk (*) were documented in field notes but were not sampled.

Map Class #	Map Class Code	Map Class Name	Associations Assigned to Map Class	Relation
40	W-HACK	Hackberry Shrubland	**Celtis laevigata* var. *reticulata* Woodland Alliance	1 : 1
50	W-PDEN	Rio Grande Cottonwood / Rabbitbrush Woodland	*Populus deltoides (*ssp. *wislizeni*, ssp. *monilifera) / Ericameria nauseosa* Woodland	1 : 1
51	W-PDSE	Rio Grande Cottonwood / Coyote Willow Woodland	*Populus deltoides (*ssp. *wislizeni*, ssp. *monilifera) / Salix exigua* Woodland	1 : 1
Multiple Ecological Systems: Inter-Mountain Basins Semi-Desert Grassland (CES304.787) Intermountain Basins Shale Badland (CES304.789)				
15	S-GUSA	Snakeweed – Sparse Grasses Dwarf-shrubland	*Gutierrezia sarothrae* Dwarf-shrubland Alliance *Leymus salinus* Shale Sparse Vegetation	1 : many
Unvegetated Geologic Map Classes:				
2	G-SLIC	Slickrock (unvegetated)	Areas of exposed Dakota Sandstone	N/A
3	G-WASH	Unvegetated Wash	Barren sandy intermittent stream beds	N/A
Non-Vegetated (Anderson Land Use) Map Classes:				
60	L-ROAD	Roads	Paved and dirt roads within the Monument, regardless of whether they are open to travel	N/A
61	L-PAFA	Monument Facilities	NPS buildings and facilities, including housing, campground, visitor center, parking lots, and outbuildings	N/A

Map Class Descriptions

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

- a summary of the ecological concept of the map class. Reference is made to the abundance of the map class within the project area and its ecological system
- 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
- at least one ground photograph, if available
- a table of summary statistics

Map Polygons

Four hundred-eight polygons totaling 326 hectares (805 acres) were mapped at HOVE. Average polygon size was 0.8 ha (2 acres). This is smaller than the average for most parks on the Colorado Plateau, primarily because polygon size was not limited by the 0.5 ha minimum mapping unit. Of the total, 338 polygons (83%) represent natural or semi-natural vegetation map classes covering 95% of the mapping project area. Map classes representing exposed bedrock, unvegetated washes, roads, and NPS facilities account for the remaining 70 polygons (17% of polygons and 5% of the total area).

Table 12 provides summary statistics for all HOVE vegetation map classes. Four map classes (W-JUOS, W-PJWS, W-PJPS, and S-SBDI) comprise 66% of the vegetation of HOVE. Map Class S-SBDI (Wyoming Sagebrush Disturbed Understory) alone covers nearly 24% of the total area. The five smallest map classes (W-PDEN, W-PDSE, W-PJAT, S-MONT, and H-BRTE) contribute only 0.25% of the total area mapped. Three of these five smallest map classes represent mesic or riparian communities.

Figure 17 is an example of a map of the vegetation of HOVE created from the GIS spatial database. Because we used a geodatabase format to store and organize spatial information, there is 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 and detail.

Discussion

Things that worked well: The decision to map vegetation at HOVE primarily in the field resulted in an accurate map with a minimum of effort. Traditional photointerpretation followed by field verification of the map and an accuracy assessment process would have greatly increased the amount of time, effort and expense associated with producing an accurate map. The six management units of HOVE are small and every part of them was accessible or visible to field crews on foot. We are confident that this map meets or exceeds the 80% accuracy standard set by the USGS-NPS Vegetation Mapping Program.

Areas for Improvement: One area that posed difficulties for mapping vegetation at HOVE was the relatively outdated aerial photography available to the mappers. HOVE built a new visitor center in a different part of the Square Tower Unit between 1996, when the photos were flown, and 2003, when the field data were collected. The available photography showed the older facilities; field crews had to hand-digitize the location of the new facilities. Several fires had also burned through various units since this photography was flown; their boundaries had to be estimated and hand digitized. Black-and white orthophotography available from USGS was too poor in contrast and resolution to assist in the mapping phase of this project. As newer, higher resolution imagery becomes available, it should replace the current base imagery.

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

Map No.	Map Code	Map Class Common Name	Polygons	Area (ha)	Area (acres)
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)					
41	W-JUOS	Juniper Woodland	12	33.7	83.3
42	W-PJQG	Pinyon-Juniper / Gambel Oak Woodland	12	3.8	9.5
43	W-PJAT	Pinyon-Juniper / Saltbush Woodland	2	0.1	0.3
44	W-PJBG	Pinyon-Juniper / Grasses Woodland	3	1.5	3.6
45	W-PJWS	Pinyon-Juniper / Wyoming Sagebrush Woodland	79	65.8	162.6
46	W-PJMM	Pinyon-Juniper / Mountain Mahogany Woodland	5	1.3	3.2
47	W-PJSP	Pinyon-Juniper / Sparse Understory Woodland	20	17.5	43.2
48	W-PJPS	Pinyon-Juniper / Bitterbrush Woodland	24	39.7	98.2
49	W-PJAB	Pinyon-Juniper / Bigelow Sagebrush Woodland	4	6.2	15.3
		Subtotal	*161*	*169.6*	*419.2*
Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)					
31	S-MONT	Montane Deciduous Shrubland	1	0.2	0.4
		Subtotal	*1*	*0.2*	*0.4*
Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)					
20	S-SBCG	Basin Big Sagebrush Shrubland	4	6.8	16.7
22	S-SBSS	Wyoming Sagebrush – Shadscale Shrubland	3	0.4	1.0
23	S-SBDI	Wyoming Sagebrush Disturbed Shrubland	54	77.6	191.8
24	S-SBNG	Wyoming Sagebrush / Native Grass Shrubland	23	15.2	37.5
25	S-SBSP	Wyoming Sagebrush / Sparse Understory Shrubland	12	7.9	19.6
		Subtotal	*96*	*107.9*	*266.6*
Colorado Plateau Mixed Low Sagebrush Shrubland (CES304.762)					
26	S-ARBI	Bigelow Sagebrush Shrubland	3	1.6	4.0
		Subtotal	*3*	*1.6*	*4.0*

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

Map No.	Map Code	Map Class Common Name	Polygons	Area (ha)	Area (acres)
Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784)					
27	S-FWGA	Fourwing Saltbush / Galleta Shrubland	2	3.4	8.5
28	S-SSGA	Shadscale / Galleta Shrubland	12	8.4	20.8
		Subtotal	*14*	*11.8*	*29.3*
Inter-Mountain Basins Greasewood Flat (CES304.780)					
8	H-SPAI	Alkali Sacaton Grassland	2	0.7	1.8
33	S-SAVE	Greasewood Shrubland	4	3.8	9.5
		Subtotal	*6*	*4.5*	*11.3*
Inter-Mountain Basins Semi-Desert Grassland (CES304.787)					
10	H-GRAS	Mixed Short Grassland	4	2.7	6.8
13	H-BRTE	Cheatgrass Grassland	1	1.4	0.3
		Subtotal	*5*	*4.1*	*7.1*
Southern Rocky Mountain Montane-Subalpine Grassland (CES306.824)					
11	H-PASM	Western Wheatgrass Grassland	1	1.2	3.0
12	H-BRIN	Smooth Brome Grassland	4	2.0	4.9
		Subtotal	*5*	*3.2*	*7.9*
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)					
34	C-RIPA	Mixed Riparian Shrubland	1	0.6	1.4
40	W-HACK	Hackberry Woodland	5	0.4	1.1
50	W-PDEN	Rio Grande Cottonwood / Rabbitbrush Woodland	2	0.1	0.3
51	W-PDSE	Rio Grande Cottonwood / Coyote Willow Woodland	2	0.3	0.7
		Subtotal	*10*	*1.4*	*3.5*
MULTIPLE ECOLOGICAL SYSTEMS: **Inter-Mountain Basins Semi-Desert Grassland (CES304.787)** **Intermountain Basins Shale Badland (CES304.789)**					

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

Map No.	Map Code	Map Class Common Name	Polygons	Area (ha)	Area (acres)
15	S-GUSA	Snakeweed – Sparse Grasses Dwarf-shrubland	37	7.0	17.2
		Subtotal	*37*	*7.0*	*17.2*
UNVEGETATED GEOLOGIC MAP CLASSES					
2	G-SLIC	Slickrock (unvegetated)	54	10.1	25.1
3	G-WASH	Unvegetated Wash	3	0.6	1.5
		Subtotal	*57*	*10.7*	*26.6*
LAND USE MAP CLASSES					
60	L-ROAD	Roads	6	4.2	10.4
61	L-PAFA	Monument Facilities	7	0.7	1.7
		Subtotal	*13*	*4.9*	*12.1*
		Total All Map Classes	**408**	**325.9**	**805.3**

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

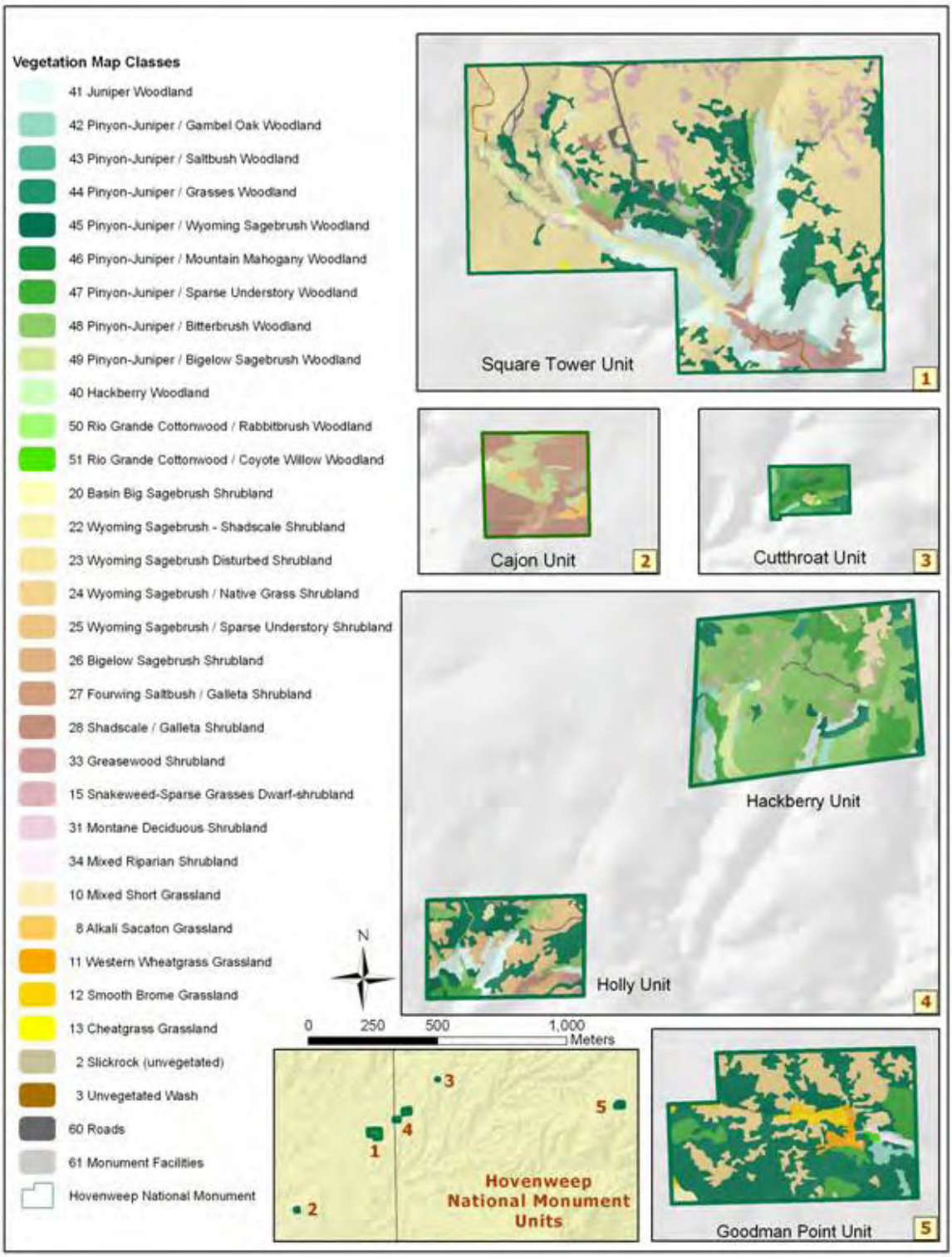


Figure 17. The HOVE vegetation map based on the final map classes.

Accuracy Assessment

Methods

The HOVE vegetation map was not verified by means of the USGS-NPS standard accuracy assessment protocol (ESRI and TNC 1994). The Monument consists of six management units, ranging from six to 160 ha (14 to 400 acres) in size. Although the terrain is difficult, each unit may be walked or viewed in its entirety by a reasonably fit individual. The standard procedure for mapping larger parks is to have four types of field visits spread over the life of the project: (1) reconnaissance, (2) vegetation plot sampling, (3) map verification, and (4) accuracy assessment. For a park as small and accessible as HOVE, following this process would have resulted in a great deal of redundant data and wasted field time.

Because of this potential for redundancy, NCPN ecologists and project partners agreed that it would be more efficient to invest time in the field at the beginning of the project delineating and attributing vegetation polygons in the field as they were observed. The initial map was created in 2003 from detailed field notes recorded on photocopies of the aerial imagery. A brief field verification in 2007 resulted in minor changes to polygon boundaries and attributes. Most changes were necessary because of shifts in the vegetation resulting from the severe drought of 2002-2003.

The downside of this procedure is that it is impossible to quantify the degree of confidence users may have in this vegetation map. However, the authors will certify that virtually every acre or each management unit was walked, observed, and evaluated, and that (as of April, 2008) this map is as accurate as human effort can achieve.

References

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.

Bailey, R.G. 2001. Descriptions of the ecoregions of the United States. 2d ed. Rev. and expanded (1st ed. 1980). Misc. Publ. No. 1391 (rev.), Washington, D.C.: USDA Forest Service. 108 p. with 1:7,500,000-scale map.

Belnap, J., J.H. 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, CO. 119 p.

Betancourt, J.L., E.A. Pierson, K. Aasen-Rylander, J.A. Fairchild-Parks, J.S. Dean, 1993. Influence of history and climate on New Mexico pinyon-juniper woodlands. Pages 42-62 in: Aldon, E.F. and D.W. Shaw, editors. Managing Pinyon-Juniper Ecosystems for Sustainability and Social Needs. April 26-30, Santa Fe, New Mexico. General Technical Report RM-236, Fort Collins, CO.

Bureau of Land Management [BLM]. 2007. Canyons of the Ancients National Monument Draft Resource Management Plan and Environmental Impact Statement. USDI-BLM Colorado State Office, Denver, CO.

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.

Dewey, S. and K. Andersen. 2005. An inventory of invasive non-native plants in Hovenweep National Monument (2003) - Final report. Utah State University. Weed Science Research Project Report No. SD0518A.

Driscoll, R.S., D.L. Merkel, R.L. Radloff, D.E. Snyder, and J.S. 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.

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.

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.

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, UT. 20 p.

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, UT. 10 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 [FGDC]. 1998a. Content standard for digital geospatial metadata, FGDC-STD-001-1998. Web address: http://www.fgdc.gov/metadata/contstan.html.

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

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

Fewkes, J.W. 1919. Prehistoric Villages, Castles, and Towers of Southwestern Colorado. Smithsonian Institution Bureau of American Ethnology Bulletin 70. Washington, DC.

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

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, VA.

Hall, S.A. 1988. Prehistoric vegetation and environment at Chaco Canyon. American Antiquity 53(3):582-592.

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, NC.

McCune, B. and M.J. Mefford. 1999. PC-ORD. Multivariate analysis of ecological data, ver. 4. MjM Software Design. Gleneden Beach, OR.

Miller, R.F. and P.E. Wigand. 1994. Holocene changes in semi-arid pinyon-juniper woodlands:

Response to climate, fire and human activities in the Great Basin. BioScience 44(7):465-474.

Mueller-Dombois, D. H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York, NY. 547 pp.

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 [NPS]. 2005. Hovenweep National Monument – Nature & Science. Accessed online at: http://www.nps.gov/HOVE/pphtml.

Natural Resources Conservation Service [NRCS]. 2003. Soil survey of Cortez area, Colorado, parts of Dolores and Montezuma Counties. Washington, D.C.

Natural Resources Conservation Service [NRCS].1993. Soil survey of San Juan County, Utah, central part. Washington, D.C.

Natural Resources Conservation Service [NRCS]. 1980. Soil survey of Navajo Indian Reservation, San Juan County, Utah. Washington, D.C.

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

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

NatureServe Explorer. 2006. An online encyclopedia of life [Web application]. Version 1.8. Arlington, VA. Available online: http://www.natureserve.org/explorer.

O'Dell, T.E., S.L. Garman, A. Evenden, M. Beer, E. Nance, A. Wight, M. Powell, D. Perry, R. DenBleyker, et al. 2005. Northern Colorado Plateau Inventory and Monitoring Network, Vital Signs Monitoring Plan, NPS I&M Network, Moab, UT. 174 pp. plus appendices.

Ponzetti, 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, OR. 89 pp.

Reid, M. and P. Comer. 1998. Vegetation Alliance Descriptions of the Western U.S. Available online at 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, comps. Proceedings –

Symposium on the biology of Artemisia and Chrysothamnus. General Technical Report INT-200. USDA Forest Service, Intermountain Research Station. Ogden, UT. pp. 273-277.

Schelz, C. 2002. General Floristic Survey of Hovenweep National Monument. NPS-SEUG, Resource Management Division. Moab, UT.

Schelz, C. 2004. Floristic Survey at Hovenweep National Monument 2001-2003. General Technical Report SEUG-003-2003. Moab, UT. 91 pp.

Schelz, C. and S. Budalier. 2000. List of exotic plants for Arches and Canyonlands National Parks and Hovenweep and Natural Bridges National Monument – NPS, SEUG. Natural Bridges National Monument-NPS, SEUG. 3pp.

Schelz, C. and M. Moran. 2002. Vegetation long-term monitoring, Hovenweep National Monument, 2001. SEUG. Moab, UT.

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, VA.

The Nature Conservancy and Environmental Systems Research Institute [TNC and ESRI]. 1994b. NBS/NPS Vegetation Mapping Program: Field Methods for Vegetation Mapping. Prepared for National Biological Survey and National Park Service. Arlington, VA.

The Nature Conservancy [TNC]. 1997. PLOTS database system, Version 1.1. The Nature Conservancy. Arlington, VA.

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 USGS-Biological Resources Division and National Park Service.

Thompson, K. 1993. Alluvial history of Hovenweep – summary of findings in 1992. NPS-SEUG. Moab, UT.

Thornberry-Ehrlich, T. 2004. Hovenweep National Monument Geologic Resource Evaluation Report. Natural Resource Report NPS/NRPC/GRD/NRR—2004/002. National Park Service, Denver, Colorado.

United Nations Educational, Scientific, and Cultural Organization. 1973. International classification and mapping of vegetation. UNESCO, Paris, France.

U.S. Geological Survey [USGS]. 1999. Map accuracy standards. Fact sheet FS-171-99 (November 1999). Web address: http://mac.usgs.gov/mac/isb/pubs/factsheets/fs17199.html.

Welsh, S.L., N.D. Atwood, S. Goodrich and L.C. Higgins. 2003. A Utah Flora. Third Edition, revised. Brigham Young University Print Services, Provo, UT 912 pp.

West, N.E. 1988. Intermountain Deserts, Shrub Steppes, and Woodlands. In North American Terrestrial Vegetation. eds. Barbour, M.G. and W.D. Billings. Cambridge University Press.

Western Regional Climate Center. 2007. Reno, NV. Available online at: http://www.wrcc.dri.edu/weather/nnsc.html. Accessed September 4, 2004

Appendix A

Ecological Systems of Hovenweep National Monument

Introduction

This appendix contains summary descriptions of 11 terrestrial and riparian/wetland ecological system (ES) units (NatureServe 2003b, Comer et al. 2003) occurring at Natural Bridges National Monument. Each ecological system represents one or more National Vegetation Classification (NVC) plant associations (Table 6 within the main report). Map classes were also crosswalked to ES units (Table 9 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 [Temperate Xeric]; Aridic; *Pinus edulis, Juniperus osteosperma*
Concept Summary: This ecological system occurs in dry mountains and foothills of the Colorado Plateau region including the Western Slope of Colorado to the Wasatch Range, south to the Mogollon Rim and east into the northwestern corner of New Mexico. It is typically found at lower elevations ranging from 1,500 m to 2,440 m. These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges. 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 the southern portion of the Colorado Plateau 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 where sympatric.
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 lower elevations ranging from 1,500 m–2,440 m.
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 (Shrub-dominated); 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 most commonly found along dry foothills, lower mountain slopes, and at the edge of the western Great Plains from approximately 2,000 m to 2,900 m in elevation, and are often situated above pinyon-juniper woodlands. Substrates are variable and include soil types ranging from calcareous, heavy, 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 codominant 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 relatively minor component. This ecological system intergrades with the lower montane-foothills shrubland system and shares many 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

CES304.777 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 [Lowland]; Shrubland (Shrub-dominated); 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 broad basins between mountain ranges, plains, and foothills between 1,500 m and 2,300 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 1,500 m to 2,300 m elevation.
Subnations: CA, CO, ID, MT, NV, OR, UT, WA, WY

CES304.762 COLORADO PLATEAU MIXED LOW SAGEBRUSH SHRUBLAND

Division 304 (Inter-Mountain Basins); Shrubland

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Montane [Lower Montane]; Lowland [Foothill]; Shrubland (Shrub-dominated); Ridge/Summit/Upper Slope; Temperate [Temperate Xeric]; Aridic
Concept Summary: This ecological system occurs in the Colorado Plateau, Tavaputs Plateau and Uinta Basin in canyons, gravelly draws, hilltops, and dry flats at elevations generally below 1800 m. Soils are often rocky, shallow, and alkaline. This type extends across northern New Mexico into the southern Great Plains on limestone hills. It includes open shrublands and steppe dominated by Artemisia nova or Artemisia bigelovii sometimes with *Artemisia tridentata* ssp. *wyomingensis* codominant. Semi-arid grasses such as *Achnatherum hymenoides, Aristida purpurea, Bouteloua gracilis, Hesperostipa comata, Pleuraphis jamesii,* or *Poa fendleriana* are often present and may form a graminoid layer with over 25% cover.
Range: Occurs in the Colorado Plateau, Tavaputs Plateau and Uinta Basin in canyons, gravelly draws, hilltops, and dry flats at elevations generally below 1800 m.
Subnations: AZ, CO, NM

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 [Lowland]; Shrubland (Shrub-dominated); Alluvial flat; Alluvial plain; Plain; Alkaline Soil; Saline Substrate Chemistry; Calcareous; Silt Soil Texture; Clay Soil Texture; Xeromorphic Shrub; Dwarf-Shrub; *Atriplex* spp.
Concept Summary: This extensive ecological system includes open-canopied shrublands of typically saline basins, alluvial slopes and plains across the Intermountain western 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 does not codominate. 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*. Various

forbs are also present.
Range: Intermountain western U.S., extending into the southern Great Plains.
Subnations: AZ, CA, CO, ID, MT, NM, NV, OR,

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 [Lowland]; Shrubland (Shrub-dominated); Toeslope/Valley Bottom; Alkaline Soil; Deep Soil; Xeromorphic Shrub
Concept Summary: This ecological system occurs throughout much of the western U.S. in Intermountain basins and extends onto the western Great Plains. It typically occurs near drainages on stream terraces and flats or may form rings around more 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 that tolerates 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,* or *Eleocharis palustris* (where water remains ponded the longest) 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

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

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Unvegetated (<10% vasc.); Upland
Diagnostic Classifiers: Lowland [Lowland]; Badlands; Badland; Alkaline Soil; Shale and Mudstone; Silt Soil Texture; Clay Soil Texture
Concept Summary: This widespread ecological 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 includes substrates derived 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, Lowland]; Herbaceous; Temperate [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 1,450 m to 2,320 m (4,750–7,610 ft) elevation. These grasslands occur in lowland and upland areas and may occupy swales, playas, mesa tops, 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 codominated 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 1,450 m to 2,320 m (4,750–7,610 ft) in elevation.
Subnations: AZ, CA, CO, ID, MT?, NM, NV, OR, UT, WA, WY

CES306.824 SOUTHERN ROCKY MOUNTAIN MONTANE-SUBLAPINE GRASSLAND
Division 306 (Rocky Mountain); Herbaceous

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Herbaceous; Acidic Soil; Mineral: W/ A-Horizon >10 cm; Loam Soil Texture; Silt Soil Texture; Aridic; Short Disturbance Interval; Graminoid; Cool-season bunch grasses
Concept Summary: This Rocky Mountain ecological system typically occurs between 2200 and 3,000 m on flat to rolling plains and parks or on lower sideslopes that are dry, but it may extend

up to 3,350 m on warm aspects. Soils resemble prairie soils in that the A-horizon is dark brown, relatively high in organic matter, slightly acid, and usually well-drained. An occurrence usually consists of a mosaic of two or three plant associations with one of the following dominant bunch grasses: *Danthonia intermedia, Danthonia parryi, Festuca idahoensis, Festuca arizonica, Festuca thurberi, Muhlenbergia filiculmis,* or *Pseudoroegneria spicata*. The subdominants include *Muhlenbergia montana, Bouteloua gracilis,* and *Poa secunda*. These large-patch grasslands are intermixed with matrix stands of spruce-fir, lodgepole, ponderosa pine, and quaking aspen forests. In limited circumstances (e.g., South Park in Colorado), they form the "matrix" of high-elevation plateaus.
Comments: Montane grasslands intergrade with their subalpine counterparts, but are separated here to represent those species that do not occur at higher altitudes.
Range: Occurs between 2,200-3,000 m in the Colorado Rockies.
Subnations: AZ, CO, NM, UT, WY

RIPARIAN, WETLAND, AND MESIC 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: Montane [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 occurs throughout the Rocky Mountain and Colorado Plateau regions between approximately 900 m to 2,800 m. It often occurs as a mosaic of communities that are tree-dominated with a diverse shrub component. This system is dependent on a hydrologic regive of annual to episodic flooding. Occurrences occupy the flood zone of rivers, islands, sand or cobble bars, and stream banks. They can form broad stands on 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, Populus angustifolia, Populus balsamifera, Populus deltoides, Populus 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. *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 m to 2,800 m. It is also found in the island mountain ranges of central and eastern Montana.
Subnations: AZ, CO, ID, MT, NM, NV, OR, SD, UT, WY

Appendix B

Plot and Observation Point Instructions and Data Forms

Introduction

This appendix contains the forms and instruction manuals used in collecting field data for the NCPN Vegetation Mapping Project. Two types of data were collected: vegetation plot and observation point. Vegetation plots were used primarily in developing the NVC classification for the Monument. 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.

Appendix B.1. Plot and Observation Point Field Sampling Manual

Hovenweep National Monument
A Basic Guide for Field Work Modified for the 2003 Field Seasons

This document is intended to give you general instructions and guidelines for conducting your field work at Hovenweep National Monument. Detailed, field-by-field coding conventions for the primary form you'll be completing in the field (the Plot Survey form) are provided in the 'cheat sheet' at the back of this guide. You will also be taking Observation Points on a form reduced from and similar to the Plot Survey form.

OVERVIEW

The data that you collect this year will be used to create a relatively fine-scale delineation of vegetation pattern in this Northern Colorado Plateau Network (NCPN) park and its environs. The range of habitats and the corresponding diversity of vegetation types, found in this park are complex. The understanding of finer-scale, ecologically distinct vegetation types that you will help create may be used by the park to plan appropriate management activities, monitor the results of these activities, track long-term changes in vegetation, direct searches for rare species, model fire behavior, and portray the wealth of natural diversity on park lands to the public.

Establishing a field sampling strategy that captures sufficient data on all the distinct vegetation types in Hovenweep National Monument, an area that is somewhat diverse and rugged, is a challenge. To make the sampling as efficient as possible, the key environmental variables thought to be driving vegetation pattern were identified. These included factors such as geology, soils, aspect, elevation, and land use/fire history (see TNC 1998).

Plot location will be guided by aerial photographs, geology maps, and topographic maps, with the goal of adequately sampling the vegetation. A classification based on this sampling will result in interpretation of aerial photos to produce a vegetation map. A combination of manual and electronic delineation and digitizing approaches will be used for Hovenweep National Monument to delineate polygons and label the vegetation types. The vegetation "types" the photointerpreters will choose to name their polygons are those included in the preliminary classification of the parks vegetation created using the U.S. National Vegetation Classification System (Grossman et al. 1998).

The field crew will evaluate the field data, assign a preliminary vegetation type based on a list of potential vegetation types developed from the existing literature, and update the tally of vegetation types by number of plots still needed. The goal is to use your time as efficiently as possible: we are trying our best to avoid oversampling of some types and undersampling of others. Deciding where to sample to capture the full range of diversity throughout the Monument is an iterative process.

GETTING THERE

You will have a copy of the 1:12,000-scale aerial photography to guide you. You and your partner will navigate towards each selected photo-signature using your Monument road and trail

map, USGS 7.5 mm. topographic map, the photo, and/or GPS receiver.

Before you leave…check that you have all the materials needed to complete your field work (Please see the checklist and 'considerations for mission planning" at the end of this document to help you).

Every single morning…check your GPS receiver to make sure it is set to NAD 83.

Along the way...look around. The goal of this field work is to sample all the different vegetation types that occur in Hovenweep National Monument. If, on the way to one vegetation type, you see an assemblage of plants that seems unique and that is not included on the list of vegetation types, please sample if time allows. In this Monument, these undescribed vegetation types are more likely various pinyon – juniper woodland understories, riparian woodlands, or shrublands. You will be better able to recognize these undescribed vegetation types as the season progresses and you become more familiar with the vegetation types and how they can look on the ground.

ONCE THERE

Establishing a Plot

1) Figure out where to place your plot. This 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 signature as a whole. Avoid areas where the vegetation appears to be transitioning from one type to another (ecotones) and areas with anomalous or heterogeneous structure or species composition. Look at *all* the vegetation strata to determine if the area is structurally and floristically uniform and generally try to place your plots at least 30 m from what you see as the 'boundary' between this vegetation type and any neighboring, distinctly different types. During the training period this step will be emphasized and discussed in detail. However, the rule-of-thumb is to conduct a reconnaissance of the plot area if time and topography allows.

Note: In cases where a signature is very heterogeneous, more than one plot or a plot and observation points may be needed. Again, look around, use that human perception.

2) Using your GPS (Global Positioning System) receiver, record the UTM (Universal Transverse Mercator) coordinates in the center of the plot under the Field UTM X and Field UTM Y on the field form. Also mark and label the location of the plot on a USGS 7.5 min. topographic map and/or on an aerial photo. If you cannot obtain UTM coordinates, estimate them from the USGS topographic map and note on the form that you had to resort to this method. Plots may be circular, rectangular or square. Note shape and dimensions on the field form. If the plot is rectangular or square, record the azimuth of the long side (any side if square) to help relocate the plot. It may make more sense to establish rectangular plots in linear vegetation types (e.g. riparian or ridgeline types). Standard plot sizes should be as follows:

If you're in a ...	**You should usually make your plot…**	**Giving you a plot area of…**
Forest (trees have overlapping crowns usually forming 60-100% cover)	11.3 m radius OR 20 m x 20 m	400 m^2 400 m^2

Woodland (open stands of trees with crowns usually not touching. Canopy tree cover is 25-60% OR exceeds shrub, dwarf-shrub, herb, & nonvascular cover).	11.3 m radius OR 20 m x 20 m	400 m^2 400 m^2
Shrubland (shrubs greater than 0.5 m tall are dominant, usually forming more than 25% cover OR exceeding tree, dwarf shrub, herb, & nonvascular cover)	11.3 m radius OR 20 m x 20 m	400 m^2 400 m^2
Dwarf-shrubland (shrubs less than 0.5 m tall are dominant, usually forming more than 25% cover OR exceeding tree, shrub, herb, & nonvascular cover).	5.65 m radius OR 10 m x 10 m	100 m^2 100 m^2
Herbaceous herbs dominant, usually forming more than 25 percent cover OR exceeding tree, shrub, dwarf-shrub, & nonvascular cover).	5.65 m radius OR 10 m x 10 m	100 m^2 100 m^2
Nonvascular (lichen or moss cover dominant, usually more than 25% cover).	2.82 m radius OR 5 m x *5* m	25 m^2 25 m^2

Note: You can deviate from the standard plot shapes where that makes sense, but the total plot *area* encompassed by the boundaries should be as listed above for each class of vegetation. For example, forested riparian vegetation may be sampled in a 10 x 40 m (400 m2) plot; herbaceous riparian or ridgeline vegetation in a 2 x 50 m (100m2) plot. You may also increase the size of the plot to the next standard size if necessary to sample the heterogeneity of the vegetation. Forests, woodlands and shrublands can be increased to 1000 m2. Please make a note on plot form.

3) Once the plot is established, it is generally a good time to fill out the **Identifiers/Locators** part of your Plot Survey Form (see the cheat sheet) and take the plot photos.

Taking photographs
Two photos will be taken of each plot using slide film. The purpose is to obtain a good representation of the vegetation of the plot. A chalk board or small dry erase board should be placed in the plot, with the plot number recorded on it, so that the photo includes the plot number. Preprinted plot numbers could be printed or copied onto colored paper (white has such strong contrast as to be unreadable in the photo) and attached to the back of a clipboard. This saves having to write plot numbers in the field. Take the photograph looking across the contour if the slope is steep. Record roll #, frame # and azimuth on plot form.

Data Collection
Environmental Description
See the coding instructions at the end of this document for guidance on the specific fields.

Vegetation Description
For guidance on the specific fields on the second page of the form, see the coding instructions.

As you begin to collect the species, DBH (diameter at breast height – 4.5’), and cover information, keep these rules in mind they will speed your data collection considerably:

1) Except in very diverse plots, don't spend more than **20 minutes** looking for new and different species to record. Remember that these plot data are to be used to classify the overall vegetation of the Monument, not to make a complete species list for it. And 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. For diverse plots with over 25 taxa you may take up to 30 minutes on the listing process.

2) If you can't identify a plant to species, record it on your form as "unknown species 1,' "unknown species 2,' "*Carex* unknown sp. I", etc. Record associated cover class and other data for the unknown as you would for any other species. Then do one of two things:

If you need the species identified right away because it appears to be dominant or diagnostic (you're seeing it all over the place or you're seeing much more in this particular vegetation type than in others), take a sample of the species with as much of the plant as possible, especially intact sexual parts (flowers and fruits), if present. Place the sample in a baggie, and label the baggie (or specimen) with the plot code and the name you gave it on the data form.

If you don't need the plant keyed right away, press it. Mark the pressed specimen with the plot code and the name you gave it on the data form.

Store specimens in a cool, dry place. Bagged specimens will keep fresh longer in the refrigerator or ice chest until pressed or identified. You can key some of these out yourself if you want to, but don't let plant keying get in the way of your primary responsibility: field data *collection*. No one expects you to identify every plant but you should make an effort to learn at least the common species that keep recurring in plots. A quick prioritization of what to key and what to press may be made based on the recurrence of the species in samples and on the cover-class estimate of the species in a particular plot. If the species has a high cover value (>1%) it is more of a priority to identify. Field crews should mark the specimen tag with its cover class estimate as well as its unique identifying number for the vegetation sample.

Observation Point Form

When you have sampled one particular vegetation type thoroughly, but want to further define its distribution or when you encounter small but unique vegetation patches that are below the minimum mapping unit in size (<1.5 ha), record the site on an Observation Point form. This is an abbreviated Plot Survey form and usually takes about 15 minutes to fill in the data. The major difference is that an Observation Point is unbounded and includes an area roughly equal to that of the minimum mapping unit (20 m radius around the observer) or it encompasses the entirety of a small but unique vegetation patch. The data fields are the same as those on the Plot Survey form, so use the above instructions. Minor differences in the Observation Point form from the Plot Survey form include the elimination of some data fields, more general cover classes for ground cover estimates, and only the dominant or diagnostic species are recorded. Also, only one photograph is taken to record the Observation Point plant community.

We hope your field season on the northern Colorado Plateau enjoyable and rewarding. Good luck!

LITERATURE CITED

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. The Nature Conservancy [TNC]. 1998. An environmentally-driven approach to vegetation sampling and mapping at Yosemite National Park. Report prepared for the U.S. Department of the Interior, National Biological Survey and National Park Service. The Nature Conservancy, Arlington, Virginia.

INSTRUCTIONS FOR FILLING OUT PLOT AND OBSERVATION POINT SURVEY FORMS

PLOT DESCRIPTION

Plot Code

Code indicating the specific plot within the vegetation polygon. For the 2003 field season, the codes will be in the following format "PARK ACRONYM.XXX" (i.e., Hovenweep National Monument = "HOVE.XXX"). Begin with HOVE.00l and go from there. If another team is working, decide with them which plot numbers each team will use to identify the data they gather. For example, if a second team is working one week at Hovenweep National Monument and approximately 100 plots have already been collected, they may number their plots HOVE.125 through HOVE.150.

Provisional Community Name

Using the provisional classification of the parks with which you've been provided, assign the name of the vegetation type that most closely resembles this type. Enter the finest level of the classification possible. In fact, none of the names may be a good fit; you may have found a new type. If that is the case, create a provisional name with the dominant and diagnostic species. The 'provisional community name' that is assigned will be used to update the tally of types x number of plots needed.

State UT

Park Name HOVE

Park Site Name

Provisional name assigned by field worker that describes where the data were collected. It should represent an identifiable feature on a topographic or park map.

Quad Name

Appropriate name/scale from survey map used; use 7.5-minute quadrangle if possible.

Quad Code

Code of quadrangle map.

Field UTM X

Use a GPS receiver, but if you can't locate the coordinates by this method, estimate coordinates from a topographic map and note on the form that this method was used.

Field UTM Y

Use a GPS receiver, but if you can't locate the coordinates by this method, estimate coordinates from a topographic map and note on the form that this method was used.

GPS Receiver Error

Note the locational error from the GPS receiver.

Survey Date
Date the survey was taken; year, month, day.

Surveyors
Names of surveyors, with principal surveyor (usually the Lead Ecologist) listed first.

Directions to Plot
Precise directions to the site using a landmark (e.g., a named point on the topographic map, a major highway, using park naming conventions for roads) readily locatable on a 7.5 minute topographic or park 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 as closely as possible to the 0.1 mile and use compass directions. Give additional directions to the plot within the site. Do not take more than a couple of minutes to fill this out.

Plot Length and Plot Width
Enter diameter for circular plots and width and length dimensions for square or rectangular plots. Choose the appropriate plot size based on the following:

Vegetation Class	Standard Plot Dimensions	PLOT AREA
Forest	11.3 m radius or 20 m x 20 m	400 m^2
Woodland	11.3 m radius or 20 m x 20 m	400 m^2
Shrubland	11.3 m radius or 20 m x 20 m	400 m^2
Dwarf-shrubland	5.65 m radius or 10 m x 10m	100 m^2
Herbaceous	5.65 m radius or 10 m x 10 m	100 m^2
Nonvascular	2.82 m radius or 5 m x 5 m	25 m^2

Plot Photos / Roll Number/Frame Numbers
Indicate (Y or N) if photos of the plot were taken at the time of sampling, and their roll and frame numbers. Also record azimuth of the photograph if not taken in the standard direction.

Plot Permanent (if/when applicable)
Check off that the plot has been permanently marked.

Plot Representativeness
Does this plot represent the full variability of the photo signature? If not, were additional plots taken? Note additional species not seen in the plot in the space provided below. Note: we distinguish in this section the plot's ability to represent the stand or polygon you are sampling as one component and the ability of this sample to represent the range of variability of the association in the entire mapping area. The former comment may be ascertained by reconnaissance of the stand. The latter comment comes only after some familiarity with the vegetation type throughout the mapping area and may be left blank.

ENVIRONMENTAL DESCRIPTION
Elevation
Elevation of the plot. Specify whether in feet or meters. In general, we have determined that the

reading you obtain from a topographic map, provided you are certain where you are, is more accurate than the average reading from the GPS receiver. Thus, please attempt to estimate your elevation with the topographic map.

Slope
Measure the slope in degrees using a clinometer.

Aspect
Measure the slope aspect using a compass (be sure to correct for the magnetic declination). Note: all compasses should be pre-set to an average declination for the park and thus, readings from the compasses carried by the field crews may be directly noted.

Topographic Position
Topographic position of the plot. Choose one:

INTERFLUVE (crest, summit, ridge). Linear top of ridge, hill, or mountain; the elevated area between two fluves (drainageways) that sheds water to the drainageways.

HIGH SLOPE (shoulder slope, upper slope, convex creep slope). Geomorphic component that forms 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). Level top of a plateau.

MIDSLOPE (transportational midslope, middle slope). Intermediate slope position.

BACKSLOPE (dipslope). Midslopes that are steep, linear, and may include cliff segments.

STEP IN SLOPE (ledge, terracette). Level shelf interrupting a steep slope, rock wall, or cliff face.

LOWSLOPE (lower slope, foot slope, colluvial footslope). Gently inclined surface at the base of a slope. Surface profile is usually concave and transitions between midslope and toeslope.

TOESLOPE (alluvial toeslope). Outermost gently inclined surface at base of a slope. In profile, commonly gentle and linear and characterized by alluvial deposition.

LOW LEVEL (terrace). Valley floor or shoreline representing the former position of an alluvial plain, lake, or shore.

CHANNEL WALL (bank). Sloping side of a channel.

CHANNEL BED (narrow valley bottom, gully, arroyo, wash). Bed of single or braided watercourse commonly barren of vegetation and formed of modern alluvium.

BASIN FLOOR (depression). Nearly level to gently sloping, bottom surface of a basin.

Landform

Enter the landform that describes the site where the plot was taken. Note on the code sheet the landform choices are listed at different scales. Thus, one can select more than one for plot if appropriate (e.g., mountain could be macro and ridge could be meso scale). You can develop your own list for HOVE. Please be consistent so we can analyze by landform.

arroyo	lowland
alluvial fan	mid slope
alluvial flat	mountain
alluvial terrace	lake
bajada	mud flat
bank	piedmont
basin	plain
bench	plateau
butte	ravine
channel	ridge
cinder cone	rim
cliff	rock fall avalanche
colluvial slope	saddle
debris slide	seep
depression	shoreline
drainage	slide
drainage channel (undifferentiated)	slope
dune (undifferentiated)	slough
escarpment	soil creep slope
flood plain	stream terrace (undifferentiated)
foothills	streambed
gap	swale
gorge	talus
hills	toe slope
hogback	valley floor
interfluve	wash

Surficial Geology

Note the geologic substrate influencing the plant community (bedrock or surficial materials). Accurately recording the geology at the plot is especially important if the plot is on an inclusion in the type on the geology map. The list below provides types from the HOVE geology map.

Hovenweep National Monument Geology Map Units

- Quaternary Alluvium
- Eolian Sand
- Morrison Formation
- Burro Canyon Formation

- Dakota Sandstone

Cowardin System
If the system is a wetland, check off the name of the USFWS system which best describes its hydrology and landform. Indicate "upland" if the system is not a wetland.

Assess the hydrologic regime of the plot using the descriptions below (from Cowardin et al. 1979).

SEMIPERMANENTLY FLOODED - Surface water persists throughout growing season except during periods of drought. Land surface is normally saturated when water level drops below soil surface. Includes Cowardin's Intermittently Exposed and Semipermanently Flooded modifiers.

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. Includes Cowardin's Seasonal, Seasonal-Saturated, and Seasonal-Well Drained modifiers.

SATURATED - Surface water is seldom present, but substrate is saturated to surface for extended periods during the growing season. Equivalent to Cowardin's Saturated modifier.

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. Equivalent to Cowardin's Temporary modifier.

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. Equivalent to Cowardin's Intermittently Flooded modifier.

PERMANENTLY FLOODED - Water covers the land surface at all times of the year in all years. Equivalent to Cowardin's "permanently flooded."

UNKNOWN - The water regime of the area is unclear. The unit is described as a non-tidal wetland.

Environmental Comments
Enter any additional noteworthy comments on the environmental setting. This field can be used to describe site history such as fire events (date since last fire or evidence of severity) as well as other disturbance or reproduction factors.

Unvegetated Surface

Estimate the approximate percentage of the *total* surface area covered by each category. Only include categories with over 5 percent cover.

Soil Texture

Using the key below, assess average soil texture.

Simplified Key to Soil Texture (Brewer and McCann 1982)

Al Soil does not remain in a ball when squeezed ..... sand
A2 Soil remains in a ball when squeezed.....B

Bl Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you push up over your finger.
Soil makes no ribbon ..... loamy sand
B2 Soil makes a ribbon; may be very short.....C

C1 Ribbon extends less than 1 inch before breaking.....D
C2 Ribbon extends 1 inch or more before breaking..... E

D1 Add excess water to small amount of soil
Soil feels at least slightly gritty.....loam or sandy loam
D2 Soil feels smooth.....silt loam

E1 Soil makes a ribbon that breaks when 1 to 2 inches long;
Cracks if bent into a ring..... F
E2 Soil makes a ribbon 2+ inches long; does not crack when bent into a ring.....G

Fl Add excess water to small amount of soil;
Soil feels at least slightly gritty.....sandy clay loam or clay loam
F2 Soil feels smooth.....silty clay loam or silt

G1 Add excess water to a small amount of soil;
Soil feels at least slightly gritty..... sandy clay or clay
G2 Soil feels smooth.....silty clay

Soil Drainage

The soil drainage classes are defined in terms of (l) 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. We recognize that 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 be used as criteria of moisture status. We also know that soil profile morphology, such as mottling, normally but not always reflects soil moisture status; however, it should not be the overriding criterion. Soil drainage classes cannot be based solely on the presence or absence of mottling. Topographic position and vegetation as well as soil morphology are useful field criteria for assessing soil moisture status.

RAPIDLY DRAINED - The soil moisture content seldom exceeds field capacity in any horizon except immediately after water addition. Soils are free from any evidence of gleying throughout the profile. Rapidly drained soils are commonly coarse textured or soils on steep slopes.

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.

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.

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 Ac horizon, if present, may be mottled. The matrix generally has a lower chroma than in the well-drained soil on similar parent material.

POORLY DRA1NED - 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

Leaf Phenology

Select the value which best describes the leaf phenology of the dominant stratum. The dominant stratum is the uppermost stratum that contains at least 10% cover.

EVERGREEN - Greater than 75% of the total woody cover is never without green foliage.

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 generally contribute 25-75% of the total woody cover. Evergreen and cold-deciduous species admixed.

PERENNIAL - Herbaceous vegetation composed of more than 50% perennial species.

ANNUAL - Herbaceous vegetation composed of more than 50% annual species.

Leaf Type
Select one value which best describes the leaf form of the dominant stratum. The dominant stratum is the uppermost stratum that contains at least 10% cover.

BROAD-LEAVED - Woody vegetation primarily broad-leaved (generally contributes greater than 50% of the total woody cover).

NEEDLE-LEAVED - Woody vegetation primarily needle-leaved (generally contributes greater than 50%cover).

MICROPHYLLOUS - Woody cover primarily microphyllous.

GRAMINOID - Herbaceous vegetation composed of more than 50% graminoid species.

FORB (BROAD-LEAF-HERBACEOUS) - Herbaceous vegetation composed of more than 50% broad-leaf forb species.

PTERIDOPHYTE - Herbaceous vegetation composed of more than 50%species with frond or frond-like leaves.

Physiognomic Class Choose one:

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 10% cover, trees generally less than 10% cover). Shrub cover may be less than 10% where it exceeds tree, dwarf-shrub, herb, and nonvascular cover, respectively. Vegetation dominated by woody vines is generally treated in this class.

Dwarf-shrubland: Low-growing shrubs usually under 0.5 m tall. Individuals or clumps overlapping to not touching (generally forming more than 10% cover, trees and tall shrubs generally less than 10% cover). Dwarf-shrub cover may be less than 10% where it exceeds tree, shrub, herb, and nonvascular cover, respectively

Herbaceous: Herbs (graminoids, forbs, and ferns) dominant (generally forming at least 10% cover; trees, shrubs, and dwarf-shrubs generally with less than 10% cover). Herb cover may be less than 10% 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 cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and herb cover, respectively.

Sparse Vegetation: Abiotic substrate features dominant. Vegetation is scattered to nearly absent and generally restricted to areas of concentrated resources (total vegetation cover is typically less than 10% and greater than 0%).

Strata/Lifeform, Height, Cover, Diagnostic Species
Visually divide the community into vegetation layers (strata). Indicate the average height class of the stratum in the first column, using the Height Scale on the form. Enter the average percent cover class of the whole stratum in the second column, using the Cover Scale on the form. Height and Cover classes are also listed below.

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.

Herbaceous layers are: Ht = total, H1 = Graminoids (grass, sedge, rush), H2 = Forbs (Dicot herbaceous), H3 = Ferns and Fern allies, and H4 = tree seedlings. List the dominant species in each stratum. If a species present is known to be diagnostic of a particular vegetation type, list these as well, marking them with an asterisk.

Cover Scale for Strata		**Height Scale for Strata**	
T	<1%	01	<0.5 m
P	1-5%	02	0.5-1 m
1	5-15%	03	l-2 m
2	15-25%	04	2-5 m
3	25-35%	05	5-10 m
4	35-45%	06	l0-l5 m
5	45-55%	07	15-20 m
6	55-65%	08	20-35 m
7	65-75%	09	35-50 m
8	75-85%	10	>50 m
9	85-95%		
10	95+		

Animal Use Evidence
Comment on any evidence of use of the plot/polygon by non-domestic animals (i.e., tracks, scat, gopher mounds, etc.). Notes on domestic animals should be made in the field below.

Natural and Anthropogenic
Disturbance Comment on any evidence of natural or anthropogenic disturbance and specify the source.

Other Comments

Any other comments.

Species/DBH/Percent Cover Table

Starting with the uppermost stratum, list all the species present and cover class (using the 12 point scale) and percent cover of each species in that particular stratum. Indicate strata in the left-hand columns. If in the tree layer (single-stemmed woody plants, generally 5m in height or greater at maturity), note in the "T" column if Tl (emergent tree), T2 (tree canopy), or T3 (tree sub-canopy). If in the shrub layer, note in the "5', column if S1 (tall shrub, > 2m), S2 (short shrub, < 2m), or S3 (dwarf-shrub, < 0.5m). If in the ground layer, note in the "G" column if H1 (herbaceous - graminoid), H2 (herbaceous - forb), H3 (herbaceous - fern), H4 (tree seedlings) N (nonvascular other than ferns), V (vine/liana), or F (epiphyte).

*For plots with trees, estimate cover of seedlings, saplings, mature (all others), and total cover for each tree species. Use a separate line for each and assign the most appropriate strata class (by height). Seedlings are generally less than 1.5 m, but that may vary by species.

Also record the DBH (in cm) of all trees above 5 cm diameter. Separate the measurements with a comma. For plots with very high tree density DBH measurements will be conducted using a subplot. If the number of trees with a DBH greater than 5 cm is more than about 25, divide the plot into quarters and measure the DBH of trees in the southeast quadrant, or the quadrant nearest southeast. CLEARLY NOTE on the form that this is what you've done.

HOVENWEEP NATIONAL MONUMENT – 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
dike
dip
ditch
divide
dome
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
oxbow
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 alluvium
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 ATTACHED DIAGRAM

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)

Hanging Gardens
Invasive tamarisk

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

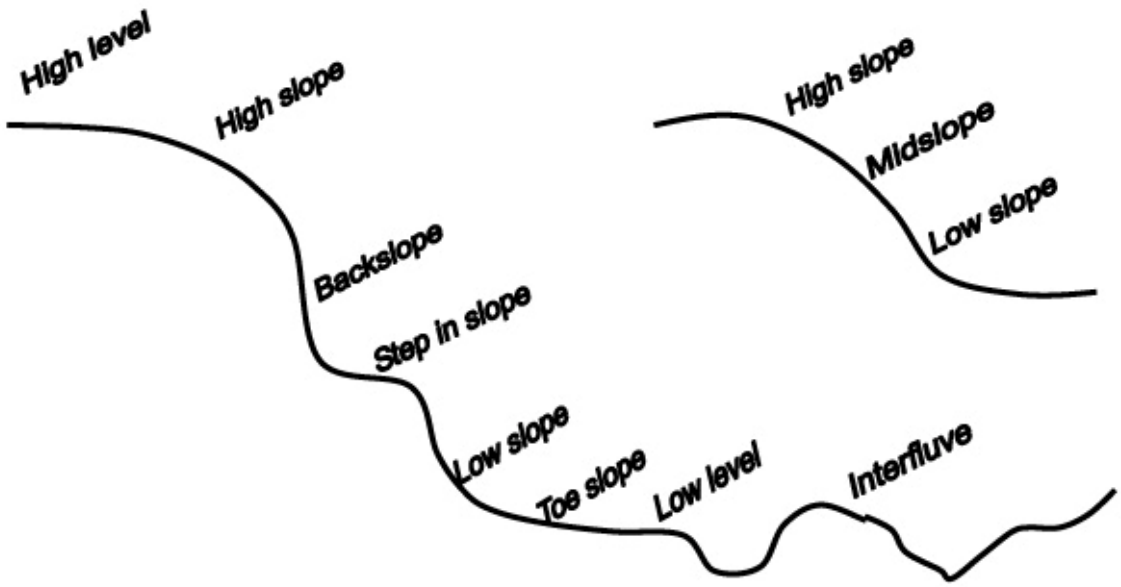
SURFICIAL GEOLOGY

Obscured by soil
Quaternary Alluvium
Eolian Sands
Morrison Formation
Burro Canyon Formation
Dakota Formation

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

TOPOGRAPHIC POSITION - CHEAT SHEET



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? 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:
   a. Plan travel based on topography, best access routes, density and complexity of vegetation
   b. 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. File observation points separately.
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 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?

Materials Checklist

- Monument research permit
- Topo maps
- Monument and BLM maps for general navigation
- DOQQ photos of AA point locations
- Geology map
- Compass with adjustable declination
- Clinometer
- GPS receiver
- 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 point)
- Baggies for temporary storage of unknown plants, and masking tape for labeling
- Plant press & paper
- Plant Keys / Flora(s)
- Pencils / sharpies
- Forms: plot 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
- 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.)

APPENDIX A: Landform Glossary
(from http://soils.usda.gov/technical/handbook/contents/part629glossary1.html)

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

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. Compare - colluvium, slope alluvium.

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 short-lived torrent after heavy rain within the watershed. Where arroyos intersect zones of ground-water discharge, they are more properly classed as intermittent stream channels.

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. Compare - summit, shoulder, footslope, toeslope.

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.

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. A generic term for any of various elongate offshore ridges, banks, or mounds of sand, gravel, or other unconsolidated material submerged at least at high tide, and built up by the action of waves or currents, especially at the mouth of a river or estuary, or at a slight distance offshore from the beach.

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.

bench - (not preferred) refer to structural bench.

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 ofa 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. Compare - meandering channel, flood-plain landforms.

break - (slopes) An abrupt change or inflection in a slope or profile. Compare - knickpoint, shoulder, escarpment. (geomorphology) A marked variation of topography, or a tract of land distinct from adjacent land, or an irregular or rough piece of ground. Compare - breaks.

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 relatively steep slopes and talus or precipitous 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. Compare - gorge, box canyon, slot canyon.

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 relatively 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. Compare - bluff.

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. Compare - alluvium, slope alluvium, scree, talus, mass movement.

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*.

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. Compare - rock fall, soil fall, landslide.

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. Compare - blowout.

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 (e.g. a sinkhole). An open depression has a natural outlet for surface drainage. Compare - closed depression, open depression.

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. Compare - erosion pavement, stone line.

ditch - An open and usually unpaved (unlined), channel or trench excavated to convey water for drainage (removal) or irrigation (addition) 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. Compare – interfluve.

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.

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. Compare - loess, parna, beach sands.

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

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. Compare - arroyo, intermittent stream, perennial stream.

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.

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.

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 (not preferred – use alluvial fan). Compare - alluvial fan, alluvial cone. (b) A fan-shaped mass of congealed lava that formed on a steep slope by the continually changing direction of flow.

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.

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.

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). Compare - summit, shoulder, backslope, and toeslope.

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

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. General synonym - ravine. Compare - arroyo, draw, gully, wash.

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). Compare - rill, ravine, arroyo, swale, draw.

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. Compare - side slope, nose slope, free face, interfluve, crest, base slope.

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 dependent on local convention.

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. Compare - mountain slope.

hoodoo - A bizarrely shaped 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.

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.

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. GG

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. Compare - divide.

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. Compare - ephemeral stream.

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 or projection 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. Compare - structural bench.

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

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. Compare - meander belt, point bar. (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..

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. Compare - closed basin.

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.

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. Compare - Ephemeral stream, Intermittent 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. Compare - lowland, plateau.

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 large part of a plateau surface is near summit level.

point bar - One of a series of low, arcuate ridges of sand and gravel developed on the inside of a growing meander by the slow addition of individual accretions accompanying 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. Compare - salt pond.

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. Compare - arroyo, draw, gully.

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.

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. Compare - debris fall, soil fall, landslide.

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. 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). Compare - rotational debris slide, rotational earth slide, rotational rock slide, translational slide, lateral spread, landslide.

rubble - An accumulation of loose angular rock fragments, commonly overlying outcropping rock; the unconsolidated equivalent of a breccia. Compare - scree, talus.

saddle - A low point on a ridge or interfluve, generally a divide (pass, col) between the heads of streams flowing in opposite directions. Compare - summit, crest.

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

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. Compare - escarpment.

scarp slope - The relatively steeper face of a cuesta, facing in a direction opposite to the dip of the strata. Compare - dip slope.

scree - A collective term for an accumulation of coarse rock debris or a sheet of coarse debris mantling a slope. Scree is not a synonym of talus, as scree includes loose, coarse fragment material on slopes without cliffs. Compare - talus, colluvium, mass movement.

scree slope - A portion of a hillside or mountainslope mantled by scree and lacking an up-slope 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. Compare - summit, crest, backslope, footslope, and toeslope.

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. Compare - head slope, nose slope, free face, interfluve, crest, base slope. 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. Compare -fall, topple, lateral spread, flow, complex landslide. (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.

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. Compare - colluvium, slope wash.

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. Compare - river.

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 produced during a former state of fluvial erosion or deposition (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. Compare - alluvial terrace, flood-plain step, strath terrace, terrace.

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. Compare - pediment, ledge; see scarp.

summit - (a) The topographically highest position of a hillslope profile with a nearly level (planar or only slightly convex) surface. Compare - shoulder, backslope, footslope, and toeslope, crest. (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; Compare - swell-and-swale topography. (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.

tableland - A term for a broad upland with an extensive, nearly level or undulating summit area and steep side slopes descending to surrounding lowlands. Compare - plateau, mesa, cuesta.

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. Compare - alluvial cone, beveled base, talus slope.

talus slope - a portion of a hillslope or mountainslope mantled by talus and lying below a rockfall source (e.g. cliff). Compare - scree slope, scree, talus. Compare - beveled base.

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 base 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. Compare - summit, shoulder, backslope, footslope, valley floor.

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. Compare - rotational slide, slide, landslide.

valley - An elongate, relatively large, externally drained depression of the Earth's surface that is primarily developed by stream erosion or glacial activity. Compare - basin.

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. Compare - flood-plain landforms, meander, braided channel, valley side.

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. Synonym - arroyo. Compare - gully.

Appendix B.2. Example of a Vegetation Plot Data Form

NATIONAL PARK VEGETATION MAPPING PROGRAM: PLOT SURVEY FORM
IDENTIFIERS/LOCATORS

9 of 39

Plot Code HOVE 004 BPU Code

Provisional Community Name Pinyon Pine – Utah Juniper Woodland

State UT/(CO) Park Name HOVENWEEP NM Park Site Name Cutthroat

Quad Code

Quad Name Negro Canyon Quad Code Aerial Photo # 11-55

GPS file name Field UTM X 6 7 8 3 6 9 m E Field UTM Y 4 1 4 5 9 9 9 m N
DATUM NAD83 UTM Zone: 12 S Error +/- 4.2 m 3D Differential? Y/(N)
Comments/GPS device used:
Garman Map 12 J.V.L's

Survey Date 4/28/03 Surveyors Jim/Sarah

Directions to Plot
~250 m W of parking circle
~75 m S of N boundary fence

Plot Permanent: NO

Plot length(m)____ Azimuth ____ Plot Photos (y/n) __ Roll # 1 J.V. Frame # 10+11

Plot width(m)____ Diameter if circle 22.6 m Digital camera frame # ____

Photo Comments: Cryptogamic Soils Photos (y/n) __ Roll # ____ Frame # ____

Digital camera frame # ____

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: Fair – b/c it includes Mt. Mahogany lower on slope are Utah Service berry

ENVIRONMENTAL DESCRIPTION 1714 m

Elevation: 5820 ft / m (circle one) Slope: 11 deg. Aspect: 240 deg.

Topographic Position (see cheat sheet) Upper Slope, Canyon

Landform (see cheat sheet) Small Canyon

Surficial Geology (see cheat sheet/map) Morrison Formation

Cowardin System		Hydrology		
X Upland	__ Palustrine	__ Permanently Flooded	__ Unknown	
__ Riverine	__ Lacustrine	__ Semipermanently Flooded	__ Seasonally Flooded	__ Temporarily Flooded
			__ Saturated	__ Intermittently Flooded

Environmental Comments (factors controlling community/plant distribution, seral stage, fire history etc):
- broken bedrock → 1/2 plot
- rapid runoff
- soil build up on lower end of plot
- exposure supports more Pinyon Pine than Juniper Pine

Ground Cover: *(please estimate to the nearest percentage. Sum = 100%)*

6	Bare soil	12	Large rocks (>10 cm)
3	Bedrock	2	Lichen
6	Sand (0.1-2 mm) dune /alluvium	2	Wood (>1 cm)
0	Moss	55	Small rocks (0.2-10 cm)
0	Other (describe):	0	Water
16	Litter / duff	4	Cryptogam

Soil Texture (see cheat sheet):
__ sand __ loamy sand __ sandy loam __ loam
__ silt loam __ silt X clay loam __ silty clay
__ sandy clay __ clay __ peat __ muck

Soil Drainage:
__ Rapidly drained X 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 __Cold-deciduous __Mixed evergreen-cold-deciduous Herbs __Annual __Perennial	__Broad-leaved ✓ Needle-leaved __Microphyllous __Graminoid __Forb __Pteridophyte __Non-vascular __Mixed (describe)	__Forest ✓ Woodland __Shrubland __Dwarf Shrubland __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	4	*Pin Edu, *Jun Ost,
T3 Sub-canopy			
S1 Tall shrub	03	1	*Cer Mon,
S2 Short Shrub	02	P	*Eph Vir, Jun Ost, Ame UTA, [illegible] Eri Nau
S3 Dwarf-shrub	01	P	Gut Sar, Yuc Ang, Sce whi, Gut Mic, Opo Eri
Ht Herbaceous			
H1 Graminoids	01	T	Ory Hym
H2 Forbs	01	P	Cyn New, Hym Aca, Het Vil, Are Fen
H3 Ferns			
H4 Tree seedlings			
N Non-vascular	01	P	Cryptogamic Crusts
V Vine/liana			
E Epiphyte			

Animal Use Evidence (including scat, browse, burrows, bedding sites, etc)
Elk tracks & scat

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)
rapid run-off caused by slope of plot

Other Comments/Continuation from previous sections. **Describe surrounding communities and how they relate to the plot.**

Plot Code: HOVE. 004

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, and 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	Pinedu (Pinus edulis)	3	H1	Oryhym	T		Achnatherum hymenoides		
	Junost (Juniperus osteosperma)	1							
S1	Cermon (Cercocarpus montanus)	1							T1=
									T2= 38
									T3=
			H2	Cymnow	T		Cymopterus newberryi		S1= 7
S2	Ephvir (ephedra viridis)	P		Hymaca	T		Hymenopappus newberryi		S2= 4
	Junost (Juniperus osteosperma)	T		Hetvil	T		Nothocalais silicola		S3= 2
	Amelnta (Amelanchier utahensis)	P		Arefen	T		Arenaria fendleri		H1= 1
	Chanau Eri Wan	P							H2= 2
	Erigeronera (Erigeron neomexicanus)								H3=
									H4=
									N= 4
S3	Gutsar (Gutierrezia sarothrae)	T							V=
	Yucang (Yucca angustissima)	T							E=
	Schwilt (Schoenocrambe utahensis)	T							
	Gutmic (Gutierrezia microcephala)	T							
	Opuspe (Opuntia species)	T	N	Cryptogamic crusts	P				
	Echtri (Echinocereus triglochidiatus)	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: HOVE .004 Units in (cm) or inches (circle one) Subplot? (Y/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(s) for multi-stemmed trees	Avg
JUN OST	15.4	
"	15.6	
"	13.6, 17.3	15.45
"	28.8 (base)	
"	12.2	
"	20.4, 12.2, 19.3	17.3
"	23.7	
"	16.3	
"	22.6, 17.2	19.9
"	29.9 (base)	

Species	DBH(s) for multi-stemmed trees	
PIN EDU	15.1	
"	8.4, 11.3	9.85
"	12.6, 10.3	11.45
"	20.4	
"	11.9 (base)	
"	24.3	
"	8.3	
"	13.8	
"	19.8	
"	27.6	

Pinyon-juniper age classes (check one)

___Not PJ
___Old-growth (>500 years old)
✓ Mature (350-500 years old, shrub layer absent)
___Young (100-350 years old)
___Invasive (<80 years old)

Appendix B.3. Example of a Vegetation Plot Data Form

NATIONAL PARK VEGETATION MAPPING PROGRAM: OBSERVATION POINT FORM

IDENTIFIERS/LOCATORS 25 of 59

Plot Code: HOVE ~~020~~ 9020 **Polygon Code:** N/A

Provisional Community Name: Sarcobatus vermiculatus shrubland

State: UT/CO **Park Name:** Hovenweep National Monument **Park Site Name:** Square Tower

Quad Name: **Quad Code:**

GPS File Name: HO.020 **Field UTM X:** 671027 mE **Field UTM Y:** 4138678 mN +/-5.2 m

Please do not complete the following information when in the field.

Corrected UTM X: mE **Corrected UTM Y:** mN **Zone:** 12S

Observers: Coles **Date:** 5/2/03 **Photos:** no

ENVIRONMENTAL DESCRIPTION 1593 m

Elevation: 5160' **Slope:** Flat deg. **Aspect:** 0 deg.

Topographic Position: Low level

Landform: Valley bottom/terrace **Geology:** Quaternary alluvium

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:	Unvegetated Surface (*please use cover scale below*)
Original understory destroyed by cattle. Recovering - incipient cryptosoils & moss clumps. Understory veg mostly weeds, altho patches of SPOAIR scattered through type.	0 Bedrock; 0 Rocks > 10 cm; 0 Rocks 0.2-10 cm; 0 Sand; 01 Other (describe) moss/cryptosoil crusts; 02 Bare Soil; 04 Litter/Duff; 01 Wood

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic Class	Cover Scale for Strata and Unvegetated Surface
Trees and Shrubs	X Broad-leaved	___ Forest	01 = 0 - 10%
___ Evergreen	___ Needle-leaved	___ Woodland	02 = 10 - 25%
X Cold-deciduous	___ Microphyllous	X Shrubland	03 = 25 - 60%
___ Drought-deciduous	___ Graminoid	___ Dwarf shrubland	04 = 60 - 100%
___ Mixed evergreen/ cold-deciduous	___ Forb	___ Shrub Herbaceous	
	___ Pteridophyte	___ Herbaceous	
Herbs	___ Mixed (describe)	___ Nonvascular	
___ Annual		___ Sparsely vegetated	
___ 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	02	03	Sarcobatus vermiculatus	03
S2: Short shrub				
H: Herbaceous	01	03	Descurainia pinnata	02
			Lappula occidentalis	01
			Astragalus mettallicus micranthiformis	02
			Rumex hymenosepalus	01
			Cryptantha spp (annual)	01
			Erodium circutarium	01
			Vulpia octoflora	01
			Sporobolus airoides	01
			Bromus tectorum	01
N: Non-vascular	01	01	Mosses (black)	01
			Cryptobiotic crusts	01
V: Vine/liana				
E: Epiphyte				

Height Scale for strata:

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

Cover scale for strata and Unvegetated Surface:

01 =	0 - 10%
02 =	10 - 25%
03 =	25 - 60%
04 =	60 - 100%

Appendix C

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 HOVE VegMapDB, have been used for all vegetation mapping projects conducted by NCPN. HOVE VegMapDB contains plot and observation point data collected during field work.

Two database files are required to use HOVE VegMapDB:

- *HOVE_Plots.mdb.* This "frontend" file contains all queries, forms, reports, associated modules and Visual Basic code.
- *HOVE_Plots_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 (HOVE_Plots_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.

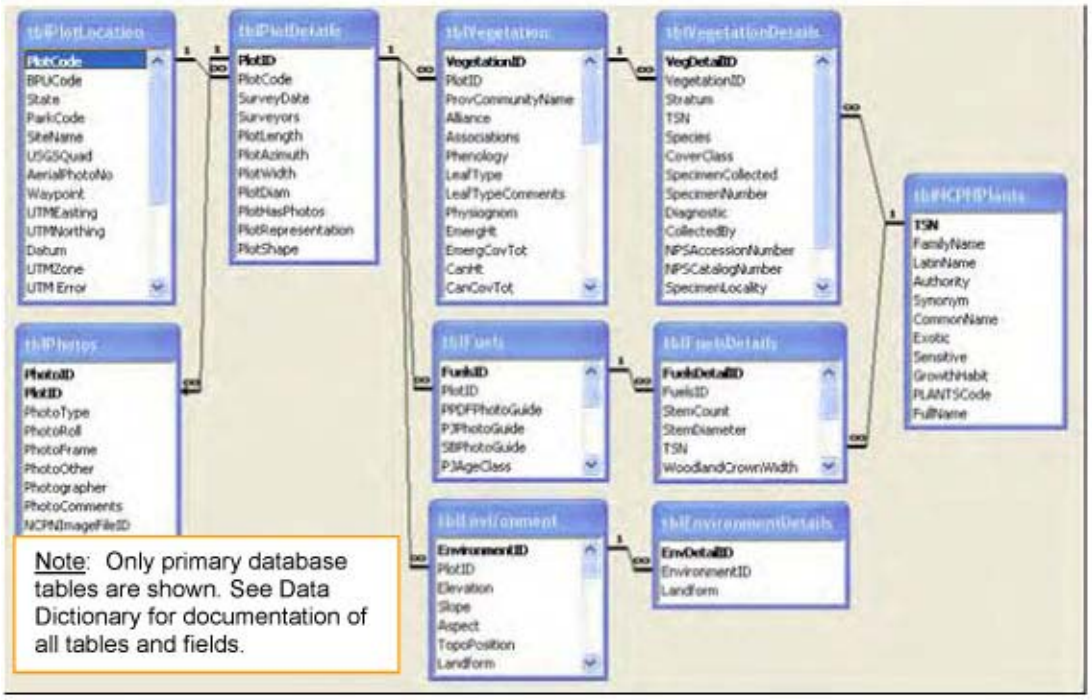


Figure 1. Entity Relationship Diagram for HOVE VegMapDB.

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 massaged or manipulated.	dbDate	8
ActionMonth	If ActionDate known to month only, use this and 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, massaged, manipulated, etc. Include changes to data and changes to database objects or structures.	dbMemo	0
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 as estimated from either	dbLong	4

Field Name	Field Description	Field Type	Field Width
	map or GPS unit		
Slope	Slope of plot measured in degrees	dbLong	4
Aspect	Aspect of plot	dbText	50
TopoPosition	Topographic position of plot; value selected from tlkpTopography	dbText	50
Landform	Landform on which plot is located, any landform could be entered by crew	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 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
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
Wood	Estimate to the nearest percentage of wood >1cm ground cover	dbText	3
Gravel	Estimate to the nearest percentage of rocks <10cm wide ground cover	dbText	3
Water	Estimate to the nearest percentage of water ground cover	dbText	3
Cryptogam	Estimate to the nearest percentage of cryptogram ground cover (observation points only)	dbText	3
SoilTexture	Assessment of average soil texture from sample taken a few inches below the surface; values selected from tlkpSoilTexture	dbText	50
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

Field Name	Field Description	Field Type	Field Width
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	dbDouble	8
LiveVegWood	Estimate to the nearest percentage of live veg wood ground cover	dbDouble	8
LichenRocks	Estimate to the nearest percentage of lichen covering rocks	dbDouble	8
LichenGround	Estimate to the nearest percentage of lichen ground cover (on the soil, associated with cryptogams)	dbDouble	8
MossPct	Estimate to the nearest percentage of moss ground cover (plot only)	dbDouble	8
DarkCyanobacteria	Estimate to the nearest percentage of dark cyanobacteria ground cover	dbDouble	8
TotalPct	Calculated total percentage for data verification	dbInteger	2

Table Name: tblEnvironmentDetails
Description: Table containing values on environmental features and conditions of plot or observation point.

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; any value may be entered by crew	dbText	50

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
PPDFPhotoGuide	n/a for HOVE plots	dbText	3
PJPhotoGuide	n/a for HOVE plots	dbText	3
SBPhotoGuide	n/a for HOVE plots	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	n/a for HOVE plots	dbText	3
LitterNorth	n/a for HOVE plots	dbText	3
LitterEast	n/a for HOVE plots	dbText	3
LitterSouth	n/a for HOVE plots	dbText	3
LitterWest	n/a for HOVE plots	dbText	3
DuffOrigin	n/a for HOVE plots	dbText	3
DuffNorth	n/a for HOVE plots	dbText	3

Field Name	Field Description	Field Type	Field Width
DuffEast	n/a for HOVE plots	dbText	3
DuffSouth	n/a for HOVE plots	dbText	3
DuffWest	n/a for HOVE plots	dbText	3
IsSubplot	Indicate if measurements are for subplot (if plot has >25 trees, one quadrant (subplot) of plot can be measured DBH's	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	n/a for HOVE plots	dbDouble	8
WoodlandCrownHeight	n/a for HOVE plots	dbDouble	8
ForestCrownBaseHeight	n/a for HOVE plots	dbDouble	8
ForestCrownHeight	n/a for HOVE plots	dbDouble	8
CrownRatio	n/a for HOVE plots	dbText	12
StructureStage	n/a for HOVE plots	dbText	12
Comments	n/a for HOVE plots	dbText	255

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 identifier	dbLong	4
PlotID	Foreign key, links to tblPlotDetails	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	25
Photographer	Name of photographer	dbText	50
PhotoComments	Brief description of photo	dbText	255
NCPNImageFileID	Cross-reference for NCPN Photo Database field, NCPNImageFieldID	dbText	50

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

Field Name	Field Description	Field Type	Field Width
SurveyDate	Date plot was visited and data collected	dbDate	8
Surveyors	Names of persons collecting data at plot (last names)	dbText	75
PlotLength	Length of plot, in meters	dbText	3
PlotAzimuth	Azimuth of plot; synonymous with aspect. One or the other, or both, can be used	dbText	3
PlotWidth	Width of plot, in meters	dbText	3
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	Garmin plot code	dbText	7
UTMEasting	UTM easting of plot	dbText	50
UTMNorthing	UTM northing of plot	dbText	7
Datum	Datum of UTM coordinates	dbText	10
UTMZone	UTM zone of coordinates	dbText	4
UTMError	Error, in meters, of location data (based on reading from Garmin GPS unit)	dbText	5
DiffCorrected	Indicate if coordinates have been differentially corrected	dbText	3
DirectionsTo Plot	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
PhotoID	Foreign key, links to tblPlotDetails	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

Field Name	Field Description	Field Type	Field Width
Associations	Association corresponding to provisional community name	dbText	100
Phenology	Leaf phenology of the dominant stratum. Field is blank for non-vascular plots	dbText	35
LeafType	Leaf form of the dominant stratum	dbText	20
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 tllkPhysiogClass)	dbText	20
EmergHt	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
EmergCovTot	Height class of emergent stratum (classes are in tlkpHeight)	dbText	2
CanHt	Height class of canopy stratum	dbText	2
CanCovTot	Cover class of canopy stratum	dbText	50
SubHt	Height class of subcanopy stratum	dbText	2
SubCovTot	Cover class of subcanopy stratum	dbText	2
TallShHt	Height class of tall shrub stratum	dbText	2
TallShCovTot	Cover class of tall shrub stratum	dbText	2
ShrubHt	Height class of short shrub stratum	dbText	2
ShrubCovTot	Cover class of short shrub stratum	dbText	2
DwarfHt	Height class of dwarf shrub stratum	dbText	2
DwarfCovTot	Cover class of dwarf shrub stratum	dbText	2
HerbHt	Height class of herbaceous stratum (all H layers)	dbText	2
HerbCovTot	Cover class of herbaceous stratum (all H layers)	dbText	2
GramHt	Height class of graminoid stratum	dbText	2
GramCovTot	Cover class of graminoid stratum	dbText	2
ForbHt	Height class of forb stratum	dbText	2
ForbCovTot	Cover class of forb stratum	dbText	2
FernHt	Height class of fern and fern ally stratum	dbText	2
FernCovTot	Cover class of fern and fern ally stratum	dbText	2
SeedlHt	Height class of seedling stratum	dbText	2
SeedlCovTot	Cover class of seedling stratum	dbText	2
NonvasHt	Height class of nonvascular stratum	dbText	2
NonvasCovTot	Cover class of nonvascular stratum	dbText	2
VineHt	Height class of vine stratum	dbText	2
VineTotCov	Cover class of vine stratum	dbText	2
EpiHt	Height class of epiphyte stratum	dbText	2
EpiTotCov	Cover class of epiphyte stratum	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 tllkStrata	dbText	2
TSN	Taxonomic Serial Number - unique taxon identifier assigned by ITIS	dbDouble	8
Species	Latin name of species, from tblNCPNPlants	dbText	100
CoverClass	Cover class to describe species and strata (from tllkCover)	dbText	2
SpecimenCollected	Check yes if a specimen of the species was collected	dbBoolean	1

Field Name	Field Description	Field Type	Field Width
SpecimenNumber	Enter the collector's reference number for the specimen collected	dbText	50
Diagnostic	Check yes if the species is known to be diagnostic of the vegetation type	dbBoolean	1
CollectedBy	Name of person making collection	dbText	50
NPSAccessionNumber	Accession number of specimen assigned by SEUG curator	dbText	50
NPSCatalogNumber	Catalog number assigned to specimen from a range provided by SEUG curator	dbText	50
SpecimenLocality	Brief description of locality where specimen was collected	dbText	250
SpecimenHabitat	Brief description of habitat where specimen was collected	dbText	250
SpecimenAssocSpecies	Brief description of associated species where specimen was collected	dbText	250

Lookup tables

Table Name: tblNCPNPlants
Description: Master look-up table for plant species names and taxonomic information. Derived from ITIS (USDA - 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
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: 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: tlkpCover
Description: Look-up of cover classes assigned to species and strata in tblVegetationDetails.

Field Name	Field Description	Field Type	Field Width
CoverClass	T >0-1% P >1-5% 1 >5-15% 2 >15-25% etc.	dbText	50

Table Name: tlkpCowardin
Description: Look-up 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 tblVegetationDetails.

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

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: Look-up 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 Veg Mapping 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 Veg Mapping 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 of parks in the Northern Colorado Plateau Network of I&M.

Field Name	Field Description	Field Type	Field Width
ParkCode	Four-letter abbreviation for park name	dbText	4
ParkName	Full name of park where data were collected	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	Pinyon- Juniper age class, if plot contains either of these two species	dbText	15

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
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 Veg Mapping Manual 04/04).

Field Name	Field Description	Field Type	Field Width
Stratum	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	3

Table Name: tlkpStructureStages
Description: Look-up

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: 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 HOVE.

Field Name	Field Description	Field Type	Field Width
USGSQuad	Names of all 7.5 minute USGS quads for HOVE	dbText	50
USGSQuadCode	n/a for HOVE	dbText	7

Table Name: tlkpUTMZone
Description: Look-up for UTM zone of HOVE.

Field Name	Field Description	Field Type	Field Width
TMZone	UTM zone where all HOVE 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 HOVE vegetation mapping project. In the geodatabase, feature classes were created for the spatial datasets, including plots, observation 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.

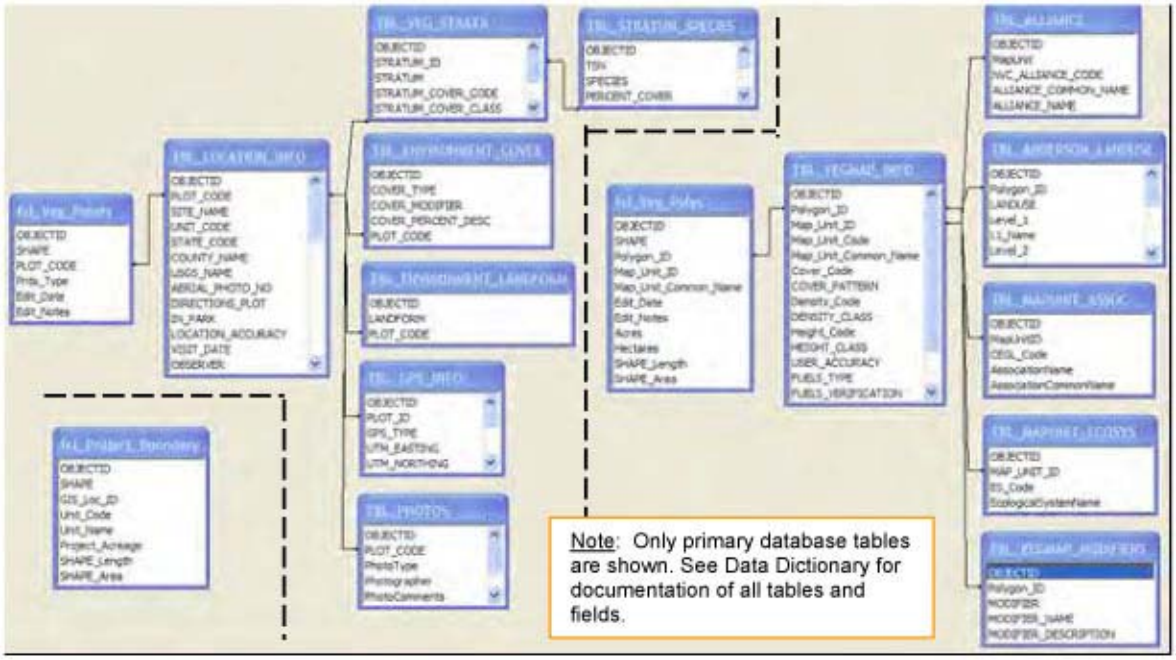


Figure 2. Entity Relationship Diagram for HOVE Geodatabase.

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 (HOVE)	dbText	10

Field Name	Field Description	Field Type	Field Width
Unit_Name	Full name of national park (Hovenweep National Monument)	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).

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 (plot, observation)	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

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)	dbText	12
NVC_ALLIANCE_CODE	The NVC alliance code	dbText	20
ALLIANCE_COMMON_NAME	NVC alliance common name	dbText	250

Field Name	Field Description	Field Type	Field Width
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_MODIFIER	Estimate to the nearest percentage of ground cover type	dbText	10
COVER_PERCENT_DESC	Description of cover	dbText	255
PLOT_CODE	Unique Plot code, used for relating tables	dbText	12

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

Field Name	Field Description	Field Type	Field Width
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 Woodland 208	dbText	255

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 and model of GPS unit (e.g., Garmin Etrex)	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
SITE_NAME	General Site name given by field crew	dbText	255
UNIT_CODE	4 letter park code (HOVE)	dbText	10
STATE_CODE	State (Utah)	dbText	2
COUNTY_NAME	County where plot is located (San Juan County)	dbText	100
USGS_NAME	USGS 1:24k Topo Name	dbText	100
AERIAL_PHOTO_NO	9X9 photo name on which the point most directly falls	dbText	30
DIRECTIONS_PLOT	Directions to the location of the plot	dbText	255
IN_PARK	Indicates if the point was inside or outside the park boundary	dbBoolean	1
LOCATION_ACCURACY	Indicates general range of locational error of the point coordinates.	dbText	45

Field Name	Field Description	Field Type	Field Width
VISIT_DATE	Date the location was visited	dbText	10
OBSERVER	The names of the field crew member(s) observing the site.	dbText	50
PLOT_WIDTH	The width of the point	dbText	3
PLOT_LENGTH	The length of the point	dbText	3
PLOT_DIAMETER	The diameter of the point	dbText	5
PLOT_AZIMUTH	The azimuth of the point	dbText	5
PLOT_SHAPE	The shape of the area observed as a point	dbText	20
REPRESENTATIVENESS	The representativeness of the vegetation	dbText	255
ASPECT	Aspect of plot	dbText	50
ELEVATION	Elevation of plot in meters, created from 10 meter DEMs	dbDouble	8
SLOPE	Slope of plot measured in degrees	dbText	15
TOPO_POSITION	Topographic position of plot	dbText	50
SOIL_TEXTURE	Assessment of average soil texture from sample taken a few inches below the surface	dbText	50
COWARDIN_SYSTEM	If the plot is in a wetland system, select term that best describes its hydrology (Upland, Palustrine, Riverine, Lacustrine)	dbText	50
HYDROLOGY	Describes hydrology of plot	dbText	50
GEOLOGY	Geologic substrate influencing the plant community	dbText	50
SOIL_DRAINAGE	Soil drainage class based on actual moisture content and extent period	dbText	30
ENV_COMMENTS	Comments on environmental setting and its effect on the vegetation; also comments on any disturbance or reproduction factors	dbText	255
ANIMAL_USE_COMMENTS	Comments on evidence of use by non-domestic animals in plot area	dbText	255
DISTURBANCE_COMMENTS	Comments on evidence of natural or anthropogenic disturbance in plot area, severity and effects on vegetation	dbText	255
LANDSCAPE_COMMENTS	Description of landscape context of plot, including any important landscape features influencing the community	dbText	255
OTHER_COMMENTS	Other general comments	dbText	255
SOIL_TAXON_DESC	Field used for either identifying soils keyed, or to describe if large rocks or outcrops are present on the surface	dbText	255
ALLIANCE	Alliance corresponding to provisional community name	dbText	100
PROVISIONAL_COMM_NAME	Community name (provisional) assigned by field crews by following naming protocols as described in field manual and training (2004).	dbText	200
PHENOLOGY	Leaf phenology of the dominant stratum. Field is blank for non-vascular plots	dbText	200
LEAF_TYPE	Leaf form of the dominant stratum.	dbText	100
LEAF_TYPE_COMMENTS	If Leaf Type is "mixed," this field describes the multiple leaf types found in the dominant stratum.	dbText	255

Field Name	Field Description	Field Type	Field Width
PHYSIOGNOMIC_NAME	Physiognomic class of plot	dbTex	100
PLANT_SPECIES_COMMENTS	Comments about the plant species observed.	dbText	200

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	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
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	Path to photos	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	Percent cover by species (Applicable to AA data only; not applicable to HOVE)	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

Field Name	Field Description	Field Type	Field Width
DIAGNOSTIC	Check yes if the species is known to be diagnostic of the vegetation type.	dbInteger	2
SPECIMEN_COLLECTED	"yes" 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 coverof 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	12

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 (X-XXXX)	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 (Not applicable to HOVE)	dbText	3
FUELS_TYPE	Fuels vegetation types	dbText	50
FUELS_VERIFICATION	Fuels verification	dbText	255

Field Name	Field Description	Field Type	Field Width
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:/HOVE/Vegetation/MapClassDescriptions/MU4.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

One hundred-five vascular plant species representing 33 families were identified during plot and observation point collection at Hovenweep National Monument (HOVE). 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 HOVE 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 HOVE 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.

Family	Scientific Name (Welch et al. 2003)	Scientific Name (Kartez 1999)	Common Name (NatureServe)	TSN
Agavaceae	Yucca angustissima Engelm. ex Trel.	Yucca angustissima	Fineleaf Yucca	43131
	Yucca baccata Torr.	Yucca baccata	Banana Yucca	43134
Anacardiaceae	Rhus aromatica Ait.	Rhus trilobata	Threeleaf Sumac	28779
Apiaceae	Cymopterus acaulis var. fendleri (Gray) Goodrich	Cymopterus acaulis var. fendleri	Plains Spring-parsley	527614
	Cymopterus newberryi (S. Wats.) M.E. Jones	Cymopterus newberryi	Sweet-root Spring-parsley	29649
	Cymopterus purpureus S. Wats.	Cymopterus purpureus	Purple Spring-parsley	29654
Asteraceae	Arctium minus Bernh.	Arctium minus	Lesser Burdock	36546
	Artemisia bigelovii Gray	Artemisia bigelovii	Bigelow Sagebrush	35452
	Artemisia ludoviciana Nutt.	Artemisia ludoviciana	White Sagebrush	35474
	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
	Chaenactis stevioides Hook. & Arn.	Chaenactis stevioides	Broad-flower Pincushion	36998
	Chrysopsis villosa (Pursh) Nutt. ex DC.	Heterotheca villosa	Hairy Goldenaster	510984
	Chrysothamnus depressus Nutt.	Chrysothamnus depressus	Long-flower Rabbitbrush	37051
	Chrysothamnus nauseosus (Pallas ex Pursh) Britt.	Ericameria nauseosa	Rubber Rabbitbrush	37055
	Chrysothamnus viscidiflorus (Hook.) Nutt.	Chrysothamnus viscidiflorus	Green Rabbitbrush	37090
	Cirsium P. Mill.	Cirsium	Thistle	36334
	Gutierrezia microcephala (DC.) Gray	Gutierrezia microcephala	Small-head Snakeweed	37482
	Gutierrezia sarothrae (Pursh) Britt. & Rusby	Gutierrezia sarothrae	Snakeweed	37483
	Hymenoxys acaulis (Pursh) Parker	Tetraneuris acaulis	Arizona Bitterweed	514991
	Senecio douglasii var. longilobus (Benth.) L. Benson	Senecio flaccidus var. flaccidus	Threadleaf Ragwort	540563
	Tetradymia canescens DC.	Tetradymia canescens	Gray Horsebrush	38494
	Tetradymia spinosa Hook. & Arn.	Tetradymia spinosa	Short-spine Horsebrush	38499
Boraginaceae	Cryptantha crassisepala (Torr. & Gray) Greene	Cryptantha crassisepala	Thick-sepal Cat's-eye	31800
	Cryptantha Lehm. ex G. Don	Cryptantha	Cat's-eye	31765
	Lappula occidentalis (S. Wats.) Greene	Lappula occidentalis	Flat-spine Sheepburr	503329
	Lithospermum L	Lithospermum	Gromwell	31937
Brassicaceae	Descurainia pinnata (Walt.) Britt.	Descurainia pinnata	Western Tansy-mustard	22826
	Sisymbrium altissimum L.	Sisymbrium altissimum	Tall Hedge-mustard	23312
	Stanleya pinnata (Pursh) Britt.	Stanleya pinnata	Golden Prince's-plume	23329
Cactaceae	Echinocereus triglochidiatus Engelm.	Echinocereus triglochidiatus	King-cup Cactus	19815
	Opuntia erinacea Engelm. & Bigelow ex Engelm.	Opuntia erinacea	Oldman Cactus	19705
	Opuntia fragilis (Nutt.) Haw.	Opuntia fragilis	Brittle Prickly-pear	19707

Family	Scientific Name (Welch et al. 2003)	Scientific Name (Kartez 1999)	Common Name (NatureServe)	TSN
	Opuntia polyacantha Haw.	Opuntia polyacantha	Panhandle Prickly-pear	19726
	Sclerocactus whipplei (Engelm. & Bigelow) Britt. & Rose	Sclerocactus whipplei	Whipple's Fishhook Cactu	19765
Caryophyllaceae	Arenaria fendleri Gray	Arenaria fendleri	Fendler's Sandwort	20245
	Arenaria fendleri var. fendleri Gray	Arenaria fendleri var. fendleri	Fendler's Sandwort	184229
	Atriplex canescens (Pursh) Nutt.	Atriplex canescens	Fourwing Saltbush	20518
	Atriplex confertifolia (Torr. & Frém.) S. Wats.	Atriplex confertifolia	Shadscale	20519
	Grayia spinosa (Hook.) Moq.	Grayia spinosa	Spiny Hop-sage	20690
	Sarcobatus vermiculatus (Hook.) Torr.	Sarcobatus vermiculatus	Black Greasewood	20707
Commelinaceae	Tradescantia occidentalis (Britt.) Smyth	Tradescantia occidentalis	Prairie Spiderwort	39168
Cupressaceae	Juniperus osteosperma (Torr.) Little	Juniperus osteosperma	Utah Junipe	194859
Ephedraceae	Ephedra torreyana S. Wats.	Ephedra torreyana	Torrey's Joint-fir	502318
	Ephedra viridis Coville	Ephedra viridis	Mormon-tea	502319
Fabaceae	Astragalus mollissimus Torr.	Astragalus mollissimus	Woolly Milk-vetch	25589
	Astragalus nuttallianus var. micranthiformis Barneby	Astragalus nuttallianus var. micranthiformis	Turkey-peas	192670
	Astragalus scopulorum Porter	Astragalus scopulorum	Rocky Mountain Milk-vetch	25670
	Lupinus argenteus Pursh	Lupinus argenteus	Silver-stem Lupine	503575
	Trifolium pratense L.	Trifolium pratense	Red Clover	26313
Fagaceae	Quercus gambelii Nutt.	Quercus gambelii	Gambel Oak	19337
Fumariaceae	Corydalis aurea Willd.	Corydalis aurea	Scrambledeggs	18999
Geraniaceae	Erodium cicutarium (L.) L'Hér. ex Ait.	Erodium cicutarium	Crane’s-bill	29147
Grossulariaceae	Ribes aureum Pursh	Ribes aureum	Golden Currant	24452
Hydrophyllaceae	Phacelia crenulata Torr. ex S. Wats.	Phacelia crenulata	Notchleaf Scorpionweed	31478
	Phacelia crenulata var. corrugata (A. Nels.) Brand	Phacelia crenulata var. corrugata	Notchleaf Scorpionweed	529549
Juncaceae	Juncus arcticus Willd.	Juncus arcticus	Arctic Rush	39222
Liliaceae	Calochortus flexuosus S. Wats.	Calochortus flexuosus	Winding Mariposa-lily	42848
	Zigadenus elegans Pursh	Zigadenus elegans	Mountain Deathcamas	43158
	Zigadenus paniculatus (Nutt.) S. Wats.	Zigadenus paniculatus	Sand-corn	43167
Malvaceae	Sphaeralcea coccinea (Nutt.) Rydb.	Sphaeralcea coccinea	Scarlet Globemallow	21920
Nyctaginaceae	Mirabilis multiflora (Torr.) Gray	Mirabilis multiflora	Colorado Four-o'clock	19654
Oleaceae	Fraxinus anomala Torr. ex S. Wats.	Fraxinus anomala	Singleleaf Ash	32937
Onagraceae	Oenothera caespitosa Nutt.	Oenothera caespitosa	Tufted Evening-primrose	565328
	Oenothera pallida Lindl.	Oenothera pallida	White-pole Evening-primrose	27436
Pinaceae	Pinus edulis Engelm.	Pinus edulis	Two-needle Pinyon	183336

Family	Scientific Name (Welch et al. 2003)	Scientific Name (Kartez 1999)	Common Name (NatureServe)	TSN
Plantaginaceae	Plantago patagonica Jacq.	Plantago patagonica	Woolly Plantain	32907
Poaceae	Agropyron smithii Rydb.	Pascopyrum smithii	Western Wheatgrass	40385
	Agrostis L.	Agrostis	Bentgrass	40389
	Aristida purpurea Nutt.	Aristida purpurea	Purple Three-awn	41429
	Bromus inermis Leyss.	Bromus inermis	Smooth Brome	40502
	Bromus japonicus Thunb. ex Murr.	Bromus japonicus	Japanese Brome	40479
	Bromus tectorum L.	Bromus tectorum	Cheatgrass	40524
	Elymus elymoides (Raf.) Swezey	Elymus elymoides	Bottlebrush	502264
	Elymus salinus M.E. Jones	Leymus salinus	Salinas Wildrye	512841
	Festuca L.	Festuca	Fescue	40792
	Festuca octoflora Walt.	Vulpia octoflora	Eight-flower Six-weeks Grass	513551
	Hilaria jamesii (Torr.) Benth.	Pleuraphis jamesii	James' Galleta	41768
	Poa fendleriana (Steud.) Vasey	Poa fendleriana	Muttongrass	504467
	Poa pratensis L.	Poa pratensis	Kentucky Bluegrass	41088
	Sporobolus airoides (Torr.) Torr.	Sporobolus airoides	Alkali Sacaton	42128
	Stipa hymenoides Roemer & J.A. Schultes	Achnatherum hymenoides	Indian Ricegrass	522063
Polemoniaceae	Microsteris gracilis (Hook.) Greene	Phlox gracilis	Slender Phlox	31309
	Phlox longifolia Nutt.	Phlox longifolia	Longleaf Phlox	30956
Polygonaceae	Eriogonum ovalifolium Nutt.	Eriogonum ovalifolium	Cushion Wild Buckwheat	21212
	Rumex hymenosepalus Torr.	Rumex hymenosepalus	Sand Dock	20962
Ranunculaceae	Delphinium nuttallianum Pritz. ex Walp.	Delphinium nuttallianum	Two-lobe Larkspur	18483
	Ranunculus testiculatus Crantz	Ceratocephala testiculata	Curveseed Butterwort	18649
Rosaceae	Amelanchier utahensis Koehne	Amelanchier utahensis	Utah Serviceberry	25121
	Cercocarpus montanus Raf.	Cercocarpus montanus	Mountain-mahogany	25136
	Peraphyllum ramosissimum Nutt.	Peraphyllum ramosissimum	Wild Crabapple	25270
	Prunus virginiana L.	Prunus virginiana	Choke Cherry	24806
	Purshia mexicana (D. Don) Henrickson	Purshia stansburiana	Mexican Cliffrose	195899
	Purshia tridentata (Pursh) DC.	Purshia tridentata	Bitterbrush	25290
Salicaceae	Populus deltoides ssp. wislizeni (S. Wats.) Eckenwalder	Populus deltoides ssp. wislizeni	Rio Grande Cottonwood	524563
	Salix exigua Nutt.	Salix exigua	Coyote Willow	22529
Solanaceae	Chamaesaracha coronopus (Dunal) Gray	Chamaesaracha coronopus	Greenleaf Five-eyes	30507
	Lycium pallidum Miers	Lycium pallidum	Pale Desert-thorn	30544
Tamaricaceae	Tamarix chinensis Lour.	Tamarix chinensis	Chinese Tamarisk	22308

Appendix E

Field Plot Crosswalk to NVC Associations

Plots and observation points from HOVE are assigned to National Vegetation Classification associations based on their composition and structure as they were recorded in the field. Five associations or alliances were noted in the field but were not sampled, although they form the basis for several map classes (#8, #43, #44; see also Appendix G, Appendix J). 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 Plots and Observation Points
Amelanchier utahensis Shrubland	CEGL001067	1	HOVE.9029
Artemisia bigelovii Shrubland	CEGL000267	1	HOVE.0001
Artemisia tridentata - (Chrysothamnus nauseosus) / Bromus tectorum Semi-natural Shrubland	CEGL002699	2	HOVE.0022, HOVE.0031
Artemisia tridentata ssp. wyomingensis - Atriplex confertifolia Shrubland	CEGL001040	2	HOVE.9006, HOVE.9007
Artemisia tridentata ssp. wyomingensis / Disturbed Understory Semi-natural Shrubland	CEGL002083	5	HOVE.0032, HOVE.0033, HOVE.0034, HOVE.9003, HOVE.9010
Artemisia tridentata ssp. wyomingensis / Pleuraphis jamesii Shrubland	CEGL002084	3	HOVE.0018, HOVE.0019, HOVE.0023
Artemisia tridentata ssp. wyomingensis / Poa fendleriana Shrubland	CEGL002775	2	HOVE.9025
Artemisia tridentata ssp. wyomingensis / Sparse Understory Shrubland	CEGL002768	2	HOVE.0005
Atriplex canescens / Pleuraphis jamesii Shrubland	CEGL001288	2	HOVE.0002
Atriplex confertifolia / Pleuraphis jamesii Shrubland	CEGL001304	3	HOVE.0006, HOVE.9001, HOVE.9008
Bromus inermis - (Pascopyrum smithii) Semi-natural Herbaceous Vegetation	CEGL005264	2	HOVE.0010, HOVE.9023
Bromus tectorum Semi-natural Herbaceous Vegetation	CEGL003019	1	HOVE.9030
Celtis laevigata var. reticulata Woodland Alliance	A.632	0	Described from field notes
Erodium cicutarium Semi-natural Annual Herbaceous Vegetation	CEGL002085	1	HOVE.9012
Juniperus osteosperma / Artemisia tridentata ssp. wyomingensis Woodland	CEGL000730	2	HOVE.0009, HOVE.9031

Plant Association Scientific Name	Element Code	No. of Samples	Supporting Plots and Observation Points
Juniperus osteosperma / Sparse Understory Woodland	CEGL000732	2	HOVE.0011, HOVE.9019
Leymus salinus Shale Sparse Vegetation	CEGL002745	1	HOVE.0021
Mixed Riparian Shrubland	Park Special	1	HOVE.9018
Pascopyrum smithii Herbaceous Vegetation	CEGL001577	2	HOVE.0015, HOVE.9022
Pinus edulis - Juniperus osteosperma / Artemisia bigelovii Woodland	CEGL002118	1	HOVE.0008
Pinus edulis – Juniperus osteosperma / Atriplex spp. Woodland	CEGL002366	0	Described from field notes
Pinus edulis – Juniperus osteosperma / Pleuraphis jamesii Woodland	CEGL002379	0	Described from field notes
Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland	CEGL000782	9	HOVE.0012, HOVE.0014, HOVE.0020, HOVE.9009, HOVE.9011, HOVE.9013, HOVE.9014, HOVE.9015, HOVE.9027
Pinus edulis - Juniperus osteosperma / Sparse Understory Woodland	CEGL002148	5	HOVE.0003, HOVE.0017, HOVE.9002, HOVE.9017, HOVE.9024
Pinus edulis - Juniperus spp. / Artemisia tridentata (ssp. wyomingensis, ssp. vaseyana) Woodland	CEGL000776	2	HOVE.0016, HOVE.9005
Pinus edulis - Juniperus spp. / Cercocarpus montanus - Mixed Shrub Woodland	CEGL000780	1	HOVE.0004
Pinus edulis - Juniperus spp. / Quercus gambelii Woodland	CEGL000791	1	HOVE.9016
Pleuraphis jamesii Herbaceous Vegetation	CEGL001777	3	HOVE.0013, HOVE.9021, HOVE.9032
Populus deltoides (ssp. wislizeni, ssp. monilifera) / Artemisia tridentata Woodland	CEGL005966	1	HOVE.9028
Populus deltoides (ssp. wislizeni, ssp. monilifera) / Salix exigua Woodland	CEGL002685	1	HOVE.9004

Plant Association Scientific Name	Element Code	No. of Samples	Supporting Plots and Observation Points
Quercus gambelii Shrubland Alliance	A.920	0	Described from field notes
Sarcobatus vermiculatus / Artemisia tridentata Shrubland	CEGL001359	1	HOVE.9026
Sarcobatus vermiculatus Disturbed Shrubland	CEGL001357	2	HOVE.0007, HOVE.9020
Sporobolus airoides Herbaceous Alliance	A.1267	0	Described from field notes

Appendix F

Plant Association Descriptions for Hovenweep National Monument

The Hovenweep National Monument (HOVE) vegetation mapping project identified 28 National Vegetation Classification (NVC) plant associations and one park special vegetation type representing 16 vegetation alliances. 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 HOVE. 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.

In this appendix, NVC plant associations are arranged by physiognomic class (e.g., Forest, Woodland). Within each physiognomic class, associations are sorted into formations (e.g., Conical-crowned temperate), and alliances (e.g., *Juniperus osteosperma* Woodland Alliance). This arrangement follows the current NVC hierarchy.

Two additional woodland associations and three alliances were recognized from field notes and descriptions, but were not sampled. These vegetation types are not included in the descriptions that follow:

- *Celtis laevigata* var. *reticulata* Woodland Alliance (A.632)
- *Quercus gambelii* Shrubland Alliance (A.920)
- *Sporobolus airoides* Herbaceous Alliance (A.1267)
- *Pinus edulis - Juniperus osteosperma / Atriplex* spp. Woodland (CEGL002366)
- *Pinus edulis - Juniperus osteosperma / Pleuraphis jamesii* Woodland (CEGL002379)

TABLE OF CONTENTS

II. WOODLAND 183

Rounded-crowned temperate or subpolar needle-leaved evergreen woodland 132

Juniperus osteosperma Woodland Alliance 132

Juniperus osteosperma / Artemisia tridentata ssp. *wyomingensis* Woodland 132
Juniperus osteosperma / Sparse Understory Woodland 134
Pinus edulis - (Juniperus spp.*)* Woodland Alliance 136
Pinus edulis - Juniperus osteosperma / Artemisia bigelovii Woodland 136
Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland 138
Pinus edulis - Juniperus osteosperma / Sparse Understory Woodland 141
Pinus edulis - Juniperus spp. */ Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland 143
Pinus edulis - Juniperus spp. */ Cercocarpus montanus* - Mixed Shrubs Woodland 146
Pinus edulis - Juniperus spp. */ Quercus gambelii* Woodland 149

Temporarily flooded cold-deciduous woodland 151

Populus deltoides Temporarily Flooded Woodland Alliance 151

Populus deltoides (ssp. *wislizeni*, ssp. *monilifera) / Artemisia tridentata* Woodland 151
Populus deltoides (ssp. *wislizeni*, ssp. *monilifera) / Salix exigua* Woodland 154

III. SHRUBLAND 156

Lowland microphyllous evergreen shrubland 156

Artemisia tridentata Shrubland Alliance 156

Artemisia tridentata - (Ericameria nauseosa) / Bromus tectorum Semi-natural Shrubland 156

Artemisia tridentata ssp. wyomingensis Shrubland Alliance 158

Artemisia tridentata ssp. *wyomingensis - Atriplex confertifolia* Shrubland 158
Artemisia tridentata ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland 160
Artemisia tridentata ssp. *wyomingensis / Pleuraphis jamesii* Shrubland 163
Artemisia tridentata ssp. *wyomingensis / Poa fendleriana* Shrubland 165
Artemisia tridentata ssp. *wyomingensis* / Sparse Understory Shrubland 167

Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland 169

Artemisia bigelovii Shrubland Alliance 169

Artemisia bigelovii Shrubland 169

Facultatively deciduous extremely xeromorphic subdesert shrubland 171

Atriplex canescens Shrubland Alliance 171

Atriplex canescens / Pleuraphis jamesii Shrubland 171

Atriplex confertifolia Shrubland Alliance 173

Atriplex confertifolia / Pleuraphis jamesii Shrubland 173

Temperate cold-deciduous shrubland 176

Amelanchier utahensis Shrubland Alliance 176

Amelanchier utahensis Shrubland 176

Intermittently flooded extremely xeromorphic deciduous subdesert shrubland 178

Sarcobatus vermiculatus Intermittently Flooded Shrubland Alliance 178

Sarcobatus vermiculatus / Artemisia tridentata Shrubland 178
Sarcobatus vermiculatus Shrubland 180

V. HERBACEOUS VEGETATION 182

Medium-tall sod temperate or subpolar grassland *182*
Pascopyrum smithii Herbaceous Alliance 182
Pascopyrum smithii Herbaceous Vegetation 182
Medium-tall bunch temperate or subpolar grassland *184*
Bromus inermis Semi-natural Herbaceous Alliance 184
Bromus inermis - (Pascopyrum smithii) Semi-natural Herbaceous Vegetation 184
Short sod temperate or subpolar grassland *186*
Pleuraphis jamesii Herbaceous Alliance 186
Pleuraphis jamesii Herbaceous Vegetation 186
Tall temperate or subpolar annual forb vegetation *188*
Erodium cicutarium Herbaceous Alliance 188
Erodium cicutarium Semi-natural Annual Herbaceous Vegetation 188
Short temperate annual grassland *190*
Bromus tectorum Semi-natural Herbaceous Alliance 190
Bromus tectorum Semi-natural Herbaceous Vegetation 190
VII. SPARSE VEGETATION 192
Dry slopes *192*
Leymus salinus Sparsely Vegetated Alliance 192
Leymus salinus Shale Sparse Vegetation 192
X. HIERARCHY PLACEMENT UNDETERMINED 194
Park Specials *194*
Mixed Riparian Shrubland [Park Special] 194
BIBLIOGRAPHY 197

Juniperus osteosperma / Artemisia tridentata ssp. wyomingensis Woodland
Utah Juniper / Wyoming Big Sagebrush Woodland

CODE	CEGL000730
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)
Rocky Mountain Foothill Limber Pine-Juniper Woodland (CES306.955)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This sparse woodland association has been reported from semi-arid foothills, plateaus and mountains throughout much of the western Rocky Mountains, Colorado Plateau, and Great Basin. Elevation ranges from 1220 to 2260 m (4000-7400 feet). This community generally occurs on a variety of slopes and aspects, often at the break between foothill and basin. Soils are generally coarse-textured, calcareous alluvial or eolian deposits derived from sandstone and shale. Evidence of erosion such as gullies and rills is not uncommon. There are generally significant amounts of bare ground, litter, and desert pavement at the soil surface. Rock cover is variable. The vegetation is characterized by an open tree canopy dominated by *Juniperus osteosperma* with *Artemisia tridentata* ssp. *wyomingensis* dominating the sparse to moderately dense short-shrub layer. Tree canopy cover values are over 5%, but typically less than 20%, and canopy height is usually 2-10 m. Other shrubs, such as *Atriplex canescens, Atriplex confertifolia, Artemisia nova, Chrysothamnus viscidiflorus, Ephedra nevadensis, Ericameria nauseosa, Gutierrezia sarothrae, Opuntia* spp., or *Purshia* spp., may be present but generally with low cover. The sparse to moderately dense herbaceous layer is dominated by graminoids such as *Achnatherum hymenoides, Aristida* spp., *Bouteloua* spp., *Carex filifolia, Elymus elymoides, Hesperostipa comata, Pleuraphis jamesii, Pascopyrum smithii, Poa secunda, Pseudoroegneria spicata, Sporobolus* spp., and introduced annual *Bromus* spp. Associated forbs may include *Artemisia frigida, Eriogonum* spp., *Gayophytum racemosum, Leptodactylon pungens, Phlox hoodii*, and *Plantago patagonica*.

DISTRIBUTION

Hovenweep National Monument

This association was sampled near the eastern boundary and in the central canyon of the Holly Unit and in the Goodman Point Unit of the monument. It is likely to also be found in the Square Tower Unit.

Globally

This sparse woodland association occurs throughout much of the western Rocky Mountains, Colorado Plateau, and Great Basin region and extends east to the Bighorn Mountains and hills of central Wyoming.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This woodland association was observed on upper slopes of ridges, lower slopes of hills, and in drainage bottoms in the Holly and Goodman Point units. Sites are gentle (3-4° slopes), occur between 1619 and 2045 m elevation, and include eastern and southwestern aspects. The unvegetated surface has low to high cover of litter and low to high cover of large and small rocks and exposure of bare ground. Cryptogam cover can be moderate in some stands. Soils are rapidly drained sandy loams derived from Dakota sandstone and Burro Canyon Formation shale that have eroded and been re-deposited as alluvium, colluvium, and eolian material.

Globally

This sparse woodland association has been reported from semi-arid foothills, plateaus and mountains throughout much of the western Rocky Mountains, Colorado Plateau, and Great Basin. Elevation ranges from 1220 to 2260 m (4000-7400 feet). This community occurs on a variety of slopes and aspects, often at the break between foothill and

basin. Soils are generally coarse-textured, calcareous alluvial or eolian deposits derived from sandstone and shale. Evidence of erosion such as gullies and rills is not uncommon. There are generally significant amounts of bare ground, litter, and desert pavement at the soil surface. Rock cover is variable.

VEGETATION DESCRIPTION

Hovenweep National Monument

This Utah juniper woodland association is distributed on upper slopes of ridges and in drainages in the Holly Unit and on the lower slopes of hills in the Goodman Point Unit of the monument. The total vegetation cover ranges from 27 to 76% in these moderately to densely vegetated stands. This woodland association is characterized by an open tree canopy, typically 2-15 m tall, of *Juniperus osteosperma* trees that range in cover from 10 to 35%, and *Artemisia tridentata* ssp. *wyomingensis* short shrubs that range in cover from 2 to 12%. In the subcanopy of one stand, *Juniperus osteosperma* trees from 2-5 m tall provide up to 4% cover. The shrub layer is low in diversity but low to moderate in cover. Tall shrubs provide sparse cover and include *Amelanchier utahensis, Juniperus osteosperma, Pinus edulis*, and *Salix exigua*. Associated short and dwarf-shrubs provide sparse cover and include *Atriplex confertifolia, Ephedra viridis, Ericameria nauseosa, Gutierrezia sarothrae, Juniperus osteosperma, Opuntia polyacantha, Purshia stansburiana*, and *Yucca baccata*. The herbaceous layer is moderately diverse and provides low to moderate cover. Graminoids provide sparse to moderate cover and include *Achnatherum hymenoides, Bromus tectorum, Pleuraphis jamesii*, and *Poa fendleriana*. Forbs provide sparse cover, including *Arenaria fendleri, Astragalus nuttallianus, Calochortus flexuosus, Cymopterus newberryi, Descurainia pinnata, Lappula occidentalis, Mirabilis multiflora*, and *Phacelia crenulata* var. *corrugata*. Cryptogam cover is moderate in one stand, up to 23%.

Globally

The vegetation is characterized by an open tree canopy of Juniperus osteosperma with *Artemisia tridentata* ssp. *wyomingensis* dominating the sparse to moderately dense short-shrub layer. Tree canopy cover is over 5%, but typically less than 20%, and the height of the tree canopy is 2-10 m. Other shrubs, such as *Atriplex canescens, Atriplex confertifolia, Artemisia nova, Chrysothamnus viscidiflorus, Ephedra nevadensis, Ericameria nauseosa, Gutierrezia sarothrae, Opuntia* spp., or *Purshia* spp., may be present but generally with low cover. The herbaceous layer tends to have sparse to low cover but can range to moderately dense cover in some stands. It is dominated by graminoids such as *Achnatherum hymenoides, Aristida* spp., *Bouteloua* spp., *Carex filifolia, Elymus elymoides, Hesperostipa comata, Pleuraphis jamesii, Pascopyrum smithii, Poa secunda, Pseudoroegneria spicata, Sporobolus* spp., and introduced annual *Bromus* spp. Associated forbs may include *Artemisia frigida, Eriogonum* spp., *Gayophytum racemosum, Leptodactylon pungens, Phlox hoodii*, and *Plantago patagonica*.

MOST ABUNDANT SPECIES

Hovenweep National Monument

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*

Global

Stratum	Species
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*

OTHER NOTEWORTHY SPECIES

Hovenweep National Monument

Bromus tectorum (cheatgrass)

Globally

Data are not available

CONSERVATION STATUS RANK

Global Rank & Reasons: G5? (1-Feb-1996).

CLASSIFICATION COMMENTS

Hovenweep National Monument

Some of the stands at Hovenweep had denser tree canopies (to 35% cover) than is typical for this association

(usually <20% cover).

Globally
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 Artemisia tridentata ssp. wyomingensis shrublands with scattered pinyon and juniper trees, but they are considered a variation of the woodland type because of the ecological values of the trees.

CLASSIFICATION CONFIDENCE: 2 – Moderate

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: Occurs on a variety of substrates and topographic positions. One stand had a die-off of mature *Pinus edulis* leaving *Juniperus osteosperma* dominant.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0009, 2 observation points: HOVE.9043, HOVE.9053)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Drake and J. Coles

REFERENCES: Barney and Frischknecht 1974, Blackburn 1967, Blackburn et al. 1968a, Blackburn et al. 1968c, Blackburn et al. 1969a, Blackburn et al. 1969e, Blackburn et al. 1971, Bourgeron and Engelking 1994, Bradley 1964, Brotherson and Evenson 1983, Bunting 1987, CONHP unpubl. data 2003, Cogan et al. 2004, Dastrup 1963, DeVelice and Lesica 1993, Donart et al. 1978b, Driscoll et al. 1984, Everett 1987, Francis 1986, Isaacson 1967, Jameson et al. 1962, Johnson and Payne 1968, Johnston 1987, Jones 1992b, Larson and Moir 1987, MTNHP 2002b, Milton and Purdy 1983, Moir and Carleton 1987, NVNHP 2003, Stuever and Hayden 1997a, USFS 1983a, West et al. 1998, Wright et al. 1979

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 and Colorado Plateau 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 20 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
Hovenweep National Monument
This association was sampled in the southeastern corner of the Hackberry Unit and in Little Ruin Canyon of the

Square Tower Unit of the monument.

Globally
This association occurs widely in the Great Basin of Nevada and western Utah, as well as the Colorado Plateau of southeastern Utah and western Colorado, and extends north to the Uinta Mountains.

ENVIRONMENTAL DESCRIPTION
Hovenweep National Monument
This woodland association was observed on the midslopes of hills and the talus or rockfall slopes of canyons. Sites are gentle to moderately steep (4-11° slopes), occur between 1562 and1689 m elevation, and include several aspects. The unvegetated surface has low to moderate cover of litter and exposure of bare soil and low to moderate cover of bedrock and large and small rocks. Soils are rapidly drained sandy loams derived from Dakota sandstone.

Globally
This widespread woodland association occurs on slopes, ridges, benches and mesas throughout the Colorado Plateau and the eastern Great Basin. Elevations range 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
Hovenweep National Monument
This uncommon association occurs on hillslopes and in the canyons of the monument. The total vegetation cover ranged from 24 to 31% in these sparsely to moderately vegetated stands. This woodland association is characterized by an open tree canopy, typically 2-15 m tall (the trees are sometimes stunted on dry exposures), of Juniperus osteosperma that range in cover from 20 to 30%. The shrub layer is sparse to low in cover and is relatively diverse. Tall, short, and dwarf-shrubs include *Purshia stansburiana, Artemisia tridentata* ssp. *wyomingensis, Atriplex canescens, Ephedra viridis, Ericameria nauseosa, Gutierrezia sarothrae, Juniperus osteosperma*, and the succulents *Echinocereus triglochidiatus* and *Yucca harrimaniae*. The herbaceous layer is sparse in terms of cover and low in species diversity. Graminoids provide sparse cover and include *Aristida purpurea* and *Pleuraphis jamesii*. Forbs present include *Astragalus nuttallianus, Eriogonum ovalifolium, Lappula occidentalis, Mirabilis multiflora*, and *Phacelia crenulata*. Cryptogams are present on one site and provide 10% cover.

Globally
This common woodland association is characterized by a canopy of *Juniperus osteosperma* with between 10 and 65% cover. 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
Hovenweep National Monument

Stratum	**Species**
Tree canopy	*Juniperus osteosperma*

Global

Stratum	**Species**
Tree canopy	*Juniperus osteosperma*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: GNRQ (23-Feb-1994).

CLASSIFICATION COMMENTS
Hovenweep National Monument
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: 2 – Moderate

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: The stands are located on rapidly drained slopes that include sandy to fine soils and rockfall substrates that are too hot and dry for pinyon pine to establish. One stand had undergone historic wood-chopping.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0011, 2 observation points: HOVE.9047, HOVE.9061)
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 / Artemisia bigelovii* Woodland**
Two-needle Pinyon - Utah Juniper / Bigelow Sagebrush Woodland

CODE	CEGL002118
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 association is found in western Colorado and eastern Utah, usually on mesa tops and canyon rims. Sites can have gentle to steep slopes and with varying local aspects but have been most commonly observed on sites whose general aspect is north or east. This association has been found at sites between 1476 and 2104 m (4840-6900 feet) elevation and mostly on sandstone. Soils are shallow, well-drained to rapidly drained loamy sands, sandy loams, or silt loams. The unvegetated ground surface is typically composed of litter, bedrock, and bare soil. This woodland association generally has sparse to moderate total vegetation cover. There is an open tree canopy 2-5 m tall dominated by *Pinus edulis* and *Juniperus osteosperma* with 2-20% cover each. The shrub layer is also open and, besides the abundance of *Artemisia bigelovii*, is usually mixed in composition. *Artemisia bigelovii* is the most

abundant shrub with 2-10% cover. Other typical shrubs are *Echinocereus triglochidiatus, Ephedra torreyana, Ephedra viridis, Eriogonum corymbosum, Fraxinus anomala* (which can be present in the tree canopy, as well), and *Gutierrezia sarothrae*. The herbaceous layer typically has less than 5% cover and contains graminoid species such as Achnatherum hymenoides, Elymus elymoides, and Pleuraphis jamesii and forbs such as *Arenaria fendleri, Erodium cicutarium, Heterotheca villosa*, and *Tetraneuris acaulis*.

DISTRIBUTION

Hovenweep National Monument

This association was sampled in the northwestern corner of the Holly Unit.

Globally

This association is found in western Colorado and southeastern Utah.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This woodland association was observed on bedrock formations of the mesatop and canyon rim of the Holly Unit. The site is moderately steep (9° slope), occurs at 1635 m elevation, and is oriented to a southeastern aspect. The unvegetated surface has low cover of litter and high cover of bedrock and large rocks. Soils are rapidly drained sandy loams derived from Dakota sandstone.

Globally

This association is most commonly found on mesa tops and canyon rims but has been found on valley midslopes with rocky or ledgy substrates. Slopes can vary in steepness (sampled plots are 1-35°) and aspect but have been most commonly observed on north or east-facing sites. This association has been found at sites between 1476 and 2104 m elevation and mostly on sandstone substrates. Soils are shallow, well-drained to rapidly drained loamy sands, sandy loams, or silt loams. The unvegetated ground surface is typically composed of litter, bedrock, and bare soil. Large and small rocks can be present but are rarely abundant; fractures in the underlying bedrock control the density and distribution of woody vegetation.

VEGETATION DESCRIPTION

Hovenweep National Monument

This pinyon-juniper / Bigelow (flat) sagebrush woodland association is rare, occupying the mesatop bedrock where Dakota sandstone is exposed along the canyon rim. The total vegetation cover is 17% in this sparsely vegetated stand. This woodland association is characterized by an open tree canopy, 2-5 m tall, of *Juniperus osteosperma* trees that provide 10% cover, and the short shrub *Artemisia bigelovii* that provides 3% cover. The shrub layer is moderately variable in composition and sparse in cover. Tall, short, dwarf-shrubs, and succulents include *Echinocereus triglochidiatus, Ephedra viridis, Ephedra torreyana, Fraxinus anomala, Gutierrezia sarothrae, Purshia stansburiana, Rhus trilobata*, and *Tetradymia spinosa*. The herbaceous layer is sparse, less than 5% total cover. The graminoids include only *Pleuraphis jamesii*. Forbs include *Astragalus nuttallianus, Arenaria fendleri, Cryptantha* sp., *Eriogonum ovalifolium*, and *Tetraneuris acaulis*. Cryptogam cover is sparse, less than 5%.

Globally

This woodland association generally has sparse to moderate total vegetation cover. There is an open tree canopy 2-5 m tall and dominated by *Pinus edulis* and *Juniperus osteosperma*. These tree species can vary in abundance from 2-20% cover each. The shrub layer has sparse to low cover and, besides the abundance of *Artemisia bigelovii*, is variable in composition. *Artemisia bigelovii* is the most abundant shrub with 2-10% cover. Other typical components of the shrub stratum include *Echinocereus triglochidiatus, Ephedra torreyana, Ephedra viridis, Eriogonum corymbosum, Fraxinus anomala* (which can be present in the tree canopy, as well), and *Gutierrezia sarothrae*. Occasional *Purshia stansburiana, Rhus trilobata*, and *Tetradymia spinosa* may be present in some stands. The herbaceous layer is sparse, typically less than 5% cover, and contains graminoid species such as *Achnatherum hymenoides, Elymus elymoides*, and *Pleuraphis jamesii*. Forbs include *Arenaria fendleri, Erodium cicutarium, Heterotheca villosa*, and *Tetraneuris acaulis*. Stands of this community sampled at higher elevation have northern aspects and more dense vegetation cover.

MOST ABUNDANT SPECIES

Hovenweep National Monument

Stratum	**Species**
Tree canopy	*Juniperus osteosperma*
Tall shrub/sapling	*Purshia stansburiana*
Short shrub/sapling	*Artemisia bigelovii*

Global

Stratum	**Species**
Tree canopy	*Juniperus osteosperma*
Herb (field)	*Artemisia bigelovii*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Erodium cicutarium

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (15-Dec-2004).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
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 *Artemisia bigelovii* dwarf-shrublands with scattered pinyon and juniper trees, but they are considered a variation of the woodland type because of the ecological values of the trees.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: Stands grow on bedrock overlain by very thin soils or from the cracks in exposed sandstone bedrock. There is little *Pinus edulis* present in the vicinity and none on this site.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0008)
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.

***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 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
Hovenweep National Monument
This association is uncommon, occupying bedrock exposures in the Hackberry and Square Tower units. In the Square Tower Unit the association occupies an alcove near the western fenceline. In the Hackberry Unit it is located between the two canyons approximately 300 m south of the parking area and near the southern boundary fence.

Globally
This woodland association occurs in the Colorado Plateau region of central Arizona, western New Mexico, southwestern Colorado, and southern Utah.

ENVIRONMENTAL DESCRIPTION
Hovenweep National Monument
This woodland association was observed on the midslopes and upper slopes of ridges, midslopes of hills, canyon rims, and drainages. Sites are moderate (5-10° slopes), occur between 1579 and 1680 m elevation, and includes all aspects. The unvegetated surface has low to high cover of litter. Bedrock, large and small rocks, and exposures of bare soil typically comprise much of the unvegetated surface but can be variable. Cryptogamic cover can be up to 25% in some stands. Soils are rapidly drained and range from loamy sand to clay loam, derived from Dakota sandstone and shales of the Burro Canyon Formation.

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 occur on gentle to moderately steep slopes on all aspects. Soils are generally shallow and rocky, ranging from sand in most stands to clay loam in texture. 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.

VEGETATION DESCRIPTION
Hovenweep National Monument
This pinyon-juniper / Mexican cliffrose woodland association is uncommon, occurring mostly in the Hackberry Unit. The total vegetation cover ranged from 21 to 44% in these sparsely to moderately vegetated stands. This woodland association is characterized by an open tree canopy, typically 2-15 m tall, of *Pinus edulis* and *Juniperus osteosperma* trees that range in cover from 0 to 2% and 12 to 35%, respectively. One stand supported *Fraxinus anomala* trees that provided low cover in the canopy layer. The shrub layer is variable in cover and composition. *Purshia stansburiana* is present in all stands, ranging in cover from 2 to 10%, and with heights varying from <0.5 to 2 m. Other tall shrubs present and providing sparse cover include *Amelanchier utahensis* and sapling *Juniperus osteosperma*. Short and dwarf-shrubs provide sparse to low cover and include *Artemisia tridentata* ssp. *wyomingensis, Atriplex canescens, Chrysothamnus depressus, Ephedra viridis, Ericameria nauseosa, Gutierrezia sarothrae, Rhus trilobata*, and the succulents *Echinocereus triglochidiatus, Opuntia erinacea*, and *Yucca harrimaniae*. The herbaceous layer is typically sparse, usually less than 5% total cover, and is low in diversity. Graminoids include *Vulpia octoflora, Pleuraphis jamesii*, and *Poa fendleriana*. Forbs present are mostly annuals and include *Arenaria fendleri, Astragalus nuttallianus, Calochortus flexuosus, Cymopterus purpurascens, Eriogonum ovalifolium, Lappula occidentalis, Mirabilis multiflora, Oenothera pallida, Plantago patagonica*, and *Stanleya*

pinnata. Cryptogam cover is variable with some stands having very little, but rarely cover can be as high as 25%.

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%. *Cercocarpus montanus* and *Purshia tridentata* are scarce or absent. Other shrubs may be present, including *Amelanchier utahensis, Arctostaphylos patula, Artemisia tridentata, Chamaebatiaria millefolium, Ephedra viridis, Ericameria nauseosa, Eriogonum corymbosum, Fraxinus anomala, 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 forbs. Associated graminoids include *Achnatherum hymenoides, 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, Eriogonum ovalifolium, Oenothera pallida,* and *Penstemon linarioides*.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	**Species**
Tree canopy	*Juniperus osteosperma*
Tall shrub/sapling	*Purshia stansburiana*
Short shrub/sapling	*Rhus trilobata*
Short shrub/sapling	*Ephedra viridis*
Herb (field)	*Gutierrezia sarothrae, Yucca harrimaniae*
Herb (field)	*Astragalus nuttallianus*

Global

Stratum	**Species**
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Amelanchier utahensis*
Tall shrub/sapling	*Purshia stansburiana*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Bromus tectorum, Descurainia pinnata, Erodium cicutarium

CONSERVATION STATUS RANK
Global Rank & Reasons: G4? (1-Feb-1996).

CLASSIFICATION COMMENTS
Hovenweep National Monument
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 in 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
Hovenweep National Monument Inventory Notes: This is an uncommon association that occurs on thin soils over bedrock or on bedrock exposures in the Hackberry Unit of the monument. It is also present on the rim of Little Ruin Canyon in the Square Tower Unit.
Hovenweep National Monument Plots: The description is based on 2003 field data (3 plots: HOVE.0012, HOVE.0014, HOVE.0020, 3 observation points: HOVE.9045, HOVE.9048, HOVE.9049)
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* / Sparse Understory Woodland**
Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland

CODE	CEGL002148
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) Great Basin Pinyon-Juniper Woodland (CES304.773)
USFWS WETLAND SYSTEM:	Not applicable

CONCEPT SUMMARY
Globally
This variable woodland association is widespread in parts of western Colorado and southeastern Utah. It is found most commonly on mid- to upper slopes, though other topographic positions are possible. It has been sampled at elevations between 1580 and 2389 m and on all aspects. At higher elevations, it tends toward southwestern aspects. Sites range from flat to moderately steep. The ground has variable amounts of litter and often has moderate to high amounts of gravel, rocks, and exposed bedrock. Cryptogamic cover is usually low to moderate, but some sites have up to 55-65% cover. Soils are always rapidly drained to moderately well-drained. Parent materials are also highly variable and can be sandstones, shales, or limestones. The lack of an understory may be due to high rock cover, low soil moisture, or a closed evergreen canopy of pinyon and juniper. This widespread association occurs as relatively sparse to moderately vegetated stands with total vegetation cover ranging from 10-75%. Sparsely vegetated stands (<10% total vegetation cover) composed of only trees are included as a best fit in this woodland association in extremely dry, rocky portions of the Colorado Plateau. The tree canopy is dominated by *Pinus edulis* and *Juniperus osteosperma*. Both typically range from 1-35% cover with some stands having canopy cover by one species up to 50%. The tree canopy is short, usually 2-10 m tall, and open to moderately closed. *Fraxinus anomala* has been observed in the canopy of some stands but always at no more than 5% cover. Several shrub species are commonly found in this association, but they occur as widely scattered individuals or an open shrub stratum. Scattered small *Pinus edulis* and *Juniperus osteosperma* are found along with shrubs such as *Amelanchier utahensis, Artemisia tridentata* ssp. *wyomingensis, Cercocarpus montanus, Ephedra viridis, Eriogonum microthecum, Shepherdia*

rotundifolia, and *Opuntia* spp. The herbaceous layer is low in cover (<5%) and usually low in diversity. *Achnatherum hymenoides, Bouteloua gracilis, Bromus tectorum, Poa fendleriana,* and *Pleuraphis jamesii* are common graminoids. Forbs are not abundant, but typical species include *Descurainia pinnata, Cryptantha* spp., and *Tetraneuris acaulis.*

DISTRIBUTION

Hovenweep National Monument

This association was sampled in the northeast corner of the Cutthroat CastleUnit and northwest corner of the Goodman Point Unit of the monument.

Globally

This association is known to occur in western Colorado and southeastern Utah.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This woodland association was observed on the mid- and upper slopes of hills and in an upper canyon. Sites are gentle to moderately steep (3-12° slope), occur between 1768 and 2055 m elevation, and include several aspects. The unvegetated surface has moderate to high cover of litter and low to moderate cover of small and large rocks, bedrock, and exposure of bare soil. Downed wood is common and can have cover up to 10%. Cryptogamic cover is sparse, less than 10%. The soils are rapidly drained to moderately well-drained silt loams derived from Dakota sandstone and Burro Canyon Formation shale.

Globally

This woodland association is found most commonly on mid- to upper slopes, though other topographic positions are possible. It has been sampled at elevations between 1580 and 2389 m and on all aspects. At higher elevations, such as in Black Canyon of the Gunnison National Park it tends toward southwestern aspects. Sites range from flat to moderately steep (0-25). The ground has variable amounts of litter and often has moderate to high amounts of gravel, rocks, and exposed bedrock. Cryptogamic cover is usually low to moderate, but some sites have up to 55-65% cover. Soils vary in texture but are always rapidly drained to moderately well-drained. Parent materials are also highly variable and can be sandstones, shales, limestones, among others.

VEGETATION DESCRIPTION

Hovenweep National Monument

This association is found primarily in the Cutthroat Castle and Goodman Point units of the monument. The total vegetation cover ranges from 33 to 49% in these moderately vegetated stands. This woodland association is characterized by an open tree canopy, typically 2-15 m tall, of *Pinus edulis* and *Juniperus osteosperma* trees that each range in cover from 5 to 25%. In the subcanopy, *Pinus edulis* and *Juniperus osteosperma* trees from 5-10 m tall provide up to 6% cover. The shrub layer is low in composition and is sparse to low in cover. Tall shrubs include *Amelanchier utahensis* and *Purshia stansburiana,* in addition to sapling *Juniperus osteosperma* and *Pinus edulis* trees. Short and dwarf-shrubs provide sparse to low cover by *Artemisia tridentata* ssp. *wyomingensis, Cercocarpus montanus, Ephedra viridis, Juniperus osteosperma, Pinus edulis, Gutierrezia sarothrae, Purshia tridentata,* and *Tetradymia canescens,* and the succulents *Echinocereus triglochidiatus, Opuntia fragilis,* and *Opuntia polyacantha*. The herbaceous layer is low in diversity and sparse, usually less than 5% total cover. Graminoids include *Elymus elymoides, Pleuraphis jamesii,* and *Poa fendleriana*. Forbs include *Cymopterus newberryi, Lappula occidentalis,* and *Tetraneuris acaulis*. Cryptogam cover is sparse to low, up to 10%.

Globally

This widespread association occurs as relatively sparse to moderately vegetated stands with total vegetation cover ranging from 10-75%. Sparsely vegetated stands (<10% total vegetation cover) composed of only trees are included as a best fit in this woodland association in extremely dry, rocky portions of the Colorado Plateau. The tree canopy is dominated by *Pinus edulis* and *Juniperus osteosperma*. Both typically range from 1-35% cover with some stands having canopy cover by one species up to 50%. The tree canopy is short, usually 2-10 m tall, and open to moderately closed. *Fraxinus anomala* has been observed in the canopy of some stands at Colorado National Monument but always at no more than 5% cover. Several shrub species are commonly found in this association, but they occur as widely scattered individuals or an open shrub stratum. Scattered small *Pinus edulis* and *Juniperus osteosperma* are found along with shrubs such as *Amelanchier utahensis, Artemisia tridentata* ssp. *wyomingensis,*

Cercocarpus montanus, Ephedra viridis, Eriogonum microthecum, Shepherdia rotundifolia, and *Opuntia* spp., usually *Opuntia fragilis* or *Opuntia polyacantha*. The herbaceous layer is low in cover (<5%) and usually low in diversity. *Achnatherum hymenoides, Bouteloua gracilis, Bromus tectorum, Poa fendleriana,* and *Pleuraphis jamesii* are common graminoids. Forbs are not abundant, but typical species include *Descurainia pinnata, Cryptantha* spp., and *Tetraneuris acaulis.*

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	Species
Tree canopy	*Juniperus osteosperma, Pinus edulis*

Global

Stratum	Species
Tree canopy	*Juniperus osteosperma, Pinus edulis*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Bromus tectorum

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (15-Dec-2004).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
Environmental and physiognomic variability within this association is high. There are few consistent understory species across all parks, but that is part of the concept of this type. The general sparseness of the understory is one of the main diagnostic features. Because of the wide range of circumstances that result in a sparse understory, a lot of variability in the floristic components of the understory is allowed. It is possible that this type will be split into several associations based on environmental factors, since floristic factors are not diagnostic. 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%, and they are considered a variation of the woodland type because of the ecological values of the trees.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: This association occupies a variety of substrates from eolian deposits to exposed bedrock. The sparsely vegetated soil usually has good cover of litter.
Hovenweep National Monument Plots: The description is based on 2003 field data (2 plots: HOVE.0003, HOVE.0017, 2 observation points: HOVE.9036, HOVE.9051)
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.

***Pinus edulis - Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland**
Two-needle Pinyon - Juniper species / (Wyoming Big Sagebrush, Mountain Big Sagebrush) Woodland

CODE	CEGL000776
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 broadly defined woodland association is common in the Colorado Plateau but also occurs on dry foothills and mesas from north-central New Mexico and southern Colorado west to the eastern Mojave Desert, in extreme northwestern Colorado and adjacent Utah. Elevations range from 1465 to 2500 m (4800-8200 feet). Stands occur most often on flat to gentle slopes on all aspects. The soils are generally poorly developed, moderately deep to deep, well-drained to rapidly drained loams and sands. Ground cover is variable; bare soil is common, but bedrock, litter, and large or small rocks can also be abundant on some sites. Parent material includes sandstone and shale. The vegetation is characterized by a typically open tree canopy (10-30% cover but ranges up to 50% cover) that is 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 osteosperma* is common from northwestern New Mexico west and north into Arizona and Utah. *Juniperus scopulorum* is more common in higher elevation stands. *Artemisia tridentata* (either ssp. *vaseyana* or ssp. *wyomingensis* depending on location) strongly dominates the sparse to moderately dense short-shrub layer (10-35% cover). *Purshia stansburiana* is typically absent or scarce. Other shrubs present may include *Amelanchier utahensis, Arctostaphylos patula, Cercocarpus montanus, Ephedra viridis, Gutierrezia sarothrae, Quercus gambelii* (typically <5% cover), or species of *Yucca* and *Opuntia*. Herbaceous cover is variable but generally sparse and dominated by graminoids (<5% cover) with scattered forbs.

DISTRIBUTION

Hovenweep National Monument

This association is distributed on hillslopes and was sampled at the southeastern corner and central portion of the Goodman Point Unit and in the southeastern corner of the Cutthroat Castle Unit.

Globally

This woodland association is common on the Colorado Plateau, occurring from north-central New Mexico and southern Colorado west to the Mogollon Rim of Arizona and the eastern Mojave Desert, and in extreme northwestern Colorado and adjacent Utah.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This association was observed on hillslopes with deep soil. Sites are relatively gentle (4-6 slopes), occur between 1779 and 2045 m elevation, and are oriented to northern aspects. The unvegetated surface has low to high cover of litter and low to moderate exposure of bare soil. Some sites have moderate cover of small rocks. Downed wood is typically low in cover, but one stand contained 15%. Cryptogams are sparse in cover. Soils are moderately well-drained to rapidly drained loamy sands derived from Dakota sandstone and Burro Canyon Formation shale that have weathered and been re-deposited by wind.

Globally

This broadly defined woodland association occurs on dry foothills and mesas across much of the Colorado Plateau and adjacent areas. Elevations range from 1459 to 2502 m. Stands occur most often on flat to gentle slopes but can be found on moderate to moderately steep slopes on all aspects. The soils are often deep, generally poorly developed, moderately well-drained to rapidly drained loams and sands, and skeletal. Ground cover is variable; bare soil is common, but bedrock, litter, and large or small rocks can also be abundant on some sites. Parent material includes sandstone and shale.

VEGETATION DESCRIPTION

Hovenweep National Monument

This pinyon-juniper / big sagebrush woodland association is uncommon, occupying hillslopes in the monument. The total vegetation cover ranges from 39 to 54% in these moderately vegetated stands. This woodland association is characterized by an open tree canopy, typically 2-15 m tall, of *Pinus edulis* and *Juniperus osteosperma* trees that range in cover from 1 to 10% and 15 to 30%, respectively. The characteristic short shrub *Artemisia tridentata* ssp. *wyomingensis* ranges in cover from 2 to 6%. The shrub layer is somewhat diverse and provides low cover. Tall shrubs, typically 2-5 m tall, provide sparse cover and include *Amelanchier utahensis* and sapling *Juniperus osteosperma* and *Pinus edulis* trees. Short and dwarf-shrubs, including succulents, are moderately diverse and provide sparse to low cover, including *Gutierrezia microcephala, Opuntia fragilis, Opuntia polyacantha, Peraphyllum ramosissimum*, and *Yucca harrimaniae*. The herbaceous layer is sparse to moderate in cover but low in diversity. Graminoids provide sparse to moderate cover and include *Achnatherum hymenoides, Bromus tectorum*, and *Poa fendleriana*. Forbs are sparse in cover and low in diversity, including *Cymopterus newberryi, Eriogonum ovalifolium, Lupinus* sp., *Phlox gracilis, Ceratocephala testiculata, Trifolium pratense*, and *Zigadenus paniculatus*. Cryptogams are sparse in terms of cover, less than 5%.

Globally
This woodland is characterized by a typically open tree canopy (usually 10-30% cover but ranges up to 50% cover) that ranges from 2 to 10 m tall in most stands. The tree canopy is 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 osteosperma* is common from northwestern New Mexico, western Colorado, Arizona and Utah. *Juniperus scopulorum* is more common in higher elevation stands. *Artemisia tridentata* strongly dominates the relatively sparse to moderately dense short-shrub layer (10-35% cover); either ssp. *vaseyana* or ssp. *wyomingensis* may be present, with ssp. *vaseyana* being more characteristic of higher elevations or more mesic conditions. *Purshia stansburiana* is typically absent or scarce. Other shrubs present may include *Amelanchier utahensis, Arctostaphylos patula, Cercocarpus montanus, Ephedra viridis, Gutierrezia sarothrae, Quercus gambelii* (typically <5% cover), or species of *Yucca* and *Opuntia*. Herbaceous cover is variable but is generally sparse and dominated by graminoids (<5% cover) with scattered forbs. Associated graminoids include *Achnatherum hymenoides, Bouteloua gracilis, Carex filifolia, Hesperostipa comata, Koeleria macrantha, Muhlenbergia torreyi, Pascopyrum smithii, Pleuraphis jamesii*, and *Poa fendleriana*. Forbs include species of *Cryptantha, Eriogonum, Penstemon*, and *Phlox*. Cryptogram cover tends to be low, but some stands may have moderate cover.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	**Species**
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Tree subcanopy	*Juniperus osteosperma, Pinus edulis*
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*

Global

Stratum	**Species**
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Short shrub/sapling	*Artemisia tridentata* ssp. *vaseyana*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (1-Feb-1996).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
On dry, rocky or slickrock sites on the Colorado Plateau, this 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 Artemisia tridentata 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: 1 - Strong

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: Some stands experience erosion via small channels and on unstable slopes. The stands are old and decadent. Some *Pinus edulis* trees have succumbed to drought.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0016, 2 observation points: HOVE.9039, HOVE.9058)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Drake and J. Coles

REFERENCES: Bourgeron and Engelking 1994, Bunting 1987, CONHP unpubl. data 2003, Cogan et al. 2004, Dick-Peddie 1993, Driscoll et al. 1984, Erdman 1970, Everett 1987, Heinze et al. 1962, Isaacson 1967, Jameson et al. 1962, Johnston 1987, Larson and Moir 1987, Mason et al. 1967, Moir and Carleton 1987, NVNHP 2003, Stuever and Hayden 1997a, Tiedemann 1978, USFS 1983a, USFS 1985a, USFS 1985e, Warren et al. 1982, Wright et al. 1979

***Pinus edulis* - *Juniperus* spp. / *Cercocarpus montanus* - Mixed Shrub Woodland**
Two-needle Pinyon - Juniper species / Mountain-mahogany - Mixed Shrub 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 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. 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 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 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

Hovenweep National Monument

This association is rare and found on upper canyon slopes in the Cutthroat Castle Unit of the monument.

Globally

This widespread 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

Hovenweep National Monument

This woodland association was observed on the upper slope of a small canyon in the Cutthroat Castle Unit. The site is moderately steep (11° slope), occurs at 1774 m elevation, and is oriented to a southwestern aspect. The unvegetated surface has low cover of litter. Large and small rocks and exposures of bare soil comprise much of the unvegetated surface. Cryptogamic cover is sparse. Soils are derived from Burro Canyon Formation shale and are well-drained clay loams.

Globally

This broadly defined woodland association is common on the Colorado Plateau, occurring on 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 (3-35°) 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

Hovenweep National Monument

This pinyon-juniper / mountain mahogany woodland association is rare, occurring only in the Cutthroat Castle Unit of the monument. The total vegetation cover is 53% in this moderately vegetated stand. This woodland association is characterized by an open tree canopy, 2-5 m tall, of *Pinus edulis* and *Juniperus osteosperma* trees that provide cover of 30% and 8%, respectively. The shrub layer is variable in diversity and low in cover. *Cercocarpus montanus* provides 7% cover and is 1-2 m tall. Short and dwarf-shrubs (including succulents) are diverse and provide low cover, including *Amelanchier utahensis, Echinocereus triglochidiatus, Ephedra viridis, Ericameria nauseosa, Juniperus osteosperma, Opuntia erinacea, Gutierrezia microcephala, Gutierrezia sarothrae, Sclerocactus whipplei*, and *Yucca harrimaniae*. The herbaceous layer is sparse and low in diversity. The graminoid *Achnatherum hymenoides* provides sparse cover. Forbs include *Arenaria fendleri, Cymopterus newberryi, Stenotus armerioides*, and *Heterotheca villosa.* Cryptogam cover is sparse, less than 5%.

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 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. Associated graminoids include *Achnatherum hymenoides, Andropogon gerardii, Bouteloua curtipendula, Bouteloua gracilis, Bouteloua hirsuta, Carex rossii, Leymus salinus, Hesperostipa comata, Koeleria macrantha, Muhlenbergia pauciflora, Pascopyrum smithii, Pleuraphis jamesii, Poa fendleriana, Pseudoroegneria spicata*, and *Schizachyrium scoparium*. Common forbs include species of *Cryptantha, Eriogonum, Penstemon* and *Phlox*. 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.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	Species
Tree canopy	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Cercocarpus montanus*

Global

Stratum	Species
Tree canopy	*Juniperus monosperma, Juniperus osteosperma, Pinus edulis*
Short shrub/sapling	*Cercocarpus montanus*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Hovenweep National Monument
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 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 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: 1 - Strong

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: This is a rare association that occurs in the Cutthroat Castle Unit of the monument.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0004)
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 1962, 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, 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 1580-2665 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 mesatops, 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
Hovenweep National Monument
This type was sampled on the east-facing slope of the main drainage in the Goodman Point Unit. It is within 100 m of the seep/spring at the head of the drainage and the beginning of extensive ruins.

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
Hovenweep National Monument
This woodland association was observed on the slope of the primary drainage in the Goodman Point Unit. The site is gentle (4° slope), occurs at 2010 m elevation, and is oriented to an eastern aspect. The unvegetated surface has high cover by litter and low to moderate cover of downed wood, mostly of recently killed *Pinus edulis* trees. Soils are deep Quaternary alluvium and are moderately well-drained and fine in texture.

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 1580-2665 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 mesatops, 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 sandstone, shale, limestone and rhyolite.

VEGETATION DESCRIPTION

Hovenweep National Monument

This pinyon-juniper / Gambel oak woodland association occurs only in the Goodman Point Unit at the highest monument elevations. The total vegetation cover is up to 81% in this densely vegetated stand. This association is characterized by a closed and relatively homogenous tall-shrub or small-tree canopy of 2- to 5-m tall *Quercus gambelii* that provide 60% cover. The 10- to 15-m tall canopy trees *Juniperus osteosperma* and *Pinus edulis* provide relatively sparse cover. The remaining tall- and short-shrub layers provide sparse cover, have low diversity, and include *Amelanchier utahensis, Juniperus osteosperma, Peraphyllum ramosissimum*, and *Pinus edulis*. The herbaceous layer is relatively diverse and provides low cover. Graminoids include *Bromus tectorum* and *Poa fendleriana*. Forbs provide sparse cover and include *Asteraceae* sp., *Corydalis aurea, Lupinus argenteus*, and *Phlox longifolia*. Species of lichens provide sparse cover.

Globally

This widespread association 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 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 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., *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, Packera neomexicana, Thalictrum fendleri*, or *Vicia americana*.

MOST ABUNDANT SPECIES

Hovenweep National Monument

Stratum	**Species**
Tree canopy	*Juniperus osteosperma*
Tall shrub/sapling	*Quercus gambelii*
Herb (field)	*Poa fendleriana*

Global

Stratum	**Species**
Tree canopy	*Juniperus monosperma, Juniperus osteosperma, Juniperus scopulorum, Pinus edulis*
Tall shrub/sapling	*Amelanchier utahensis, Quercus gambelii*
Tall shrub/sapling	*Cercocarpus montanus*
Short shrub/sapling	*Symphoricarpos oreophilus*

OTHER NOTEWORTHY SPECIES

Hovenweep National Monument
Bromus tectorum (cheatgrass)

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
Data are not available

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: Distributed as a small patch or stand of tree-like shrubs on a drainage slope in the Goodman Point Unit. The site is more protected and mesic than the adjacent uplands. It is the only stand known in the monument. The stand was dominated by Pinus edulis historically, but these trees are now dead.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 observation point: HOVE.9050)
Local Description Authors: J. Von Loh, mod. 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

***Populus deltoides* (ssp. *wislizeni*, ssp. *monilifera*) / *Artemisia tridentata* Woodland (Rio Grande Cottonwood, Plains Cottonwood) / Basin Big Sagebrush Woodland**

CODE	CEGL005966
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	POPULUS DELTOIDES TEMPORARILY FLOODED WOODLAND ALLIANCE Eastern Cottonwood Temporarily Flooded Woodland 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 Riparian Woodland and Shrubland (CES306.821)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This riparian association is found in the San Juan River drainage in northwestern New Mexico and adjacent southeastern Utah. It is probably present in northeastern Arizona. It occurs along low-gradient rivers of wide lowland valleys at elevations from 1640 to 1840 m (5375-6025 feet). Stands are located on high terraces well above the active channel (discharge ratio >5), and flooding is infrequent (50- to 100-year recurrence intervals). Soils have

coarse loamy profiles throughout and are mostly young and undeveloped Entisols, although Inceptisols can occur on higher terraces where soil development has not been disrupted by flooding. Mature *Populus deltoides* canopies are generally open, with *Juniperus scopulorum*, *Elaeagnus angustifolia*, and *Salix amygdaloides* in the subcanopy. The shrub layer is dominated by *Artemisia tridentata* with other upland species associates such as *Ericameria nauseosa* and *Rhus trilobata*. The presence of *Artemisia*, a common dominant from surrounding desert uplands, in these floodplain gallery forests is an indicator of infrequent flooding, perhaps because of regulated streamflows, or because the channel is actively cutting down or away from the forest. Grasses can be well-represented to abundant and are typically dominated by upland species, such as *Sporobolus cryptandrus* and *Achnatherum hymenoides*. Although a relatively dry type, some wetland indicator species still occasionally occur, such as *Schoenoplectus pungens*, *Distichlis spicata*, and *Muhlenbergia asperifolia*. Forbs are very scattered and low in diversity. As a keystone species, the reproduction of *Populus deltoides* after flooding (and sufficient subsequent base flows) is critical to the sustainability of this community.

DISTRIBUTION

Hovenweep National Monument

This association was sampled in Little Ruin Canyon of the Square Tower Unit. It is also present in five of the six Hovenweep units (not in the Cajon Unit), and sometimes is dominated by *Celtis laevigata* var. *reticulata*.

Globally

This association is found in the San Juan River drainage in northwestern New Mexico, in adjacent southeastern Utah and is probably present in northeastern Arizona.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This woodland association was observed as a small stand on elevated terraces in the Little Ruin Canyon bottom. The site is gentle (2° slope), occurs at 1567 m elevation, and is oriented to a southeastern aspect. The unvegetated surface has high cover of litter and low cover of large rocks. Soils are rapidly drained and are a sandy loam derived from the Dakota sandstone and Burro Canyon Formation.

Globally

This mature riparian forest association is characteristic of high terraces along low-gradient rivers in northwestern New Mexico, adjacent southeastern Utah and probably northeastern Arizona. It occurs in wide lowland valleys at elevations from 1640 to 1840 m (5375-6025 feet). Stands are located on terraces well above the active channel (discharge ratio >5). The water table is usually at least 3 m below ground surface, and flooding is infrequent to absent (minimum 50- to 100-year recurrence intervals). Soils have coarse loamy profiles throughout and are mostly young and undeveloped Entisols (Aquic and Typic Ustifluvents). Inceptisols can occur on higher terraces where soil development has not been disrupted by flooding (Fluventic Ustochrept).

VEGETATION DESCRIPTION

Hovenweep National Monument

This cottonwood woodland is rare, occupying terraces in deeper canyons in the monument, where seeps and springs emerge. The total vegetation cover is 137% in this densely vegetated stand. This woodland association is characterized by a moderately dense tree canopy, 20-35 m tall, of *Populus deltoides* ssp. *wislizeni* trees that provide 60% cover. The shrub layer is low in diversity and provides low cover, with the tall shrubs *Artemisia tridentata* ssp. *wyomingensis*, *Ericameria nauseosa*, and *Tamarix chinensis* providing 12%. The herbaceous layer is low in diversity but provides high cover of exotic species. Graminoids include *Bromus tectorum*, that provides 65% cover, *Agrostis* sp., and *Poa pratensis*. Forbs include only *Sisymbrium altissimum*.

Globally

The open canopy is dominated by *Populus deltoides* (between 30 - 60% cover) and 10-20 m high, sometimes with a sparse subcanopy of *Juniperus scopulorum*, *Juniperus osteosperma*, *Elaeagnus angustifolia*, *Celtis laevigata* var. *reticulata*, and *Salix amygdaloides*. The shrub layer is dominated by *Artemisia tridentata* with other upland species such as *Ericameria nauseosa* and *Rhus trilobata*. Grasses can be well-represented to abundant and are typically dominated by upland species, such as *Sporobolus cryptandrus* and *Achnatherum hymenoides*. Although a relatively dry type, some wetland indicator species still occasionally occur, such as *Schoenoplectus pungens*, *Distichlis spicata*, and *Muhlenbergia asperifolia*. Forbs are very scattered and low in diversity (16 species), of which 75% (12

species) are native.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	Species
Tree canopy	*Populus deltoides* ssp. *wislizeni*
Tall shrub/sapling	*Ericameria nauseosa*
Tall shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*

Global

Stratum	Species
Tree canopy	*Populus deltoides* ssp. *monilifera, Populus deltoides* ssp. *wislizeni*
Tall shrub/sapling	*Artemisia tridentata* ssp. *tridentata*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Bromus tectorum (cheatgrass)

Globally
Bromus tectorum, Tamarix chinensis

CONSERVATION STATUS RANK
Global Rank & Reasons: G2G3 (28-Sep-2004). This association has likely undergone significant declines in the San Juan River basin as a result of impoundments and subsequent river regulation along with agricultural conversion and urban development. It requires low-gradient floodplain habitats in which natural hydrological processes are operational to ensure reproduction and maintenance of Populus deltoides and other key wetland species. Conditions such as these are now rare in river basins of the Southwest. Many extant occurrences are approaching senescence and loss without replacement due to the lack of natural floods. Others are declining because minimum in-stream base flows are not being maintained. In addition, many occurrences are significantly invaded by alien species. The rank of G2G3 was assigned with limited information; further documentation is desirable. However, the expectation is that this rank will be upheld and may be trending towards a rank of G2.

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
This type, although it lacks significant wetland indicators other than cottonwood, is often found in a mosaic with wetter forested and shrub wetland types than occur on lower floodplain terraces. It is ecologically similar to *Populus deltoides / Ericameria nauseosa* Forest (CEGL005969), but *Artemisia tridentata* has significantly higher cover than *Ericameria nauseosa*. Dick-Peddie (1993) refers to a *Populus fremontii / Chrysothamnus nauseosus* / Mesic Grass - Forb type as part of his Floodplain-Plains Riparian group, which may also be related.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: These are small patches of riparian vegetation that grow from seep and spring sites formed at the interface between Dakota sandstone and Burro Canyon shale. All are associated with the ruins (principal water source).
Hovenweep National Monument Plots: The description is based on 2003 field data (1 observation point: HOVE.9062)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: E. Muldavin et al., mod. J. Coles

REFERENCES: Dick-Peddie 1993, Muldavin et al. 2000a

Populus deltoides (ssp. *wislizeni*, ssp. *monilifera*) / *Salix exigua* Woodland (Rio Grande Cottonwood, Plains Cottonwood) / Coyote Willow Woodland

CODE	CEGL002685
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	POPULUS DELTOIDES TEMPORARILY FLOODED WOODLAND ALLIANCE Eastern Cottonwood Temporarily Flooded Woodland Alliance

ECOLOGICAL SYSTEM(S):

Western Great Plains Floodplain (CES303.678)
Rocky Mountain Lower Montane Riparian Woodland and Shrubland (CES306.821)
North American Warm Desert Lower Montane Riparian Woodland and Shrubland (CES302.748)
Western Great Plains Riparian Woodland and Shrubland (CES303.956)
Northwestern Great Plains Canyon (CES303.658)

USFWS WETLAND SYSTEM: Palustrine

CONCEPT SUMMARY

Globally

This is a lowland riparian association known from the Rio Grande, Pecos and Canadian river drainages of central and eastern New Mexico and probably elsewhere in northern New Mexico. It also occurs in the Great Plains of Colorado, North Dakota, Nebraska, Oklahoma, South Dakota, and Texas, and in the Colorado Plateau of Utah and Colorado. This association occurs in wide river corridors that have low-gradient and primarily sandy/gravelly beds (becoming cobbly with increasing gradients). Elevations range from 1380-1980 m (4525-6500 feet). The type is most often found proximal to perennial rivers on low sidebars and streambanks near stream bankfull levels (discharge ratios close to 1). Occasionally, it can be found within the active channel or nearby. Because of its low position, the type is flooded frequently (average recurrence interval is 5 years). Most soils are young and undeveloped Entisols, and soils within the active channel are classified as riverwash. Soils tend to be well-drained sands with mixtures of cobbles and gravels throughout the profile. Most soils tend to be moist or wet within 1 m, at least during seasonal high water. In some soils, moisture indicators are found at greater depths. This association is dominated by relatively young stands of *Populus deltoides* that form open to moderately open overstories (25-50 % cover) with thickets of *Salix exigua* in the understory. *Baccharis salicina* is often well-represented to abundant and may codominate. Herbaceous cover is abundant, particularly among graminoids, and numerous (23) native wetland indicators can be present, such as *Schoenoplectus pungens, Scirpus microcarpus, Eleocharis palustris, Juncus balticus, Juncus longistylis, Juncus tenuis, Glyceria striata, Carex aquatilis, Carex oreocharis, Carex scoparia, Carex stipata, Equisetum arvense*, and *Equisetum laevigatum*. Overall herbaceous diversity is high (90 species) and still predominantly native in composition (66 species or 73%).

DISTRIBUTION

Hovenweep National Monument

This association was sampled at the bottom of a pour-off in the narrow drainage of the main canyon in the Cutthroat Castle Unit of the Monument.

Globally

This association is found in the Rio Grande, Pecos and Canadian river drainages of central and eastern New Mexico and probably elsewhere in northern New Mexico. It also occurs in the Great Plains of Colorado, North Dakota, Nebraska, Oklahoma, South Dakota, and Texas, as well as the Colorado Plateau of Colorado and Utah.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This association was documented below a pour-off in the Cutthroat Castle Unit. The site is gentle (1° slope), occurs at 1594 m elevation, and is oriented to a western aspect. The unvegetated surface has high cover of litter and low cover of large and small rocks. The soils are poorly drained and sandy, derived from the Burro Canyon Formation and covered by boulders of Dakota sandstone.

Globally
This community occurs in wide river corridors that have low-gradient and primarily sandy/gravelly beds (becoming cobbly with increasing gradients). Elevations range from 1380 to 1980 m (4525-6500 feet). The type is most often found proximal to perennial rivers on low sidebars and streambanks near stream bankfull levels (discharge ratios close to 1). Occasionally, it can be found within the active channel or nearby, or at the base of pour-offs in slickrock canyons. Because of its low position, the type is flooded frequently (average recurrence interval 5 years). Most soils are young and undeveloped Entisols, and soils within the active channel are classified as riverwash. Soils tend to be well-drained sands with mixtures of cobbles and gravels throughout the profile. Most soils tend to be moist or wet within 1 m, at least during seasonal high water. In some soils, moisture indicators are found at greater depths.

VEGETATION DESCRIPTION
Hovenweep National Monument
This forest association is distributed in drainage bottoms on seeps and under pour-offs, but is rare, growing as small patches within the monument. The total vegetation cover is 67% in this moderately vegetated stand. This forest association is characterized by a somewhat closed tree canopy, 15-20 m tall, of *Populus deltoides* ssp. *wislizeni* that provides 45% cover, and the tall shrub *Salix exigua* that provides 6% cover. Subcanopy trees that are 5-10 m tall provide low cover, including *Juniperus osteosperma* and *Pinus edulis*. The tall- and short-shrub layer is low in diversity and in cover, and includes *Cercocarpus montanus* and *Purshia stansburiana*. The herbaceous layer provides sparse cover and includes the annual grass *Vulpia octoflora*.

Globally
This type is dominated by relatively young stands of Populus deltoides that form open to moderately open canopies (10-50% cover) with thickets of *Salix exigua* in the understory. Colorado Plateau stands may include *Populus* X *acuminata* in the canopy. *Baccharis salicina* is often well-represented to abundant and may codominate with *Salix* in some parts of the range. Herbaceous cover is abundant, particularly among graminoids, and numerous (23) native wetland indicators can be present, such as *Schoenoplectus pungens, Scirpus microcarpus, Eleocharis palustris, Juncus balticus, Juncus longistylis, Juncus tenuis, Glyceria striata, Carex aquatilis, Carex oreocharis, Carex scoparia, Carex stipata, Equisetum arvense*, and *Equisetum laevigatum*. Invasive exotic species can also be prevalent, such as *Agrostis gigantea, Agrostis stolonifera, Poa pratensis*, and *Melilotus officinalis*. Overall herbaceous diversity is high (90 species) and still predominantly native in composition (66 species or 73%).

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	Species
Tree canopy	*Populus deltoides* ssp. *wislizeni*
Tree subcanopy	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Salix exigua*
Tall shrub/sapling	*Cercocarpus montanus*

Global

Stratum	Species
Tree canopy	*Populus deltoides* ssp. *wislizeni*
Tall shrub/sapling	*Salix exigua*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: G3 (1-Dec-2000). This lowland riparian association is restricted to scattered stands along the Rio Grande and Pecos rivers (and their tributaries) in New Mexico, where plants, particularly trees and shrubs, have access to an active ground water table. The number of high-quality occurrences is not likely to exceed 25 in

number, because as with many riparian zone communities in the Southwest, impacts over the past 150 years from livestock use, agricultural conversion, urbanization, recreational use, exotic tree and shrub invasion, and the alteration of hydrological regimes have led to extensive fragmentation and loss of this community. Viable occurrences are mostly found along unregulated rivers where periodic flooding and sustained maintenance flows lead to successful reproduction and establishment of native riparian species. In the Southwest, such unregulated rivers are few, hence this community still is threatened, and declines continue, suggesting a rank of G3. Should declines continue the rank might need to be raised to G2.

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
Initially developing on exposed depositional sandbars, this mid-successional community type depends on periodic flooding for maintenance and growth, even when well-established. As sediments and debris become trapped among the woody stems, the bar becomes more stable. In this community type, the cottonwoods overtop the shrubby willows. Because the willows are limited to lower riverside bars or cutoff channels, the community type eventually changes as the trees develop into mature forests on higher terraces without the willow understory. Historically, when cottonwoods eventually died from old age or were removed in high-energy flood events, they were replaced by new, young trees. For this cycle to occur under regulated conditions, flows should mimic the natural flood regime as closely as possible.

Hink and Ohmart (1984) describe a cottonwood/coyote willow mapping unit with four structural sub-types for the middle Rio Grande. Dick-Peddie (1993) refers to a *Populus fremontii / Salix exigua* / Mesic Grass - Forb vegetation type as part of a Floodplains-Plains Riparian group that is probably inclusive of this type. This association is similar to *Populus deltoides – (Salix amygdaloides) / Salix (exigua, interior)* Woodland (CEGL000659) reported from the Great Plains states.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: Restricted to canyon heads and mesic sites in canyon bottoms where seeps and springs emerge.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 observation point: HOVE.9038)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: E. Muldavin et al., mod. J. Coles

REFERENCES: CONHP Ecology Team 2001, Dick-Peddie 1993, Hink and Ohmart 1984, Muldavin et al. 2000a

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, occurring in small to moderate-sized patches on alluvial terraces, floodplains, and point bars. *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

Hovenweep National Monument

This association was sampled on the principle ruins of the Goodman Point Unit and at the confluence of Little Ruin Canyon and another canyon in the Square Tower Unit of the monument.

Globally

This association is widespread in southern Utah and western Colorado.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This association was observed on the first terrace along the Little Ruin Canyon bottom drainage and on rubble mounds from prehistoric ruins. Sites are gentle (0-3° slopes), occur between 1573 and 2045 m elevation, and are oriented to southern aspects. The unvegetated surface has high cover of litter and low cover of large rocks (prehistoric rock rubble) and bare soil. Cryptogamic cover can be up to 15% in some stands. Parent materials are Dakota sandstone and Burro Canyon Formation reworked by water and deposited as Quaternary alluvium at one site. Soils are well-drained sandy loams.

Globally

This association occurs on alluvial terraces, flats and fans or valley floors throughout the Colorado Plateau. Most stands occur below 2000 m (6560 feet) on level to gently sloping sites. Soils are variable and include sandy loams, silt loams, and clay loams, depending on the size of the stream and the geology of the watershed. Cryptobiotic soil crusts are often extensive.

VEGETATION DESCRIPTION

Hovenweep National Monument

This shrubland association is uncommon and distributed on prehistoric rubble and deep drainage courses in canyon bottoms. The total vegetation cover ranges from 70 to 119% in these densely vegetated stands. This shrubland association is characterized by an open to closed tall-shrub canopy, typically 1-2 m tall, of *Artemisia tridentata* ssp. *tridentata* or *Artemisia tridentata* ssp. *wyomingensis* shrubs that provide cover of 35% or 40%, respectively. A few *Juniperus osteosperma* and *Pinus edulis* trees, typically 2-5 m tall, that each provide cover up to 3%, are present. Short shrubs are low in diversity and provide sparse to low cover, including *Atriplex canescens, Ericameria nauseosa*, and *Sarcobatus vermiculatus*. The herbaceous layer is typically sparse but has low to high cover (5-65%) of the exotic annual grass *Bromus tectorum*. Other graminoids provide sparse cover and include *Vulpia octoflora* and *Poa fendleriana*. Forbs provide sparse to low cover, are relatively diverse and include *Astragalus nuttallianus, Corydalis aurea, Descurainia pinnata, Erodium cicutarium, Lappula occidentalis, Oenothera caespitosa,* and *Sisymbrium altissimum*. Cryptogams occur in a patchy distribution providing low cover from 1-15%.

Globally

This association is widespread on floodplains and terraces within the Colorado Plateau that have been subject to grazing. *Artemisia tridentata* ssp. *tridentata* is always present with cover ranging between 10 and 70% and up to2 m in height. *Ericameria nauseosa* is not always present, but is likely to be present in the vicinity. Other shrubs that occur in this community consistently include *Atriplex canescens, Chrysothamnus viscidiflorus,* and *Sarcobatus vermiculatus*. In some stands there may be scattered individuals of *Pinus edulis* or *Juniperus osteosperma*. The herbaceous layer reflects a long history of disturbance and is dominated by exotic annual species, especially *Bromus tectorum*. Other common herbaceous species include *Erodium cicutarium, Lappula occidentalis,* and *Sisymbrium altissimum*. Remnant native herbaceous vegetation may include scattered individuals or patches of *Achnatherum hymenoides* and *Oenothera caespitosa*.

MOST ABUNDANT SPECIES

Hovenweep National Monument

Stratum	**Species**
Tall shrub/sapling	*Artemisia tridentata* ssp. *tridentata, Artemisia tridentata* ssp. *wyomingensis*
Short shrub/sapling	*Ericameria nauseosa, Sarcobatus vermiculatus*
Short shrub/sapling	*Atriplex canescens*
Herb (field)	*Descurainia pinnata, Erodium cicutarium*
Herb (field)	*Bromus tectorum*

Global

Stratum	**Species**
Tall shrub/sapling	*Artemisia tridentata* ssp. *tridentata*
Herb (field)	*Bromus tectorum*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (14-Aug-2001).

CLASSIFICATION COMMENTS
Hovenweep National Monument
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
Hovenweep National Monument Inventory Notes: One stand has colonized rubble mounds of a prehistoric village. Another stand has established on a valley floor terrace that no longer floods.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0022, 1 observation point: HOVE.9044)
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.

***Artemisia tridentata* ssp. *wyomingensis* - *Atriplex confertifolia* Shrubland**
Wyoming Big Sagebrush - Shadscale Shrubland

CODE	CEGL001040
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 SSP. WYOMINGENSIS SHRUBLAND ALLIANCE Wyoming Big Sagebrush Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)
Great Basin Xeric Mixed Sagebrush Shrubland (CES304.774)
Columbia Plateau Ash and Tuff Badland (CES304.081)

USFWS WETLAND SYSTEM: Not Applicable

CONCEPT SUMMARY

Globally

This type is found irregularly in xeric, alkaline sites in the Colorado Plateau, Great Basin and northwestern Great Plains of the United States. Slopes tend to be gentle to moderate, and alkaline substrates may be modified by a thin layer of alluvial or colluvial deposits. Stands are dominated by *Artemisia tridentata* ssp. *wyomingensis*, with *Atriplex confertifolia* as an associate. The understory tends to be sparse and inconsistent in its composition.

DISTRIBUTION

Hovenweep National Monument

This association was sampled on the hillslope near the north boundary of the Holly Unit.

Globally

This type is found irregularly in the Great Basin and northwestern Great Plains of the United States, ranging from western North Dakota, southwest to Utah and California.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This shrubland association was observed on the midslope of a hill in the Holly Unit. The site is gentle (4° slope), occurs at 1634 m elevation, and is oriented to a southern aspect. The unvegetated surface has moderate litter cover and low exposure of bare soil. Cryptogamic cover is moderate. Soils are rapidly drained and appear extremely alkaline; they are derived from Burro Canyon shale.

Globally

This short shrubland association occurs on slopes, ridgetops, and benches in dry habitats of the Colorado Plateau and Great Basin, extending into the northwestern Great Plains. It is found in lowlands and on terraces and alluvial fans in the outwash plains near Bighorn and Prior mountains (Knight et al. 1987, DeVelice and Lesica 1993) in north-central Wyoming and south-central Montana. Elevations range between 1120 and 1634 m (3680-5360 feet), slopes range from level to gently sloping, and sites may be oriented to any aspect. Soil textures are variable, including silty loam, clay loam, sandy loam and sandy clay, and generally are derived from alluvium, sandstone, siltstone or shale. Soils of this association are more alkaline than those of adjacent sagebrush steppe associations (Knight et al. 1987) and similar in alkalinity to soils supporting saltbush associations. Cryptobiotic crusts may cover up to 50% of the unvegetated ground surface in undisturbed stands.

VEGETATION DESCRIPTION

Hovenweep National Monument

This Wyoming big sagebrush - shadscale shrubland association is present on one site in the Holly Unit. The total vegetation cover is 41% in this moderately vegetated stand. This shrubland association is characterized by the short-shrub layer of *Artemisia tridentata* ssp. *wyomingensis* and *Atriplex confertifolia* that each provide cover of 15%. The associated shrubs are low in diversity and cover, including *Ephedra torreyana, Gutierrezia sarothrae*, and *Sarcobatus vermiculatus*. Graminoids are uncommon and sparse with only *Pleuraphis jamesii* observed. Forbs are uncommon but provide low cover, including *Astragalus nuttallianus* and *Calochortus flexuosus*. Cryptogam cover is moderate for this association.

Globally

Stands of this somewhat sparsely vegetated association are dominated by *Artemisia tridentata* ssp. *wyomingensis*, with between 1 and 28% cover. *Atriplex confertifolia* is present and may be codominant. Other shrub species that may be present include *Atriplex gardneri, Ericameria nauseosa, Krascheninnikovia lanata, Grayia spinosa, Gutierrezia sarothrae, Opuntia polyacantha, Picrothamnus desertorum*, and *Sarcobatus vermiculatus*. The understory in most stands is relatively sparse, rarely exceeding 10% total cover. Herbaceous species may include small amounts of *Achnatherum hymenoides, Aristida purpurea, Elymus elymoides, Hesperostipa comata, Lepidium montanum, Oenothera pallida, Phlox hoodii, Pleuraphis jamesii, Sphaeralcea coccinea*, and *Sporobolus airoides*.

MOST ABUNDANT SPECIES

Hovenweep National Monument

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia*

Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*
Herb (field)	*Astragalus nuttallianus*

Global

Stratum	**Species**
Short shrub/sapling	*Atriplex confertifolia*
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Bromus tectorum

CONSERVATION STATUS RANK
Global Rank & Reasons: G3G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
This type needs further study. In the Great Plains, the type is largely synonymous with *Artemisia tridentata - Atriplex confertifolia* Shrubland (CEGL000993). DeVelice and Lesica (1993) described stands of *Artemisia tridentata - Atriplex confertifolia* Community Type that likely were dominated by *Artemisia tridentata* ssp. *wyomingensis*, but sagebrush was not keyed to subspecies. These stands were included in the concept of this association but are also referenced in *Artemisia tridentata - Atriplex confertifolia* Shrubland (CEGL000993) because of the possibility that some of the stands were dominated by *Artemisia tridentata* ssp. *tridentata*. More information is needed as to how much *Atriplex confertifolia* cover is needed to classify a stand as this association. A number of the existing *Artemisia tridentata* ssp. *wyomingensis* associations list *Atriplex confertifolia* as an associate. DeVelice and Lesica (1993) sampled four stands that averaged 28% cover *Artemisia tridentata*, 4% cover *Atriplex confertifolia*, 2% cover *Picrothamnus desertorum*, and 2% cover *Atriplex gardneri*. Knight et al. (1987) indicate that in their stands *Artemisia tridentata* ssp. *wyomingensis* averaged 7% cover, *Picrothamnus desertorum* averaged 1% cover, and *Atriplex confertifolia* averaged <1%. This closely resembles plots at Dinosaur National Monument that were assigned to other *Artemisia tridentata* ssp. *wyomingensis* associations.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: This type is limited to one known stand in the Holly Unit, although additional small patches or stands may exist where Burro Canyon shale outcrops occur in the monument.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 observation point: HOVE.9041)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: D. Faber-Langendoen, mod. J. Coles and K.A. Schulz

REFERENCES: Bourgeron and Engelking 1994, Brown 1971, DeVelice and Lesica 1993, Driscoll et al. 1984, Kagan et al. 2000, Knight et al. 1987, MTNHP 2002b, NDNHI unpubl. data

Artemisia tridentata ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland
Wyoming Big Sagebrush / Disturbed Understory Semi-natural Shrubland

CODE	CEGL002083
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 SSP. WYOMINGENSIS SHRUBLAND ALLIANCE Wyoming Big Sagebrush Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)

USFWS WETLAND SYSTEM: Not Applicable

CONCEPT SUMMARY

Globally

This association has been found in western Colorado and eastern Utah but is likely widespread in other parts of the interior western U.S. It can occur on a variety of landscape positions on sites that are flat to moderately steep. This association has been sampled at elevations between 1455 and 2095 m (4770-6870 feet) but is probably found elsewhere. The unvegetated surface is mostly composed of litter, bare soil, and rocks. Soils are typically eolian, alluvial, or colluvial loamy sands to sandy loams. This shrubland association has moderately open to dense vegetation cover with an open to closed short-shrub layer. The dominant shrub is *Artemisia tridentata* ssp. *wyomingensis* with low to moderate cover. Scattered (2-5 m tall) *Pinus edulis* and *Juniperus osteosperma* trees may be present with sparse cover. Other tall, short, and dwarf-shrubs that may be found are E*ricameria nauseosa, Ephedra viridis, Gutierrezia sarothrae, Sarcobatus vermiculatus* and succulents. The herbaceous stratum has low to high cover and diversity, but weedy, exotic and invasive species tend to dominate. Common graminoids include *Achnatherum hymenoides, Aristida purpurea, Bromus tectorum, Vulpia octoflora*, and *Pleuraphis jamesii*. Forbs provide sparse to high cover and include *Astragalus nuttallianus, Descurainia pinnata, Erodium cicutarium, Lappula occidentalis*, and *Phacelia crenulata*.

DISTRIBUTION

Hovenweep National Monument

This association was sampled as a small patch in the ruins of the Cutthroat Castle Unit and in the northeastern corner, Little Ruin Canyon, northwestern corner, and north-central portion of the Square Tower Unit.

Globally

This association has been observed in western Colorado and eastern Utah. It is very likely to occur in other parts of the western U.S.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This association was observed on the midslopes of hills and terraces, and low slopes, midslopes, and rims of canyons. Sites are gentle to moderately steep (2-10° slopes), occur between 1561 and 1658 m elevation, and include all aspects. The unvegetated surface has moderate to high cover of litter and low to high exposure of bare soil. Cryptogamic cover is absent to low, up to 15%. Soils are often eolian deposits or alluvium that are moderately well-drained and are loamy sands or sandy loams.

Globally

This association has been found on a variety of landscape features including mesatops, midslopes and low slopes of canyons, hills, and valleys, and on terraces. Sites can be flat to moderately steep (0-15°) and have any aspect. Sampled sites have had elevations between 1455 and 2095 m (4770-6870 feet). The unvegetated surface can be composed of variable amounts of litter and bare soil and large or small rocks. Soils are typically eolian, alluvial, or colluvial loamy sands to sandy loams.

VEGETATION DESCRIPTION

Hovenweep National Monument

This association is distributed predominantly in the Square Tower Unit and rarely in the Cutthroat Castle Unit of the monument. The total vegetation cover ranges from 28 to 89% in these moderately open to densely vegetated stands. This shrubland association is characterized by an open to relatively closed short-shrub canopy of *Artemisia tridentata* ssp. *wyomingensis* that ranges in cover from 12 to 45%. *Artemisia tridentata* ssp. *wyomingensis* is present as a tall shrub in one stand and provides 25% cover. The canopy tree, typically 2-5 m tall, of *Juniperus osteosperma* is occasionally present and provides up to 10% cover. The shrub layer is low in cover and composition. Tall shrubs provide low cover and include *Ericameria nauseosa* and *Purshia stansburiana*. Short and dwarf-shrubs are low in

diversity and provide sparse to low cover, including *Ephedra viridis, Gutierrezia sarothrae*, and *Sarcobatus vermiculatus*. The herbaceous layer provides sparse to high cover and is diverse. Common graminoids include *Achnatherum hymenoides, Aristida purpurea, Bromus tectorum, Vulpia octoflora*, and *Pleuraphis jamesii*. Forbs provide sparse to high cover and include *Astragalus nuttallianus, Cryptantha crassisepala, Descurainia pinnata, Erodium cicutarium, Lappula occidentalis, Lithospermum* sp., and *Phacelia crenulata*. Cryptogam cover is typically absent but may be as high as 5%.

Globally
This shrubland association has moderately open to dense vegetation cover (28-89%) with an open to closed short-shrub layer. The dominant shrub, *Artemisia tridentata* ssp. *wyomingensis*, typically has 5-45% cover, though some stands may have more or less. Scattered (2-5 m tall) *Pinus edulis* and *Juniperus osteosperma* trees may provide up to 5-10% cover. In addition to *Artemisia tridentata* ssp. *wyomingensis*, other tall, short, and dwarf-shrubs that may be found are *Ericameria nauseosa, Ephedra viridis, Gutierrezia sarothrae, Sarcobatus vermiculatus*, and succulents. The herbaceous stratum has low to high cover and diversity and tends to be dominated by weedy and exotic species. Common graminoids include *Achnatherum hymenoides, Aristida purpurea, Bromus tectorum, Vulpia octoflora*, and *Pleuraphis jamesii*. Forbs provide sparse to high cover and include *Astragalus nuttallianus, Descurainia pinnata, Erodium cicutarium, Lappula occidentalis*, and *Phacelia crenulata*.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	**Species**
Tree canopy	*Juniperus osteosperma*
Short shrub/sapling	*Ericameria nauseosa*
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*
Herb (field)	*Astragalus nuttallianus, Erodium cicutarium*
Herb (field)	*Bromus tectorum*

Global

Stratum	**Species**
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: GNA (invasive) (14-Dec-2004).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
Data are not available

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: Stands were historically disturbed by grazing; there are several annual species and little cryptogamic crust. Most stands are very old with decadent shrubs. Utah juniper trees are invading some stands.
Hovenweep National Monument Plots: The description is based on 2003 field data (4 plots: HOVE.0018, HOVE.0031, HOVE.0033, HOVE.0034, 2 observation points: HOVE.9037, HOVE.9065)
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.

Artemisia tridentata ssp. *wyomingensis / Pleuraphis jamesii* Shrubland
Wyoming Big Sagebrush / James' Galleta Shrubland

CODE	CEGL002084
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 SSP. WYOMINGENSIS SHRUBLAND ALLIANCE Wyoming Big Sagebrush Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)

USFWS WETLAND SYSTEM: Not Applicable

CONCEPT SUMMARY

Globally

This shrubland association occurs on alluvial flats and terraces, as well as on upland slopes and mesas in the Colorado Plateau. Sites tend to have gentle to moderately steep slopes, and elevations range from 1400 to 1939 m (4600-6360 feet). Known sites have an east or southeast aspect. Soils are derived from a wide variety of substrates; however, soil texture tends to be a sandy loam. Cryptobiotic crust cover is usually present. The vegetation is characterized by a moderately dense canopy of *Artemisia tridentata* ssp. *wyomingensis* with a sparse herbaceous understory dominated by *Pleuraphis jamesii*. Other shrubs present may include scattered individuals of *Atriplex confertifolia, Sarcobatus vermiculatus, Ericameria nauseosa, Gutierrezia sarothrae,* and *Opuntia* spp. *Achnatherum hymenoides, Hesperostipa comata, Pseudoroegneria spicata, Poa secunda,* and *Leymus salinus* may be present in addition to *Pleuraphis jamesii*. Forbs tend to be sparse and inconsistent among stands but may include *Calochortus* spp., *Astragalus nuttallianus, Oenothera pallida,* and *Sphaeralcea coccinea*.

DISTRIBUTION

Hovenweep National Monument

This association was sampled on the rim of Little Ruin Canyon and adjoining mesa along the east side of the Square Tower Unit.

Globally

This association is known from the Colorado Plateau of southeastern Utah and western Colorado.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This shrubland association was observed on the rim of Little Ruin Canyon and adjacent mesa. The site is gentle (2° slope), occurs at 1591 m elevation, and is oriented to a southeastern aspect. The unvegetated surface has high cover by litter and low exposure of bare soil. Cryptogamic cover is sparse, less than 5%. Soils are rapidly drained sandy loams derived from eolian deposits.

Globally

This shrubland association occurs on alluvial flats and terraces, as well as on ridges, slopes, benches and mesas throughout the Colorado Plateau. Sites tend to have gentle slopes, but some sites range up to 55% slope. Elevations range from 1400 to 1939 m (4600-6360 feet), and sites may be oriented to any aspect, although most of the sampled stands have either an east or southeast aspect. Soils are derived from a wide variety of substrates, from alluvium, sandstone and eolian sands to limestone, metamorphic rocks and shales; however, soil texture tends to be a sandy loam. Cryptobiotic crust cover is usually present and ranges from sparse to nearly 30% cover.

VEGETATION DESCRIPTION

Hovenweep National Monument

This Wyoming big sagebrush / James' galleta shrubland association occurs occasionally in the Square Tower Unit of the monument. The total vegetation cover is up to 83% in this densely vegetated stand. This association is characterized by an open and homogenous shrub canopy of *Artemisia tridentata* ssp. *wyomingensis* that ranges in cover from 30 to 35%, and low to sparse graminoid cover of *Pleuraphis jamesii* that ranges from 1 to 2% cover. Other short and dwarf-shrubs present, but with cover less than 5%, include *Ephedra viridis, Gutierrezia sarothrae*, and *Sarcobatus vermiculatus*. The herbaceous layer provides sparse to low cover, less than 10%. Associated graminoids include only Achnatherum hymenoides. Forbs present include *Astragalus nuttallianus, Calochortus flexuosus*, and *Oenothera pallida*. Cryptogam cover is sparse.

Globally
This shrubland association is characterized by a moderately dense canopy of *Artemisia tridentata* ssp. *wyomingensis*, with low cover of herbaceous species in the understory dominated by *Pleuraphis jamesii* (1-10% cover). Total shrub cover ranges from 20 to 40% and may include scattered individuals of Atriplex confertifolia, *Sarcobatus vermiculatus, Ericameria nauseosa, Gutierrezia sarothrae*, and *Opuntia* spp. The herbaceous layer tends to be dominated in most years by perennial bunch grasses, with *Achnatherum hymenoides, Hesperostipa comata, Pseudoroegneria spicata, Poa secunda*, and *Leymus salinus* evident in addition to *Pleuraphis jamesii*. Forbs tend to be sparse and inconsistent among stands but may include *Calochortus* spp., *Astragalus nuttallianus, Oenothera pallida*, and *Sphaeralcea coccinea*.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	Species
Short shrub/sapling	*Sarcobatus vermiculatus*
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*
Herb (field)	*Astragalus nuttallianus*
Herb (field)	*Pleuraphis jamesii*

Global

Stratum	Species
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*
Herb (field)	*Opuntia polyacantha*
Herb (field)	*Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Bromus tectorum

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (14-Dec-2004).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
Data are not available

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: Covers the entire ridge on the east side of the Square Tower Unit. This association grows on deeper eolian deposits; where the soils thin, *Juniperus osteosperma* dominates.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0023)
Local Description Authors: J. Von Loh, mod. J. Coles

Global Description Authors: J. Coles

REFERENCES: Naumann pers. comm., Western Ecology Working Group n.d.

Artemisia tridentata ssp. *wyomingensis / Poa fendleriana* Shrubland
Wyoming Big Sagebrush / Muttongrass Shrubland

CODE	CEGL002775
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 SSP. WYOMINGENSIS SHRUBLAND ALLIANCE Wyoming Big Sagebrush Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)

USFWS WETLAND SYSTEM: Not Applicable

CONCEPT SUMMARY

Globally

This sagebrush shrubland association is widespread throughout the northern Colorado Plateau, occurring on ridges, mesas and hills between 1600 and 2400 m (5250-7875 feet) elevation. Stands may cover entire plateaus or less than an acre in small openings in pinyon-juniper woodlands. Slopes range from 3% to more than 50% and are oriented to all aspects. Soils are deep and often derived from eolian loess or sand, although some stands are on residual soils derived from the underlying sandstone or shale. Total vegetation cover ranges widely, from 10 to 80%. The shrub layer is sparse in hot, dry sites (around 10% cover) but may cover more than 50% in sheltered areas. Other shrubs are usually present and may include *Purshia tridentata*, *Atriplex confertifolia*, *Symphoricarpos oreophilus*, *Amelanchier utahensis*, and *Chrysothamnus viscidiflorus*. The herbaceous understory is generally well-developed and is dominated by *Poa fendleriana* with around 3% cover in sparse shrublands and up to 35% cover in denser shrublands. Associated herbaceous species vary but generally include a number of grass species, especially *Achnatherum hymenoides*, *Hesperostipa comata*, *Koeleria macrantha*, *Pseudoroegneria spicata*, *Bouteloua gracilis*, and *Achnatherum pinetorum*. Forbs are inconsistent and usually contribute 1% cover or less. Some stands will have scattered *Pinus edulis* and *Juniperus osteosperma* trees.

DISTRIBUTION

Hovenweep National Monument

This association was sampled on deep eolian soils of the Goodman Point Unit of the monument.

Globally

This association is widespread within the sagebrush shrublands of the Colorado Plateau. It has been documented from western Colorado and southeastern Utah.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This association grows on small plains, high slopes of hills, and on hilltops. Sites are gentle (2° slopes), occur between 2025 and 2040 m elevation, and include several aspects. The unvegetated surface has low to high cover of litter and bare soil and low cover of cryptogams. Downed wood is common, providing up to 15% cover. Soils are wind-deposited, moderately well-drained silt loams.

Globally

This sagebrush shrubland is widespread throughout the northern Colorado Plateau, occurring on ridges, mesas and hills between 1600 and 2400 m (5250-7875 feet) elevation. Stands may cover hundreds of acres or less than an acre in small openings in pinyon-juniper woodlands. Slopes range from 3% to more than 50% and are oriented to all aspects. Soils are deep and often derived from eolian loess or sand, although some stands are on residual soils derived from the underlying sandstone or shale.

VEGETATION DESCRIPTION

Hovenweep National Monument

This Wyoming big sagebrush / muttongrass shrubland association is common on flats and hills only in the Goodman Unit at the highest monument elevations. The total vegetation cover ranges from 28 to 51% in these moderately vegetated stands. This shrub association is characterized by the short shrub *Artemisia tridentata* ssp. *wyomingensis* that ranges in cover from 30 to 40%, and the associated graminoid *Poa fendleriana* that ranges in cover from 3 to 15%. The canopy trees *Pinus edulis* and *Juniperus osteosperma*, from 5-10 m tall, provide low cover. Sapling *Juniperus osteosperma* and *Pinus edulis* trees provide sparse cover. The shrub layer is sparse in terms of diversity and cover, including *Gutierrezia sarothrae* and *Opuntia fragilis*. The herbaceous layer provides low cover and includes *Bromus tectorum* and *Elymus elymoides*. Forbs present include *Lithospermum* sp., *Lupinus argenteus*, *Ceratocephala testiculata*, *Rumex hymenosepalus*, and *Zigadenus elegans*. Cryptobiotic soil crusts are sparse and provide up to 5% cover.

Globally

This type of Wyoming big sagebrush shrubland is common in the northern Colorado Plateau. The total vegetation cover ranges widely from 10 to 80%. The shrub layer ranges from sparse in hot, dry sites (around 10% cover) to more than 50% in sheltered sites. Other shrubs are usually present and may include *Purshia tridentata*, *Atriplex confertifolia*, *Symphoricarpos oreophilus*, *Amelanchier utahensis*, and *Chrysothamnus viscidiflorus*. The herbaceous understory is generally well-developed and is dominated by *Poa fendleriana* with around 3% cover in sparse shrublands and up to 35% cover in denser shrublands. Associated herbaceous species vary but generally include a number of grass species, especially *Achnatherum hymenoides*, *Hesperostipa comata*, *Koeleria macrantha*, *Pseudoroegneria spicata*, *Bouteloua gracilis*, and *Achnatherum pinetorum*. Forbs are inconsistent and usually contribute 1% cover or less. Some stands will have scattered trees of *Pinus edulis* and *Juniperus osteosperma*.

MOST ABUNDANT SPECIES

Hovenweep National Monument

Stratum	**Species**
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*
Herb (field)	*Poa fendleriana*

Global

Stratum	**Species**
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*
Herb (field)	*Poa fendleriana*

OTHER NOTEWORTHY SPECIES

Hovenweep National Monument

Bromus tectorum (cheatgrass)

Globally

Bromus tectorum

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (13-Apr-2005).

CLASSIFICATION COMMENTS

Hovenweep National Monument

Data are not available

Globally

Data are not available

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Hovenweep National Monument Inventory Notes: Stands consist of very old Wyoming big sagebrush shrubs that are being invaded by pinyon-juniper trees. The soils are deep and fine in texture.

Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0019, 1 observation point: HOVE.9059)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles

REFERENCES: Western Ecology Working Group n.d.

Artemisia tridentata ssp. *wyomingensis* / Sparse Understory Shrubland
Wyoming Big Sagebrush / Sparse Understory Shrubland

CODE	CEGL002768
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 SSP. WYOMINGENSIS SHRUBLAND ALLIANCE Wyoming Big Sagebrush Shrubland Alliance

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)

USFWS WETLAND SYSTEM: Not Applicable

CONCEPT SUMMARY
Globally
This association is intended to represent sagebrush shrublands where the sparse understory is the result of edaphic conditions, not grazing or other disturbance. It occurs in scattered patches throughout the sagebrush zone of the Colorado Plateau. Elevations range from 1590 to 2390 m (5215-7840 feet), and sites occur on level to moderately steep slopes. There is a slight tendency toward hot western and southern exposures. Soils may be thin over bedrock, or loose, unstable sands, or tight clays, or extremely well-drained gravels; all of these situations tend to discourage herbaceous growth. Total vegetation cover is somewhat sparse in these sagebrush communities, rarely exceeding 40% and usually closer to 25%. The shrub layer consists of dwarfed *Artemisia tridentata* ssp. *wyomingensis* shrubs, sometimes accompanied by *Purshia tridentata, Atriplex confertifolia, Ephedra viridis*, or *Ericameria nauseosa*. The understory of dwarf-shrubs and herbaceous species has less than 5% cover, and usually much less. Common species include *Gutierrezia sarothrae, Achnatherum hymenoides, Pleuraphis jamesii,* and *Bouteloua gracilis*. Cryptobiotic crusts may be well-developed in sandy sites.

DISTRIBUTION
Hovenweep National Monument
This association was sampled in the south-central portion of the Holly Unit and the northern portion of the Square Tower Unit of the monument.

Globally
This association is scattered widely over the Colorado Plateau of Utah and Colorado.

ENVIRONMENTAL DESCRIPTION
Hovenweep National Monument
This short-shrub association was observed on midslopes of hills. Sites are gentle (3-4° slopes), occur at 1587 and 1640 m elevation, and are oriented to northeast and southwest aspects. The unvegetated surface has low to moderate cover of litter. Large and small rocks and exposures of bare soil provide low to high cover. One stand has low cover of bedrock, and downed wood provides sparse to low cover. Cryptogam cover is sparse to high. Soils are well-drained to rapidly drained clay loams and sandy loams derived from Dakota sandstone and Burro Canyon Formation shale.

Globally
This association occurs in scattered patches throughout the sagebrush zone of the Colorado Plateau. Elevations range from 1590 to 2390 m (5215-7840 feet), and sites occur on level to moderately steep slopes. There is a slight tendency toward hot western and southern exposures. Soils may be thin over bedrock, or loose, unstable sands, or

tight clays, or extremely well-drained gravels; all of these situations tend to discourage herbaceous growth.

VEGETATION DESCRIPTION

Hovenweep National Monument

This Wyoming big sagebrush association is uncommon within the Holly and Square Tower units of the monument. The total vegetation cover ranges from 29 to 37% in these moderately vegetated stands. The short-shrub layer is characterized by an open canopy of *Artemisia tridentata* ssp. *wyomingensis* that provides 20% cover. The tall shrub *Purshia stansburiana* provides low to moderate cover in a stand occupying thin soils over bedrock. Associated short and dwarf-shrubs are low in diversity and provide sparse to low cover, including *Atriplex confertifolia, Ephedra viridis, Ephedra torreyana, Ericameria nauseosa*, and *Gutierrezia sarothrae*. The herbaceous layer is sparse in terms of cover and low in composition. Graminoids are absent or provide sparse cover and include *Achnatherum hymenoides* and *Pleuraphis jamesii*. Forbs are relatively diverse but provide sparse cover, including *Arenaria fendleri, Astragalus nuttallianus, Calochortus flexuosus, Cryptantha* sp., and *Lappula occidentalis*. Cryptogams provide sparse cover on deep eolian soils and dense cover, to 50%, on thin soils over exposed bedrock.

Globally

Total vegetation cover is relatively low in these sagebrush communities, rarely exceeding 40% and usually closer to 25%. The shrub layer consists of dwarfed *Artemisia tridentata* ssp. *wyomingensis* shrubs, sometimes accompanied by Purshia tridentata, *Atriplex confertifolia, Ephedra viridis*, or *Ericameria nauseosa*. The understory of dwarf-shrubs and herbaceous species has less than 5% cover, and usually much less. Common species include Gutierrezia sarothrae, *Achnatherum hymenoides, Pleuraphis jamesii*, and *Bouteloua gracilis*. Cryptobiotic crusts may be well-developed in sandy sites.

MOST ABUNDANT SPECIES

Hovenweep National Monument

Stratum	**Species**
Tall shrub/sapling	*Purshia stansburiana*
Short shrub/sapling	*Ericameria nauseosa*
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis, Ephedra viridis*

Global

Stratum	**Species**
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*

OTHER NOTEWORTHY SPECIES

Hovenweep National Monument

Bromus inermis, Poa pratensis, Taraxacum officinale

Globally

Data are not available

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (13-Apr-2005).

CLASSIFICATION COMMENTS

Hovenweep National Monument

Data are not available

Globally

This association is intended to represent sagebrush shrublands in which the substrate is such that few herbaceous species can grow. Situations in which the understory has been removed by grazing or other disturbance should be assigned to *Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland (CEGL002083).

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Hovenweep National Monument Inventory Notes: Found on both deep eolian deposits and on exposed bedrock in the monument. There is minor invasion by Juniperus osteosperma trees on eolian deposits, and the stands are

subject to slope wash.
Hovenweep National Monument Plots: The description is based on 2003 field data (2 plots: HOVE.0005, HOVE.0032)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles

REFERENCES: Western Ecology Working Group n.d.

Artemisia bigelovii Shrubland
Bigelow Sagebrush Shrubland

CODE	CEGL000276
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 Low Sagebrush Shrubland (CES304.762)

USFWS WETLAND SYSTEM: Not Applicable

CONCEPT SUMMARY
Globally
This association occurs on ledgy slopes, canyon rims and ridges in the east-central Colorado Plateau (southeastern Utah and northern Arizona). Slopes are gentle and elevations range from 1552 to 1890 m (5090-6200 feet). Substrates include alluvial and eolian deposits that have weathered into coarse loamy sands. These soils are often thin and overlie sandstone bedrock. The vegetation is dominated by *Artemisia bigelovii*, but other shrub species are always present, including *Atriplex confertifolia, Ephedra torreyana, Gutierrezia sarothrae, Purshia stansburiana,* and *Yucca harrimaniae*. The total cover of the associated shrubs may exceed that of *Artemisia bigelovii*. The herbaceous understory is sparse, rarely exceeding 5-10% cover, and variable from stand to stand. *Pleuraphis jamesii* is often present in the otherwise graminoid-poor understory; other herbaceous species may include *Arenaria fendleri, Calochortus flexuosus, Chaenactis stevioides, Oenothera pallida*, and *Rumex hymenosepalus*. Cryptobiotic soil crusts may have high cover. Scattered individuals of *Juniperus osteosperma* may be present.

DISTRIBUTION
Hovenweep National Monument
This association was sampled on thin soils near the east boundary of the Cajon Unit of the Monument.

Globally
This association has been documented from northern Arizona and adjacent parts of southeastern Utah.

ENVIRONMENTAL DESCRIPTION
Hovenweep National Monument
This shrubland association was observed on thin soils and bedrock exposures in the Cajon Unit. The site is gentle (2° slope), occurs at 1552 m elevation, and is oriented to the southeast. The unvegetated surface has high cover of litter and low to moderate exposure of bare soil. Cryptogam cover is moderate. Soils are rapidly drained loamy sands derived from eolian deposits.

Globally
This association occurs on ledgy slopes, canyon rims and ridges in the east-central part of the Colorado Plateau (southeastern Utah and northern Arizona). Slopes are gentle and elevations range from 1552 to 1890 m (5090-6200 feet). Substrates include alluvial and eolian deposits derived from sandstones and shales that have weathered into coarse loamy sands. These soils are often thin and overlie sandstone bedrock. A high percentage of the unvegetated surface may be covered by cryptobiotic soil crusts.

VEGETATION DESCRIPTION

Hovenweep National Monument

This Bigelow (flat) sagebrush shrubland association is found only on bedrock exposures and adjacent thin soils of the Cajon Unit. The total vegetation cover ranges from 5 to 20% in this sparsely vegetated stand. This association is characterized by the short shrub *Artemisia bigelovii* that ranges in cover from 1 to 5%. The short- and dwarf-shrub layer is low in diversity and cover and includes *Atriplex confertifolia, Ephedra torreyana, Gutierrezia sarothrae, Opuntia erinacea, Purshia stansburiana, Senecio flaccidus,* and *Yucca harrimaniae*. The herbaceous layer provides sparse to low cover and is relatively diverse. Graminoids provide sparse cover and include *Bromus tectorum, Vulpia octoflora*, and *Pleuraphis jamesii.* Forbs provide sparse to low cover and include *Arenaria fendleri, Astragalus nuttallianus, Astragalus mollissimus, Calochortus flexuosus, Chaenactis stevioides, Cymopterus newberryi, Lappula occidentalis, Oenothera pallida, Plantago patagonica*, and *Rumex hymenosepalus*. Cryptobiotic soil crusts provide low cover, growing around the base of shrubs.

Globally

This association occurs primarily in sites where the coarse sandy soils are thin and overlie sandstone bedrock. The total vegetation cover, therefore, is generally somewhat sparse, rarely exceeding 25%. The shrub layer is dominated by Artemisia bigelovii, but other shrub species are always present, including *Atriplex confertifolia, Ephedra torreyana, Gutierrezia sarothrae, Purshia stansburiana*, and *Yucca harrimaniae*. The total cover of the associated shrubs may exceed that of *Artemisia bigelovii.* The herbaceous understory is sparse, rarely exceeding 5-10% cover, and variable from stand to stand. *Pleuraphis jamesii* is often present in the otherwise graminoid-poor understory; other herbaceous species may include *Arenaria fendleri, Calochortus flexuosus, Chaenactis stevioides, Oenothera pallida*, and *Rumex hymenosepalus*. Scattered individuals of *Juniperus osteosperma* may be present, but total tree cover is usually less than 5%, and there is little chance that trees will take over the community because of the lack of suitable sites for establishment of deep-rooted species such as juniper.

MOST ABUNDANT SPECIES

Hovenweep National Monument

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia*
Short shrub/sapling	*Artemisia bigelovii, Purshia stansburiana*
Herb (field)	*Astragalus nuttallianus*

Global

Stratum	Species
Short shrub/sapling	*Atriplex confertifolia*
Short shrub/sapling	*Artemisia bigelovii*

OTHER NOTEWORTHY SPECIES

Hovenweep National Monument

Data are not available

Globally

Data are not available

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (7-Jan-2003).

CLASSIFICATION COMMENTS

Hovenweep National Monument

Data are not available

Globally

A closely related association, *Artemisia bigelovii - Ephedra (viridis, torreyana)* Talus Shrubland (CEGL003755), occurs on colluvial slopes, sometimes below the rim habitats that support *Artemisia bigelovii* Shrubland (CEGL000276). It is possible that these associations should be combined.

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: Grows on thin soils and exposed bedrock in the Cajon Unit. Shrubs grow from pedestals indicating erosion by wind and water and soil capture by the shrub canopies during windstorms.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0001)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles

REFERENCES: Romme et al. 1993, Thomas et al. 2003b

Atriplex canescens / Pleuraphis jamesii Shrubland
Fourwing Saltbush / James' Galleta Shrubland

CODE	CEGL001288
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 broadly defined shrubland association has been reported from the Colorado Plateau and Uinta Basin and may occur in the Chihuahuan Desert and eastern California. As defined, this association occurs on two distinct types of landforms: alluvial flats and stream terraces with fine-textured, alkaline or saline silty clay loam soils, or on upland flats covered by eolian sand deposits. The vegetation is characterized by a sparse to moderately dense shrub layer (10-40% cover) dominated by *Atriplex canescens* with *Pleuraphis jamesii* dominating the herbaceous layer. Associated shrubs include *Ericameria nauseosa, Ephedra torreyana, Chrysothamnus viscidiflorus, Krascheninnikovia lanata, Gutierrezia sarothrae, Artemisia bigelovii,* or *Opuntia polyacantha*, depending on topographic position and substrate. Other graminoids include *Achnatherum hymenoides* and *Sporobolus cryptandrus* on sandy sites, and *Bouteloua gracilis* and *Sporobolus airoides* on fine-textured soil. Forbs generally have low cover and may include *Sphaeralcea grossulariifolia* and *Chenopodium* spp. Introduced or weedy species, such as *Bromus tectorum, Descurainia pinnata,* and *Salsola kali*, are common on some sites.

DISTRIBUTION
Hovenweep National Monument
This association was sampled in the Cajon Unit where sand has deposited sufficiently deep, into small dunes and sand flats over bedrock.

Globally
This association has been documented from the Colorado Plateau (Four Corners region) of southeastern Utah and southwestern Colorado. It is to be expected in adjacent northern Arizona and New Mexico, and probably occurs in the Chihuahuan Desert and eastern California. Because the habitat and the diagnostic species are relatively common in this region, the association should be widespread; grazing by sheep and cattle may have eliminated most stands. The sites used in this description have also been grazed heavily and show high cover by disturbance-tolerant herbaceous species.

ENVIRONMENTAL DESCRIPTION
Hovenweep National Monument
This association was observed on eolian deposits capping the Cajon Unit mesa. The site is gentle (1° slope), occurs at 1582 m elevation, and is oriented to a southwestern aspect. The unvegetated surface has high cover of litter and

low exposure of bare soil. Parent materials are Dakota sandstone that has eroded and been re-deposited by wind. Soils are rapidly drained fine sandy loams.

Globally
This shrubland association occurs in the Colorado Plateau and Uinta Basin of eastern Utah and western Colorado and may occur in the Chihuahuan Desert and eastern California. Elevation ranges from 300-1900 m. It occurs on two distinct types of landforms: upland sites such as sandsheets with coarse-textured soils, or lowland sites such as alluvial flats and stream terraces with fine-textured soils. Water tends to pond temporarily in both kinds of sites following heavy rainstorms or spring floods; thus salts tend to accumulate in the soils. Sites are generally level to gently sloping or may be in nearly undetectable shallow depressions. The upland soils are somewhat shallow eolian sands or sandy loams. Lowland sites typically have deep, alkaline, saline silty clay loams derived from alluvium. These substrates are generally less saline and occur higher in the floodplain than *Atriplex canescens / Sporobolus airoides*- or *Atriplex confertifolia*-dominated shrublands that prefer saline bottomland sites.

VEGETATION DESCRIPTION
Hovenweep National Monument
This fourwing saltbush / James' galleta shrubland association is rare on the Cajon Unit at the lowest monument elevations. The total vegetation cover is 62% in this moderately vegetated stand. This short-shrub association is characterized by an open canopy of *Atriplex canescens* and sparse cover of the short bunchgrass *Pleuraphis jamesii* that provide cover of 15% and 4%, respectively. Other short and dwarf-shrubs and succulents provide low cover and include *Ericameria nauseosa, Grayia spinosa*, and *Opuntia erinacea*. The herbaceous layer is low in diversity and contributes moderate cover, up to 40%. Additional graminoids include *Aristida purpurea* and *Bromus tectorum*. Forbs provide moderate cover and include *Astragalus nuttallianus, Chaenactis stevioides, Descurainia pinnata, Erodium cicutarium, Oenothera pallida*, and *Rumex hymenosepalus*.

Globally
This broadly defined shrubland association is characterized by a sparse to moderately dense canopy (10-40% cover) of shrubs dominated by Atriplex canescens with a sparse to moderate graminoid layer that is dominated by *Pleuraphis jamesii*. Many stands have the appearance of a shrubby grassland and may form a mosaic with rabbitbrush, greasewood or shadscale shrublands. Associated shrubs may include *Ericameria nauseosa, Ephedra torreyana, Ericameria nauseosa, Grayia spinosa*, several species of *Opuntia, Chrysothamnus viscidiflorus, Krascheninnikovia lanata, Gutierrezia sarothrae*, and *Artemisia bigelovii*. Other graminoids include *Achnatherum hymenoides* and *Sporobolus cryptandrus* on sandy sites, and *Bouteloua gracilis* and *Sporobolus airoides* on fine-textured soil of the lowland sites. Forbs generally have low cover and may include *Sphaeralcea grossulariifolia* and *Chenopodium* spp. Introduced species such as *Bromus tectorum* and *Salsola kali* are common on some sites. In many sites, the herbaceous layer is sparse because of a history of grazing or other disturbance.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	Species
Short shrub/sapling	*Ericameria nauseosa, Grayia spinosa*
Short shrub/sapling	*Atriplex canescens*
Herb (field)	*Astragalus nuttallianus, Descurainia pinnata, Erodium cicutarium*
Herb (field)	*Pleuraphis jamesii*

Global

Stratum	Species
Short shrub/sapling	*Chrysothamnus viscidiflorus, Ericameria nauseosa*
Short shrub/sapling	*Atriplex canescens*
Short shrub/sapling	*Gutierrezia sarothrae, Krascheninnikovia lanata*
Herb (field)	*Achnatherum hymenoides, Bouteloua gracilis, Pleuraphis jamesii, Sporobolus airoides, Sporobolus cryptandrus*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Bromus tectorum (cheatgrass)

Globally
Bromus tectorum, Salsola kali

CONSERVATION STATUS RANK
Global Rank & Reasons: G3G4 (1-Feb-1996).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
This loosely defined association is characterized by the codominance of *Atriplex canescens* and *Pleuraphis jamesii*. Its relation to several similar associations is unclear. Most of the information available suggests that the sparse shrub canopy is typical and that this association should not be classified as a shrubland (Miller et al. 1977, Francis 1986, Von Loh 2000). Because it has a wide distribution (from southern Great Plains to the Mojave Desert), stands occur in diverse habitats (clayey bottomland to sand dunes) and vary from a sparse to moderate shrub canopy. It is likely that, when more information becomes available and the needed classification work is completed, this association will be subdivided.

The diagnostic species require warm sites with somewhat alkaline soils, so this association should be relatively widespread throughout the Colorado Plateau and western Great Plains. That it is not may reflect spotty sampling of the region, or it may indicate that this association has been mostly altered by grazing. This association may represent a form of *Atriplex canescens / Sporobolus airoides* Shrubland (CEGL001291) that has been degraded by domestic livestock grazing. The concept of *Atriplex canescens / Sporobolus airoides* Shrubland includes *Pleuraphis jamesii* in the herbaceous layer. In addition, the species lists for related and equivalent communities cited in the References section include both *Pleuraphis jamesii* and *Sporobolus airoides* in the herbaceous layer. It is possible that these associations (CEGL001288 and CEGL001291) should be combined, as it appears they are distinguished primarily by which of the two grasses is dominant. It is possible that summer-long grazing has reduced or eliminated Sporobolus airoides from many stands in the Colorado Plateau, leaving *Pleuraphis jamesii* and *Bouteloua gracilis* as more grazing-resistant species. Distinguishing these two associations because of different intensities of historic grazing may not be ecologically valid.

CLASSIFICATION CONFIDENCE: 2 – Moderate

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: This association is affected by grazing and wind erosion.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0002)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: BLM 1979a, BLM 1979b, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Diamond 1993, Driscoll et al. 1984, Francis 1986, Miller et al. 1977, Shute and West 1978, Soil Conservation Service 1978, U.S. Bureau of Reclamation 1976, Von Loh 2000

***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 shrubland association is reported from the southwestern Great Plains, Colorado Plateau, Great Basin, and Mojave Desert mountains. It 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 association is characterized by a sparse to open canopy (1-25% cover) of short shrubs dominated by *Atriplex confertifolia* with a sparse to moderate graminoid layer dominated by *Pleuraphis jamesii*. Associated shrubs include *Ericameria nauseosa, Ephedra torreyana, Chrysothamnus viscidiflorus, Krascheninnikovia lanata, Gutierrezia sarothrae, Artemisia bigelovii, Picrothamnus desertorum, Grayia spinosa, Suaeda moquinii*, and *Opuntia polyacantha* depending on substrate, or *Amphipappus fremontii, Ambrosia dumosa*, and *Lycium pallidum* 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, Phacelia*, and *Chenopodium*. Introduced species such as *Bromus tectorum* and *Salsola kali* are common on some sites.

DISTRIBUTION

Hovenweep National Monument

This association is uncommon and was sampled near the southern and northern boundaries of the Holly Unit and on the eastern side of the Cajon Unit in the monument.

Globally

This shrubland association is reported from the southwestern Great Plains, Colorado Plateau, Great Basin, and Mojave Desert mountains.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This shrubland association was observed on the midslopes of hills, ridges, and valleys, upper slopes of ridges, and ridgetops. Sites are nearly flat to moderately steep (1-13° slopes), occur between 1577 and 1632 m elevation, and include several aspects. The unvegetated surface has low to high cover of litter and moderate to high cover of small rocks and exposure of bare soil. Soils are rapidly drained silty clay loams derived from Burro Canyon Formation.

Globally

This association 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, mesa escarpments, mountain and hillslopes, ridges, and along toeslopes of river bluffs. Fine-textured soil sites include 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 alkalinity. The unvegetated surface is composed largely of bare soil, gravel, and large or small rocks. Cryptogamic crusts and mosses are important in some stands.

VEGETATION DESCRIPTION

Hovenweep National Monument

This shadscale / James' galleta association is uncommon within the Cajon and Holly units of the monument. The total vegetation cover ranges from 8 to 27% in these sparsely to moderately vegetated stands. This shrubland association is characterized by a very open short-shrub canopy of *Atriplex confertifolia* that ranges in cover from 3 to 15%, and the sparse graminoid layer of *Pleuraphis jamesii* that ranges in cover from 1 to 8%. The shrub layer is sparse in cover and moderately diverse in composition. The short- and dwarf-shrub layers include *Artemisia*

bigelovii, Artemisia tridentata ssp. *wyomingensis, Atriplex canescens, Echinocereus triglochidiatus, Ephedra viridis, Ericameria nauseosa, Gutierrezia sarothrae, Lycium pallidum, Opuntia erinacea*, and *Sarcobatus vermiculatus*. The herbaceous layer is typically sparse, usually less than 10% total cover and often less. Additional graminoids provide sparse cover and include *Achnatherum hymenoides* and *Elymus elymoides*. Forbs provide sparse to low cover and moderate diversity, including *Astragalus nuttallianus, Calochortus flexuosus, Cirsium* sp., *Cryptantha flavoculata, Cymopterus purpurascens, Descurainia pinnata, Lappula occidentalis, Oenothera pallida, Phacelia crenulata*, and *Rumex hymenosepalus*.

Globally
This association is characterized by a sparse to open canopy (1-25% cover) of short shrubs dominated by *Atriplex confertifolia* with a sparse to moderate graminoid layer dominated by *Pleuraphis jamesii*. Some stands can be even more sparsely vegetated, and total vegetation cover is widely variable (1-70% in sampled stands). Associated shrubs include *Ericameria nauseosa, Ephedra torreyana, Chrysothamnus viscidiflorus, Krascheninnikovia lanata, Gutierrezia sarothrae, Artemisia bigelovii, Picrothamnus desertorum, Grayia spinosa, Suaeda moquinii*, and *Opuntia polyacantha* depending on substrate, or *Amphipappus fremontii, Ambrosia dumosa*, and *Lycium pallidum* 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, Phacelia*, and *Chenopodium*. Introduced species such as *Bromus tectorum* and *Salsola kali* are common on some sites.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	**Species**
Short shrub/sapling	*Atriplex confertifolia, Sarcobatus vermiculatus*
Herb (field)	*Astragalus nuttallianus, Lappula occidentalis, Phacelia crenulata*
Herb (field)	*Pleuraphis jamesii*

Global

Stratum	**Species**
Short shrub/sapling	*Atriplex confertifolia*
Short shrub/sapling	*Gutierrezia sarothrae*
Herb (field)	*Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Bromus tectorum

CONSERVATION STATUS RANK
Global Rank & Reasons: G3G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
This widespread 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.

CLASSIFICATION CONFIDENCE: 2 – Moderate

ELEMENT SOURCES

Hovenweep National Monument Inventory Notes: This association is distributed within the Cajon and Holly units on shale exposures at lower elevations in the monument.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0006, 3 observation points: HOVE.9035, HOVE.9040, HOVE.9042)
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, NVNHP 2003, 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

***Amelanchier utahensis* Shrubland**
Utah Serviceberry Shrubland

CODE	CEGL001067
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	AMELANCHIER UTAHENSIS SHRUBLAND ALLIANCE (A.916) Utah Serviceberry Shrubland Alliance

ECOLOGICAL SYSTEM(S): Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)

USFWS WETLAND SYSTEM: Not Applicable

CONCEPT SUMMARY
Globally
This mountain shrubland association occurs at middle elevations in the foothills, mountains and mesas in north-central Utah, the Colorado Plateau and Great Basin of the western U.S. Stands occur on moderate to steep slopes characterized by talus or rockfall from further upslope. It is found on relatively warm southern aspects in the Wasatch Mountains but also occurs on northern aspects at lower elevations and at more southern latitudes. Substrates are moderately deep, rocky loams and clays. The sparse to moderately dense tall-shrub layer (10-60% cover) is dominated by the cold-deciduous shrub *Amelanchier utahensis. Symphoricarpos oreophilus* often dominates in the short-shrub layer. Other shrub associates may include low cover of *Acer grandidentatum, Artemisia tridentata, Chrysothamnus viscidiflorus, Ephedra viridis, Mahonia repens, Purshia tridentata, Rhus trilobata,* and *Rosa woodsii. Quercus gambelii* may also be present, but it is always poorly represented (<5%). Tree species are sometimes present with the tall shrubs or as a very sparse emergent layer. The sparse to moderately dense herbaceous layer is a mixture of perennial graminoids and forbs. Introduced species such as *Agropyron cristatum* and *Bromus tectorum* are common in disturbed stands.

DISTRIBUTION
Hovenweep National Monument
This association occurred as a small stand and was sampled only in the upper portion of Little Ruin Canyon of the Square Tower Unit.

Globally
This shrubland association occurs in the foothills and mountain areas in north-central Utah, Colorado Plateau and Great Basin of the western U.S.

ENVIRONMENTAL DESCRIPTION
Hovenweep National Monument
This association was observed on a steep talus slope, midslope on upper Little Ruin Canyon of the Square Tower Unit. The site is steep (32° slope), occurs at 1570 m elevation, and has a north aspect. The unvegetated surface has high cover of litter and low to moderate cover of bedrock and large and small rocks. Soils are rapidly drained and

fine in texture, derived from Burro Canyon Formation shale and covered by rockfall of Dakota sandstone.

Globally
This montane shrubland association occurs the foothills, mountains and mesas at elevations from 1480-2440 m (4855-8000 feet). Stands occur on moderate to steep slopes (9-37°) with a high proportion of talus or rockfall. It is found on relatively warm southern aspects in the Wasatch Mountains (Yake and Brotherson 1979) but also occurs on northern aspects at lower elevations and more southern latitudes. Substrates are moderately deep, rocky loams and clays and are rapidly drained.

VEGETATION DESCRIPTION
Hovenweep National Monument
This Utah serviceberry shrubland association occupies a small patch distributed on a rockfall or talus slope in Little Ruin Canyon of the Square Tower Unit. The total vegetation cover ranges from 24 to 27% in this moderately vegetated stand. This shrubland association is characterized by an open tall-shrub canopy, 2-5 m tall, of *Amelanchier utahensis* shrubs that provide 10% cover. Sapling *Juniperus osteosperma* trees provide sparse cover in the stand. The shrub layer is relatively diverse for this small stand, but cover is low. Short shrubs include *Artemisia tridentata* ssp. *wyomingensis*, *Ericameria nauseosa*, *Ephedra viridis*, and *Rhus trilobata*. The herbaceous layer provides moderate cover, greater than 20%, mostly by exotic annual grasses. The graminoids include *Bromus japonicus*, *Bromus tectorum*, and *Poa fendleriana*. Forbs present include *Descurainia pinnata* and *Lappula occidentalis*.

Globally
The vegetation is characterized by a sparse to moderately dense (10-60% cover) tall-shrub layer dominated by the cold-deciduous shrub *Amelanchier utahensis. Symphoricarpos oreophilus* often forms a short-shrub layer. Other shrub associates may include low cover of *Acer grandidentatum*, *Artemisia tridentata*, *Chrysothamnus viscidiflorus*, *Ephedra viridis*, *Mahonia repens*, *Purshia tridentata*, *Rhus trilobata*, and *Rosa woodsii. Quercus gambelii* may also be present, but it is always poorly represented (<5% cover). Short trees of *Pinus edulis*, *Juniperus osteosperma*, or *Juniperus scopulorum* may be mixed in with the tall shrubs or emerge above as a very sparse tree layer. The sparse to moderate herbaceous layer is a mixture of perennial graminoids and forbs. Herbaceous species include *Bromus carinatus*, *Koeleria macrantha*, *Achnatherum nelsonii* ssp. *dorei*, *Poa fendleriana*, *Balsamorhiza sagittata*, *Chenopodium fremontii*, *Machaeranthera canescens*, and species of *Astragalus*, *Eriogonum*, *Mertensia*, and *Penstemon* (Yake and Brotherson 1979). Introduced species such as *Agropyron cristatum* and *Bromus tectorum* are common in disturbed stands.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	**Species**
Tall shrub/sapling	*Amelanchier utahensis*
Short shrub/sapling	*Ericameria nauseosa*
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*
Herb (field)	*Bromus japonicus, Bromus tectorum*

Global

Stratum	**Species**
Tall shrub/sapling	*Amelanchier utahensis*
Short shrub/sapling	*Symphoricarpos oreophilus*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: G4 (19-Sep-2000).

CLASSIFICATION COMMENTS

Hovenweep National Monument
Data are not available

Globally
This association is not well known. More survey work and classification work are needed to further define this type.

CLASSIFICATION CONFIDENCE: 2 – Moderate

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: Occupies a steep talus area below the canyon rim and is rare in the monument.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 observation point: HOVE.9063)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Drake

REFERENCES: Bourgeron and Engelking 1994, Carmichael et al. 1978, Cogan et al. 2004, Crane 1982, Driscoll et al. 1984, Eddleman and Jaindl 1994, NVNHP 2003, Yake and Brotherson 1979

***Sarcobatus vermiculatus / Artemisia tridentata* Shrubland**
Black 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	Intermittently flooded extremely xeromorphic deciduous subdesert shrubland (III.B.3.N.b.)
ALLIANCE	SARCOBATUS VERMICULATUS INTERMITTENTLY FLOODED SHRUBLAND Black 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 bottomland shrubland is characteristic of 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. The sagebrush element may be either *Artemisia tridentata* ssp. *tridentata* or *Artemisia tridentata* ssp. *wyomingensis*, and either sagebrush or *Sarcobatus vermiculatus* may have the greater cover. *Atriplex canescens*, *Ericameria nauseosa*, and *Chrysothamnus viscidiflorus* are 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
Hovenweep National Monument
This association was sampled in Little Ruin Canyon of the Square Tower Unit, south of the hiking trail approximately 100 m.

Globally
Data are not available

ENVIRONMENTAL DESCRIPTION
Hovenweep National Monument

This tall-shrub association was observed growing in Little Ruin Canyon on an alluvial terrace. This site is nearly level (3° slope), occurs at 1588 m elevation, and is oriented to a southwestern aspect. The unvegetated surface has high cover of litter and low exposure of bare soil. Soils are well-drained sandy loams derived from Dakota sandstone and Burro Canyon Formation shale.

Globally
This minor association occurs on terraces, alluvial fans, floodplains, toeslopes and valley floors. Elevations range from 1300 to 1950 m. Slopes are generally gentle, and the upper soil layers are somewhat saline. Bare soil and litter cover most of the ground surface. Soils are deep and generally sandy, but a few sites are on well-drained silt loams.

VEGETATION DESCRIPTION
Hovenweep National Monument
This greasewood - big sagebrush association is rare, distributed as a small patch in the Little Ruin Canyon bottom of the Square Tower Unit. The total vegetation cover is 87% in this densely vegetated stand. This shrub association is characterized by the tall shrubs *Sarcobatus vermiculatus, Ericameria nauseosa*, and *Artemisia tridentata* ssp. *wyomingensis* that range from 1-2 m tall and provide 15%, 15%, and 10% cover, respectively. The annual, exotic grass *Bromus tectorum* provides moderate to high cover (40%). Annual forbs provide low cover, are low in diversity, and include *Descurainia pinnata, Erodium cicutarium*, and *Lappula occidentalis*.

Globally
This mixed bottomland shrubland is characteristic of 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, 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.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	Species
Short shrub/sapling	*Ericameria nauseosa, Sarcobatus vermiculatus*
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*

Global

Stratum	Species
Short shrub/sapling	*Sarcobatus vermiculatus*
Short shrub/sapling	*Artemisia tridentata* ssp. *tridentata, Artemisia tridentata* ssp. *wyomingensis*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Bromus tectorum, Erodium cicutarium

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: G4 (1-Feb-1996).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
Data are not available

CLASSIFICATION CONFIDENCE: 1 – Strong

ELEMENT SOURCES

Hovenweep National Monument Inventory Notes: An extremely dense mixed shrubland in deep alluvial soils.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 observation point: HOVE.9060)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles

REFERENCES: Bourgeron and Engelking 1994, Driscoll et al. 1984, Lesica and DeVelice 1992, MTNHP 2002b

Sarcobatus vermiculatus Shrubland
Black Greasewood 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	Intermittently flooded extremely xeromorphic deciduous subdesert shrubland (III.B.3.N.b.)
ALLIANCE	SARCOBATUS VERMICULATUS INTERMITTENTLY FLOODED SHRUBLAND Black 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 shrubland association occurs on saline soils of terraces, swales, alluvial fans, valley floors, toeslopes and ridges throughout the Colorado Plateau and Great Basin. 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, 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
Hovenweep National Monument
This association was sampled on alluvial deposits in drainages of the Cajon Unit, Holly Unit, and Square Tower Unit of the monument.

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 Uinta Basin (eastern Utah), Great Basin (central Utah, central Nevada, eastern California), northwestern New Mexico (Francis 1986) and Colorado Plateau (western Colorado).

ENVIRONMENTAL DESCRIPTION
Hovenweep National Monument
This short- to tall-shrub association was observed on alluvial deposits or terraces of small valleys. Sites are flat to gentle (0-1° slopes), occur between 1573 and1622 m elevation, and are oriented to southern aspects. The unvegetated surface has high cover of litter and low exposure of bare soil. Cryptogamic cover is absent to sparse. Soils are well-drained sandy loams derived from Dakota sandstone and Burro Canyon Formation shale that have eroded and been re-deposited as alluvium.

Globally
This widespread but patchy shrubland association occurs on terraces, swales, coppice dunes, alluvial fans, valley floors, toeslopes and ridges throughout the Colorado Plateau and Great Basin. Elevations range between 1200 and 2073 m (3940-6800 feet), and slopes tend to be gentle. 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. Soil textures range from sandy loam to silty clay and tend to be alkaline, often with a white salt crust on the soil surface.

VEGETATION DESCRIPTION
Hovenweep National Monument
This shrubland association is rare and distributed as small stands or patches in the Cajon, Holly, and Square Tower units of the monument. The total vegetation cover ranges from 53 to 60% in these moderately vegetated stands. This shrub association is characterized by an open tall- or short-shrub canopy of *Sarcobatus vermiculatus* that ranges in cover between 20% and 60%. Herbaceous species are low in diversity to moderately diverse and provide moderate cover, up to 35%, mostly by annual exotic species. Graminoids include *Bromus tectorum, Vulpia octoflora, Pleuraphis jamesii*, and *Sporobolus airoides.* Forbs commonly present include *Astragalus nuttallianus, Calochortus flexuosus, Cryptantha fendleri, Descurainia pinnata, Erodium cicutarium, Lappula occidentalis*, and *Rumex hymenosepalus*. Cryptogam cover is absent to sparse.

Globally
This shrubland association 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 include *Atriplex gardneri, Ericameria nauseosa, Grayia spinosa, Suaeda moquinii, Atriplex canescens*, and *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 dominants.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	Species
Short shrub/sapling	*Sarcobatus vermiculatus*
Herb (field)	*Astragalus nuttallianus, Descurainia pinnata*
Herb (field)	*Pleuraphis jamesii*

Global

Stratum	Species
Short shrub/sapling	*Sarcobatus vermiculatus*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Bromus tectorum, Erodium cicutarium

Globally
Bromus tectorum

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Hovenweep National Monument
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
Hovenweep National Monument Inventory Notes: Stands were affected by grazing, resulting in understory replacement by exotic annual species. One stand is severely drought-affected.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0007, 1 observation point: HOVE.9054)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles

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, NVNHP 2003, Shantz and Piemeisel 1940, Young et al. 1986

Pascopyrum smithii Herbaceous Vegetation
Western Wheatgrass Herbaceous Vegetation

CODE	CEGL001577
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 sod temperate or subpolar grassland (V.A.5.N.c.)
ALLIANCE	PASCOPYRUM SMITHII HERBACEOUS ALLIANCE (A.1232) Western Wheatgrass Herbaceous Alliance
ECOLOGICAL SYSTEM(S):	Central Mixedgrass Prairie (CES303.659) Northwestern Great Plains Mixedgrass Prairie (CES303.674) Southern Rocky Mountain Montane-Subalpine Grassland (CES306.824)

USFWS WETLAND SYSTEM: Not Applicable

CONCEPT SUMMARY
Globally
This midgrass prairie type is found in the northern and western Great Plains, Rocky Mountains, the interior western United States and possibly Canada. Stands occur on level to gently sloping terrain. They are found on alluvial fans, swales, river terraces, floodplains, valley floors and basins. The soils are typically clay, clay loam, and silt loam. Pascopyrum smithii strongly dominates the moderate to dense (40-100% cover) mixedgrass herbaceous canopy that grows 0.5-1 m tall. Other graminoids that co-occur and may achieve local dominance are *Koeleria macrantha, Eleocharis palustris*, and *Poa* spp. Many other species common in midgrass prairies are also found in this community. These include *Artemisia ludoviciana, Eriogonum* spp., *Bouteloua gracilis, Nassella viridula*, and *Hesperostipa comata*. Shrubs and dwarf-shrubs are rare in this community, but occasional woody plants, such as *Artemisia tridentata, Symphoricarpos* spp., *Ericameria nauseosa*, or *Krascheninnikovia lanata*, may be present. Introduced species, such as *Bromus tectorum, Bromus inermis, Poa pratensis, Melilotus* spp. or *Cirsium arvense*, are common in some stands, especially where disturbed.

DISTRIBUTION
Hovenweep National Monument
This association is rare. It was observed in a tributary to the main drainage in the central portion of the Goodman Point Unit.

Globally
This midgrass prairie type is found in the northern and western Great Plains, Rocky Mountains, intermountain western United States and possibly Canada, ranging from North Dakota and possibly Saskatchewan, south to Nebraska and Colorado, west to northern Arizona, Utah and Idaho.

ENVIRONMENTAL DESCRIPTION
Hovenweep National Monument

This herbaceous association was observed in a drainage bottom located in the small valley of the Goodman Point Unit. Sites are gentle (2-5° slopes), occur at 2030 and 2020 m elevation, and are oriented to eastern aspects. The unvegetated surface has high cover of litter and moderate exposure of bare soil. Soils are well-drained loamy sands derived from Dakota sandstone that eroded and was re-deposited as alluvium.

Globally
This grassland association is widespread in the northern and western Great Plains, Rocky Mountains, the intermountain western United States and possibly Canada. Elevation ranges from 600-3000 m. Stands occur on level to gently sloping terrain. They are found on alluvial fans, swales, river terraces, floodplains, valley bottoms and basins. The soils are typically deep (40-100 cm) and well-developed with clay, clay loam, and silt loam textures. Some stands occur on perched water tables.

VEGETATION DESCRIPTION
Hovenweep National Monument
This western wheatgrass herbaceous association is rare and distributed only as two vegetation patches occupying a mesic drainage in the Goodman Point Unit. The total vegetation cover ranged from 21 to 27% in these low to moderately vegetated stands. This herbaceous association is characterized by *Pascopyrum smithii* that ranges in cover from 15 to 25%. Exotic graminoids contribute sparse cover and include *Bromus inermis, Bromus tectorum,* and *Poa* sp. It is probable that *Pascopyrum smithii* was introduced to this area for soil stabilization following fire. The short shrub *Artemisia tridentata* ssp. *wyomingensis* provided sparse cover in one stand. Canopy *Juniperus osteosperma* trees, from 2-5 m tall, provided sparse cover in one stand.

Globally
This association is characterized by a moderate to dense (40-100% cover) mixedgrass herbaceous canopy that grows 0.5-1 m tall and is strongly dominated by *Pascopyrum smithii*. Other graminoids that co-occur and may achieve local dominance are *Koeleria macrantha, Eleocharis palustris*, and *Poa* spp. Many other species common in midgrass prairies are also found in this community. These include *Artemisia frigida, Artemisia ludoviciana, Achillea* sp., *Carex* spp., *Eriogonum* spp., *Bouteloua gracilis, Nassella viridula,* and *Hesperostipa comata*. Shrubs and dwarf-shrubs are rare in this community, but occasional woody plants, such as *Symphoricarpos* spp., *Ericameria nauseosa*, or *Krascheninnikovia lanata*, may be present. Introduced species, such as *Bromus tectorum, Bromus inermis, Poa pratensis, Melilotus* spp., *Cirsium arvense, Taraxacum officinale*, or *Salsola kali*, are common in some stands, especially where disturbed.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	**Species**
Short shrub/sapling	*Artemisia tridentata* ssp. *wyomingensis*
Herb (field)	*Bromus inermis, Bromus tectorum, Pascopyrum smithii*

Global

Stratum	**Species**
Herb (field)	*Pascopyrum smithii*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: G3G5Q (1-Feb-1996).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
This community is similar to several others that are dominated or codominated by *Pascopyrum smithii*. As currently defined, it represents a western Great Plains and foothills version of the western wheatgrass types in the central Great Plains. Further work needs to be done to refine the differences in composition and environmental characteristics. See recent descriptions by Thilenius et al. (1995) (*Pascopyrum smithii* sodgrass steppe, a more playa-like wheatgrass type) and by Steinauer and Rolfsmeier (2000). In Nebraska, Steinauer and Rolfsmeier (2000) suggest that their stands may resemble *Pascopyrum smithii - Nassella viridula* Herbaceous Vegetation (CEGL001583).

CLASSIFICATION CONFIDENCE: 3 –Weak

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: This association occurs in small patches on a mesic drainage in the Goodman Point Unit. It appears to have been planted for ground cover following a fire.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0015, 1 observation point: HOVE.9056)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Drake, mod. K.A. Schulz and J. Coles

REFERENCES: Aldous and Shantz 1924, Baker 1983c, Baker 1984a, Baker and Kennedy 1985, Bourgeron and Engelking 1994, Bunin 1985, CONHP unpubl. data 2003, Christensen and Welsh 1963, Driscoll et al. 1984, Godfread 1994, Hall and Hansen 1997, Hansen et al. 1991, Hansen et al. 1995, Hansen et al. 2004c, IDCDC 2005, Jones and Walford 1995, MTNHP 2002b, Marr and Buckner 1974, Ramaley 1916b, Ramaley 1919b, Ramaley 1942, Shanks 1977, Soil Conservation Service 1978, Steinauer and Rolfsmeier 2000, Thilenius et al. 1995, Von Loh 2000

***Bromus inermis - (Pascopyrum smithii)* Semi-natural Herbaceous Vegetation**
Smooth Brome - (Western Wheatgrass) Semi-natural Herbaceous Vegetation

CODE	CEGL005264
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	BROMUS INERMIS SEMI-NATURAL HERBACEOUS ALLIANCE (A.3561) Smooth Brome Semi-natural Herbaceous Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Semi-Desert Grassland (CES304.787) Southern Rocky Mountain Montane-Subalpine Grassland (CES306.824)

USFWS WETLAND SYSTEM: Not Applicable

CONCEPT SUMMARY
Globally
This smooth brome grassland type occurs widely throughout the northern Great Plains, in disturbed montane meadows in the Rocky Mountains, on relatively mesic sites in the semi-arid interior western United States, and perhaps more widely in the midwestern U.S. and Canada. Stands can occur in a wide variety of human-disturbed habitats, including highway rights-of-way, jeep trails, etc. The type is also widely planted for revegetating disturbed land, pasture and hay fields, and has escaped into a variety of habitats, including prairie, riparian grasslands, and mesic mountain meadows. The dominant grass is *Bromus inermis*, a naturalized species from Eurasia that forms moderately dense to dense stands that often develop into monocultures. Other weedy species such as *Cirsium arvense* and *Poa pratensis* may occur as well, but native species are generally less than 10% cover. Native species may include mixed-grass prairie and montane meadow grasses, such as *Pascopyrum smithii, Deschampsia caespitosa*, and *Hesperostipa comata*, and sparse, scattered mesic shrubs such as *Symphoricarpos* spp., as well as many others. However, the native species are not conspicuous enough to identify the native plant association that could occupy the site, or the stand would be typed as such.

DISTRIBUTION

Hovenweep National Monument
This association was sampled in the Goodman Point Unit in and adjacent to a small drainage.

Globally
This type occurs widely throughout the northern Great Plains, disturbed montane meadows in the Rocky Mountains, in relatively mesic sites in Utah and Wyoming, and perhaps more widely in the midwestern and western U.S. and Canada, as well where *Bromus inermis* has escaped from revegetation and forage plantings.

ENVIRONMENTAL DESCRIPTION
Hovenweep National Monument
This herbaceous association was observed in drainages and on drainage slopes in the Goodman Point Unit. Sites are nearly level, occur around 2035 m elevation, and are oriented to eastern and southeastern aspects. The unvegetated surface has high cover of litter. Soils are somewhat poorly drained to rapidly drained silty clays derived from alluvium and influenced by shales of the Burro Canyon Formation.

Globally
This smooth brome grassland type occurs widely throughout the northern Great Plains, on relatively mesic sites in the semi-arid interior western United States, and perhaps more widely in the midwestern U.S. and Canada. Stands can occur in a wide variety of human-disturbed habitats, including highway rights-of-way, jeep trails, etc. The type is also widely planted for revegetating disturbed land, pasture and hay fields, and has escaped into a variety of habitats, including prairie, riparian grasslands, and mesic mountain meadows. In Montana, this community is found at elevational ranges from 1100-2050 m (3590-6700 feet) with best examples occurring on mesic alluvial terraces (Hansen et al. 1995). *Bromus inermis* grows best on moist, well-drained, finer-textured loam and clay loams, not heavy clays or sand, and does not tolerate prolonged flooding (Hansen et al. 1995). In the southern Rocky Mountains, this grassland type is reported from montane elevations (2610 m [8560 feet]), on well-drained sandy loam derived from granitic parent material. It also occurs in foothills and plains at lower elevations on relatively mesic sites. On the Colorado Plateau, stands occur at about 2040 m elevation on poorly drained sites to rapidly drained sites with fine-textured alluvial soils derived from shale.

VEGETATION DESCRIPTION
Hovenweep National Monument
This smooth brome semi-natural grassland association is rare and is distributed near the highest elevations in the monument. The stands were planted historically to provide grass hay for livestock. The total vegetation cover ranges from 27 to 65% in these moderately to densely vegetated stands. This herbaceous association is characterized by the introduced perennial grass *Bromus inermis*, which ranges in cover from 20 to 65%. Other graminoids contribute sparse cover and include *Juncus balticus* and *Poa pratensis*. The shrub layer is low in diversity or absent from stands, sparse in terms of cover, and includes *Artemisia tridentata* ssp. *wyomingensis* and *Ericameria nauseosa*. Canopy *Juniperus osteosperma* and *Pinus edulis* trees are rarely present and provide sparse cover.

Globally
This association is dominated by medium-tall (0.5-1 m) graminoids. The dominant grass is *Bromus inermis*, a naturalized species from Eurasia that forms moderately dense to dense stands that often develop into monocultures. Other weedy species, such as *Cirsium arvense*, *Poa pratensis*, and other introduced forage species, may occur as well, but native species are generally less than 10% cover. Native species may include mixed-grass prairie and montane meadow grasses, such as *Juncus balticus*, *Pascopyrum smithii*, *Deschampsia caespitosa*, and *Hesperostipa comata*, and sparse scattered mesic shrubs, such as *Artemisia tridentata* ssp. *wyomingensis*, *Ericameria nauseosa*, and *Symphoricarpos* spp., and ruderal forbs, such as *Heterotheca villosa*, as well as many others. However, the native species are not conspicuous enough to identify the native plant association that could occupy the site, or the stand would be typed as such.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	**Species**
Short shrub/sapling	*Ericameria nauseosa*
Herb (field)	*Bromus inermis, Juncus balticus*

Global

Stratum	**Species**
Herb (field)	*Bromus inermis, Pascopyrum smithii*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: GNA (invasive) (17-Jun-1999). This is a naturalized type from Europe and Asia, widely planted for cover, pasture, and hay, and has escaped into a variety of habitats.

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
Where native species are abundant enough to identify a native plant association that could occupy the site, the stand should be typed as such. *Bromus inermis* occurs widely throughout the midwestern and western U.S., and perhaps this association should be broadened to include almost any stand dominated almost exclusively by *Bromus inermis*.

CLASSIFICATION CONFIDENCE: 3 –Weak

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: Introduced patches of smooth brome were planted to support historic livestock grazing. The association is only found in the Goodman Point Unit.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0010, 1 observation point: HOVE.9057)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: D. Faber-Langendoen, mod. K.A. Schulz and J. Coles

REFERENCES: Butler et al. 2002, Cogan et al. 2004, Cronquist et al. 1977, Hansen et al. 1995, MTNHP 2002b, NDNHI unpubl. data, Trammel and Butler 1995, Von Loh et al. 2000

***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

Hovenweep National Monument

This association was sampled northeast of the parking area in the Hackberry Unit and on ridge and mesatops in the Square Tower Unit of the monument.

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

Hovenweep National Monument

This association was observed on the upper slopes of ridges, hills, and on mesatops. Sites are gentle (2-4° slopes), occur between 1593 and 1687 m elevation, and are oriented to southern aspects. The unvegetated surface has low to high exposure of bare soil and gravel and moderate cover of litter. Sparse to low cover of cryptogams can occur. Soils are well-drained and are loamy sands derived from Dakota sandstones and Burro Canyon Formation shale, eroded and re-deposited as eolian and alluvial material.

Globally

This widespread association is found on alluvial flats, 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 mesa tops and slopes to basin floors. Stands may be small woodland parks or extensive plains. Soils are variable. In bottomland stands soils tend to be fine-textured; however, stands also occur on sandy loams, remnant lavaflow, basaltic cobbles, black or red cinders, or alluvium derived from relict Pleistocene river cobbles, sandstone, sand, or clay soils.

VEGETATION DESCRIPTION

Hovenweep National Monument

This James' galleta grassland association is uncommon and is distributed in the Hackberry and Square Tower units at the middle elevations in the monument. The total vegetation cover ranges from 8 to 30% in these sparsely to moderately vegetated stands. This herbaceous association is characterized by the perennial bunchgrass *Pleuraphis jamesii* that ranges in cover from 4 to 30%. Another graminoid providing sparse cover is the annual *Vulpia octoflora*. Forbs are moderately diverse and provide sparse cover by *Astragalus nuttallianus, Calochortus flexuosus, Chamaesyce* sp., *Cymopterus newberryi, Erodium cicutarium, Lappula occidentalis, Phacelia crenulata*, and *Sphaeralcea coccinea*. The shrub layer is sparse, consisting of dwarf-shrubs that include *Gutierrezia sarothrae, Opuntia erinacea*, and *Opuntia polyacantha*. Cryptogam cover is absent to 10%.

Globally

This association is characterized by a relatively 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, 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, 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 filifolia, Atriplex canescens, Atriplex confertifolia, Brickellia oblongifolia, Ephedra torreyana, Ephedra viridis, Ericameria nauseosa, Fallugia paradoxa, Gutierrezia* spp., *Tetradymia* spp., and occasional *Juniperus monosperma* 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
Hovenweep National Monument

Stratum	Species
Herb (field)	*Astragalus nuttallianus, Phacelia crenulata*
Herb (field)	*Pleuraphis jamesii*

Global

Stratum	Species
Herb (field)	*Pleuraphis jamesii*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Erodium cicutarium

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: G2G4 (23-Feb-1994).

CLASSIFICATION COMMENTS
Hovenweep National Monument
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
Hovenweep National Monument Inventory Notes: Grassland stands are small (patches), subject to erosion by wind and water and invasion by shrubs.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0013, 2 observation points: HOVE.9055, HOVE.9066.]
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, 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, NVNHP 2003, 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

Erodium cicutarium Semi-natural Annual Herbaceous Vegetation
Crane's-bill Semi-natural Annual Herbaceous Vegetation

CODE	CEGL002085
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	Natural/Semi-natural temperate or subpolar annual grasslands or forb vegetation (V.D.2.N.)
FORMATION	Tall temperate or subpolar annual forb vegetation (V.D.2.N.b.)
ALLIANCE	ERODIUM CICUTARIUM HERBACEOUS ALLIANCE (A.2647) Crane's-bill Herbaceous Alliance

ECOLOGICAL SYSTEM(S): Not assigned

USFWS WETLAND SYSTEM: Not Applicable

CONCEPT SUMMARY

Globally

This small-patch annual exotic herbaceous association occurs on ridges and valley bottoms in highly disturbed sites in the Colorado Plateau. Sites occupied by this association are generally associated with severe disturbance, such as annual grazing by sheep and/or cattle, mining or a very hot fire. Elevations range from 1692 to 2306 m (5550-7565 feet), and sites occur on level to moderate slopes with south to west exposures. Soils are generally sandy and derived from eolian or alluvial deposits. Cryptobiotic crusts may cover much of the unvegetated surface in sites that have not been grazed recently. Total vegetation cover is sparse to moderate (16-40%), depending on the amount of winter/spring precipitation and the time of year a site is sampled. The exotic annual forb *Erodium cicutarium* provides most of the vegetative cover, but other weedy and exotic species are also generally present, including *Bromus tectorum, Descurainia pinnata, Sisymbrium altissimum, Carduus nutans*, and *Tragopogon dubius*. A few scattered shrubs typical of sandy alkaline conditions may be present, including *Atriplex canescens, Opuntia polyacantha, Ephedra viridis, Lycium pallidum*, and *Quercus gambelii*.

DISTRIBUTION

Hovenweep National Monument

This association occupies a historic burn in the Hackberry Unit, on the northern edge, near the access road and north of the parking area.

Globally

This association is of limited extent in northern Arizona, southeastern Utah, and western Colorado. It has been documented from western Colorado and southeastern Utah and has been observed, but not sampled, on the floor of Canyon del Muerto and Canyon de Chelly at Canyon de Chelly National Monument.

ENVIRONMENTAL DESCRIPTION

Hovenweep National Monument

This annual herbaceous association was observed on the midslope of a small ridge. The site is gently sloped (5°), occurs at 1692 m elevation, and is oriented to the southwest. The unvegetated surface has moderate to high exposure of large rocks and low to moderate exposure of small rocks and bare soil. Parent materials are Dakota sandstone and Burro Canyon Formation. Soils are eolian deposits that are rapidly drained and are fine-textured or sandy.

Globally

This small-patch annual herbaceous association occurs on ridges and valley bottoms in highly disturbed sites in the Colorado Plateau. Elevations range from 1692 to 2306 m (5550-7565 feet), and sites occur on level to moderate slopes with south to west exposures. Soils are generally sandy and derived from eolian or alluvial deposits. Cryptobiotic crusts may cover much of the unvegetated surface in sites that have not been grazed in a number of years; in grazed sites, bare ground and rocks cover most of the surface.

VEGETATION DESCRIPTION

Hovenweep National Monument

This crane's-bill annual forb association is limited to the site of a burn that occurred near an access road in the Hackberry Unit. The total vegetation cover is less than 6% in this sparsely vegetated stand. This annual herbaceous association is characterized by the low-growing, exotic forb *Erodium cicutarium* that provides 3% cover. Additional exotic forbs that have invaded this site and provide sparse cover include *Descurainia pinnata* and *Sisymbrium altissimum*. The shrub layer is sparse, low in diversity, and includes *Gutierrezia microcephala* and *Lycium pallidum*. Sparse canopy cover is provided in the stand by 2- to 5-m-tall *Juniperus osteosperma* trees.

Globally

This annual herbaceous association indicates sites that have experienced severe or chronic disturbance. Total vegetation cover in this annual herbaceous type is sparse to moderate (16-40%), depending on the amount of winter/spring precipitation and the time of year a site is sampled. The exotic annual forb *Erodium cicutarium* provides most of the vegetative cover, but other weedy and exotic species are also generally present, including *Bromus tectorum, Descurainia pinnata, Sisymbrium altissimum, Carduus nutans*, and *Tragopogon dubius*. A few scattered shrubs may be present, including *Opuntia polyacantha, Ephedra viridis, Lycium pallidum, Atriplex*

canescens, and *Quercus gambelii*.

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	Species
Short shrub/sapling	*Lycium pallidum*
Herb (field)	*Erodium cicutarium*

Global

Stratum	Species
Herb (field)	*Erodium cicutarium*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: GNA (invasive) (14-Dec-2004).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
Data are not available

CLASSIFICATION CONFIDENCE: 2 –Moderate

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: This site was burned historically; it was a sparse Utah juniper stand that contained some Wyoming big sagebrush in the understory.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 observation point: HOVE.9046)
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles

REFERENCES: Bentley and Talbot 1948, Felger n.d., Wagner et al. 1978

***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	Natural/Semi-natural temperate or subpolar annual grasslands or forb vegetation (V.D.2.N.)
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

Hovenweep National Monument

This association is rare and was sampled on a historic burn on a hillslope in the southwestern corner of the Square Tower Unit of the monument.

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

Hovenweep National Monument

This herbaceous association occupies the midslope of a hill that is disturbed by fire. The site is moderately steep (12° slope), occurs at 1600 m elevation, and is oriented to the northeast. The unvegetated surface has moderate to high cover of bare soil and litter. Soils are well-drained and are silt loams derived from eolian loess.

Globally

This association occurs throughout much of western North America from the western Great Plains to the Intermountain and southwestern U.S. Elevation ranges from sea level to 2200 m. Stands occur after disturbance of a shrub- or grass-dominated community, resulting in the replacement of the natural vegetation by non-native, annual grass species of *Bromus*, although invasion of undisturbed sites has also been reported (e.g., Evans et al. 2001). At Wind Cave National Park in South Dakota, weedy non-native graminoid vegetation occurs on recently disturbed areas, most commonly along roads. Small stands also occur in prairie dog towns (H. Marriott pers. comm. 1999). In the Great Basin, *Bromus tectorum* grasslands have invaded large areas of burned-over sagebrush steppe. *Bromus tectorum* increases the fire frequency of steppe communities, which eventually eliminates sagebrush (FEIS 2001).

VEGETATION DESCRIPTION

Hovenweep National Monument

This cheatgrass association occupies a burned slope within the Square Tower Unit of the monument. The total vegetation cover is 42% in this moderately vegetated stand. This herbaceous association is characterized by moderate (35%) graminoid cover of the annual exotic *Bromus tectorum*. The other graminoid species present, the native annual *Vulpia octoflora*, provides sparse cover. Forbs are somewhat diverse, disturbance-oriented, provide sparse cover, and include *Astragalus nuttallianus, Cryptantha* sp., *Lappula occidentalis, Oenothera pallida*, and *Sisymbrium altissimum*. The shrub layer is sparse and provides sparse cover; the only shrub present is the short shrub *Chrysothamnus viscidiflorus*.

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. 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

Hovenweep National Monument

Stratum	**Species**
Herb (field)	*Sisymbrium altissimum*
Herb (field)	*Bromus tectorum*

Global

Stratum	**Species**
Herb (field)	*Bromus hordeaceus, Bromus japonicus, Bromus madritensis, Bromus rigidus, Bromus rubens, Bromus tectorum*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: GNA (invasive) (1-Dec-1997).

CLASSIFICATION COMMENTS
Hovenweep National Monument
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
Hovenweep National Monument Inventory Notes: The site is in a Wyoming big sagebrush stand that has burned.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 observation point: HOVE.9064)
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, Young and Evans 1973, Young and Evans 1978

***Leymus salinus* Shale Sparse Vegetation**
Salinas Wildrye 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) Salinas 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

Hovenweep National Monument

This association is rare, occupying steep shale soils that are less than 1 ha in area, and was sampled near the monument boundary where Little Ruin Canyon exits to the south in the Square Tower Unit.

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

Hovenweep National Monument

This sparse association is observed on the midslope of Little Ruin Canyon. The site is moderately steep (17 °), occurs at 1594 m elevation, and is oriented to the east. Litter and small rocks comprise low to moderate amounts of the unvegetated surface. Cryptogamic cover is over 60% in this stand. The soil is a rapidly drained silty clay derived from shales of the Burro Canyon Formation.

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.

VEGETATION DESCRIPTION

Hovenweep National Monument

This Salinas wildrye association is rare, observed only in the Square Tower Unit below a shale outcrop. The total vegetation cover is 38% in this moderately vegetated stand. This herbaceous association is characterized by the tall bunchgrass *Leymus salinus* ssp. salinus that provides up to 5% cover. Another graminoid providing sparse cover is the short bunchgrass *Pleuraphis jamesii*. Forbs are low in diversity and provide sparse cover, including *Delphinium nuttallianum* and *Sphaeralcea coccinea*. The shrub layer is low in diversity and provides low cover by short and dwarf-shrubs, including *Atriplex confertifolia*, *Ephedra viridis*, *Ericameria nauseosa*, and *Gutierrezia sarothrae*. Cryptogam cover is high, over 60%.

Globally

This 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% 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

Hovenweep National Monument

Stratum	**Species**
Short shrub/sapling	*Atriplex confertifolia, Ericameria nauseosa*
Short shrub/sapling	*Ephedra viridis*
Herb (field)	*Leymus salinus* ssp. *salinus, Pleuraphis jamesii*

Global

Stratum	**Species**
Short shrub/sapling	*Atriplex confertifolia*
Herb (field)	*Leymus salinus*

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Data are not available

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (26-Jun-2001).

CLASSIFICATION COMMENTS
Hovenweep National Monument
Data are not available

Globally
Data are not available

CLASSIFICATION CONFIDENCE: 2 –Moderate

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: This association is found on steep, sparsely vegetated, shale slopes in a narrow band between sandstone ledges of the canyon rim and sandy alluvium of the canyon floor.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 plot: HOVE.0021)
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.

Mixed Riparian Shrubland [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
	Not Applicable

ECOLOGICAL SYSTEM(S): North American Warm Desert Lower Montane Riparian Woodland and Shrubland (CES302.748)
Rocky Mountain Lower Montane Riparian Woodland and Shrubland (CES306.821)

USFWS WETLAND SYSTEM: Not Applicable

CONCEPT SUMMARY
Globally
Data are not available

DISTRIBUTION
Hovenweep National Monument
This association was sampled in the main drainage near the south boundary of the Goodman Point Unit.

Globally
Data are not available

ENVIRONMENTAL DESCRIPTION
Hovenweep National Monument
This association was observed on the banks of the lower portion of the main drainage in the Goodman Point Unit. The site is gentle (4o slope), occurs at 2025 m, and is oriented to an eastern aspect. The unvegetated surface has high cover of litter. Parent materials are Dakota sandstone. The soils are moderately well drained, fine grained, and are deep, up to 4 m. This vegetation stand is stable, rooted on and armoring the banks of a relatively straight drainage. Downcutting to 1 m deep does not affect these shrub species. An understory of exotic grasses persists.

Globally
Data are not available

VEGETATION DESCRIPTION
Hovenweep National Monument
This shrubland association is distributed along the lower drainage reach, below an active spring and is rare in the Monument. The total vegetation cover is 84% in this densely vegetated stand. This shrubland association is characterized by a closed canopy, from 5 m to 10 m tall, of a mix of tall and short shrubs. At the sampled site, the tall shrub *Peraphyllum ramosissimum* provided 40% cover. Canopy trees from 5 m to 10 m tall include *Pinus edulis* and *Juniperus osteosperma* that provide low cover. Additional tall and short shrubs are diverse and provide low to moderate cover including *Amelanchier utahensis*, *Artemisia tridentata* ssp. *wyomingensis*, *Ericameria nauseosa*, *Prunus virginiana*, *Ribes aureum*, and *Salix exigua*. The herbaceous layer provides moderate cover and is largely exotic grasses and forbs. Graminoids include *Bromus inermis*, *Bromus tectorum*, *Poa fendleriana*, and *Poa pratensis*. Forbs provide sparse cover and include *Arctium minus*, *Cirsium* sp., and *Taraxacum officianale*.

Globally
Data are not available

MOST ABUNDANT SPECIES
Hovenweep National Monument

Stratum	Species
Tall shrub	*Peraphyllum ramosissimum, Ribes aureum, Prunus virginiana*
Short shrub	*Ericameria nauseosa*
Graminoid	*Bromus inerme*

Global

Stratum	Species
Data are not available	

OTHER NOTEWORTHY SPECIES
Hovenweep National Monument
Amelanchier utahensis, Salix exigua

Globally
Data are not available

CONSERVATION STATUS RANK
Global Rank & Reasons: Data are not available

CLASSIFICATION COMMENTS
Hovenweep National Monument
This association is found on previously disturbed land that is undergoing revegetation. Most sites were used as

sources for sand and gravel extraction, and one large site is a highway fill slope. Over time each site will revegetate to reflect the surrounding plant community, typically *Artemisia tridentata* ssp. *wyomingensis* shrubland or *Pinus edulis - Juniperus osteosperm*a woodland.

Globally
Data are not available

CLASSIFICATION CONFIDENCE: 3 –Weak

ELEMENT SOURCES
Hovenweep National Monument Inventory Notes: Stand was sampled early in the growing season and some shrubs were difficult to identify. Drainage bank densely covered by shrubs.
Hovenweep National Monument Plots: The description is based on 2003 field data (1 observation point: HOVE.9052)
Local Description Authors: J. Von Loh
Global Description Authors: Data are not available

REFERENCES: Data are not available

Bibliography

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.

Anhold, J. 2005. Piñon pine mortality event in the Southwest: An update for 2005. Poster abstract. Ecological Restoration of Southwest Ponderosa Pine and Pinyon-Juniper Ecosystems, May 11 and 12, 2005, St. George, UT.

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.

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 Arizona, Tucson.

Bureau of Land Management. 1979a. Pages 2-6 to 2-15 in: Grand Junction Resource Area grazing management-draft environmental statement.

Bureau of Land Management. 1979b. Final environmental impact statement, proposed development of coal resources in Eastern Powder River, WY. 67 pp.

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. 1982b. Natural vegetation of the Piceance Basin, Colorado. Appendix D, pages 1-113 in: J.S. Peterson and W. L. Baker, editors. Inventory of the Piceance Basin, Colorado. Unpublished report for the Bureau Land Management, Craig, CO.

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., 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, New York. 1002 pp.

Barnes, F.J. 1987. Carbon and water relations across a pinyon-juniper habitat gradient. Unpublished dissertation, New Mexico State University, Las Cruces.

Barney, M.A., and N.C. Frischknecht. 1974. Vegetation changes following fire in the pinyon-juniper types of west-central Utah. Journal of Range Management 27(2):91-96.

Bassett, D., M. Larson, and W. Moir. 1987. Forest and woodland habitat types of Arizona south of the Mogollon Rim and southwestern New Mexico. Edition 2. USDA Forest Service, SW, Albuquerque, NM.

Bassett, R.L. 1987. Silvicultural systems for pinyon-juniper. Pages 273-278 in: R.L. Everett, compiler. Proceedings--pinyon-juniper conference: 1986 January 13-16; Reno, NV. USDA Forest Service, Intermountain Research Station. General Technical Report INT-215. Ogden, UT.

Bear Creek Uranium Mine Application. No date. Unpublished report No. 399 prepared for Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne, WY.

Beatley, J.C. 1975. Climates and vegetation pattern across the Mojave/Great Basin desert transition of southern Nevada. The American Midland Naturalist 93:53-70.

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.

Beatley, J.C. 1993. Climatic and vegetation pattern across the Mojave / Great Basin Desert Transition of southern Nevada. The American Midland Naturalist 93:53-70.

Bentley, J.R., and M.W. Talbot. 1948. Annual-plant vegetation of the California foothills as related to range management. Ecology 29:72-79.

Betancourt, J.L., and T.R. Van Devender. 1981. Holocene vegetation in Chaco Canyon, New Mexico. Science 214:656-658.

Bighorn Coal Mine. No date. Application No. 213-T2, on file at Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne.

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.

Blackburn, W.H. 1967. Plant succession on selected habitat types in Nevada. Unpublished thesis, University of Nevada, Reno. 162 pp.

Blackburn, W.H., P.T. Tueller, and R.E. Eckert, Jr. 1968a. Vegetation and soils of the Mill Creek Watershed. Nevada Agricultural Experiment Station Bulletin R-43. Reno. 69 pp.

Blackburn, W.H., P.T. Tueller, and R.E. Eckert, Jr. 1968b. Vegetation and soils of the Crowley Creek Watershed. Nevada Agricultural Experiment Station Bulletin R-42. Reno. 60 pp.

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., P.T. Tueller, and R.E. Eckert, Jr. 1969a. Vegetation and soils of the Cow Creek Watershed. Nevada Agricultural Experiment Station Bulletin R-49. Reno. 80 pp.

Blackburn, W.H., P.T. Tueller, and R.E. Eckert, Jr. 1969b. Vegetation and soils of the Coils Creek Watershed. Nevada Agricultural Experiment Station Bulletin R-48. Reno. 81 pp.

Blackburn, W.H., P.T. Tueller, and R.E. Eckert, Jr. 1969c. Vegetation and soils of the Churchill Canyon Watershed. Nevada Agricultural Experiment Station Bulletin R-45. Reno. 157 pp.

Blackburn, W.H., P.T. Tueller, and R.E. Eckert, Jr. 1969d. Vegetation and soils of the Pine and Mathews Canyon Watersheds. Nevada Agricultural Experiment Station Bulletin R-46. Reno. 111 pp.

Blackburn, W.H., P.T. Tueller, and R.E. Eckert, Jr. 1971. Vegetation and soils of the Rock Springs Watershed. Nevada Agricultural Experiment Station Bulletin R-83. Reno. 116 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.

Bourgeron, P.S., and L.D. Engelking, editors. 1994. A preliminary vegetation classification of the western United States. Unpublished report. The Nature Conservancy, Boulder, CO. 175 pp. plus appendix.

Boutton, T.W., A.T. Harrison, and B.N. Smith. 1980. Distribution of biomass of species differing in photosynthetic pathway along an altitudinal transect in southwestern Wyoming grasslands. Oecologia 45:287-298.

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., R.F. Miller, and I.S. McQueen. 1961. Soil-water availability and use by grasslands on adjacent stony and shale-derived soils in Colorado. Short papers in geologic and hydrologic sciences. U.S. Geological Survey Professional Paper 424C:251-253.

Branson, F.A., R.F. Miller, and I.S. McQueen. 1964. Effects of two kinds of geologic materials on plant communities and soil moisture. American Society of Agronomy Special Publication 5:165-175.

Branson, F.A., R.F. Miller, and I.S. McQueen. 1965. Plant communities and soil moisture relationships near Denver, Colorado. Ecology 46(3):311-319.

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 K.J. Brotherson. 1979. Ecological and community relationships of *Eriogonum corymbosum* (Polygonaceae) in the Uinta Basin, Utah. Great Basin Naturalist 39:177-191.

Brotherson, J.D., and W.E. Evenson. 1982. Vegetation communities surrounding Utah Lake and its bays. Utah Lake Vegetation Studies. Unpublished report done for the Utah Division of Wildlife Resources and USDI Bureau of Reclamation, Provo, UT. 401 pp.

Brotherson, J.D., and W.T. Brotherson. 1981. Grazing impacts on the sagebrush communities of central Utah. Great Basin Naturalist 41(3):335-340.

Brown, D.E., editor. 1982. Biotic communities of the American Southwest-United States and Mexico. Desert Plants Special Issue 4(1-4):1-342.

Brown, R.W. 1971. Distribution of plant communities in southeastern Montana badlands. The American Midland Naturalist 85(2):458-477.

Bujakiewicz, A. 1975. Vegetational zonation in the Front Range of the Rocky Mountains, Colorado. USA. Fragmenta Floristica et Geobotanica 21:99-142.

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.

Bunin, J.E. 1985. Vegetation of the City of Boulder, Colorado open space lands. Report prepared for the City of Boulder, Real Estate/Open Space, Boulder, CO. 114 pp.

Bunting, S.C. 1987. Use of prescribed burning in juniper and pinyon-juniper woodlands. Pages 141-144 in: R.L. Everett, compiler. Proceedings--pinyon-juniper conference; 1986 January 13-16; Reno, NV. Department of Agriculture, Forest Service, Intermountain Research Station. General Technical Report INT-215. Ogden, UT.

Burns, R.M., and B.H. Honkala, technical coordinators. 1990a. Silvics of North America: Volume 1. Conifers. USDA Forest Service. Agriculture Handbook 654. Washington, DC. 675 pp.

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.

Colorado Natural Heritage Program. 1983. Community Characterization Abstract (CCA) for Artemisia bigelovii - *Frankenia jamesii /Oryzopsis hymenoides - Stipa neomexicana* Association. Unpublished report.

Colorado Natural Heritage Program. 2003. Unpublished data. List of Elements and Elcodes converted and entered into Biotics Tracker 4.0. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Colorado Natural Heritage Program. No date. Biological and Conservation Data (BCD) System. Unpublished data from field surveys. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Cacek, T.L. 1973. An ecological interpretation of north central Colorado. Unpublished dissertation, Colorado State University, Fort Collins. 261 pp.

Caicco, S.L., and C.A. Wellner. 1983c. Research Natural Area recommendation for Southwest Lemhi Range. Unpublished report prepared for USDI Bureau of Land Management, Idaho Falls District, Idaho by Idaho Natural Areas Coordinating Committee. On file at Idaho Conservation Data Center, Boise, ID.

Caicco, S.L., and C.A. Wellner. 1983f. Research Natural Area recommendation for Menan Buttes. Unpublished report prepared for USDI Bureau of Land Management, Idaho Falls District, Idaho by Idaho Natural Areas Coordinating Committee. 10 pp.

Caicco, S.L., and C.A. Wellner. 1983g. Research Natural Area recommendation for Middle Canyon Alluvial Fan. Unpublished report prepared for USDI Bureau of Land Management, Idaho Falls District, Idaho by Idaho Natural Areas Coordinating Committee.

Caicco, S.L., and C.A. Wellner. 1983i. Research Natural Area recommendation for Substation Tract. Unpublished report prepared for USDI Bureau of Land Management, Shoshone District, Idaho by Idaho Natural Areas Coordinating Committee. 11 pp.

Caicco, S.L., and C.A. Wellner. 1983j. Research Natural Area recommendation for Big Juniper Kipuka. Unpublished report prepared for USDI Bureau of Land Management, Shoshone District, Idaho by Idaho Natural Areas Coordinating Committee.

Caicco, S.L., and C.A. Wellner. 1983k. Research Natural Area recommendation for East Fork Salmon River Bench. Unpublished report prepared for USDI Bureau of Land Management, Salmon District, Idaho by Idaho Natural Areas Coordinating Committee. 14 pp.

Caicco, S.L., and C.A. Wellner. 1983l. Research Natural Area recommendation for Antelope Flat. Unpublished report prepared for USDI, Bureau of Land Management, Salmon District, Idaho by Idaho Natural Areas Coordinating Committee. 12 pp.

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.

Carmichael, R.S., O.D. Knipe, C.P. Pase, and W.W. Brady. 1978. Arizona chaparral: Plant associations and ecology. USDA Forest Service Research Paper RM-202. 16 pp.

Chappell, C., R. Crawford, J. Kagan, and P.J. Doran. 1997. A vegetation, land use, and habitat classification system for the terrestrial and aquatic ecosystems of Oregon and Washington. Unpublished report prepared for Wildlife habitat and species associations within Oregon and Washington landscapes: Building a common understanding for management. Prepared by Washington and Oregon Natural Heritage Programs, Olympia WA, and Portland, OR. 177 pp.

Christensen, E.M., and S.L. Welsh. 1963. Presettlement vegetation of the valleys of western Summit and Wasatch counties, Utah. Proceedings of the Utah Academy of Science, Arts and Letters 40:163-174.

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.

Clary, W.P., M.B. Baker, Jr., P.F. O'Connell, T.N. Johnsen, Jr., and R.E. Campbell. 1974. Effects of pinyon-juniper removal on natural resource products and uses in Arizona. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Research Paper RM-128. Fort Collins, CO. 28 pp.

Clements, F.E. 1904. Formation and succession herbaria. University of Nebraska, University Studies IV(4):329-355.

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.

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, Pat. Personal communication. Regional Ecologist. NatureServe, Western Resource Office, Boulder, CO.

Cooper, D.J. 1988. Advanced identification of wetlands in the City of Boulder Comprehensive Planning Area. Unpublished technical report prepared for U.S. Environmental Protection Agency, Region VIII and the City of Boulder, CO.

Copeland, W.N. 1979. Harney Lake RNA Guidebook, Supplement #9. USDA Forest Service Experiment Station, Portland, OR.

Copeland, W.N., and S.E. Greene. 1982. Stinking Lake Research Natural Area. Supplement #12 to Franklin, J.F., F.C. Hall, C.T. Dyrness and C. Maser. 1972. Federal research natural areas in Oregon and Washington: A guidebook for scientists and educators. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR.

Costello, D.F. 1944b. Important species of the major forage types in Colorado and Wyoming. Ecological Monographs 14:107-134.

Cotter-Ferguson Project. No date. Application No. 490, on file at Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne.

Crane, M.F. 1982. Fire ecology of Rocky Mountain Region forest habitat types. USDA Forest Service final report. 272 pp.

Cronquist, A., A.H. Holmgren, N.H. Holmgren, J.L. Reveal, and P.K. Holmgren. 1977. Intermountain flora: Vascular plants of the Intermountain West, U.S.A. Volume 6: The Monocotyledons. Columbia University Press, New York. 584 pp.

Cronquist, A., N.H. Holmgren, and P.K. Holmgren. 1997. Intermountain flora: Vascular plants of the Intermountain West, USA. Volume 3, Part A, subclass Rosidae (except Fabeles). NY Botanical Garden, Bronx, NY. 446 pp.

Crouch, G.L. 1961a. Wildlife populations and habitat conditions on grazed and ungrazed bottomlands in Logan County, Colorado. Unpublished thesis, Colorado State University, Fort Collins.

Crouch, G.L. 1961b. Inventory and analysis of wildlife populations and habitat, South Platte River Valley. Final report, Federal Aid in Wildlife Restoration, Project W-104-R-1-2, Colorado Game and Fish Department. 68 pp.

Crouch, G.L. 1978. Effects of protection from livestock grazing on a bottomland wildlife habitat in northeastern Colorado. Pages 118-125 in: Lowland river and stream habitat in Colorado: A symposium. Greeley, CO. 4-5 October 1978.

Crouch, G.L. 1979a. Long-term changes in cottonwoods on a grazed and an ungrazed plains bottomland in northeastern Colorado. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Research Note RM-370. Fort Collins, CO. 4 pp.

Crouch, G.L. 1979b. Changes in the vegetation complex of a cottonwood ecosystem on the South Platte River. Pages 19-22 in: Riparian and wetland habitats of the Great Plains: Proceedings of the 31st annual meeting. Great Plains Agricultural Council Publication 91. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

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.

Culwell, L.D., and K.L. Scow. 1982. Terrestrial vegetation inventory: Dominy Project Area, Custer County, Montana 1979-1980. Unpublished technical report for Western Energy Company by Westech, Helena, MT. 144 pp. plus 15 pp. appendix.

Current, F.B. 1984. The distribution and description of the vegetation of Battle Mountain as explained by abiotic factors. Unpublished dissertation, University of Wyoming, Laramie.

Dalen, R.S., and W.R. Snyder. 1987. Economic and social aspects of pinyon-juniper treatment - then and now. Pages 343-350 in: R.L. Everett, editor. Proceedings - Pinyon-Juniper Conference, Reno, NV, 13-16 January 1986. USDA Forest Service. General Technical Report INT-215.

Dastrup, B.C. 1963. Vegetational changes of the Uinta Basin since settlement. Unpublished thesis, Brigham Young University, Provo, UT. 118 pp.

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.

Day, T.A., and R.G. Wright. 1985. Vegetation types of Craters of the Moon National Monument. Forestry, Wildlife, and Range Experiment Station Bulletin # 38. University of Idaho, Moscow. 6 pp.

DeLeuw, Cather & Company. 1977. Vegetation sampling (Glenwood Canyon). Unpublished report prepared by DeLeuw, Cather & Company, Consulting Engineers and Planners, Chicago, Illinois for Colorado Division of Highways, Glenwood Springs, CO.

DeVelice, R.L., J. Lichthardt, and P.S. Bourgeron. 1991. A preliminary classification of the plant communities of northeastern Montana. Prepared for the Montana Natural Heritage Program. Helena, MT. 144 pp.

DeVelice, R.L., S.V. Cooper, J.T. McGarvey, J. Lichthardt, and P.S. Bourgeron. 1995. Plant communities of northeastern Montana: A first approximation. Montana Natural Heritage Program, Helena, MT. 116 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.

Despain, D.G. 1973a. Vegetation of the Big Horn Mountains, Wyoming, in relation to substrate and climate. Ecological Monographs 43(3):329-354.

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.

Doescher, P.S., R.F. Miller, S.R. Swanson, and A.H. Winward. 1986. Identification of the *Artemisia tridentata* ssp. *wyomingensis/Festuca idahoensis* habitat type in eastern Oregon. Northwest Science 60(1):55-60.

Donart, G.B., D.D. Sylvester, and W.C. Hickey. 1978b. Potential natural vegetation-New Mexico. New Mexico Interagency Range Commission Report 11.

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.

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.

Driese, K.L., W.A. Reiners, E.H. Merrill, and K.G. Gerow. 1997. A digital land cover map of Wyoming, USA: A tool for vegetation analysis. Journal of Vegetation Science 8:133-146.

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-FS. Miscellaneous Publication No. 1439. Washington, DC. 56 pp.

Dwyer, D.D. and R.D. Pieper. 1967. Fire effects on blue gramma-pinyon-juniper rangeland in New Mexico. Journal of Range Management 20:359-362.

Earth Resource Technology. No date. Vanguard II Mine Application No. 334-T2, on file at Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne.

Eddleman, L.E., and R. Jaindl. 1994. Great Basin National Park vegetation analysis. USDI National Park Service Technical Report NPS/PNROSU/NRTR-94/02. USDI National Park Service, PNW Region. 110 pp.

Ellis, S., and P. Hackney. 1981. Vegetation baseline report: Clear Creek property. Unpublished report prepared for Chevron Shale Oil Co., Denver, CO, by Environmental Research and Technology Inc., Fort Collins, CO.

Empire Engineering and Land Surveying. 1986. Vegetation resources, Vol. 2, Chapter 9, Sections 9.0-9.3, pages 9-1 through 9-19 and 9-38 through 9-41 in: Mining and Reclamation Plan for Black Jack Mine Number 1. Report for New Tech Mining Corporation. Utah Division of Oil, Gas, and Mining Act/019/004. Salt Lake City, UT.

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.

Erdman, J.A. 1970. Pinyon-juniper succession after natural fires on residual soils of Mesa Verde, Colorado. Brigham Young University Science Bulletin, Biological Series 11(2):1-26.

Erdman, J.A., C.L. Douglas, and J.W. Marr. 1969. Wetherill Mesa Studies, environment of Mesa Verde, Colorado. USDI National Park Service. Archeological Research Series 7-B. Washington, DC. 72 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.

Everett, R.L. 1987. Plant response to fire in the pinyon-juniper zone. Pages 152-157 in R. L. Everett, compiler. Proceedings pinyon-juniper conference: 1986 January 13-16, Reno, NV. USDA Forest Service, General Technical Report INT-215. Intermountain Research Station, Ogden, UT.

Everett, R.L., compiler. 1986. Proceedings pinyon-juniper conference: 1986 January 13-16, Reno, NV. USDA Forest Service, General Technical Report INT-215. Intermountain Research Station, Ogden, UT. 581 pp.

Eyre, F.H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.

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., and Midwest State Natural Heritage Program Ecologists. 1996. Terrestrial vegetation of the midwest United States. International classification of ecological communities: Terrestrial vegetation of the United States. The Nature Conservancy, Arlington, VA.

Faden, A.O. 1977. Vegetation zonation of a Mohave Desert playa. Unpublished thesis, University of Nevada, Las Vegas.

Fautin, R.W. 1946. Biotic communities of the northern desert shrub biome in western Utah. Ecological Monographs 16(4):251-310.

Felger, R.S. 1990. Non-native plants of Organ Pipe Cactus National Monument, Arizona. Technical Report No. 31. University of Arizona, School of Renewable Natural Resources, Cooperative National Park Resources Studies Unit, Tucson. 93 pp.

Fenemore, R.M., Jr. 1970. Plant succession in a receding lake bed in the western Great Basin. Unpublished thesis, University of Nevada, Reno.

Ferchau, H.A. 1973. Vegetation inventory analysis & impact study of the Parachute Creek area, Garfield County, Colorado. Part II, Volume 1, Chapter VI:1-77 in: Unpublished Colony Environmental Report for Colony Develop. Operation, Denver, prepared by Thorne Ecological Institute, Boulder.

Fisser, H.G. 1964. Range survey in Wyoming's Big Horn Basin of Wyoming. Wyoming Agricultural Experiment Station Bulletin 424.

Fisser, H.G. 1970. Exclosure studies with transects of permanent plots, 1969 results. University of Wyoming Cooperative Research Report to the USDI Bureau of Land Management, sections I-IV. Wyoming Agricultural Experiment Station. Science Report 240. Laramie, WY. 128 pp.

Fitzgerald, J.P. 1978. Vertebrate associations in plant communities along the South Platte River in northeastern Colorado. Pages 73-88 in: W.D. Graul and J. Bissell, editors. Lowland River and Stream Habitat in Colorado: A symposium, Greeley, Colorado, October 4-5, 1978. Colorado Chapter of the Wildlife Society and Colorado Audubon Council.

Francis, R.E. 1983. Sagebrush-steppe habitat types in northern Colorado: A first approximation. Pages 67-71 in: Proceedings of the Workshop on Southwestern habitat types. USDA Forest Service, Southwestern Region, Albuquerque, NM.

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. Fort 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.

Franklin, J.F., and C.T. Dyrness. 1973. Natural vegetation of Oregon and Washington. USDA Forest Service, PNW Forest and Range Experiment Station. General Technical Report PNW-8. Portland, OR. 417 pp.

Galatowitsch, S., and P.S. Bourgeron. 1985. Colorado plant association classification draft. Unpublished report prepared for The Nature Conservancy, Rocky Mountain Heritage Task Force, Lakewood, CO. 49 pp.

Ganskopp, D.C. 1986. Tolerances of sagebrush, rabbitbrush, and greasewood to elevated water tables. Journal of Range Management 39(4): 334-337.

Giese, T.G. 1975. The ecology of the Middle Blue River Valley, Summit County, Colorado, with an analysis of modifications due to powerline construction. Unpublished thesis, University of Colorado, Boulder. 109 pp.

Godfread, C. 1994. The vegetation of the Little Missouri Badlands of North Dakota. Pages 17-24 in: Proceedings of the Leafy Spurge Strategic Planning Workshop, March 29-30, Dickinson, ND.

Graham, E.H. 1937. Botanical studies in the Uinta Basin of Utah and Colorado. Annals of the Carnegie Museum 26:28-432.

Groeneveld, D.P., and D.E. Crowley. 1988. Root system response to flooding in three desert shrub species. Functional Ecology 2:491-497.

Gross, J.E. 1955. A vegetation survey of the Poudre bighorn sheep range. Unpublished paper prepared for Big Game Management, WM-190D, Colorado State University, Fort Collins. 65 pp.

Hadley, R.F., and F.A. Branson. 1965. Surficial geology and microclimatic effects on vegetation, soils and geomorphology in the Denver, Colorado, area. Pages 56-63 in: Guidebook for 1-day field conferences-Boulder area, CO. 7th International Association for Quaternary Research Congress. Nebraska Academy of Science.

Hall, F.C. 1973. Plant communities of the Blue Mountains in eastern Oregon and southeastern Washington. USDA Forest Service, Pacific Northwest Region. R6 Area Guide 3-1. 62 pp.

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.

Hamner, R.W. 1964. An ecological study of *Sarcobatus vermiculatus* communities of the Big Horn Basin, Wyoming. Unpublished thesis, University of Wyoming, Laramie.

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, M., J. Coles, K.A. Thomas, D. Cogan, M. Reid, J. Von Loh, and K. Schulz. 2004c. USGS-NPS Vegetation Mapping Program: Sunset Crater National Monument, Arizona, vegetation classification and distribution. U.S. Geological Survey Technical Report. Southwest Biological Science Center, Flagstaff, AZ.

Hansen, P.L. 1985. An ecological study of the vegetation of the Grand River/Cedar River, Sioux, and Ashland districts of the Custer National Forest. Unpublished dissertation, South Dakota State University. 257 pp.

Hansen, P.L., G.R. Hoffman, and A.J. Bjugstad. 1984. The vegetation of Theodore Roosevelt National Park, North Dakota: A habitat type classification. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-113. Fort Collins, CO. 35 pp.

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 G.R. Hoffman. 1988. The vegetation of the Grand River/Cedar River, Sioux, and Ashland districts of the Custer National Forest: A habitat type classification. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-157. Fort Collins, CO. 68 pp.

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.

Hanson, H.C. 1957. The use of basic principles in the classification of range vegetation. Journal of Range Management 10:26-33.

Hanson, H.C., L.D. Love and M.S. Morris. 1931. Effects of different systems of grazing by cattle upon a western wheatgrass type of range near Fort Collins, CO. Colorado Agricultural Experiment Station Bulletin 377. 82 pp.

Hanson, H.C., and E. Dahl. 1956. Some grassland communities in the mountain-front zone in northern Colorado. Vegetatio 7:249-270.

Hanson, H.C., and W.S. Ball. 1928. An application of Raunkiaer's law of frequency to grazing studies. Ecology 9:467-473.

Hanson, H.C., and W. Whitman. 1938. Characteristics of major grassland types in western North Dakota. Ecological Monographs 8:58-114.

Harmon, W.E. 1980. Survey of the flora and vegetation of the Bodo Wildlife Management Area. Unpublished report prepared for The Nature Conservancy, Denver, CO. On file at the Colorado Natural Areas Program, Denver. 40 pp.

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.

Harrington, T.C., and F.W. Cobb, Jr., editors. 1988. Leptographium root diseases on conifers. The American Phytopathological Society Press, St. Paul, MN. 149 pp.

Heerwagen, A. 1956. Mixed prairie in New Mexico. Pages 284-300 in: J. E. Weaver and F. O. Albertson, editors. Grasslands of the Great Plains, their nature and use. Johnson Publishing Company, Lincoln, NE.

Heinze, D.H., R.E. Eckert, and P.T. Tueller. 1962. The vegetation and soils of the Steptoe Watershed. Unpublished report prepared for the USDI Bureau of Land Management. 40 pp.

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. 1981. Phyto-edaphic study of habitat types of the Arapaho-Roosevelt National Forest, Colorado. Unpublished dissertation, Colorado State University, Fort Collins. 558 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.

Hink, V.C., and R.D. Ohmart 1984. Middle Rio Grande Biological Survey. Final report. Submitted to U.S. Army Corps of Engineers, Contract No. DAC W47-81-C-0015. Albuquerque, NM.

Hironaka, M. 1978. Basic synecological relationships of the Columbia River sagebrush type. University of Idaho, Forest Wildlife and Range Experiment Station Contribution Number 124:27-31.

Hironaka, M., M.A. Fosberg, and A.H. Winward. 1983. Sagebrush-grass habitat types of southern Idaho. Forestry, Wildlife, and Range Experiment Station Bulletin #15, University of Idaho, Moscow. 44 pp.

Hoagland, B.W. 1998a. Classification of Oklahoma vegetation types. Working draft. University of Oklahoma, Oklahoma Natural Heritage Inventory, Norman. 43 pp.

Holecheck, J.L., and T. Stephenson. 1983. Comparison of big sagebrush in northcentral New Mexico under moderately grazed and grazing excluded conditions. Journal of Range Management 36:455-456.

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.

Holm, T. 1927. The vegetation of the alpine region of the Rocky Mountains in Colorado. Pages 1-45 in: National Academy of Sciences 19. Third Memoir.

Hyder, D.N., R.E. Bement, E.E. Remmenga, and C. Terwilliger, Jr. 1966. Vegetation-soils and vegetation-grazing relations from frequency data. Journal of Range Management 19:11-17.

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.

Jackson, J.R. 1972. Vegetation of the flood plain of the South Platte River in the proposed Narrows Reservoir site. Unpublished thesis, University of Northern Colorado, Greeley. 83 pp.

Jackson, J.R., and I.E. Lindauer. 1978. Vegetation of the flood plain of the south Platte River in the proposed Narrows Reservoir site. Transactions of the Mississippi Academy of Science 12:37-46.

Jameson, D.A. 1962. Effects of burning on a galleta-black grama range invaded by juniper. Ecology 43:760-763.

Jameson, D.A., J.A. Williams, and E.W. Wilton. 1962. Vegetation and soils of Fishtail Mesa, Arizona. Ecology 43:403-410.

Jameson, D.A., and E.H. Reid. 1965. The pinyon-juniper type of Arizona. Journal of Range Management 18:152-154.

Jensen, M.E., L.S. Peck, and M.V. Wilson. 1988a. A sagebrush community type classification for mountainous northeastern Nevada rangelands. Great Basin Naturalist 48(4):422-433.

Johnsen, T.N., Jr. 1962. One-seed juniper invasion of northern Arizona grasslands. Ecological Monographs 32:187-207.

Johnson, C.G., Jr., and S.A. Simon. 1987. Plant associations of the Wallowa-Snake Province Wallowa-Whitman National Forest. USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest. Technical Paper R6-ECOL-TP-255A-86. 399 pp. plus appendices.

Johnson, J.L., and R.D. Pfister. 1982. A survey of potential ecological natural landmarks of the middle Rocky Mountains. USDA Forest Service Intermountain Forest and Range Experiment Station, Ogden, UT. Unpublished report prepared for USDI National Park Service. 197 pp.

Johnson, J.R., and G.F. Payne. 1968. Sagebrush reinvasion as affected by some environmental influences. Journal of Range Management 21:209-213.

Johnson, W.C., R.L. Burgess, and W.R. Keammerer. 1976. Forest overstory vegetation and environment on the Missouri River floodplain in North Dakota. Ecological Monographs 46:59-84.

Johnston, B.C. 1984. Plant associations of Region Two. Edition 3.5. USDA Forest Service, Rocky Mountain Region. Lakewood, CO.

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.

Jones, G. 1992b. Wyoming plant community classification (Draft). Wyoming Natural Diversity Database, Laramie, WY. 183 pp.

Jones, G.P. 1989b. Survey of plant species and communities of interest in the Beaver Rim Area of Critical Environmental Concern. Report submitted to the Bureau of Land Management, Rawlins District Office, under Work Effort No. WY030-09-4352-06-2512. Wyoming Natural Diversity Database, Laramie, WY.

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.

Jones, George P. Personal communication. Ecologist, Wyoming Natural Diversity Database, Laramie, WY.

Jorgensen, H.E. 1979. Vegetation of the Yellow Water Triangle, Montana. Montana Department of Fish and Game, in cooperation with the Bureau of Land Management. Helena, MT. 57 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.

Kahler, L.J. 1973. Correlation of slope exposure with differences in the composition of the vegetation community at 7000 feet in Clear Creek Canyon west of Golden, Colorado. Unpublished thesis, University of Colorado, Boulder. 105 pp.

Kallender, H.R. 1959. Controlled burning in ponderosa pine stands of the Fort Apache Indian Reservation. Pages 20-22 in: R.R. Humphrey, compiler. Your range--its management. Special Report No. 2. University of Arizona, Agricultural Extension Service, Tucson, AZ.

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.

Keammerer, W.R. 1974a. Vegetation of the Grand Valley area. Pages 73-117 in: Ecological inventory of the Grand Valley area Unpublished report prepared for the Colony Development Operation, Atlantic Richfield Company, Denver, CO.

Keammerer, W.R. 1974b. Vegetation of Parachute Creek Valley. Pages 4-91 in: Environmental inventory and impact analysis of a proposed utilities corridor in Parachute Creek Valley, Co. Unpublished report prepared for Colony Development Operation, Denver, Colo.

Keammerer, W.R. 1977. Final report: Vegetation baseline studies, oil shale tract C-b. Unpublished report. Stoecker-Keammerer and Associates, Ecological Consultants, Boulder, CO. 183 pp.

Keammerer, W.R. 1987. Bentonite regional vegetation study. Prepared for Crook County Bentonite Producers and Wyoming Department of Environmental Quality, Land Quality Division, by Stoeker-Keammerer and Associates, Boulder, CO.

Keammerer, W.R., and R.E. Stoecker. 1975. Vegetation and wildlife studies along proposed corridors for oil shale tract C-b. Unpublished report prepared for Shell Oil Co., Denver, by Stoecker-Keammerer and Associates, Boulder, CO. 86 pp.

Keammerer, W.R., and S.J. Peterson. 1981. Vegetation studies on the Naval Oil Shale Reserve. Unpublished report prepared for TRW Energy Systems Group, McLean, Virginia, by Stoecker-Keammerer and Associates, Ecological Consultants, Boulder, CO. 77 pp.

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, 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., E. Van Wie, and M. Damm. 1997a. A classification of the riparian vegetation of the South Platte Basin (and part of Republican River Basin), Colorado. Submitted to Colorado Department of Natural Resources and the Environmental Protection Agency, Region VIII. Prepared by Colorado Natural Heritage Program, Colorado State University, Fort Collins.

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 Environmental Protection Agency, Region VIII. Prepared by Colorado Natural Heritage Program, Fort Collins. 243 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.

Kline, R.P. 1973. Establishment report for West Fork Mink Creek Research Natural Area within Caribou National Forest, Bannock County, Idaho. Unpublished report. 7 pp. plus maps.

Klipple, G.E., and D.F. Costello. 1960. Vegetation and cattle responses to different intensities of grazing on short-grass ranges of the central Great Plains. USDA Forest Service Technical Bulletin 1216. 82 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.

Knopf, F.L. 1985. Significance of riparian vegetation to breeding birds along an altitudinal cline. Pages 105-111 in: R.R. Johnson, et al., editors. Riparian ecosystems and their management. USDA Forest Service General Technical Report RM-120.

Komarkova, V. 1986. Habitat types on selected parts of the Gunnison and Uncompahgre national forests. Unpublished final report prepared for USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 270 pp. plus appendices.

Komarkova, V.K., R.R. Alexander, and B.C. Johnston. 1988b. Forest vegetation of the Gunnison and parts of the Uncompahgre national forests: A preliminary habitat type classification. USDA Forest Service. Research Paper RM-163. 65 pp.

Komarkova, V., A. Peters, G. Kamani, W. Jones, V. Howard, H. Gordon, and K. Southwick. 1988a. Natural recovery of plant communities on disturbance plots and history of land use in the Niwot Ridge/Green Lakes Valley, Front Range, Colorado. University of Colorado Longterm Ecological Research Working Paper 88/1. Boulder, CO. 46 pp.

Koniak, S. 1985. Succession in pinyon-juniper woodlands following wildfire in the Great Basin. Great Basin Naturalist 45:556-566.

Kuchler, A.W. 1964. Potential natural vegetation of the conterminous United States. American Geographic Society Special Publication 36. New York, NY. 116 pp.

Kurzius, M. 1981. Vegetation and flora of the Grapevine Mountains, Death Valley National Monument, California – Nevada. Unpublished thesis, University of Nevada, Las Vegas.

Ladyman, J.A.R., and E. Muldavin. 1996. Terrestrial cryptograms of Pinyon-Juniper woodlands in the Southwestern United States: A review. USDA Forest Service General Technical Report RM-GTR-280. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 33 pp.

Larson, M., and W.H. Moir. 1986. Forest and woodland habitat types (plant associations) of southern New Mexico and central Arizona (north of the Mogollon Rim). USDA Forest Service, Southwestern Region, Albuquerque, NM. 76 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.

Leary, K.D., and P.M. Peterson. 1984. Soil analyses in relation to vegetation in the Cottonwood Mountains, Death Valley National Monument. University of Nevada Cooperative National Park Resources Studies Unit Report 036/01, Las Vegas.

Lesica, P., and R.L. DeVelice. 1992. Plant communities of the Pryor Mountains. Preliminary report prepared by the Montana Natural Heritage Program, Helena, MT.

Leucite Hills Mine Application. No date. No. 520-T2, on file at Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne.

Lewis, M.E. 1975a. Plant communities of the Jarbidge Mountain Complex, Humboldt National Forest. Unpublished report compiled for USDA Forest Service, Region IV, Ogden, UT. 22 pp.

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.

Lindauer, I.E. 1978. A comparison of the vegetative communities of the South Platte and Arkansas River drainages in eastern Colorado. Pages 56-72 in: W.D. Graul and S.J. Bissel, editors. Lowland River and Stream Habitat in Colorado: A Symposium, 4-5 October 1978. Colorado Chapter of Wildlife Society and Audubon Council.

Lindauer, I.E., J.P. Fitzgerald, and L.L. Lindauer. 1973. Ecological analyses of flood plain communities, Narrows Reservoir Site, Colorado. Unpublished report to U.S. Bureau of Reclamation, Denver, CO, by the University of Northern Colorado, Department of Biology, Greeley. 108 pp.

Lindauer, I.E., and J.P. Fitzgerald. 1974. Ecological survey and analysis of terrestrial communities at the Weld County (Hardin) proposed reservoir site. Unpublished report to U.S. Bureau of Reclamation, Denver, CO, by University of Northern Colorado, Greeley. 45 pp.

Lindauer, I.E., and R.T. Ward. 1968. A survey of the woody phreatophytes in the lower Arkansas River Valley of Colorado Unpublished report to U.S. Bureau of Reclamation, Denver, CO, by the Department of Botany, Colorado State University, Fort Collins. 46 pp.

Lindauer, I.E., and S.J. Christy. 1972. An analysis of the woody vegetation on the South Platte River floodplain in northeastern Colorado. Unpublished report to the U.S. Bureau of Reclamation, Denver, CO, by the University of Northern Colorado, Biology Department, Greeley.

Little, E.L. 1987. Pinyon trees (*Pinus edulis*) remeasured after 47 years. Pages 65-68 in: Proceedings - Pinyon-juniper Conference. USDA Forest Service General Technical Report INT-215. Intermountain Research Station, Ogden, UT.

Loope, L.L. 1969. Subalpine and alpine vegetation of northeastern Nevada. Unpublished thesis, Duke University, Durham, NC.

Lundberg, C.E. 1977. The local composition and distribution of vegetation in the soda ash producing area of Sweetwater County, Wyoming. Unpublished thesis, University of Wyoming, Laramie.

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.

Montana Natural Heritage Program. 2002b. List of ecological communities for Montana. Montana Natural Heritage Program, Montana State Library, Helena, MT.

Montana Natural Heritage Program. No date. Unpublished data on file. Helena, MT.

Marr, J.W., D.A. Boyce, and J.W. Todd. 1973b. Preliminary report on the Redcliff project, Eagle County, Colorado. Unpublished report to the D.E. Fleming Company, Denver, and the Colorado River Water Conservation District, Glenwood Springs, by University of Colorado, Boulder. 9 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 appendices.

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.

Marr, J.W., and D.L. Buckner. 1974. Colorado to Wyoming pipeline corridor study. Unpublished report for Colony Development Operation, Atlantic Richfield Co., Denver by Thorne Ecological Institute, Boulder, CO. 79 pp.

Marriott, H.J., and G.P. Jones. 1989. Special status plant surveys and plant community surveys in the Trapper Creek and Medicine Lodge Wilderness Study Areas and the Spanish Point Karst ACEC. Report submitted to the Bureau of Land Management, Worland District Office, under Cooperative Agreement Task Order No. WY910-CA9-001TQE1. Wyoming Natural Diversity Database, Laramie. 42 pp. plus appendices.

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.

Masek, J. 1979. Vegetation community descriptions for the South Platte River in Colorado and Nebraska. Unpublished report prepared for the Water and Power Resources Service, Denver, CO. 23 pp.

Mason, L.R., H.M. Andrews, J.A. Carley, and E.D. Haacke. 1967. Vegetation and soils of No Man's Mesa relict area. Journal of Range Management 20:45-59.

Maxwell, E.L. 1975. Multispectral analysis of rangeland conditions. Unpublished dissertation, Colorado State University, Fort Collins. 198 pp.

McArthur, E.D., and B.L. Welch, compilers. 1986. Proceedings-Symposium on the biology of *Artemisia* and *Chrysothamnus*. 1984 July 9-13, Provo, Utah. USDA Forest Service General Technical Report INT-200. Intermountain Research Station, Ogden, UT. 398 pp.

McEachern, K. 1979. Population biology of *Populus sargentii* in northeastern Colorado. Unpublished thesis, University of Northern Colorado, Greeley. 41 pp.

McLean, A. 1970. Plant communities of the Similkameen Valley, British Columbia, and their relationships to soils. Ecological Monographs 40(4):403-424.

Medicine Bow Mine Application. No date. Application No. 331-T1, on file at Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne.

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.

Miller, D.A., D.A. Mouat, and B.D. Treadwell. 1977. Remote sensing analysis and literature survey pertaining to the vegetation of the Petrified Forest National Park. Report of work performed under NASA and the National Park Service. 48 pp.

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.

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. 1969b. Steppe communities in the foothills of the Colorado Front Range and their relative productivities. The American Midland Naturalist 81(2):331-340.

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.

Moretti, M.C. 1979. Vegetation and soil factors in relation to slope position: A study of plant communities on foothill knolls in the Uintah Basin of Utah. Unpublished thesis, Brigham Young University, Provo. 31 pp.

Moretti, M.C., and J.D. Brotherson. 1982. Vegetation and soil factors in relation to slope position of foothill knolls in the Uinta Basin of Utah. Great Basin Naturalist 42(1):81-90.

Moseley, R.K. 1987b. Area of Critical Environmental Concern and Research Natural Area proposal for the Malm Gulch and Germer Basin area, Bureau of Land Management, Salmon District, Idaho. Unpublished report prepared for USDI Bureau of Land Management, Salmon District, ID, by The Nature Conservancy, Moscow, ID. 18 pp.

Moulton, M.P., J.R. Choate, S.J. Bissell, and R.A. Nicholson. 1981. Associations of small mammals on the central high plains of eastern Colorado. Southwestern Naturalist 26(1):53-57.

Mozingo, H. 1987. Shrubs of the Great Basin: A natural history. University of Nevada Press, Las Vegas. 342 pp.

Mueggler, W.F., and W.L. Stewart. 1980. Grassland and shrubland habitat types of western Montana. USDA Forest Service, General Technical Report INT-66. IM Forest and Range Experiment Station. Ogden, UT. 154 pp.

Muldavin, E. 1994. Organ Mountains sensitive species and plant community inventory. Unpublished report prepared by the New Mexico Natural Heritage Program, Albuquerque.

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., P. Mehlhop, and E. DeBruin. 1994a. A survey of sensitive species and vegetation communities in the Organ Mountains of Fort Bliss. Volume III: Vegetation communities. Report prepared for Fort Bliss, Texas, by New Mexico Natural Heritage Program, Albuquerque.

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.

Muldavin, E., and P. Mehlhop. 1992. A preliminary classification and test vegetation map for White Sands Missile Range and San Andreas National Wildlife Refuge, New Mexico. University of New Mexico, New Mexico Natural Heritage Program.

Muldavin, E., et al. 1998c. Plant community inventory for Fort Bliss. Unpublished report in preparation by the New Mexico Natural Heritage Program, Albuquerque, NM.

Mutel, C.F. 1976. From grassland to glacier: An ecology of Boulder County, Colorado. Johnson Publishing Company, Boulder. 169 pp.

North Dakota Natural Heritage Inventory. No date. Vegetation classification of North Dakota. North Dakota Natural Heritage Inventory, North Dakota Parks & Recreation Department, Bismarck.

Nevada Natural Heritage Program. 2003. National Vegetation Classification for Nevada. Nevada Natural Heritage Program, Department of Conservation and Natural Resources, Carson City. 26 September 2003.

Naumann, Tamara. Personal communication. Botanist, National Park Service, Dinosaur National Monument, Dinosaur, CO.

Nichol, A.A. 1937. The natural vegetation of Arizona. University of Arizona Agricultural Experiment Station Technical Bulletin 68:177-222.

Nichols, J.T. 1964a. Soil-vegetation relationships of the 15-mile drainage, Washakie County, Wyoming. Unpublished dissertation, University of Wyoming, Laramie.

Nichols, J.T. 1964b. Effect of protection from grazing on two vegetative types in the Big Horn Basin of Wyoming. Wyoming Range Management 192:60-69.

Northcutt, B.E. 1978. The plant ecology of Butler Wash, southeastern Utah. Unpublished thesis, University of Colorado, Boulder. 118 pp.

Oregon Natural Heritage Program. No date. Unpublished data files. Oregon Natural Heritage Program, The Nature Conservancy, Portland, OR.

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.

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.

Pieper, R.D. 1968. Comparison of vegetation on grazed and ungrazed pinyon-juniper grassland sites in south-central New Mexico. Journal of Range Management 21:51-53.

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.

Poulton, C.E. 1955. Ecology of the non-forested vegetation in Umatilla and Morrow counties, Oregon. Unpublished dissertation. State College of Washington, Pullman. 166 pp.

Powell, A.M. 1988b. Trees and shrubs of Trans-Pecos Texas including Big Bend and Guadalupe Mountains national parks. Big Bend Natural History Assoc., Inc. 536 pp.

Price, J., et al. 1981. Ecological study of the Alvord Basin Dunes, southeastern Oregon. Oregon State University Technical Report, Corvallis.

Ralston, G.L. 1969. Plant zonation on dune sands of Washoe Lake, Washoe County, Nevada. Unpublished thesis, University of Nevada, Reno.

Ramaley, F. 1916b. Dry grassland of a high mountain park in northern Colorado. The Plant World 19(4):249-270.

Ramaley, F. 1919b. Some mountain plant communities of sandy soil. The Plant World 22(11):313-329.

Ramaley, F. 1927. Colorado plant life. University of Colorado Semicentennial series 1877-1927. Volume II. 299 pp.

Ramaley, F. 1942. Vegetation of the San Luis Valley in southern Colorado. University of Colorado Studies, Series D, 1:231-277.

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.

Rickard, W.H., and J.C. Beatley. 1965. Canopy-coverage of the desert shrub vegetation mosaic of the Nevada Test Site. Ecology 46(4):524-529.

Rippel, P., Pieper, R.D., and G.H. Lymbery. 1983. Vegetational evaluations of pinyon-juniper cabling in south-central New Mexico. Journal of Range Management 36:13-15.

Roberts, D.W., D.W. Wight, and G.P. Hallsten. 1992. Plant community distribution and dynamics in Bryce Canyon National Park. Unpublished final report for Bryce Canyon National Park Project PX1200-7-0966. 146 pp.

Robertson, J.H. 1971. Changes on a sagebrush-grass range in Nevada ungrazed for 30 years. Journal of Range Management 24:397-400.

Rogers, C.M. 1953. The vegetation of the Mesa de Maya region of Colorado, New Mexico, and Oklahoma. Lloydia 16(4):257-290.

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.

Rust, S.K. 1999. Pinyon-juniper woodland classification and description in Research Natural Areas of southeastern Idaho. In: S.B. Monson and R. Stevens, compilers. Proceedings: Ecology and management of pinyon-juniper communities within the interior west. 1997 September 15-18, Provo, UT. Proceedings RMRS-P-9. USDA Forest Service, Rocky Mountain Research Station. Ogden, UT. 411 pp.

Savage, D.E. 1968. The relationship of sage grouse to upland meadows in Nevada. Unpublished thesis, University of Nevada, Reno.

Sawyer, J.O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento. 471 pp.

Schramm, D.R. 1982. Floristics and vegetation of the Black Mountains, Death Valley National Monument. Unpublished report prepared for the University of Nevada, Las Vegas.

Shanks, D.L. 1977. Aerial photo densitometry for rangeland planning and evaluation. Unpublished thesis, Colorado State University, Fort Collins. 66 pp.

Shantz, H.L. 1906. A study of the vegetation of the mesa region east of Pike's Peak, the Bouteloua formation. II. Development of the formation. Botanical Gazette 42:179-207.

Shantz, H.L. 1911. Natural vegetation as an indicator of the capabilities of land for crop production in the Great Plains area. USDA Bureau of Plant Industry Bulletin 201. 100 pp.

Shantz, H.L. 1923. The natural vegetation of the Great Plains region. Annals of the Association of American Geographers 13:81-107.

Shantz, H.L., and R.L. Piemeisel. 1940. Types of vegetation in Escalante Valley, Utah, as indicators of soil conditions. USDA Technical Bull. 713. U.S. Department of Agriculture, Washington, DC. 46 pp.

Shaw, R.B., S.L. Anderson, K.A. Schulz, 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.

Shiflet, T.N., editor. 1994. Rangeland cover types of the United States. Society for Range Management. 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.

Skull Point Mine Application. No date. Application No. 2335-T2, on file at Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne. Skull Point Mine Permit Renewal. No date. On file at Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne.

Smith, J. No date (b). Comprehensive data base for surface mining in Wyoming. Unpublished data, Department of Environmental Quality, Land Quality Division, Cheyenne.

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.

Steger, R.E. 1970. Soil moisture and temperature relationships of six salt desert shrub communities in northcentral Wyoming. Unpublished thesis, University of Wyoming, Laramie.

Steinauer, G., and S. Rolfsmeier. 2000. Terrestrial natural communities of Nebraska. Unpublished report of the Nebraska Game and Parks Commission. Lincoln, NE. 143 pp.

Steinhoff, H.W. 1978. Management of Gambel oak associations for wildlife and livestock. Unpublished report prepared for USDA Forest Service, Denver, CO. 119 pp.

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.

Stoecker-Keammerer Consultants. No date (a). Black Thunder Mine Application No. 233-T3, on file at Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne.

Stoecker-Keammerer Consultants. No date (b). Coal Creek Mine Application No. 483-T1, on file at Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne.

Strong, L.L. 1980. Estimating phytomass production of habitat types on sagebrush steppe. Unpublished thesis, Colorado State University, Fort Collins. 133 pp.

Stuever, M.C., and J.S. Hayden. 1997a. Plant associations of Arizona and New Mexico. Volume 2: Woodlands. USDA Forest Service, Southwestern Region, Habitat Typing Guides. 196 pp.

Sweetwater Uranium Project. 1978. Application No. 481, on file at Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne.

The Nature Conservancy. 1995a. A classification and description of plant communities in southern Illinois. Report by the Southern Illinois Field Office, Ullin, IL, and the Midwest Regional Office, Minneapolis, MN.

Terwilliger, C., Jr., and E.L. Smith. 1978. Range resource types in North Park, Colorado. Colorado State University Range Science Department Science Series 32. 48 pp.

Terwilliger, C., Jr., and J.A. Tiedemann. 1978. Habitat types of the mule deer critical winter range and adjacent steppe region of Middle Park, Colorado. Unpublished report prepared for USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 108 pp.

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.

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.

Thilenius, J.F., and D.R. Smith. 1985. Vegetation and soils of an alpine range in the Absaroka Mountains, Wyoming. USDA Forest Service General Technical Report RM-121. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 18 pp.

Thomas, K., M. Hansen and C. Seger. 2003b. Vegetation of Petrified Forest National Park, Part I: Vegetation of Petrified Forest National Park. Southwest Biological Science Center, U.S. Geological Survey unpublished \ report to Petrified Forest National Park.

Thompson, J. 2001. Draft vegetation associations of Zion National Park, Utah. Prepared for Association for Biodiversity Information, Boulder.

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].

Thorne Ecological Institute. 1973b. Pages 26-30 in: Part 1 of Vegetation. The Colony Environmental Study – Parachute Creek, Garfield County, Colorado. Unpublished report prepared for Colony Development Operation by Thorne Ecological Institute, Boulder, CO.

Tiedemann, J.A. 1978. Phyto-edaphic classification of the Piceance Basin. Unpublished dissertation, Colorado State University, Fort Collins. 281 pp.

Tiedemann, J.A., R.E. Francis, C. Terwilliger, Jr., and L.H. Carpenter. 1987. Shrub-steppe habitat types of Middle Park, Colorado. USDA Forest Service Research Paper RM-273. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 20 pp.

Tisdale, E.W. 1947. The grasslands of the southern interior of British Columbia. Ecology 28(4):346-382.

Trammel, M. A., and J. L. Butler. 1995. Effects of exotic plants on native ungulate use of habitat. Journal of Wildlife Management 59:804-815.

Tueller, P.T., D.H. Heinze, and R.E. Eckert. 1966. A tentative list of existing Nevada plant communities (A third approximation). Unpublished report prepared for the Department of Range Wildlife and Forestry, University of Nevada, Reno. 14 pp.

Tueller, P.T., and W.H. Blackburn. 1974. Condition and trend of the big sagebrush/needle-and-thread habitat type in Nevada. Journal of Range Management 27(1):36-40.

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.

Tweit, S., and K. Houston. 1980. Grassland and shrubland habitat types of the Shoshone National Forest. USDA Forest Service, Rocky Mountain Region, Shoshone National Forest.

U.S. Bureau of Reclamation. 1976. Flora and terrestrial vertebrate studies of the Grand Valley, Colorado. Pages 56-85 and 283-354 in: Final report to the U.S. Bureau of Reclamation by Ecology Consultants, Inc., Fort Collins, CO.

USDA Forest Service. 1937. Range plant handbook. Dover Publications Inc., New York. 816 pp.

USDA 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.

USDA Forest Service. 1981b. TES-2, Cuba Ranger District. Unpublished report prepared for USDA Forest Service, Southwestern Region, Albuquerque, NM. Various pages, appendices, and maps.

USDA Forest Service. 1982. TES-9, Heber Ranger District. Unpublished report prepared for USDA Forest Service, Southwestern Region, Albuquerque, NM. Various pages, appendices and maps.

USDA Forest Service. 1983a. TES-4, Coyote Ranger District. Unpublished report prepared for USDA Forest Service, Southwestern Region, Albuquerque, NM. Various pages, appendices and maps.

USDA Forest Service. 1985a. Forest and woodland plant associations (habitat types) for the Kaibab and Coconino national forests, Arizona. Unpublished training materials. USDA Forest Service, Southwestern Region, Albuquerque, NM.

USDA Forest Service. 1985b. TES-5, western portion of the Glenwood Ranger District. Unpublished report prepared for USDA Forest Service, Southwestern Region, Albuquerque, NM. Various pages, appendices and maps.

USDA Forest Service. 1985c. TES-1, Terrestrial ecosystem survey handbook, appendix B. Unpublished report prepared for USDA Forest Service, Southwestern Region, Albuquerque, NM. Various pages, appendices and maps.

USDA Forest Service. 1985d. Woodland and forest plant associations (habitat types) south of the Mogollon Rim, Arizona. Unpublished training materials. USDA Forest Service, Southwestern Region, Albuquerque, NM.

USDA 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.

USDA Forest Service. 1985g. Key to woodland plant associations and plant communities, Lincoln National Forest. Unpublished materials. USDA Forest Service, Southwestern Region, Albuquerque, NM.

USDA Forest Service. 1992. Draft habitat types of the Little Missouri National Grasslands. Medora and McKenzie ranger districts, Custer National Forest. Dickinson, ND.

Ungar, I.A., W. Hogan, and M. McClennand. 1969. Plant communities of saline soils at Lincoln, Nebraska. The American Midland Naturalist 82(2):564-577.

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.

Van Pelt, N.S. 1978. Woodland parks in southeastern Utah. Unpublished thesis, University of Utah, Salt Lake City.

Vanderhorst, J., S.V. Cooper, and B.Heidel. 1998. Botanical and vegetation survey of Carter County, Montana. Unpublished report prepared for the Bureau of Land Management. Montana Natural Heritage Program, Helena. 116 pp. + app.

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.

Vest, E.D. 1962b. The plant communities and associated fauna of Dugway Valley in western Utah. Unpublished dissertation, University of Utah, Salt Lake City.

Vestal, A.G. 1913. Plains vegetation adjoining the mountains: The region about Boulder in Colorado. Unpublished thesis, University of Colorado, Boulder. 40 pp.

Vestal, A.G. 1914. Prairie vegetation of a mountain-front area in Colorado. Botanical Gazette 58(5):377-400.

Vestal, A.G. 1919. Phytogeography of the eastern mountain front in Colorado. I. Physical geography and distribution of vegetation. Botanical Gazette 68(3):153-193.

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. J. Butler, D. Faber-Langendoen, D. Crawford, and M.J. Pucherelli. 2000. USGS-NPS Vegetation Mapping Program, Theodore Roosevelt National Park, North Dakota. USBR Technical Service Center. U.S. Department of the Interior, Bureau of Reclamation's Remote Sensing and GIS Group, Denver Federal Center, 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.

Wagner, W.L., W.C. Martin, and E.F. Aldon. 1978. Natural succession on strip-mined lands in northwestern New Mexico. Reclamation Review 1:67-73.

Ward, R.T., W. Slauson, and R.L. Dix. 1974. The natural vegetation in the landscape of the Colorado oil shale region. Pages 9-17 in: C.W. Cook, editor. Surface rehabilitation of land disturbances resulting from oilshale development. Information Series 11, Environmental Resource Center, Colorado State University, Fort Collins.

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. 1970a. Postglacial vegetational history of the Great Plains. Science 167:1574-1582.

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.

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, Volume 5. Elsevier Publishing Company, Amsterdam.

West, N.E. 1983c. Western Intermountain sagebrush steppe. Pages 351-374 in: N.E. West, editor. Temperate deserts and semi-deserts. Ecosystems of the world, Volume 5. Elsevier Publishing Company, Amsterdam.

West, N.E., F.D. Provenza, P.S. Johnson, and M.K. Owens. 1984. Vegetation change after 13 years of livestock grazing exclusion on sagebrush semidesert in west central Utah. Journal of Range Management 37(3):262-264.

West, N.E., R.J. Tausch, K.H. Rea, and A.R. Southard. 1978. Soils associated with pinyon-juniper woodlands of the Great Basin. Pages 68-88 in: C.T. Youngber, editor. Forest soils and land use, Proceedings of the 5th North American Forest and Soils Conference, Colorado State University, Fort Collins.

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.

Western Resources Development Corporation. No date (a). North Antelope Mine Application No. 532-T2. On file at Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne.

Wight, J.R. 1965. Site and vegetation characteristics and relationships of juniper communities in northwestern Wyoming Unpublished dissertation, University of Wyoming, Laramie.

Wight, J.R., and H.G. Fisser. 1968. Juniperus osteosperma in northwestern Wyoming: Their distribution and ecology. University of Wyoming Agricultural Experiment Station Science Monograph 7. Laramie. 28 pp.

Wilson, R.E. 1970. Succession in stands of Populus deltoides along the Missouri River in southeastern South Dakota. The American Midland Naturalist 83(2):330-342.

Winward, A.H. 1970. Taxonomic and ecological relationships of the big sagebrush complex in Idaho. Unpublished dissertation, University of Idaho, Moscow. 90 pp.

Wooten, S.A. 1980. Vegetation recovery following disturbance on the Central Plains Experimental Range. Unpublished thesis, Colorado State University, Fort Collins.

Wright, H.A. 1972. Shrub response to fire. Pages 204-217 in: Wildland shrubs: Their biology and utilization. USDA Forest Service. General Technical Report INT-1.

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.

Wright, H.E., Jr., A.M. Bent, B.S. Hansen, and L.J. Mahar, Jr. 1973. Present and past vegetation of the Chuska Mountains, northwestern New Mexico. Geological Society of America Bulletin 84:1155-1179.

Yake, S., and J.D. Brotherson. 1979. Differentiation of serviceberry habitats in the Wasatch Mountains of Utah. Journal of Range Management 32(4):379-386.

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.

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 HOVENWEEP NATIONAL MONUMENT

The vegetation of Hovenweep National Monument was sampled during the summer of 2003 under the USGS-NPS Vegetation Mapping Program. This dichotomous key, illustrated with images taken during the sampling effort, has been prepared to assist in the field identification of association, alliance and park special vegetation types described for Hovenweep National Monument. The key is designed to work using one or more dominant species with environmental characteristics. Because of natural variation within plant associations, observers may need to try more than one of the physiognomic keys. In ecotones (areas where plant associations mix), it may be difficult to determine a definitive association name. This illustrated key also allows the user to crosswalk plant associations directly to the Hovenweep National Monument vegetation map. Each map class may contain more than one plant association.

HOW TO USE THE KEY:

The key approaches plant association identification at two levels. The first level is physiognomic (forest, woodland, tall shrubland, shrubland, dwarf-shrubland, graminoid, or forb). The second level allows identification to plant association based on the dominant species, and to a lesser extent, habitat characteristics. Photographs demonstrating variation within vegetation types are shown below association names.

It is possible that in using this key, you will have difficulty arriving at an association that 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 10% (tree layer) or 5% (shrub or herbaceous layers), it is ignored. The exception is in very sparse communities where the total vegetation cover is less than 10% (see #3).

2. You can follow a key to a certain point, but you clearly have something not described in the key. This is to be expected – very likely you have an association that was not found during the sampling phase of the project. In this case, simply record "Unclassified pinyon-juniper (or whatever type of vegetation you have) association". Be sure to note the dominant species and their cover.

3. Communities that are sparsely vegetated (i.e., < 10% 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.

KEY I

A KEY TO THE MAJOR PHYSIOGNOMIC GROUPS OF HOVENWEEP NATIONAL MONUMENT

1a) Vegetation woody or appearing woody; predominantly trees, shrubs, or shrub-like herbs; total vegetation cover may be sparse to dense (2)

1b) Vegetation non-woody; predominantly grasses, grass-like herbs (sedge, rush, scouring-rush), or broadleaf herbs (forbs); total vegetation cover may be sparse to dense. Although some woody species may be present, they have low relative cover and are not dominant. Characteristic genera include *Bromus, Erodium, Leymus, Pascopyrum,* and *Pleuraphis*. (**Key IV**).

2a) Forest or woodland vegetation, with predominantly interlocking tree canopies (forest) or predominantly non-interlocking tree canopies (woodland). Characteristic genera include: *Celtis, Juniperus, Pinus, Populus,* and *Quercus* (**Key II**).

2b) Tall, short, or dwarf-shrubland vegetation; woody shrubs or subshrubs dominant. Canopies may interlock but are more commonly less dense. Some trees may be present with low relative cover. Characteristic genera include: *Amelanchier, Artemisia, Atriplex, Cercocarpus, Ericameria, Purshia, Quercus,* and *Sarcobatus* (**Key III**).

KEY II

A KEY TO THE FOREST AND WOODLAND ASSOCIATIONS OF HOVENWEEP NATIONAL MONUMENT

1a) Forest or woodland associations growing in canyon heads and bottoms, characterized by deciduous trees of the genera *Celtis* and/or *Populus* (generally providing at least 10% cover) sometimes with interlocking canopies **(2)**

1b) Woodland associations generally growing in dry or upland situations, characterized by evergreen trees of the genera *Juniperus, Pinus,* or *Quercus* (generally providing 10-60% cover), often with scattered young trees or shrubs present in openings **(4)**

2a (1) Deciduous riparian forest or woodland association characterized by clumps of *Celtis laevigata* var. *reticulata* trees growing in canyon heads and bottoms – ***Celtis laevigata* var. *reticulata* Woodland Alliance (Netleaf Hackberry Woodland Alliance)** [Map Class # 40]

[No Photograph Available]

2b) Deciduous riparian forest or woodland associations of small to medium-sized stands with an open canopy of *Populus deltoides* ssp. *wislizeni* trees. The understory typically has at least some cover by *Salix exigua, Artemisia tridentata,* or a mix of graminoids, forbs, and/or shrubs **(3)**

3a (2) *Populus deltoides* ssp. *wislizeni* woodland stands characterized by an understory that includes *Salix exigua* shrubs. Stands grow on canyon bottoms, often where groundwater emerges – ***Populus deltoides* (ssp. *wislizeni,* ssp. *monilifera*) / *Salix exigua* Woodland (Cottonwood / Coyote Willow Woodland)** [Map Class # 51]

3b) *Populus deltoides* ssp. *wislizeni* woodland stands with an understory dominated by a variety of mesic to upland graminoids, forbs, and/or shrubs. *Ericameria nauseosa* or *Artemisia tridentata* are generally present to dominant and *Salix exigua* is absent. Stands occupy canyon sides or bottoms, sometimes indicating where now-dry springs once emerged **- *Populus deltoides* (ssp. *wislizeni*, ssp. *monilifera*) / *Artemisia tridentata* Woodland (Cottonwood / Basin Big Sagebrush Woodland)** [Map Class # 50]

4a (1) Woodlands of *Quercus gambelii* trees occurring on gentle slopes with deep soils. Some *Pinus edulis* and *Juniperus osteosperma* trees may be present – ***Quercus gambelii* Shrubland Alliance (Gambel Oak Shrubland Alliance)** [Map Class # 31]. If more than 10% cover is by *Pinus* or *Juniperus*, the community is a ***Pinus edulis / Juniperus* spp. / *Quercus gambelii* Woodland (Two-needle Pinyon – Utah Juniper / Gambel's Oak Woodland)**, even if the cover by Gambel's oak greatly exceeds that of the conifers [Map Class 42]

4b) Woodlands strictly of *Pinus edulis* and/or *Juniperus osteosperma* trees occurring on level to rolling uplands, gentle to steep slopes, drainages, exposed bedrock, or on canyon rims **(5)**

5a (4) Woodlands of *Juniperus osteosperma* trees with a sparse understory, an understory of *Artemisia tridentata*, *Atriplex* spp., or *Purshia stansburiana* shrubs, or an herbaceous or non-vascular understory. *Pinus edulis* is absent from the canopy **(6)**

5b) Woodlands of *Juniperus osteosperma* trees with at least some *Pinus edulis* in the canopy or as seedlings in the undestory (mature trees may have been killed by insects, drought, or disease). Stands have either a sparse understory or a shrub understory dominated or co-dominated by *Artemisia*, *Cercocarpus*, or *Purshia* **(10)**

6a (5) Woodlands of Juniperus osteosperma trees with either a sparse understory (biological soil crusts may dominate) or a grassy understory dominated by *Pleuraphis jamesii* and *Gutierrezia sarothrae* **(7)**

6b) Woodlands of Juniperus osteosperma trees with significant cover (>5%) of *Artemisia tridentata*, *Atriplex* spp., or *Purshia stansburiana* shrubs in the understory **(8)**

7a (6) Woodlands of *Juniperus osteosperma* trees with a sparse understory (<5% cover of shrubs and herbaceous species). Although most stands have been disturbed, biological soil crusts in an early

stage of development are often widespread **- *Juniperus osteosperma* / Sparse Understory Woodland (Utah Juniper / Sparse Understory Woodland)** [Map Class # 41]

7b) Woodlands of *Juniperus osteosperma* trees with an herbaceous understory dominated by *Pleuraphis jamesii*, although *Gutierrezia sarothrae* may be co-dominant and *Bromus tectorum* is often also present **- *Pinus edulis - Juniperus osteosperma / Pleuraphis jamesii* Woodland (Two-Needle Pinyon – Utah Juniper / James' Galleta Woodland)** [Map Class #44]

[No photo available]

8a (6) Woodlands of *Juniperus osteosperma* trees with significant cover (>5%) of *Artemisia tridentata* shrubs in the understory. Some stands may have as much cover by sagebrush as by juniper – ***Juniperus osteosperma / Artemisia tridentata* ssp. *wyomingensis* Woodland (Utah Juniper / Big Sagebrush Woodland)** [Map Class # 41]

8b) Woodlands of *Juniperus osteosperma* trees with a shrub understory dominated by either *Purshia stansburiana* or *Atriplex* spp. (*canescens* or *confertifolia*) **(9)**

9a (8) Woodlands of *Juniperus osteosperma* trees with significant cover (>5%) of *Purshia stansburiana* shrubs in the understory, although other shrubs, including *Artemisia tridentata* are usually present to co-dominant. Many stands are in shallow draws that cross the upland mesas – ***Pinus edulis - Juniperus osteosperma / Purshia stansburiana*** **Woodland (Two-needle Pinyon - Utah Juniper / Pursh's Cliffrose Woodland)** [Map Class # 48]

9b Open woodlands of *Juniperus osteosperma* with an understory dominated by *Atriplex canescens* and/or *Atriplex confertifolia*. Most stands are saltbush shrublands being invaded by junipers - ***Pinus edulis - Juniperus osteosperma / Atriplex*** **spp. Woodland (Two-needle Pinyon – Utah Juniper / Saltbush Woodland)** [Map Class #43]

[No photo available]

10a (5) Woodlands of *Pinus edulis* and *Juniperus osteosperma* trees with a sparse understory or with a dwarf-shrub understory dominated by *Artemisia bigelovii* (>1%) **(11)**

10b) Woodlands of *Pinus edulis* and *Juniperus osteosperma* trees with a shrub understory dominated by *Artemisia tridentata, Cercocarpus montanus,* or *Purshia stansburiana* **(12)**

11a (10) Woodlands of *Pinus edulis* and *Juniperus osteosperma* trees with a sparse understory (<5% total cover). Many stands occur on canyon walls where large slabs of sandstone slumped into the canyon and limit the density of vegetation – ***Pinus edulis - Juniperus osteosperma*** **/ Sparse Understory Woodland (Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland)** [Map Class # 47]

11b) Woodlands of *Pinus edulis* and *Juniperus osteosperma* trees with the dwarf-shrub *Artemisia bigelovii* present in the understory, usually with a mix of other shrubs; typically growing on exposed bedrock or on bedrock ledges – ***Pinus edulis - Juniperus osteosperma / Artemisia bigelovii* Woodland (Two-needle Pinyon - Utah Juniper / Bigelow Sagebrush Woodland)** [Map Class # 49]

12a (10) Woodlands of *Pinus edulis* and *Juniperus osteosperma* trees with the short shrub *Artemisia tridentata* dominant (typically >5% cover); associated with deep eolian soils – ***Pinus edulis - Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland (Two-needle Pinyon - Juniper / Big Sagebrush Woodland)** [Map Class # 45]

12b) Woodlands of *Pinus edulis* and *Juniperus osteosperma* trees with *Cercocarpus montanus* or *Purshia stansburiana* present in the understory; associated with exposed, sometimes ledging bedrock of canyon rims and steep slopes, sometimes with a veneer of broken rock **(13)**

13a (12) Woodlands of *Pinus edulis* and *Juniperus osteosperma* trees occupying exposed bedrock and shallow soils of canyon rims with *Purshia stansburiana* dominating an understory of mixed shrubs – ***Pinus edulis - Juniperus osteosperma / Purshia stansburiana*** **Woodland (Two-needle Pinyon - Utah Juniper / Pursh's Cliffrose Woodland)** [Map Class # 48]

13b) Woodlands of *Pinus edulis* and *Juniperus osteosperma* trees occupying steep slopes, sometimes with broken rock; *Cercocarpus montanus* is present to dominant in the understory **- *Pinus edulis* - *Juniperus* spp. / *Cercocarpus montanus* - Mixed Shrub Woodland (Two-needle Pinyon - Utah Juniper / Mountain-mahogany – Mixed Shrub Woodland)** [Map Class # 46]

KEY III

A KEY TO THE SHRUBLAND AND WOODED SHRUBLAND ASSOCIATIONS OF HOVENWEEP NATIONAL MONUMENT

1a) Tall shrublands of mesic habitats, characterized by the genera *Peraphyllum, Prunus, Quercus, Rhus,* and/or *Ribes* **(2)**

1b) Tall or short shrublands of upland or xeric habitats, characterized by the genera *Amelanchier, Artemisia, Atriplex, Purshia,* and/or *Sarcobatus* **(3)**

2a (1) Shrublands or woodlands of *Quercus gambelii* occupying gentle slopes with deep soils. *Pinus edulis* and *Juniperus osteosperma* provide less than 10% total cover **– *Quercus gambelii* Shrubland Alliance (Gambel Oak Shrubland Alliance)** [Map Class # 31]

2b) Tall shrublands on the banks of drainages characterized by *Peraphyllum ramosissimum, Prunus virginiana, Rhus trilobata, Ribes aureum,* possibly other shrub species and low cover (<3%) of ***Salix exigua* – Mixed Riparian Shrubland** [Map Class # 34]

3a (1) Shrublands dominated by the genus *Artemisia* (sometimes with the genus *Purshia*) and occupying a variety of upland habitats **(4)**

3b) Shrublands dominated by the genera *Amelanchier, Atriplex*, or *Sarcobatus* and occupying a variety of upland habitats **(10)**

4a (3) Shrubland dominated by *Artemisia bigelovii*, sometimes mixed with low cover of other xeric shrubs, growing from crevices in exposed bedrock. Scattered *Juniperus osteosperma* may be present with less than 10% total cover – ***Artemisa bigelovii* Shrubland (Bigelow Sagebrush Shrubland)** [Map Class # 26]

4b) Shrublands dominated by *Artemisia tridentata,* sometimes with low cover of other shrubs, growing in eolian and alluvial deposits, talus, or bedrock crevices **(5)**

5a (4) *Artemisia tridentata* associations with a predominantly grass understory dominated by *Bromus tectorum, Pleuraphis jamesii*, or *Poa fendleriana* **(6)**

5b) *Artemisia tridentata* ssp. *wyomingensis* shrublands with *Purshia tridentata* or *Atriplex confertifolia* as co-dominants, or with an understory that appears disturbed or with no clearly dominant herbaceous species **(8)**

6a (5) Sagebrush communities of alluvial deposits on canyon floors with an understory of the annual exotic grass *Bromus tectorum*, low cover of *Ericameria nauseosa* may also occur – ***Artemisia tridentata – (Ericameria nauseosa) / Bromus tectorum*** **Semi-natural Shrubland (Big Sagebrush – (Rubber Rabbitbrush) / Cheatgrass Semi-natural Shrubland)** [Map Class # 20]

6b) Wyoming sagebrush shrublands of eolian and alluvial deposits, talus slopes, and thin soils deposited over bedrock with an understory of the native perennial bunchgrasses *Pleuraphis jamesii* or *Poa fendleriana* **(7)**

7a (6) Wyoming sagebrush shrublands of eolian and alluvial deposits with an understory of predominantly ***Pleuraphis jamesii – Artemisia tridentata*** **ssp.** ***wyomingensis / Pleuraphis jamesii*** **Shrubland (Wyoming Big Sagebrush / James' Galleta Shrubland)** [Map Class # 24]

7b) Wyoming sagebrush shrublands of talus slopes or thin soils deposited over bedrock with an understory of predominantly ***Poa fendleriana – Artemisia tridentata* ssp. *wyomingensis / Poa fendleriana* Shrubland (Wyoming Big Sagebrush / Muttongrass Shrubland)** [Map Class # 24]

8a (5) Shrublands where Wyoming sagebrush is co-dominant with *Atriplex confertifolia* or with at least 1% cover by shadscale **- *Artemisia tridentata* ssp. *wyomingensis - Atriplex confertifolia* Shrubland (Wyoming Big Sagebrush – Shadscale Shrubland)** [Map Class # 22]

8b) Wyoming sagebrush shrublands with a disturbed understory supporting predominantly exotic and/or native annual grass and forb species (e.g., *Astragalus nuttallianus, Bromus tectorum, Erodium cicutarium, Festuca octoflora*) or with low cover of one to several other shrub species, including *Ephedra viridis, Ericameria nauseosa*, and/or *Purshia stansburiana* **(9)**

9a (8) Wyoming sagebrush shrublands growing on eolian or alluvial deposits, sometimes on prehistoric ruins, with an understory dominated by annual grasses and/or forbs, including *Astragalus nuttallianus, Bromus tectorum*, and ***Festuca octoflora – Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland (Wyoming Big Sagebrush / Disturbed Understory Semi-natural Shrubland)** [Map Class # 23]. In dry years when annual species are not expressed, stands may be better placed in Map Class 25.

9b) Wyoming sagebrush shrublands with a variety of shrub species including *Ephedra viridis, Ericameria nauseosa*, and/or *Purshia stansburiana* contributing low to moderate cover. Little or no herbaceous understory is evident, although soil crusts may be widespread – ***Artemisia tridentata* ssp. *wyomingensis* / Sparse Understory Shrubland (Wyoming Big Sagebrush / Sparse Understory Shrubland)** [Map Class # 25]

10a (3) Shrublands dominated by Amelanchier utahensis with low to moderate cover by *Artemisia tridentata* ssp. *wyomingensis*, most stands are on north-facing talus slopes – ***Amelanchier utahensis* Shrubland (Utah Serviceberry Shrubland)** [Map Class # 31]

10b) Shrublands dominated by *Atriplex (canescens, confertifolia)* or *Sarcobatus vermiculatus* (sometimes co-dominant with *Artemisia tridentata,* or *Artemisia tridentata* is present with low cover, *Ericameria nauseosa* may also be present and provide sparse to low cover) **(11)**

11a (10) Shrublands associations dominated by *Atriplex canescens* or *Atriplex confertifolia* **(12)**

11b) Shrublands associations dominated by *Sarcobatus vermiculatus*, although low to moderate cover may be provided by *Artemisia tridentata* and/or *Ericameria nauseosa* **(13)**

12a (11) Shrublands of alluvial deposits or talus slopes dominated by *Atriplex canescens*, with sparse to low cover by ***Pleuraphis jamesii – Atriplex canescens / Pleuraphis jamesii* Shrubland (Four-wing Saltbush / James' Galleta Shrubland)** [Map Class # 27]

12b) Shrublands of shale slopes and flats dominated by *Atriplex confertifolia* with sparse to low cover by *Pleuraphis jamesii*. *Artemisia tridentata* is absent or has very low cover – ***Atriplex confertifolia / Pleuraphis jamesii* Shrubland (Shadscale / James' Galleta Shrubland)** [Map Class # 28]

13a (11) Shrublands of alluvial deposits dominated by *Sarcobatus vermiculatus* with an understory of *Pleuraphis jamesii* and annual forb species – ***Sarcobatus vermiculatus* Disturbed Shrubland (Black Greasewood Disturbed Shrubland)** [Map Class # 33]

13b) Shrublands of alluvial deposits and drainage banks dominated by *Sarcobatus vermiculatus* with nearly equal cover provided by *Artemisia tridentata* and ***Ericameria nauseosa – Sarcobatus vermiculatus - Artemisia tridentata*** **Shrubland (Black Greasewood - Big Sagebrush Shrubland)** [Map Class # 33]

KEY IV A

KEY TO THE HERBACEOUS ASSOCIATIONS OF HOVENWEEP NATIONAL MONUMENT

1a) Herbaceous communities dominated by *Erodium cicutarium* and occupying recently burned upland habitats – ***Erodium cicutarium* Semi-natural Herbaceous Vegetation (Crane's-bill Semi-natural Herbaceous Vegetation)** [Map Class # 10]

1b) Herbaceous communities dominated by the grasses *Bromus inermis, Bromus tectorum, Leymus salinus, Pascopyrum smithii, Sporobolus airoides* and/or *Pleuraphis jamesii* and occupying a variety of habitats **(2)**

2a (1) Herbaceous communities dominated by *Bromus tectorum*, occurring on sites disturbed by fire, grazing, or human occupation – ***Bromus tectorum* Semi-natural Herbaceous Vegetation (Cheatgrass Semi-natural Herbaceous Vegetation)** [Map Class # 13]

2b) Grasslands dominated by *Bromus inermis, Leymus salinus, Pascopyrum smithii, Sporobolus airoides,* or *Pleuraphis jamesii* occurring in a wide variety of mesic and xeric habitats and landscape positions **(3)**

3a (2) Grasslands dominated by the exotic *Bromus inermis* or the native *Pascopyrum smithii*, occupying swales, drainages, and drainage terraces **(4)**

3b) Sparse grasslands dominated by *Leymus salinus, Sporobolus airoides,* or *Pleuraphis jamesii,* occupying slopes, ridges, hills, and flats above canyon floors **(5)**

4a (3) Drainage terraces, drainage banks, and disturbed roadsides dominated by the introduced exotic grass, Bromus inermis – ***Bromus inermis – (Pascopyrum smithii)*** **Semi-natural Herbaceous Vegetation (Smooth Brome – (Western Wheatgrass) Semi-natural Herbaceous Vegetation)** [Map Class # 12]

4b) Drainage bottoms, banks, and terraces dominated by the native grass, *Pascopyrum smithii*, which may have been introduced following fire in *Pinus edulis – Juniperus osteosperma* Woodland habitat – ***Pascopyrum smithii*** **Herbaceous Vegetation (Western Wheatgrass Herbaceous Vegetation)** [Map Class # 11]

5a (3) Sparse grasslands dominated by *Leymus salinus* and growing on shale hills, ridges, and talus slopes, often with sparse cover of xeric shrubs or ***Juniperus osteosperma trees – Leymus salinus*** **Shale Sparse Vegetation (Salinas Wildrye Shale Sparse Vegetation)** [Map Class # 15]

5b) Grasslands of level to rolling uplands, dominated by either *Sporobolus airoides* or *Pleuraphis jamesii*, or sometimes by *Gutierrezia sarothrae* **(6)**

6a (5) Small grasslands of *Pleuraphis jamesii* growing on level to rolling uplands, often as openings in sagebrush shrublands or pinyon-juniper woodlands – ***Pleuraphis jamesii*** **Herbaceous Vegetation (James Galleta Herbaceous Vegetation)** [Map Class # 10]. Note: Following the drought of 2002, most of the galleta at the Square Tower Unit died and was replaced by ***Gutierrezia sarothrae*** **Dwarf-shrubland Alliance (Snakeweed Dwarf-shrubland Alliance)** [Map Class #15].

6b) Grasslands of rolling uplands dominated by ***Sporobolus airoides - Sporobolus airoides*** **Herbaceous Alliance (Alkali Sacaton Herbaceous Alliance)** [Map Class #8]

[No photo available]

INDEX TO THE PLANT ASSOCIATIONS OF HOVENWEEP NATIONAL MONUMENT

Alkali Sacaton Herbaceous Alliance 237
Amelanchier utahensis Shrubland 231
Artemisa bigelovii Shrubland 227
Artemisia tridentata – (Ericameria nauseosa) / Bromus tectorum Semi-natural Shrubland 228
Artemisia tridentata ssp. *wyomingensis - Atriplex confertifolia* Shrubland 229
Artemisia tridentata ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland 230
Artemisia tridentata ssp. *wyomingensis / Pleuraphis jamesii* Shrubland 228
Artemisia tridentata ssp. *wyomingensis / Poa fendleriana* Shrubland 229
Artemisia tridentata ssp. *wyomingensis* / Sparse Understory Shrubland 230
Atriplex canescens / Pleuraphis jamesii Shrubland 231
Atriplex confertifolia / Pleuraphis jamesii Shrubland 232
Big Sagebrush – (Rubber Rabbitbrush) / Cheatgrass Semi-natural Shrubland 228
Bigelow Sagebrush Shrubland 227
Black Greasewood - Big Sagebrush Shrubland 233
Black Greasewood Disturbed Shrubland 232
Bromus inermis – (Pascopyrum smithii) Semi-natural Herbaceous Vegetation 235
Bromus tectorum Semi-natural Herbaceous Vegetation 234
Celtis laevigata var. *reticulata* Woodland Alliance 218
Cheatgrass Semi-natural Herbaceous Vegetation 234
Cottonwood / Basin Big Sagebrush Woodland 219
Cottonwood / Coyote Willow Woodland 218
Crane's-bill Semi-natural Herbaceous Vegetation 234
Erodium cicutarium Semi-natural Herbaceous Vegetation 234
Four-wing saltbush / James' Galleta Shrubland 231
Gambel Oak Shrubland Alliance 220, 226
Gutierrezia sarothrae Dwarf-shrubland Alliance 236
James galleta Herbaceous Vegetation 236
Juniperus osteosperma / Artemisia tridentata ssp. *wyomingensis* Woodland 221
Juniperus osteosperma / Sparse Understory Woodland 221
Leymus salinus Shale Sparse Vegetation 236
Mixed Riparian Shrubland 226
Netleaf Hackberry Woodland Alliance 218
Pascopyrum smithii Herbaceous Vegetation 235
Pinus edulis - Juniperus osteosperma / Sparse Understory Woodland 222
Pinus edulis - Juniperus osteosperma / Artemisia bigelovii Woodland 223
Pinus edulis - Juniperus osteosperma / Atriplex spp. Woodland 222
Pinus edulis - Juniperus osteosperma / Pleuraphis jamesii Woodland 221
Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland 222, 224
Pinus edulis - Juniperus spp. */ Artemisia tridentata (*ssp. *wyomingensis,* ssp. *vaseyana)* Woodland 223
Pinus edulis - Juniperus spp. */ Cercocarpus montanus* - Mixed Shrub Woodland 225

Pinus edulis / Juniperus spp. / *Quercus gambelii* Woodland 220
Pleuraphis jamesii Herbaceous Vegetation 236
*Populus deltoides (*ssp*. wislizeni,* ssp*. monilifera) / Artemisia tridentata* Woodland ... 219
*Populus deltoides (*ssp*. wislizeni,* ssp*. monilifera) / Salix exigua* Woodland 218
Quercus gambelii Shrubland Alliance 226
Quercus gambelii Shrubland Alliance 220
Salinas Wildrye Shale Sparse Vegetation 236
Sarcobatus vermiculatus - Artemisia tridentata Shrubland 233
Sarcobatus vermiculatus Disturbed Shrubland 232
Shadscale / James' Galleta Shrubland 232
Smooth Brome – (Western Wheatgrass) Semi-natural Herbaceous Vegetation 235
Snakeweed Dwarf-shrubland Alliance 236
Sporobolus airoides Herbaceous Alliance 237
Two-needle Pinyon - Juniper / Big Sagebrush Woodland 223
Two-needle Pinyon - Utah Juniper / Bigelow Sagebrush Woodland 223
Two-needle Pinyon – Utah Juniper / Gambel's Oak Woodland 220
Two-Needle Pinyon – Utah Juniper / James' Galleta Woodland 221
Two-needle Pinyon - Utah Juniper / Mountain-mahogany – Mixed Shrub Woodland.225
Two-needle Pinyon - Utah Juniper / Pursh's Cliffrose Woodland 222, 224
Two-needle Pinyon – Utah Juniper / Saltbush Woodland 222
Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland 222
Utah Juniper / Sparse Understory Woodland 221
Utah Serviceberry Shrubland 231
Western Wheatgrass Herbaceous Vegetation 235
Wyoming Big Sagebrush – Shadscale Shrubland 229
Wyoming Big Sagebrush / Disturbed Understory Semi-natural Shrubland 230
Wyoming Big Sagebrush / James' Galleta Shrubland 228
Wyoming Big Sagebrush / Muttongrass Shrubland 229
Wyoming Big Sagebrush / Sparse Understory Shrubland 230

Appendix H

Modified Anderson Land Use-Land Cover Classification

This classification was used to attribute polygons in the environs mapped around Hovenweep National Monument.

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				

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
	3.5 Disposal				
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	
			4.223 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 watercraft. 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)

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, croplands, 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. Major retail centers consist of extremely large single buildings or a complex of large buildings

and 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, that 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 that 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.

2.23 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 that 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 grounds 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, not agricultural business.)

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 population 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.

2.27 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 landfills, trash dumps, or hazardous-waste disposal sites. Reclaimed disposal areas or those covered with vegetation do not qualify.

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 loose all 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% canopy 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 oaks.

4.121 Deciduous Shrub land - areas where 75% or more of the land cover can be determined to be shrubs that loose all 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, black greasewood, and 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

4.14 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.

4.223 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

4.224 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. Pasturelands can have a wide range of cultivation levels. It can be managed by seeding, fertilizing, application of herbicides, plowing, mowing, or baling. Pastureland 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 purposes.

4.31 Woody Wetland - areas dominated by woody vegetation. Includes seasonally flooded bottomland, 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 J

Map Class Descriptions for Hovenweep National Monument

Introduction

This document provides a visual guide and description of the map classes created for the Hovenweep National Monument Vegetation Mapping Project. Twenty-nine vegetation, two geologic and two land use map classes were delineated and are described in this guide. Each of the vegetation map classes associated with this project is documented by:

- ground photographs
- 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 throughout the Monument
- polygon statistics report (polygon number, size, area and proportion)

This key 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 a feel for the imagery and an understanding of the relationships between the vegetation classification and mapping.

Table of Contents

2 Slickrock (unvegetated) G-SLIC)..... 309
3 Unvegetated Wash (G-WASH)..... 311
8 Alkali Sacaton Grassland (H-SPAI)..... 251
10 Mixed Short Grassland (H-GRAS)..... 253
11 Western Wheatgrass Grassland (H-PASM)..... 255
12 Smooth Brome Grassland (H-BRIN)..... 257
13 Cheatgrass Grassland (H-BRTE)..... 259
15 Snakeweed-Sparse Grasses Dwarf-shrubland (S-GUSA)..... 261
20 Basin Big Sagebrush Shrubland (S-SBCG)..... 263
22 Wyoming Sagebrush – Shadscale Shrubland (S-SBSS)..... 265
23 Wyoming Sagebrush Disturbed Shrubland (S-SBDI)..... 267
24 Wyoming Sagebrush / Native Grass Shrubland (S-SBNG)..... 269
25 Wyoming Sagebrush / Sparse Understory Shrubland (S-SBSP)..... 271
26 Bigelow Sagebrush Shrubland (S-ARBI)..... 273
27 Fourwing Saltbush / Galleta Shrubland (S-FWGA)..... 275
28 Shadscale / Galleta Shrubland (S-SSGA)..... 277
31 Montane Deciduous Shrubland (S-MONT)..... 279
33 Greasewood Shrubland (S-SAVE)..... 281
34 Mixed Riparian Shrubland (C-RIPA)..... 283
40 Hackberry Woodland (W-HACK)..... 285
41 Juniper Woodland (W-JUOS)..... 287
42 Pinyon-Juniper / Gambel Oak Woodland (W-PJQG)..... 289
43 Pinyon-Juniper / Saltbush Woodland (W-PJAT)..... 291
44 Pinyon-Juniper / Grasses Woodland (W-PJBG)..... 293
45 Pinyon-Juniper / Wyoming Sagebrush Woodland (W-PJWS)..... 295
46 Pinyon-Juniper / Mountain Mahogany Woodland (W-PJMM)..... 297
47 Pinyon-Juniper / Sparse Understory Woodland (W-PJSP)..... 299
48 Pinyon-Juniper / Bitterbrush Woodland (W-PJPS)..... 301
49 Pinyon-Juniper / Bigelow Sagebrush Woodland (W-PJAB)..... 303
50 Rio Grande Cottonwood / Rabbitbrush Woodland (W-PDEN)..... 305
51 Rio Grande Cottonwood / Coyote Willow Woodland (W-PDSE)..... 307
60 Roads (L-ROAD)..... 312
61 Monument Facilities (L-PAFA)..... 313

Map Class 8
Alkali Sacaton Grassland
(H-SPAI)

Photo credit: NPS

H-SPAI Map Class Statistics

Type	Alliance
Frequency	Project polygons = 2
Area	Project area = 0.7 hectares / 1.8 acres
Average Size	Project polygons = 0.35 hectares / 0.9 acres
Proportion	0.2% of mapping area

Ecological System
Inter-Mountain Basins Greasewood Flat (CES304.780)

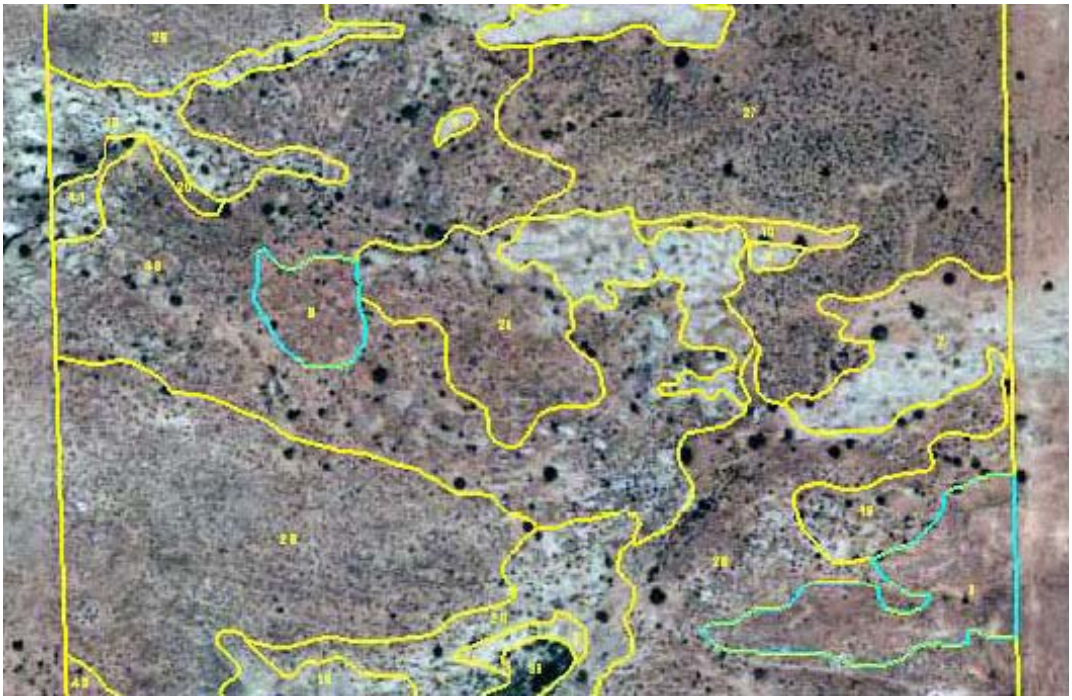
Associations
Sporobolus airoides Grassland Alliance [A.1267]

Common species
Sporobolus airoides

Distribution/Ecology/Composition
This map class is restricted to level sites with deep soils on the Cajon Unit of HOVE. It occurs in areas formerly dominated by an association of *Atriplex canescens* and *Sporobolus airoides;* however, the severe drought of 2002 killed most of the saltbush shrubs, leaving a sparse grassland.

Interpretation

Polygons of this map class are rounded to irregularly shaped. The visual signature is a mottled grayish pink, generally smooth in texture but with a few darker gray speckles representing surviving saltbush shrubs. Adjacent polygons tend to include saltbush shrublands.



Example of the photo signature for map class H-SPAI (#8) from the Cajon Unit.

Map Class 10
Mixed Short Grassland
(H-GRAS)

Photo credit: NPS

H-GRAS Map Class Statistics

Type	Complex
Frequency	Project polygons = 4
Area	Project area = 2.7 hectares / 6.8 acres
Average Size	Project polygons = 0.7 hectares / 1.7 acres
Proportion	0.8% of mapping area

Ecological System
Inter-Mountain Basins Semi-Desert Grassland (CES304.787)

Associations
Pleuraphis jamesii Herbaceous Vegetation (CEGL001777)
Erodium cicutarium Semi-natural Annual Herbaceous Vegetation (CEGL002085)

Common species
Pleuraphis jamesii *Erodium cicutarium*

Distribution/Ecology/Composition
This map class occurs in the Cajon and Hackberry units of HOVE. It occurs as small openings in woodlands or sagebrush shrublands. The only evidence of fire is in the stand dominated by *Erodium cicutarium;* most grasslands appear to be edaphically controlled. James' galleta is the only consistent species across all stands, although scattered shrubs and other herbaceous species are always present. These grasslands may contain scattered mature juniper, but trees in general do not appear to be moving into them.

Interpretation
This map class occurs in small to medium elongated polygons. The grass litter creates a gray cast to the otherwise pink color. Texture is smooth, with scattered dark round specks representing trees. Adjacent polygons are typically other woodland types.

Example of the the photo signature for map class H-GRAS (#10) from the Hackberry Unit.

Map Class 11
Western Wheatgrass Grassland
(H-PASM)

Photo credit: NPS

H-PASM Map Class Statistics

Type	Association
Frequency	Project polygons = 1
Area	Project area = 1.2 hectares / 3 acres
Average Size	Project polygons = 1.2 hectares / 3 acres
Proportion	0.4% of mapping area

Ecological System
Southern Rocky Mountain Montane-Subalpine Grassland (CES306.824)

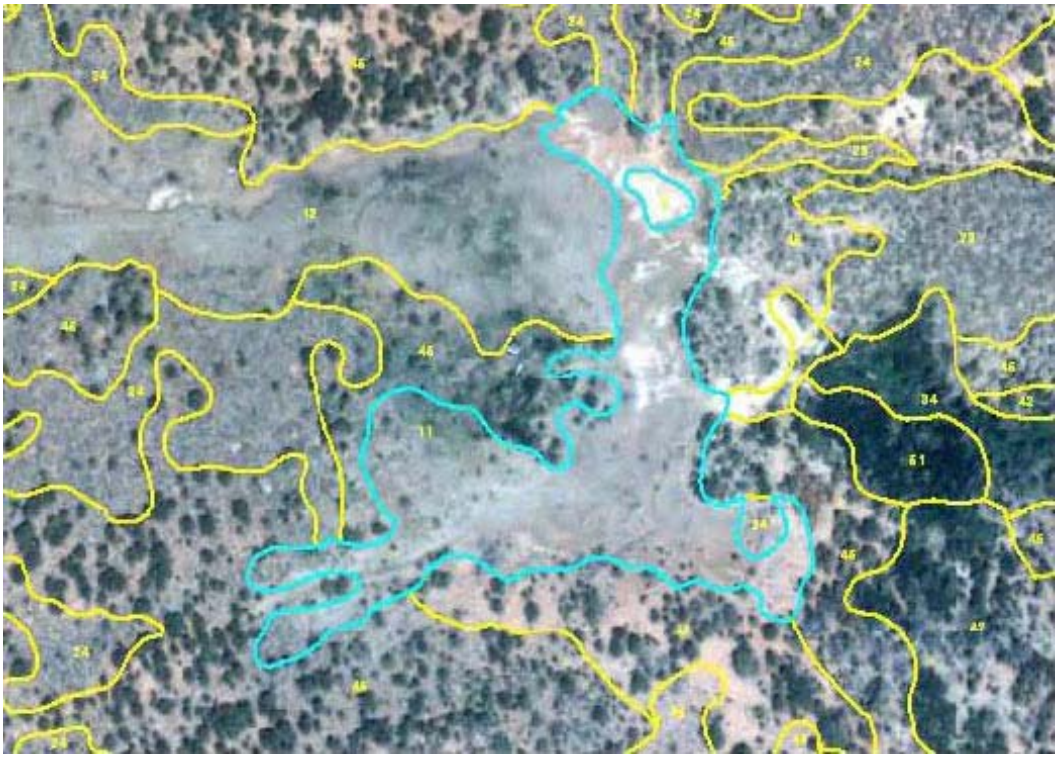
Associations
Pascopyrum smithii Herbaceous Vegetation [CEGL001577]

Common species
Pascopyrum smithii

Distribution/Ecology/Composition
This map class occurs only in the Goodman Point Unit of HOVE. It appears to be the result of a reseeding project following a fire in the pinyon-juniper woodland; there are many standing and fallen tree skeletons in the community. Over time, pinyon and juniper will become re-established at this site; western wheatgrass will probably diminish in cover as an understory species, but will likely persist and may even exclude the re-establishment of other native grasses and shrubs.

Interpretation

The basic signature of this map class is a light gray, with white patches where bedrock is exposed. Scattered trees and sagebrush shrubs appear as gray or dark green dots. Adjacent polygons tend to be woodland types.



Example of the photo signature for map class H-PASM (#11) from the Goodman Point Unit.

Map Class 12
Smooth Brome Grassland
(H-BRIN)

Photo credit: NPS

H-BRIN Map Class Statistics

Type	Association
Frequency	Project polygons = 4
Area	Project area = 2.0 hectares / 4.9 acres
Average Size	Project polygons = 0.5 hectares / 1.2 acres
Proportion	0.6% of mapping area

Ecological System Southern
Rocky Mountain Montane-Subalpine Grassland (CES306.824)

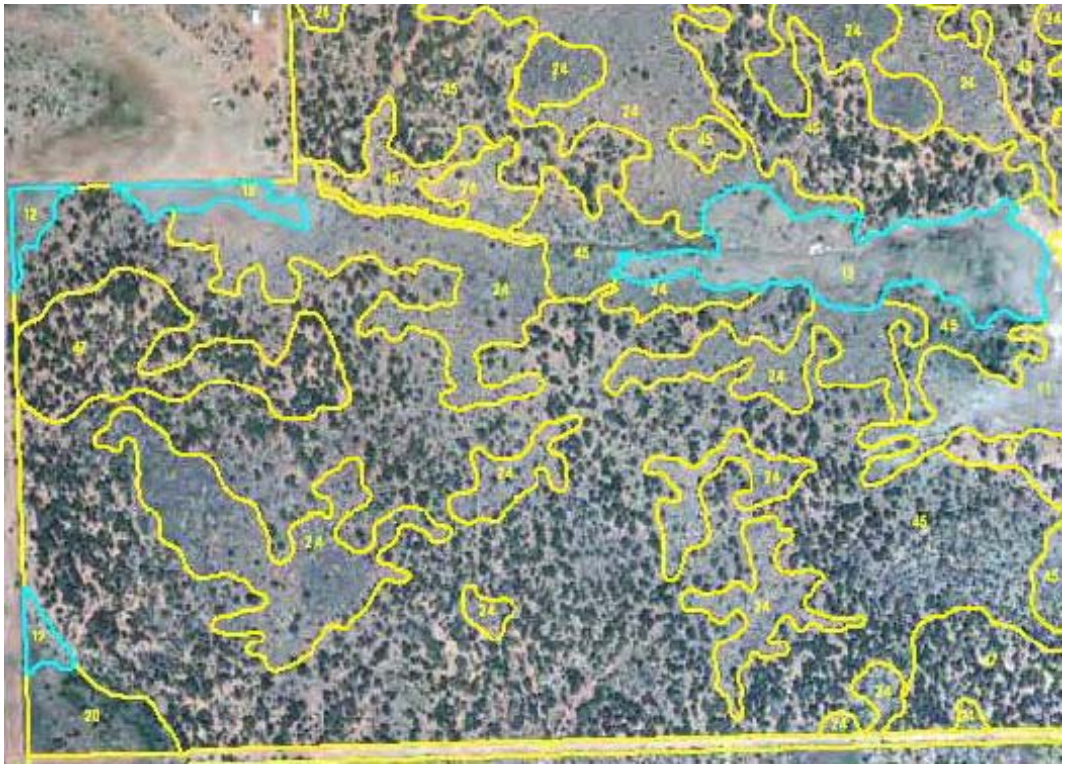
Associations
Bromus inermis - (Pascopyrum smithii) Semi-natural Herbaceous Vegetation [CEGL005264]

Common species
Bromus inermis *Juncus balticus*

Distribution/Ecology/Composition
This map class occurs only in the Goodman Point Unit of HOVE, on the banks of a swale that crosses the unit. This aggressive, exotic grass may have spread from plantings on adjacent ranch property, or it may have been planted on site for soil stabilization or to provide livestock forage.

Interpretation

The dominant signature of map class H-BRIN is the smooth-textured, light gray of herbaceous litter. Threads of dark green indicate the presence of species such as Baltic rush or Kentucky bluegrass. Adjacent polygons tend to be woodland types.



Example of the photo signature for map class H-BRIN (#12) from the Goodman Point Unit.

Map Class 13
Cheatgrass Grassland
(H-BRTE)

Photo credit: NPS

H-BRTE Map Class Statistics

Type	Association
Frequency	Project polygons = 1
Area	Project area = 0.1 hectares / 0.3 acres
Average Size	Project polygons = 0.1 hectares / 0.3 acres
Proportion	<<1% of mapping area

Ecological System
Inter-Mountain Basins Semi-Desert Grassland (CES304.787)

Associations
Bromus tectorum Semi-natural Herbaceous Vegetation [CEGL003019]

Common species
Bromus inermis *Gutierrezia sarothrae*
Astragalus nuttalianus

Distribution/Ecology/Composition
This map class occurs only in the Square Tower Unit of HOVE. It is the result of a burn that mostly affected areas outside the Monument boundary. Within a few decades, if no other disturbance occurs, sagebrush will re-occupy this stand.

Interpretation

The one polygon of this map class is from the Square Tower Unit. It is in a sagebrush stand, part of which burned after these aerial photos were flown. It was mapped using a GPS unit to mark the stand boundary. There is no representative signature on these photographs for this map class.

Example of the photo signature for map class H-BRTE (#13) from the Square Tower Unit.

Map Class 15
Snakeweed-Sparse Grasses Dwarf-shrubland
(S-GUSA)

Photo credit: NPS

S-GUSA Map Class Statistics

Type	Complex
Frequency	Project polygons = 37
Area	Project area = 7.0 hectares / 17.2 acres
Average Size	Project polygons = 0.2 hectares / 0.5 acres
Proportion	2.1% of mapping area

Ecological System
Inter-Mountain Basins Semi-Desert Grassland (CES304.787)
Intermountain Basins Shale Badland (CES304.789)

Association
Gutierrezia sarothrae Dwarf-shrubland Alliance [CEGL002690]
Leymus salinus Shale Sparse Vegetation [CEGL002745]

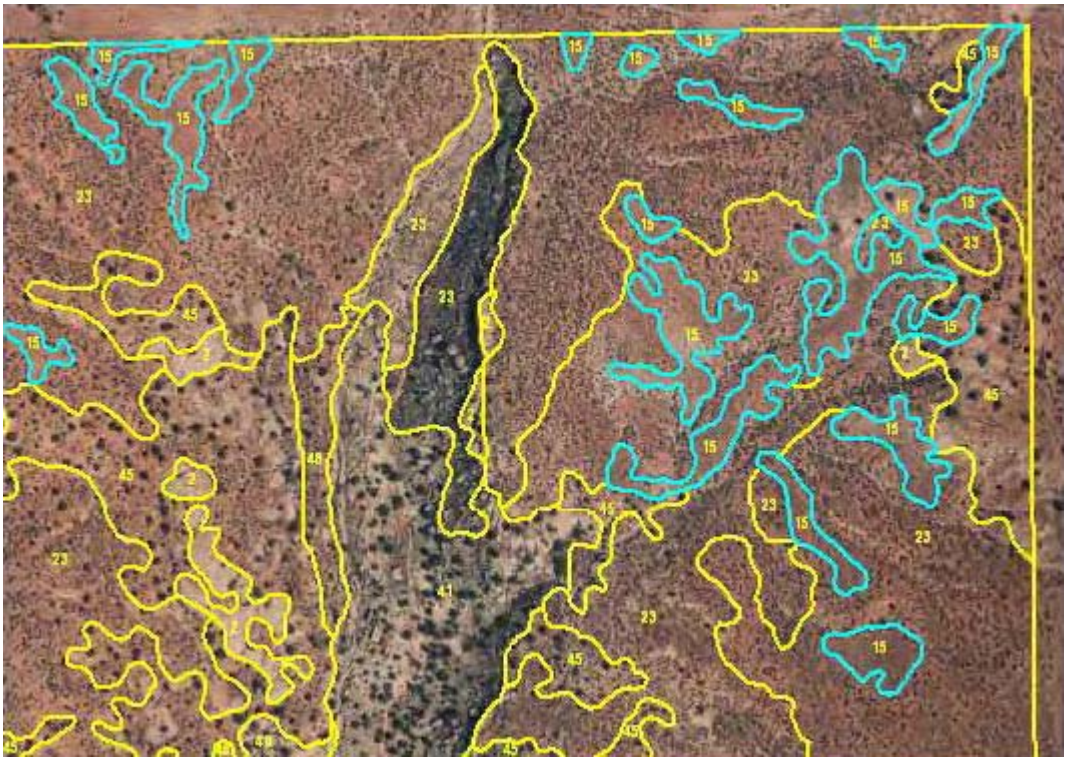
Common species
Gutierrezia sarothrae *Pleuraphis jamesii*
Leymus salinus

Distribution/Ecology/Composition
This map class occurs only in the Square Tower Unit of HOVE. Most polygons of this map class were originally mapped in 2002 as a James' galleta short grassland. However, the drought of

2002 killed most of the grass, so that by the time the map was ground-truthed in 2005, the vegetation had converted to a dwarf-shrubland of snakeweed with a few scattered grasses. The Salinas wildrye community occurs in a single small polygon whose signature cannot be distinguished from that of the other polygons in this map class.

Interpretation

Polygons are generally small and irregularly shaped.



Example of the photo signature for map class S-GUSA (#15) from the Square Tower Unit.

Map Class 20
Basin Big Sagebrush Shrubland
(S-SBCG)

Photo credit: NPS

S-SBCG Map Class Statistics

Type	Association
Frequency	Project polygons = 4
Area	Project area = 6.8 hectares / 16.2 acres
Average Size	Project polygons = 1.7 hectares / 4.2 acres
Proportion	2.1% of mapping area

Ecological System
Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)

Associations
Artemisia tridentata - (Ericameria nauseosa) / Bromus tectorum Semi-natural Shrubland [CEGL002699]
Sarcobatus vermiculatus / Artemisia tridentata Shrubland [CEGL001359]

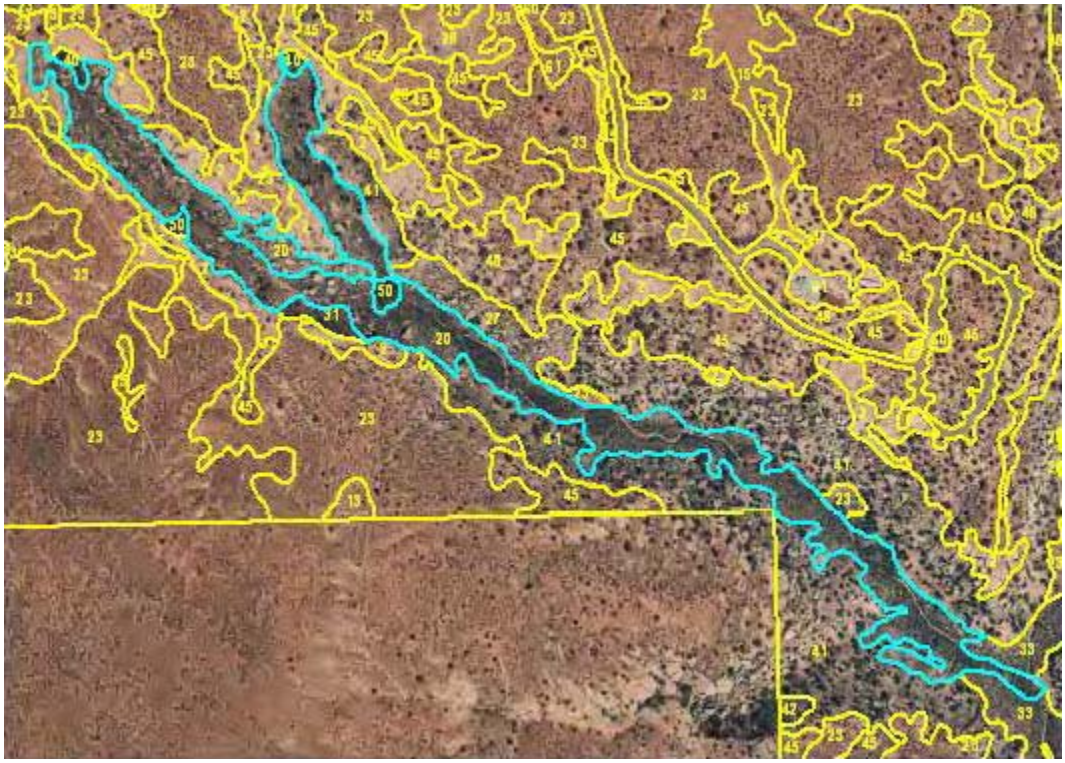
Common species
Ericameria nauseosa *Bromus tectorum*
Artemisia tridentata

Distribution/Ecology/Composition
This map class occurs in three units of HOVE: Cajon, Goodman Point, and Square Tower. It describes stands of basin big sagebrush, sometimes mixed with black greasewood, occupying dry

terraces on canyon floors. The understory is sparse, consisting primarily of exotic annual herbaceous species and incipient biological crusts.

Interpretation

Polygons of the S-SBCG map class tend to be elongated, as they follow the form of the canyon bottom. They are distinguished from adjacent polygons of other sagebrush map classes by the denser (darker) shrub canopy signature. Adjacent polygons tend to be woodland types occurring on canyon walls and rims.



Example of the photo signature for map class S-SBCG (# 20) from the Square Tower Unit.

Map Class 22
Wyoming Sagebrush – Shadscale Shrubland
(S-SBSS)

Photo credit: NPS

S-SBSS Map Class Statistics

Type	Association
Frequency	Project polygons = 3
Area	Project area = 0.4 hectares / 1.0 acres
Average Size	Project polygons = 0.1 hectares / 0.3 acres
Proportion	0.1% of mapping area

Ecological System
Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)

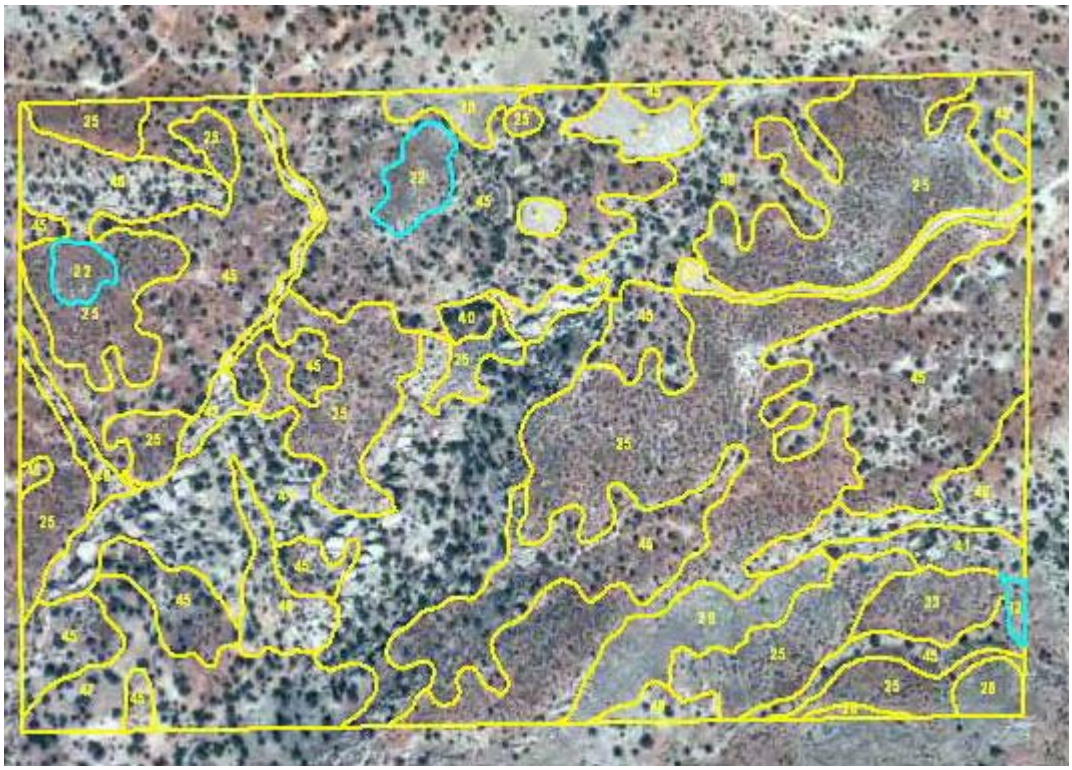
Associations
Artemisia tridentata ssp. *wyomingensis* - *Atriplex confertifolia* Shrubland [CEGL001040]

Common species
Artemisia tridentata ssp. *wyomingensis* *Atriplex confertifolia*

Distribution/Ecology/Composition
This map class occurs only in the Holly Unit of HOVE. It occupies the driest sites within the Holly Unit at the top of low hills. Shadscale tolerates drought and saline soils better than Wyoming big sagebrush, so in these sites the two shrubs are co-dominant.

Interpretation

The S-SBSS map class consists of three small polygons situated at the summits of low shale hillswithin the Holly Unit. The signature is similar to that of pure Wyoming big sagebrush shrublands, except the texture is muted and the contrast between the gray speckles representing shrubs and the pink or grayish matrix is less sharp. Adjacent polygons may be mapped as Wyoming big sagebrush shrublands or various woodlands.



Example of the photo signature for map class S-SBSS (#22) from the Holly Unit.

Map Class 23
Wyoming Sagebrush Disturbed Shrubland
(S-SBDI)

Photo credit: NPS

S-SBDI Map Class Statistics

Type	Association
Frequency	Project polygons = 54
Area	Project area = 77.6 hectares / 191.8 acres
Average Size	Project polygons = 1.4 hectares / 3.6 acres
Proportion	23.8% of mapping area

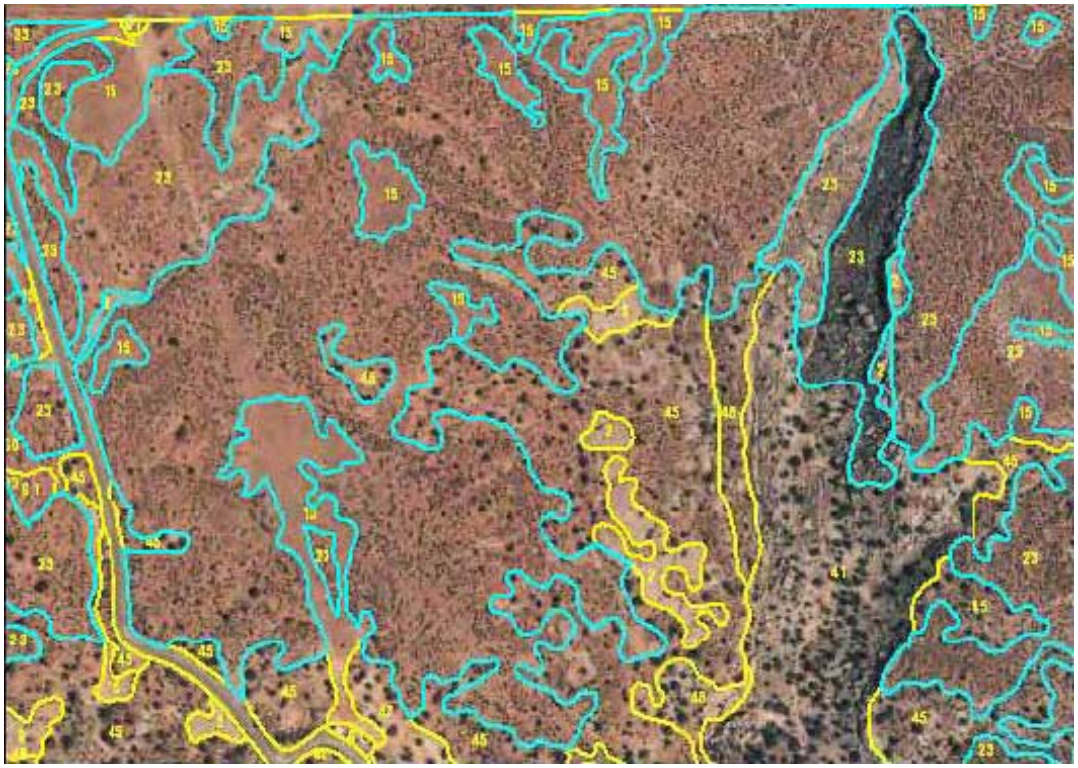
Ecological System
Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)

Associations
Artemisia tridentata ssp. *wyomingensis /* Disturbed Understory Semi-natural Shrubland [CEGL002083]

Common species
Artemisia tridentata ssp. *wyomingensis* *Astragalus nuttallianus*

Distribution/Ecology/Composition
This map class occurs in the Cutthroat Castle, Goodman Point and Square Tower units of HOVE. It is the most abundant of the map classes, covering nearly 25% of the Monument. It forms the matrix community on the west (lower elevation) end of Cajon Mesa. The understory shows the effects of many decades of livestock grazing; dominant species are exotic or native annual species such as *Bromus tectorum* and *Astragalus nuttallianus.* Burned sites are immediately converted to cheatgrass grasslands

Interpretation
The signature of this community is dominated by the pink or pinkish-gray color of the substrate. The shrubs appear as dark gray, irregular specks. Drier sites have a more open shrub canopy. Occasional juniper trees appear as dark green, rounded dots.



Example of the photo signature for Map Class S-SBDI (#23) from the Square Tower Unit. Adjacent polygons with the same map class number represent stands of different densities.

Map Class 24
Wyoming Sagebrush / Native Grass Shrubland
(S-SBNG)

Photo credit: NPS

S-SBNG Map Class Statistics

Type	Alliance
Frequency	Project polygons = 23
Area	Project area = 15.2 hectares / 37.5 acres
Average Size	Project polygons = 0.7 hectares / 1.6 acres
Proportion	4.7% of mapping area

Ecological System
Inter-Mountain Basins Big Sagebrush Shubland (CES304.777)

Associations
Artemisia tridentata ssp. *wyomingensis / Poa fendleriana Shrubland* [CEGL002775]
Artemisia tridentata ssp. *wyomingensis / Pleuraphis jamesii* Shrubland [CEGL002084]

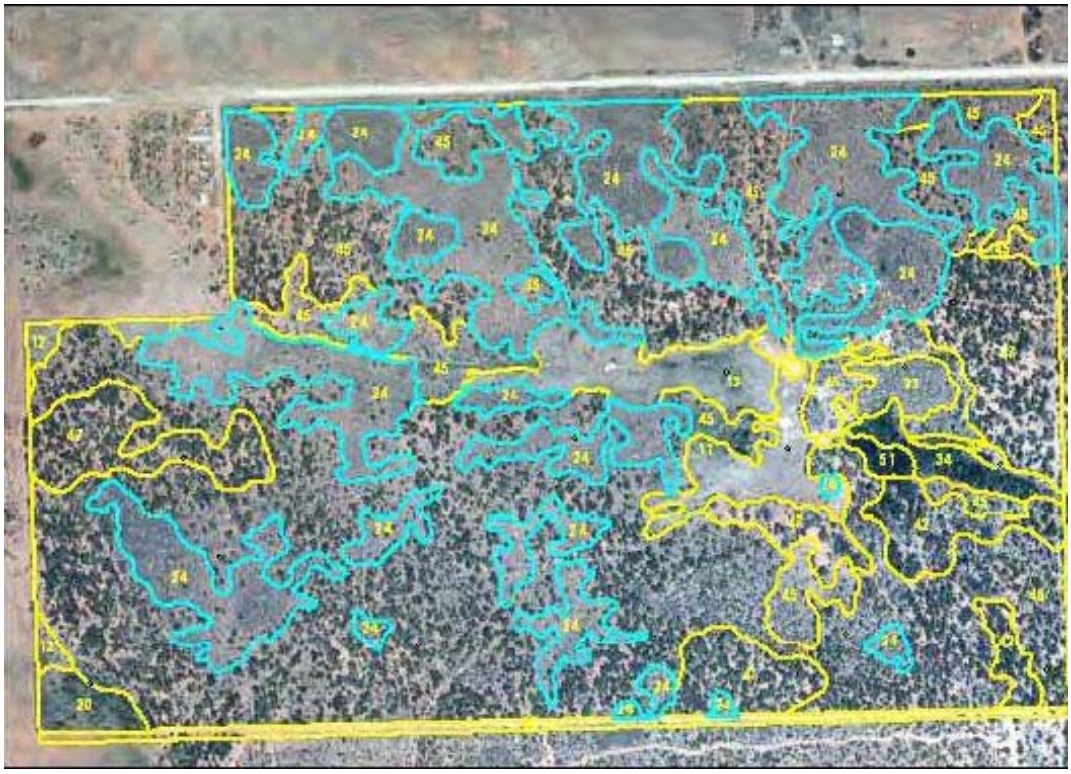
Common species
Artemisia tridentata ssp. *wyomingensis* *Poa fendleriana*
Pleuraphis jamesii

Distribution/Ecology/Composition
This map class occurs only in the Goodman Point Unit of HOVE. A few stands of Wyoming big sagebrush with an understory of muttongrass, often with James' galleta, persist in this wetter,

higher elevation site. Native grasses tend to be more resistant to grazing in areas where the annual precipitation is higher. These stands are also prone to incursions by pinyon and juniper trees; most of the shrublands are dotted with trees 1-2m high. Within a few decades, if the site doesn't burn, the shrublands will convert to a pinyon-juniper / Wyoming big sagebrush woodland.

Interpretation

Polygons of the S-SBNG map class are small to medium in size. Depending on shrub density, the signature is light to medium gray in color with a speckled texture contributed by the shrubs. Young pinyon and juniper appear as very small, dark green speckles. Adjacent polygons are most often mapped as W-PJWS.



Example of the photo signature for map class S-SBNG (#24) from the Goodman Point Unit.

Map Class 25
Wyoming Sagebrush / Sparse Understory Shrubland
(S-SBSP)

Photo credit: NPS

S-SBSP Map Class Statistics

Type	Complex
Frequency	Project polygons = 12
Area	Project area = 7.9 hectares / 19.6 acres
Average Size	Project polygons = 0.7 hectares / 1.7 acres
Proportion	2.4% of mapping area

Ecological System
Inter-Mountain Basins Big Sagebrush Shrubland (CES304.777)

Associations
Artemisia tridentata ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland [CEGL002083]
Artemisia tridentata ssp. *wyomingensis / Pleuraphis jamesii* Shrubland [CEGL002084]

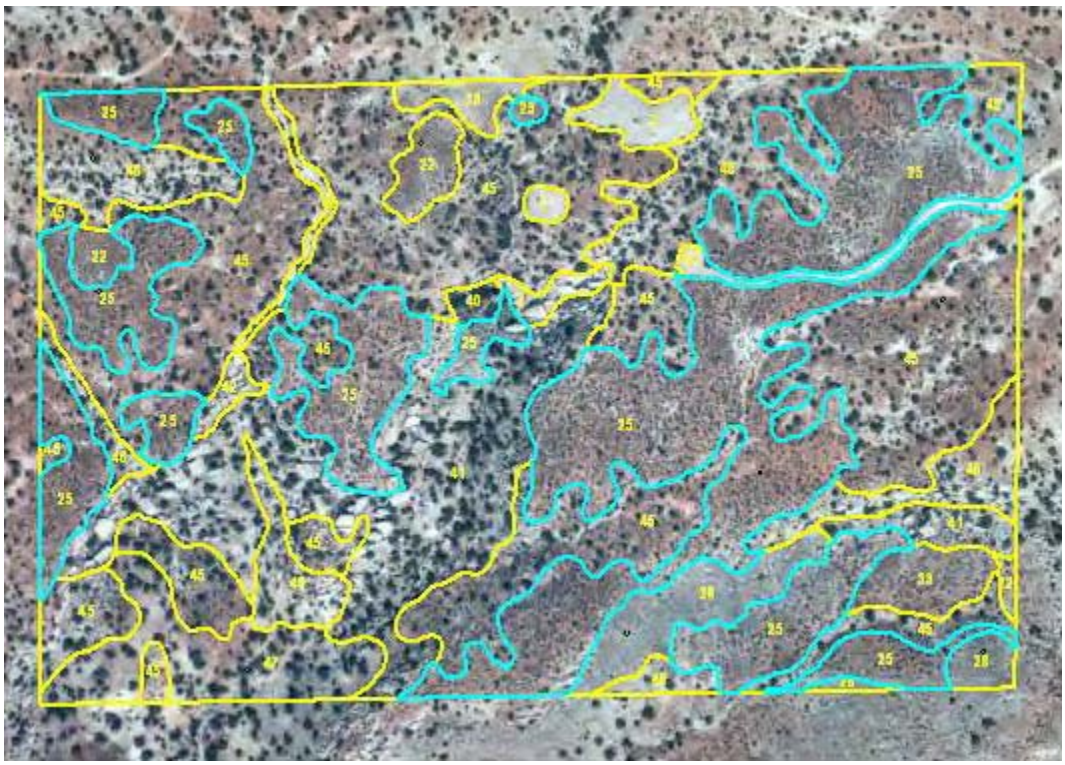
Common species
Artemisia tridentata ssp. *wyomingensis* *Astragalus nuttallianus*

Distribution/Ecology/Composition
This map class occurs only in the Holly Unit of HOVE. It is intended to describe Wyoming big sagebrush shrublands whose understory is sparse because of edaphic conditions and not because of disturbance. Patches of exotic or native annuals still occur in the understory, but for the most

part the ground is either bare or covered by biological soil crusts.

Interpretation

The S-SBSP map class has the same signature as other Wyoming big sagebrush shrublands mapped at HOVE; it was distinguished based on field notes and plot data. Adjacent stands are most often mapped as W-PJWS.



Example of the photo signature for map class S-SBSP (#25) from the Holly Unit.

Map Class 26
Bigelow Sagebrush Shrubland
(S-ARBI)

Photo credit: NPS

S-ARBI Map Class Statistics

Type	Association
Frequency	Project polygons = 3
Area	Project area = 1.6 hectares / 4.0 acres
Average Size	Project polygons = 0.5 hectares / 1.3 acres
Proportion	0.5% of mapping area

Ecological System Colorado
Plateau Mixed Low Sagebrush Shrubland (CES304.762)

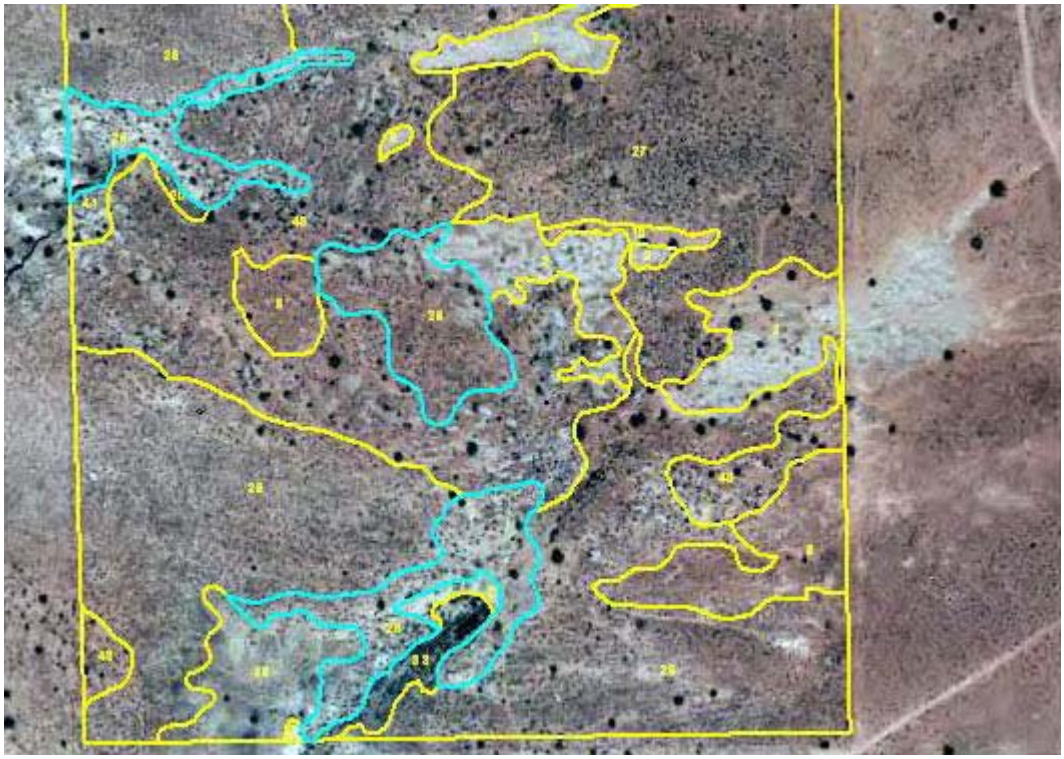
Association
Artemisia bigelovii Shrubland [CEGL000276]

Common species
Atriplex confertifolia *Artemisia bigelovii*
Purshia stansburiana

Distribution/Ecology/Composition
This map class occurs only in the Cajon Unit of HOVE. It is restricted to sites with thin soils and much exposed bedrock. The aspect of this community is that of an open shrubland with scattered juniper trees. Shadscale and Stansbury cliffrose are sometimes co-dominant with the Bigelow sagebrush. The understory is variable, but most often consists of a mix of native and exotic grasses.

Interpretation

The S-ARBI map class occurs in small, irregular polygons on mesa tops near canyon rims where soils are thin over bedrock. The dominant signature is that of the underlying bedrock whether pink or white sandstone. The shrubs appear as very small, dark gray specks; scattered juniper trees are dark green specks and dots. Adjacent polygons are most often mapped as other shrubland types.



Example of the photo signature of map class S-ARBI (#26) from the Cajon Unit.

Map Class 27
Fourwing Saltbush / Galleta Shrubland
(S-FWGA)

Photo credit: NPS

S-FWGA Map Class Statistics

Type	Association
Frequency	Project polygons = 2
Area	Project area = 3.4 hectares / 8.5 acres
Average Size	Project polygons = 1.7 hectares / 4.2 acres
Proportion	1% of mapping area

Ecological System
Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784)

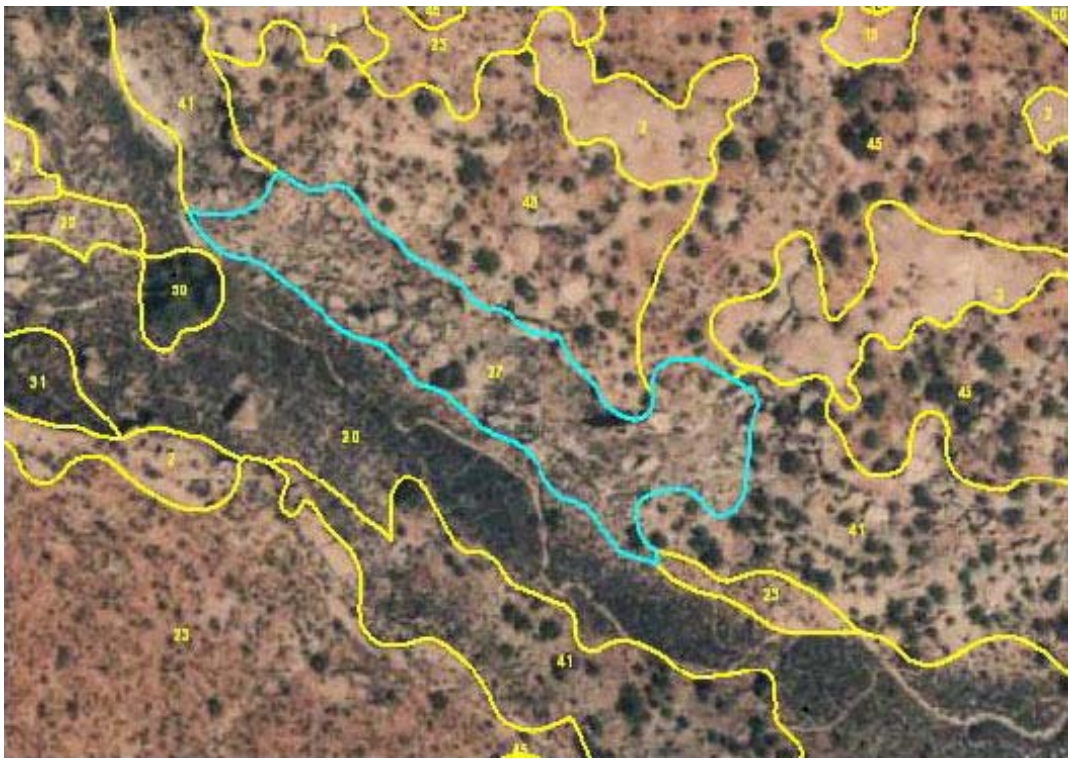
Association
Atriplex canescens / Pleuraphis jamesii Shrubland [CEGL001288]

Common species
Atriplex canescens *Pleuraphis jamesii*

Distribution/Ecology/Composition
This map class occurs in the Cajon and Square Tower units of HOVE. It occurs on talus slopes underlain by marine shale or on mesa tops where soils are somewhat saline. Fourwing saltbush tends to increase under conditions of moderate disturbance; its presence may be because of grazing or soil movement. The understory is generally sparse, consisting primarily of clumps of James' galleta.

Interpretation

The S-FWGA map class occurs in regular to elongated polygons. The signature is similar to that of Wyoming sagebrush communities, except that upon close inspection, the dark gray specks of shrubs are large and more ragged than those of sagebrush. Adjacent polygons are typically mapped as other types of shrubland.



Example of the photo signature for map class S-FWGA (#27) from the Cajon Unit.

Map Class 28
Shadscale / Galleta Shrubland
(S-SSGA)

Photo credit: NPS

S-SSGA Map Class Statistics

Type	Association
Frequency	Project polygons = 12
Area	Project area = 8.4 hectares / 20.5 acres
Average Size	Project polygons = 0.7 hectares / 1.7 acres
Proportion	2.6% of mapping area

Ecological System
Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784)

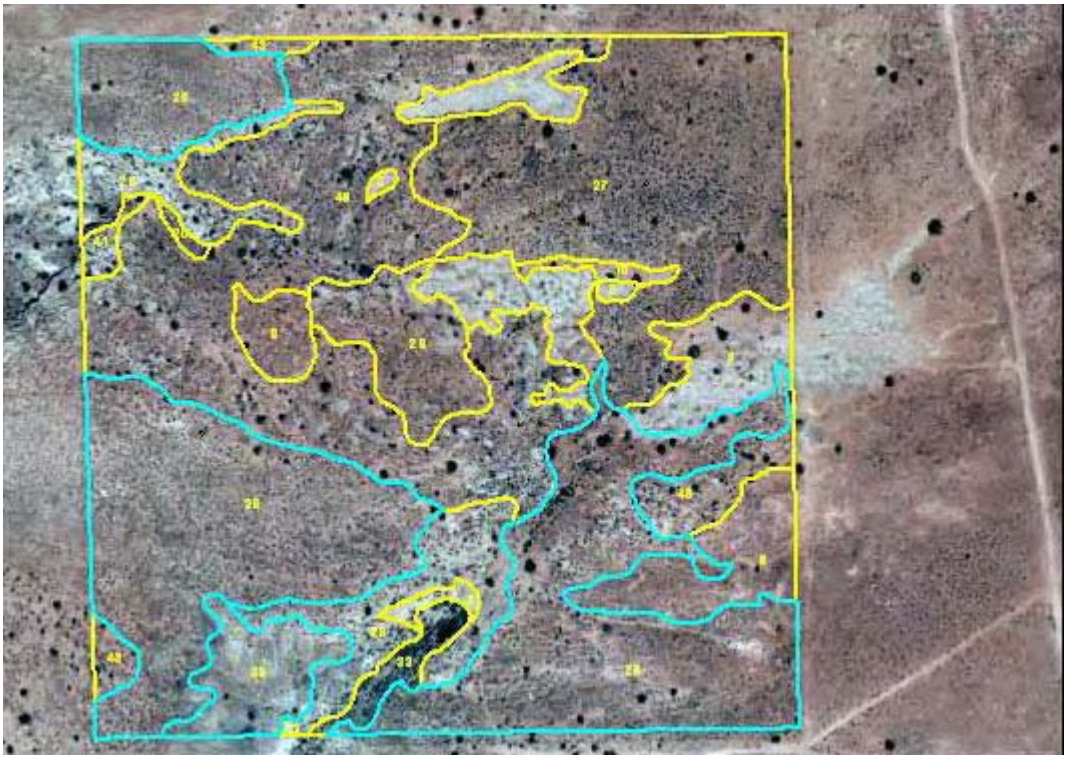
Association
Atriplex confertifolia / Pleuraphis jamesii Shrubland [CEGL001304]

Common species
Atriplex confertifolia *Pleuraphis jamesii*

Distribution/Ecology/Composition
This map class occurs in the Cajon, Holly, and Square Tower units on the western side of HOVE. It is best developed in the driest habitats on mesa tops where the soils are derived from marine shales. Stands are open, with a sparse understory of scattered James' galleta.

Interpretation

The S-SSGA map class occurs in small to medium polygons typically located on mesa tops. The signature is dominated by the substrate, either a light gray or a medium pink. The shrubs are dark gray specks that appear rounded under magnification. Adjacent polygons are most often mapped as other types of shrubland.



Example of the photo signature for map class S-SSGA (#28) from the Cajon Unit.

Map Class 31
Montane Deciduous Shrubland
(S-MONT)

Photo credit: NPS

S-MONT Map Class Statistics

Type	Mosaic
Frequency	Project polygons = 1
Area	Project area = 0.2 hectares / 0.4 acres
Average Size	Project polygons = 0.2 hectares / 0.4 acres
Proportion	<<1% of mapping area

Ecological System
Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)

Association
Amelanchier utahensis Shrubland [CEGL001067]
Quercus gambelii Shrubland Alliance [A.920]

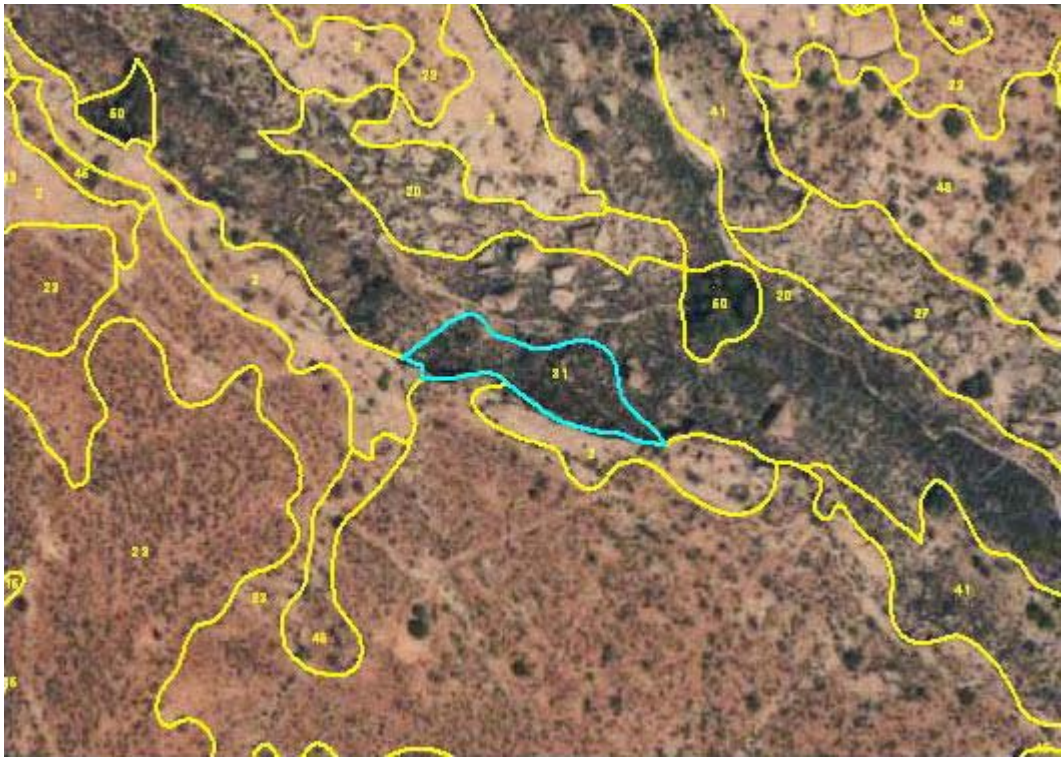
Common species
Amelanchier utahensis *Quercus gambelii*

Distribution/Ecology/Composition
This map class occurs only in the Square Tower Unit of HOVE, where it occupies a cool, sheltered north-facing canyon slope. Utah serviceberry and Gambel oak provide a dense shrub

canopy. There is little understory growth due to the dense shade cast by the tall shrubs.

Interpretation

The S-MONT map class occurs in a single small polygons located just below the canyon rim. It can be distinguished from adjacent sagebrush shrublands by the denser vegetation and brighter green color.



Example of the photo signature for map class S-MONT (#31) from the Square Tower Unit.

Map Class 33
Greasewood Shrubland
(S-SAVE)

Photo credit: NPS

S-SAVE Map Class Statistics

Type	Association
Frequency	Project polygons = 4
Area	Project area = 3.8 hectares / 9.5 acres
Average Size	Project polygons = 1.0 hectares / 2.4 acres
Proportion	1.2% of mapping area

Ecological System
Inter-Mountain Basins Greasewood Flat (CES304.780)

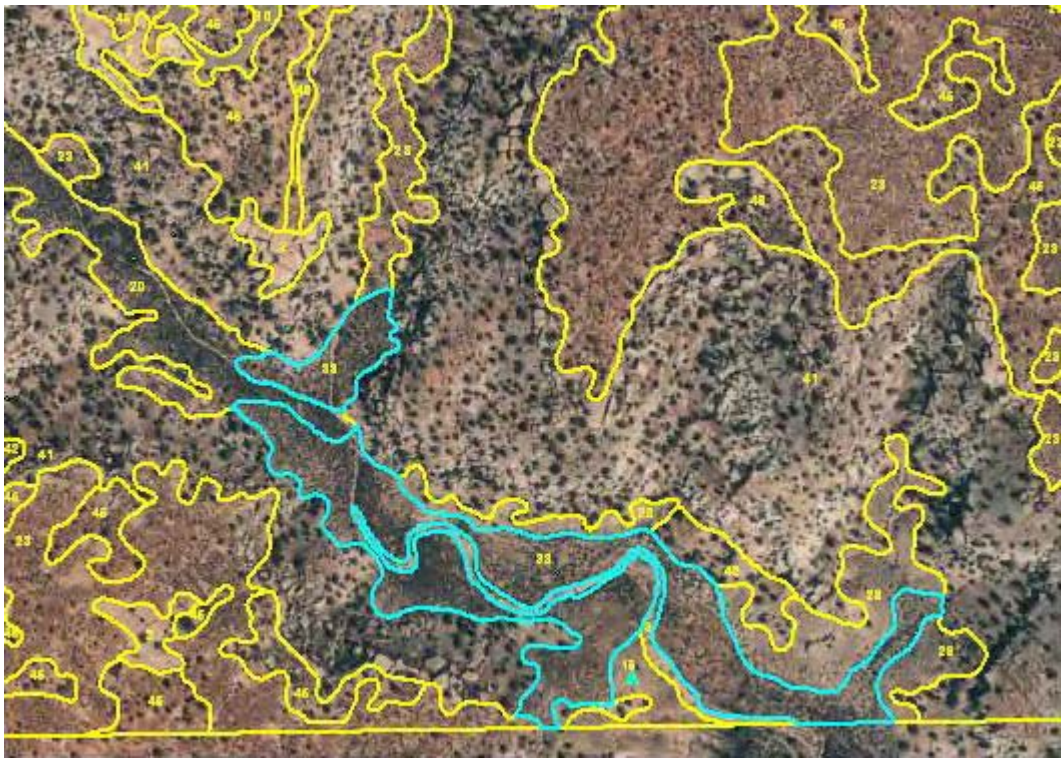
Association
Sarcobatus vermiculatus Disturbed Shrubland [CEGL001357]

Common species
Sarcobatus vermiculatus
Astragalus nuttallianus
Erodium cicutarium
Descurainia pinnata

Distribution/Ecology/Composition
This map class occurs on the Cajon, Holly and Square Tower units of HOVE. It occurs primarily on level alluvial terraces isolated from the water table. The shrub canopy is usually open, with a sparse to dense herbaceous understory consisting mostly of exotic annual species.

Interpretation

The S-SAVE map class occurs in elongated polygons typically located on floors of the larger canyons. The signature is virtually indistinguishable from that of Basin Big Sagebrush Shrubland (S-SBCG), except that the shrub canopy is slightly less dense so that more of the pinkish-gray substrate is evident.



Example of the photo signature for map class S-SAVE (#33) from the Square Tower Unit.

Map Class 34
Mixed Riparian Shrubland
(C-RIPA)

NO PHOTOGRAPH AVAILABLE

C-RIPA Map Class Statistics

Type	Complex
Frequency	Project polygons = 1
Area	Project area = 0.6 hectares / 1.4 acres
Average Size	Project polygons = 0.6 hectares / 1.4 acres
Proportion	0.2% of mapping area

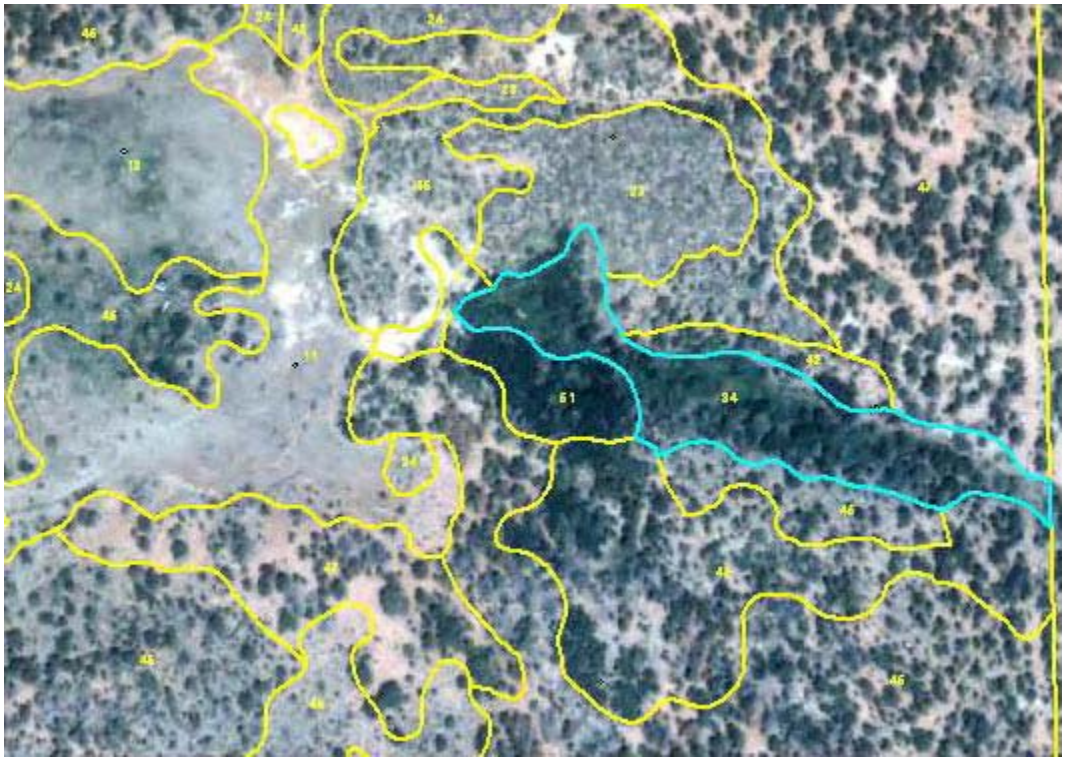
Ecological System
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)

Association
Mixed Riparian Shrubland [Park Special]

Common species
Peraphyllum ramosissimum
Amelanchier utahensis
Prunus virginiana
Salix exigua

Distribution/Ecology/Composition
This map class occurs only in the Goodman Point Unit of HOVE. It consists of a mix of mesic shrubs growing on the sheltered bank of a drainage. Squaw-apple is the dominant shrub, with lesser amounts of Utah serviceberry, coyote willow and chokecherry. The shrub layer is dense, so that the herbaceous layer is relatively sparse, consisting mostly of exotic species.

Interpretation
The C-RIPA map class occurs in a single elongated polygon following a drainage downstream from a spring. The signature is a medium dark green, dense enough so that no pink substrate is visible, and a medium texture. Adjacent polygons are generally upland woodlands or Rio Grande cottonwood woodlands associated with the spring.



Example of the photo signature for map class C-RIPA (#34) from the Goodman Point Unit.

Map Class 40
Hackberry Woodland
(W-HACK)

NO PHOTOGRAPH AVAILABLE

W-HACK Map Class Statistics

Type	Alliance
Frequency	Project polygons = 5
Area	Project area = 0.4 hectares / 1.1 acres
Average Size	Project polygons = 0.1 hectares / 0.2 acres
Proportion	0.1% of mapping area

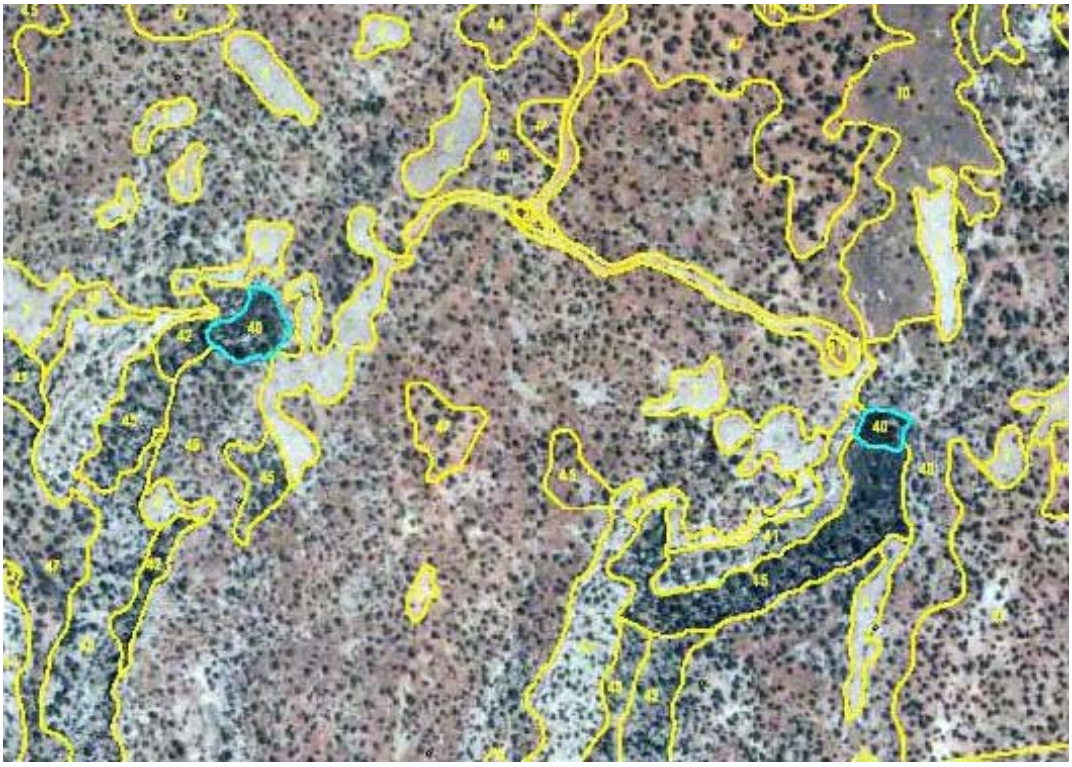
Ecological System
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)

Association
Celtis laevigata var. *reticulata* Woodland Alliance (A.632)

Common species
Celtis laevigata var. *reticulata*

Distribution/Ecology/Composition
This map class occurs in the Holly, Hackberry and Square Tower units of HOVE. Netleaf hackberry trees are commonly associated with springs that provided water to the ancestral Puebloan inhabitants.

Interpretation
The W-HACK map class occurs only in very small polygons in sheltered canyon bottom sites, often below pouroffs. The signature is recognizable by its rough texture and rich green color. Adjacent polygons tend to be woodland types typical of canyon walls such as W-JUOS and W-PJPS.



Example of the photo signature for map class W-HACK (#40) from the Hackberry Unit.

Map Class 41
Juniper Woodland
(W-JUOS)

Photo credit: NPS

W-JUOS Map Class Statistics

Type	Association
Frequency	Project polygons = 12
Area	Project area = 33.7 hectares / 83.3 acres
Average Size	Project polygons = 2.8 hectares / 6.9 acres
Proportion	10.3% of mapping area

Ecological System
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

Association
Juniperus osteosperma / Artemisia tridentata ssp. *wyomingensis* Woodland [CEGL000730]
Juniperus osteosperma / Sparse Understory Woodland [CEGL000732]

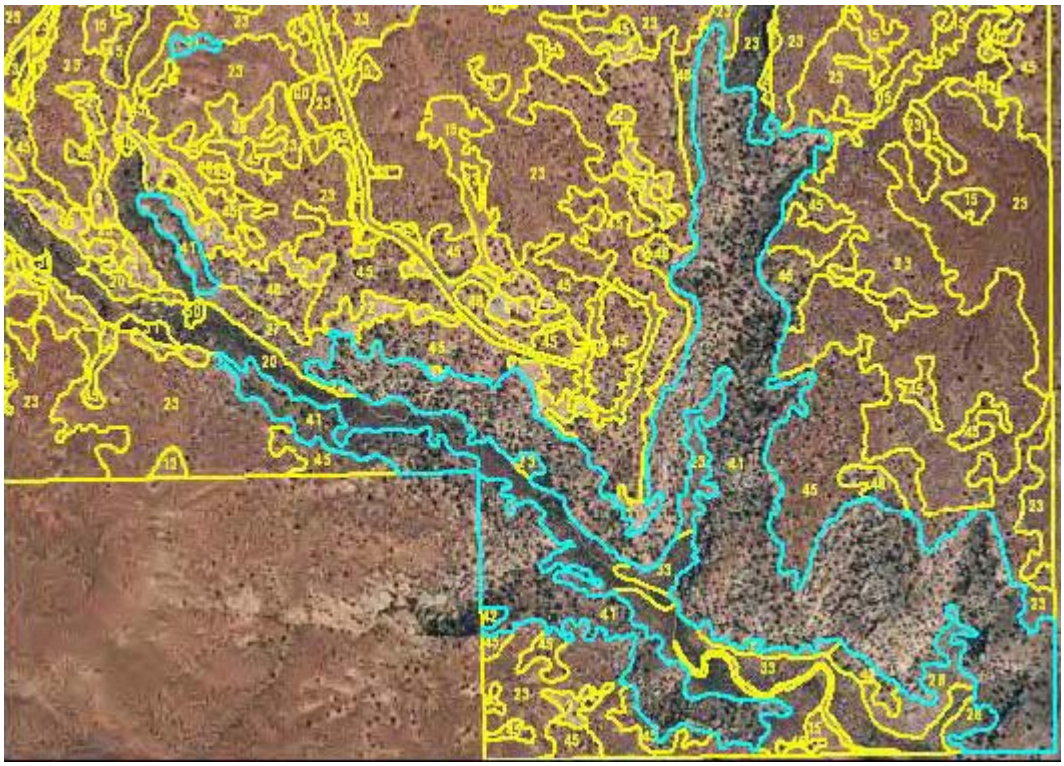
Common species
Juniperus osteosperma *Artemisia tridentata* ssp. *wyomingensis*

Distribution/Ecology/Composition
This map class is widely distributed within HOVE, occurring within the Cajon, Holly, Hackberry and Square Tower units. It is best developed on canyon walls whose slopes are

mostly covered by slabs of sandstone fallen from the rims above. The vegetation is typically sparse because of the limited areas in which plants can root. Trees and a few shrubs are scattered among the rock debris.

Interpretation

The S-WYSB map class occurs in irregular, elongated polygons that follow the trend of major canyons. The signature is a light tan or gray matrix (talus and bare soil) containing scattered dark green, irregular specks that represent tree crowns. Adjacent polygons are most commonly mapped as other woodland types.



Example of the photo signature for map class W-JUOS (#41) from the Square Tower Unit.

Map Class 42
Pinyon-Juniper / Gambel Oak Woodland
(W-PJQG)

Photo credit: NPS

W-PJQG Map Class Statistics

Type	Association
Frequency	Project polygons = 12
Area	Project area = 3.8 hectares / 9.5 acres
Average Size	Project polygons = 0.3 hectares / 0.8 acres
Proportion	1.2% of mapping area

Ecological System
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

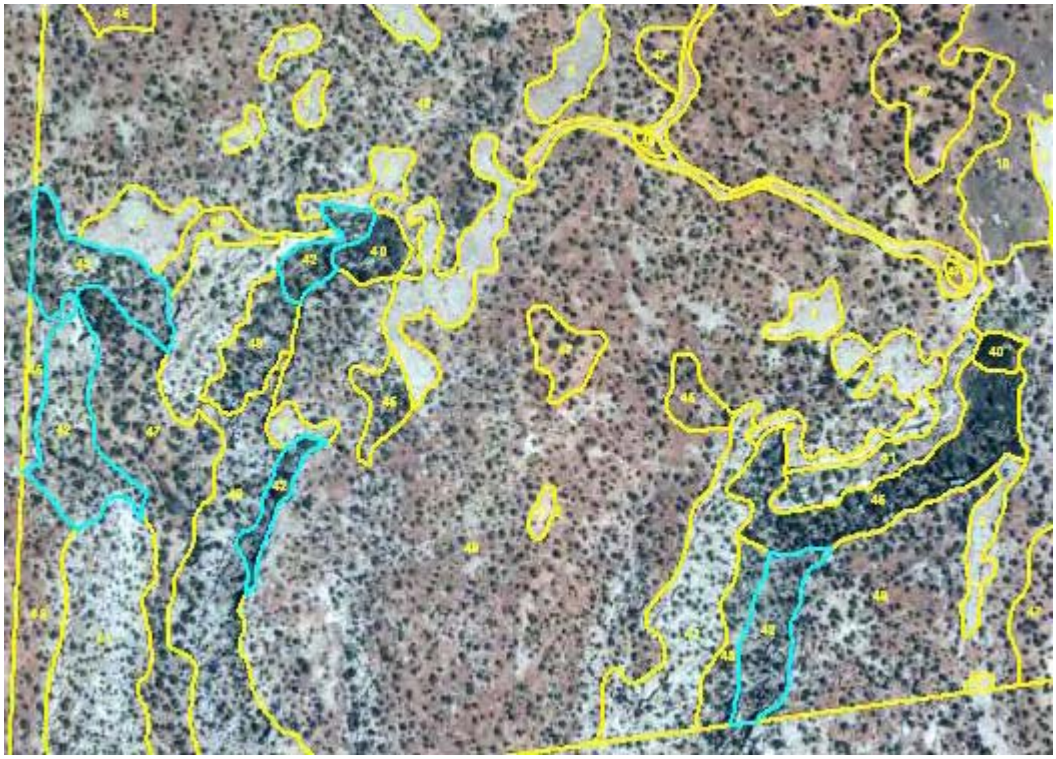
Association
Pinus edulis – Juniperus spp. / *Quercus gambelii* Woodland [CEGL000791]

Common species
Juniperus osteosperma
Pinus edulis
Quercus gambelii
Amelanchier utahensis

Distribution/Ecology/Composition
This map class is widely distributed within HOVE, occurring within the Cutthroat Castle, Goodman Point, Holly, Hackberry and Square Tower units. It is usually an open pinyon-juniper woodland with a sparse to dense understory of montane shrubs such as Utah serviceberry or Gambel oak. It is restricted to cooler canyon slopes.

Interpretation

The W-PJQG map class occurs in small regular to elongated polygons typically located on sloping canyon walls. Because soil moisture is somewhat higher, the canopy is slightly denser and the tree crowns larger than woodland stands on adjacent canyon rims.



Example of the photo signature for map class W-PJQG (#42) from the Hackberry Unit.

Map Class 43
Pinyon-Juniper / Saltbush Woodland
(W-PJAT)

NO PHOTOGRAPH AVAILABLE

W-PJAT Map Class Statistics

Type	Association
Frequency	Project polygons = 2
Area	Project area = 0.1 hectares / 0.3 acres
Average Size	Project polygons = 0.05 hectares / 0.1 acres
Proportion	<<1% of mapping area

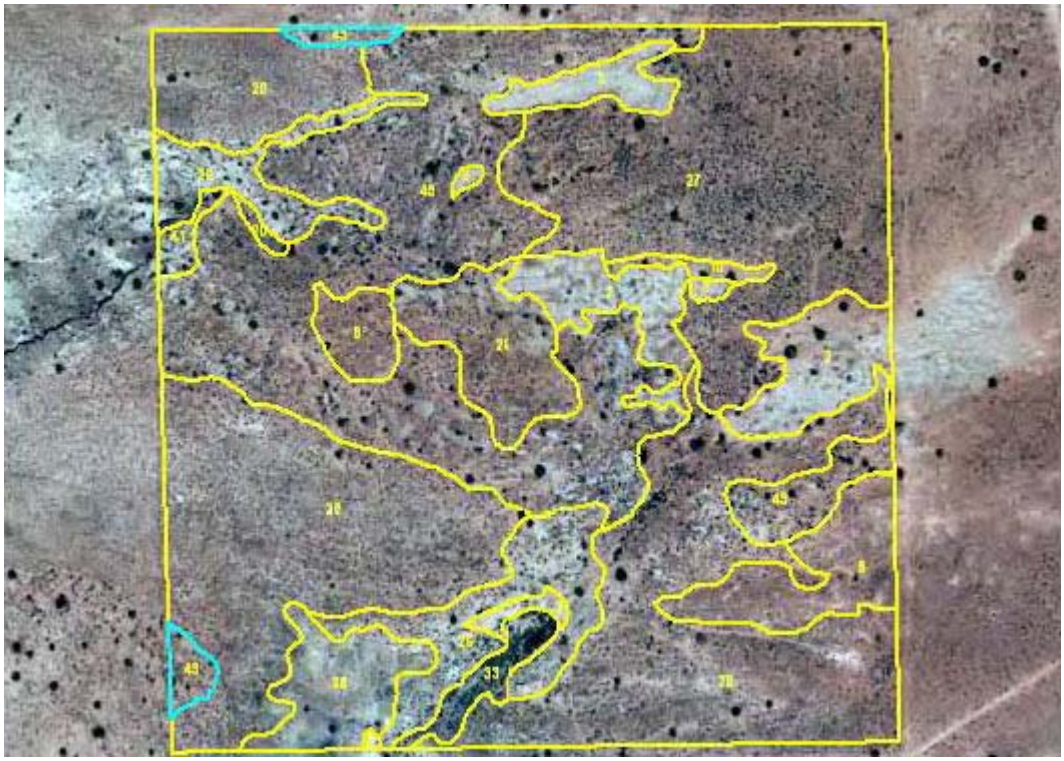
Ecological System
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

Association
Pinus edulis - Juniperus osteosperma / Atriplex spp. Woodland [CEGL002366]

Common species
Juniperus osteosperma *Atriplex confertifolia*
Atriplex canescens

Distribution/Ecology/Composition
This map class is found only within the Cajon Unit of HOVE. It occurs in two small polygons on the margins of the unit, representing areas where Utah juniper is moving into established saltbush stands.

Interpretation
The W-PJAT map class occurs in small polygons. The signature is primarily the speckled gray of the saltbush community, with scattered dark green rounded dots representing the juniper trees. Adjacent polygons are most commonly mapped as S-SSGA.



Example of the photo signature for map class W-PJAT (#43) from the Cajon Unit.

Map Class 44
Pinyon-Juniper / Grasses Woodland
(W-PJBG)

Photo credit: NPS

W-PJBG Class Statistics

Type	Association
Frequency	Project polygons = 3
Area	Project area = 1.5 hectares / 3.6 acres
Average Size	Project polygons = 0.05 hectares / 1.2 acres
Proportion	0.4% of mapping area

Ecological System
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

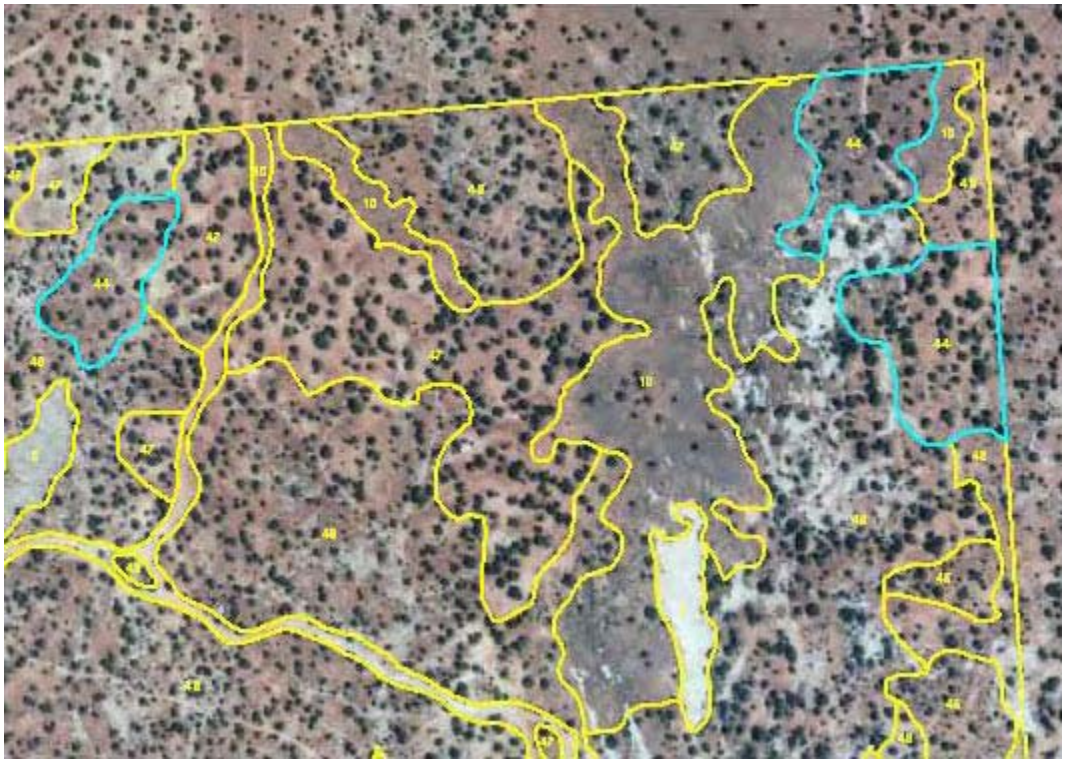
Association
Juniperus osteosperma / Pleuraphis jamesii Woodland [CEGL002362]

Common species
Juniperus osteosperma *Pleuraphis jamesii*

Distribution/Ecology/Composition
This map class occurs only within the Hackberry Unit of HOVE. It is an open woodland with an understory of scattered clumps of *Pleuraphis jamesii.* This type was not sampled.

Interpretation
The W-PJBG map class occurs in small regular polygons typically located on deep upland soils.

The signature is a medium gray-green with a smooth texture with large, green round dots representing the trees. Adjacent polygons are most commonly mapped as H-GRAS (#10).



Example of the photo signature for map class W-PJBG (#44) from the Hackberry Unit.

Map Class 45
Pinyon-Juniper / Wyoming Sagebrush
(W-PJWS)

Photo credit: NPS

W-PJWS Map Class Statistics

Type	Association
Frequency	Project polygons = 79
Area	Project area = 65.8 hectares / 162.6 acres
Average Size	Project polygons = 0.8 hectares / 2.1 acres
Proportion	20.2% of mapping area

Ecological System
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

Association
Pinus edulis - Juniperus spp. */ Artemisia tridentata (*ssp. *wyomingensis,* ssp. *vaseyana)* Woodland [CEGL000776]

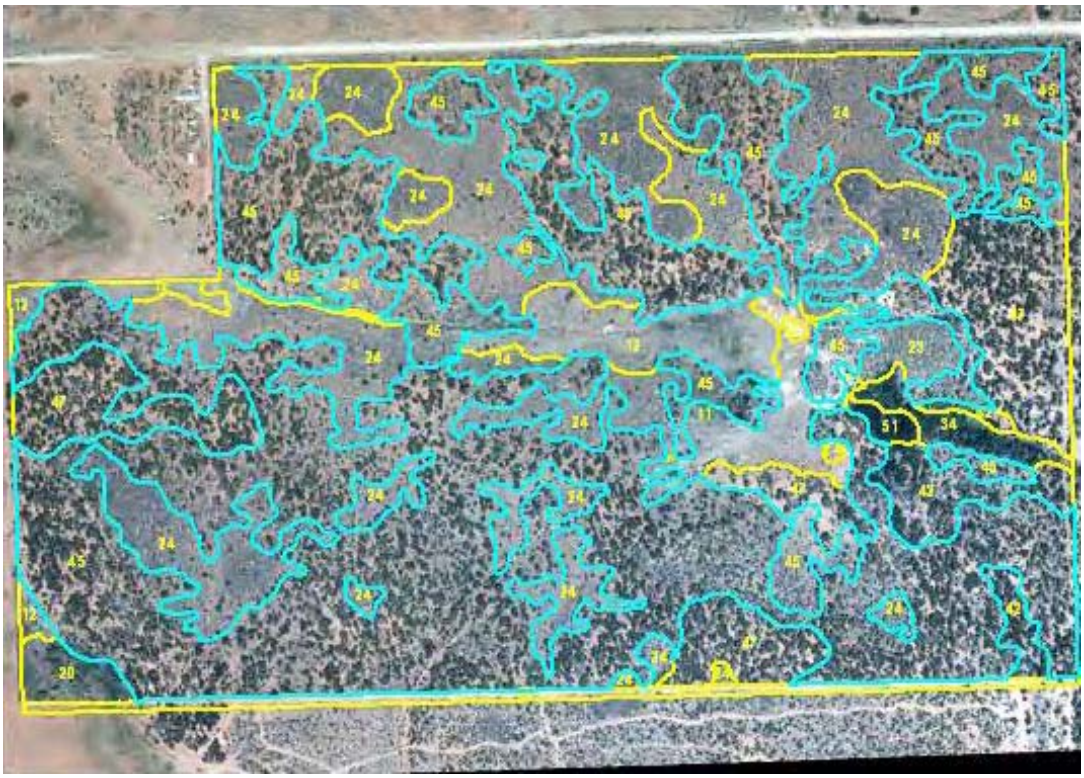
Common species
Pinus edulis *Juniperus osteosperma*
Artemisia tridentata ssp. *wyomingensis*

Distribution/Ecology/Composition
This map class is widely distributed within HOVE, occurring on rolling uplands within the Cutthroat Castle, Goodman Point, Holly, Hackberry and Square Tower units. Like Wyoming big sagebrush shrublands, it occurs on sites with deeper soils; many stands probably represent

shrublands where pinyon and juniper have become established in the absence of disturbance.

Interpretation

The W-PJWS map class occurs in large, irregular polygons scattered throughout the units. In some units, it forms the matrix vegetation type. The signature is a medium gray-green background with sparse to dense, clumped to regular dark green dots representing the trees. Adjacent polygons are most commonly mapped as other wooded types.



Example of the photo signature for map class W-PJWS (#45) from the Goodman Point Unit.

Map Class 46
Pinyon-Juniper / Mountain Mahogany Woodland
(W-PJMM)

Photo credit: NPS

W-PJMM Map Class Statistics

Type	Association
Frequency	Project polygons = 5
Area	Project area = 1.3 hectares / 3.1 acres
Average Size	Project polygons = 0.3 hectares / 0.6 acres
Proportion	0.4% of mapping area

Ecological System
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

Association
Pinus edulis - *Juniperus* spp. / *Cercocarpus montanus* - Mixed Shrub Woodland [CEGL000780]

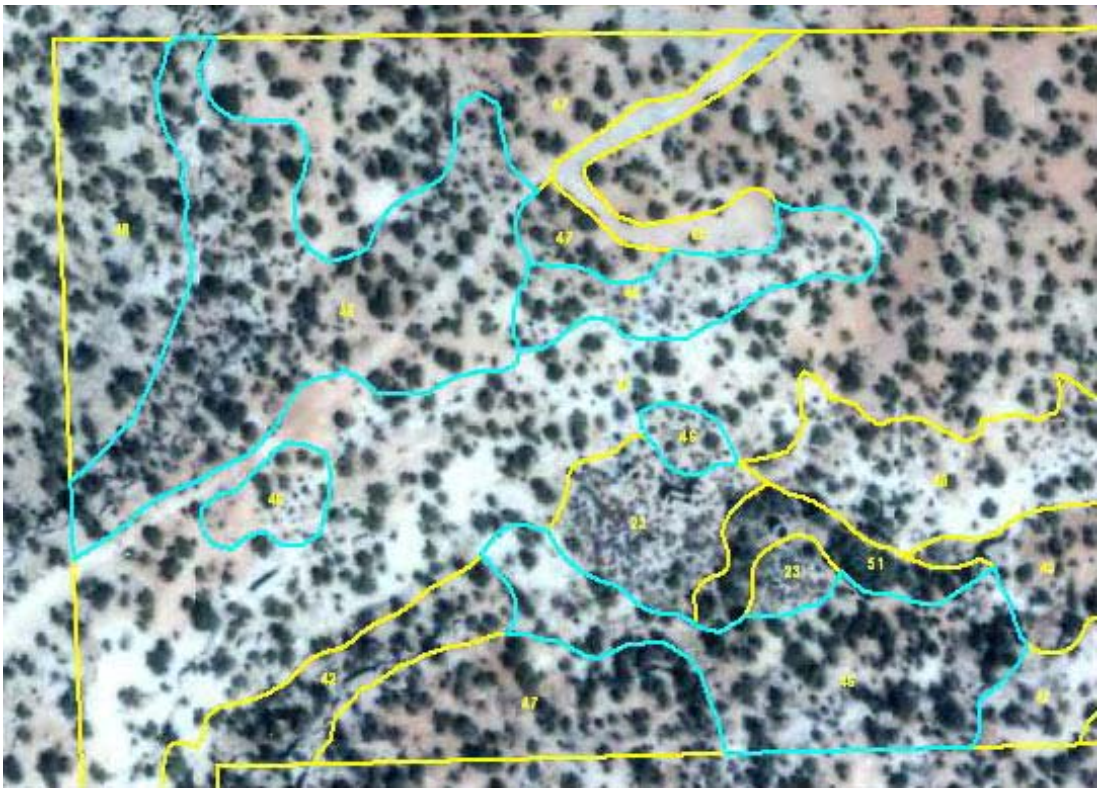
Common species
Juniperus osteosperma
Pinus edulis
Cercocarpus montanus
Amelanchier utahensis

Distribution/Ecology/Composition
This map class occurs only within the Cutthroat Castle Unit of HOVE. Stands are restricted to

sloping sites with significant exposed bedrock near canyon rims and upper canyon walls. An open canopy of pinyon and juniper trees has a mixed shrub understory in which mountain mahogany is conspicuous. The herbaceous layer is sparse and variable.

Interpretation

The W-PJMM map class occurs in small irregular polygons typically located near canyon rims. The signature is indistinguishable from W-PJPS: Clumped to scattered larger dark green dots with scattered dark gray speckles in a light gray matrix. Adjacent polygons are typically other woodland types.



Example of the photo signature for map class W-PJMM (#46) from the Cutthroat Castle Unit.

Map Class 47
Pinyon-Juniper / Sparse Understory Woodland
(W-PJSP)

Photo credit: NPS

W-PJSP Map Class Statistics

Type	Association
Frequency	Project polygons = 20
Area	Project area = 17.5 hectares / 43.2 acres
Average Size	Project polygons = 0.9 hectares / 2.2 acres
Proportion	5.4% of mapping area

Ecological System
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

Association
Pinus edulis - Juniperus osteosperma / Sparse Understory Woodland [CEGL002148]

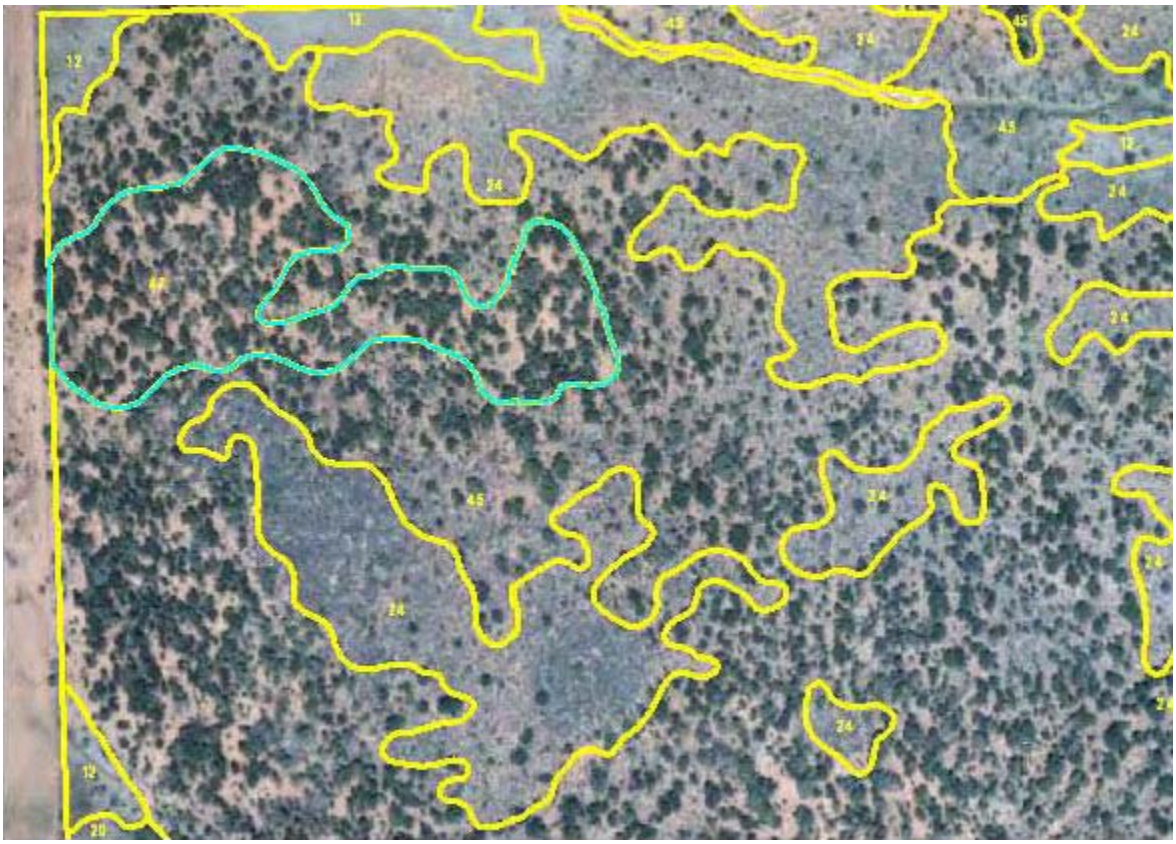
Common species
Juniperus osteosperma *Pinus edulis*

Distribution/Ecology/Composition
This map class is widely distributed within HOVE, occurring within the Cutthroat Castle, Goodman Point, Holly, Hackberry and Square Tower units. Most examples are on level to rolling sites with moderately deep soils over unfractured bedrock, usually away from canyon rims. Soils support widely spaced Utah juniper and pinyon pine, but few shrubs, forbs or grasses.

Most of the soil surface shows evidence of early biological soil crust development.

Interpretation

The W-PJSP map class occurs in medium to large polygons within most of HOVE's management units. The signature is characterized by large, clumped or regularly-spaced dark green dots (tree canopies) within a matrix of tan to light orange exposed soil. Tree crowns tend to be larger and more widely spaced than in adjacent map classes. There are few to no smaller dark specks representing shrubs. Adjacent polygons are most commonly mapped as other woodland map classes.



Example of the photo signature for map class W-PJSP (#47) from the Goodman Point Unit.

Map Class 48
Pinyon-Juniper / Bitterbrush Woodland
(W-PJPS)

Photo credit: NPS

W-PJPS Map Class Statistics

Type	Association
Frequency	Project polygons = 24
Area	Project area = 39.7 hectares / 98.2 acres
Average Size	Project polygons = 1.7 hectares / 4.1 acres
Proportion	12.2% of mapping area

Ecological System
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

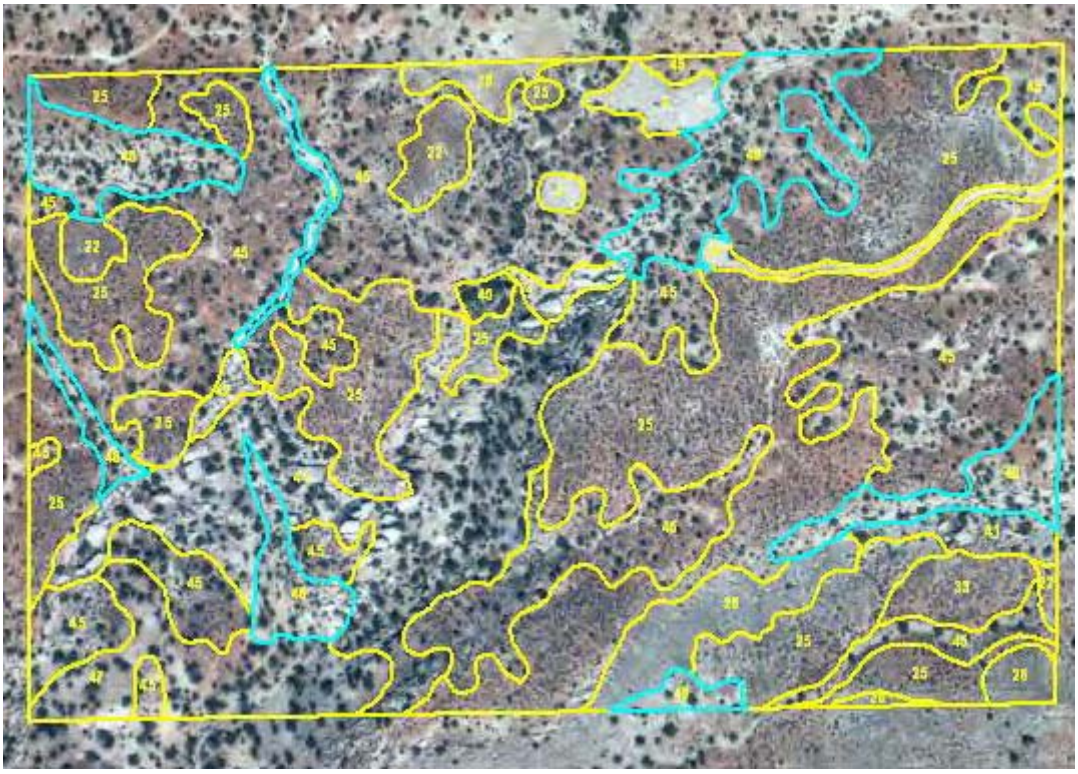
Association
Pinus edulis - Juniperus osteosperma / Purshia stansburiana Woodland [CEGL000782]

Common species
Juniperus osteosperma *Pinus edulis*
Purshia stansburiana *Ephedra viridis*

Distribution/Ecology/Composition
This map class is widely distributed within HOVE, occurring within the Cutthroat Castle, Holly, Hackberry and Square Tower units. Pursh's cliffrose is a species that prefers higher soil

moisture, and so thrives in the fractured bedrock exposed on canyon rims and in shallow drainages that cross the mesa tops. The woodland canopy tends to be open, and dominated by Utah juniper, although a few pinyon pine may also be present. The shrub layer is diverse and may equal or exceed the tree canopy in total cover. Pursh's cliffrose is rarely a clear dominant, but is always at least co-dominant with a suite of other shrubs that includes no other strong indicator species. Common associated shrubs include Wyoming sagebrush, threeleaf skunkbush, yucca, rubber rabbitbrush, snakeweed, wild buckwheat, and green Mormon tea. Forb species tend to have higher cover than grasses in this community.

Interpretation The W-PJPS map class occurs in elongated to irregular polygons typically located along shallow drainages or canyon sides. It is among the commonest and most widely distributed of the woodland map classes. The signature consists of dark green dots of various sizes in a matrix of light gray exposed bedrock or soil. The smallest dark dots or speckles represent the larger cliffrose shrubs. Adjacent polygons are mapped as various woodland or shrubland types.



Example of the photo signature for map class W-PJPS (#48) from the Holly Unit.

Map Class 49
Pinyon-Juniper / Bigelow Sagebrush Woodland
(W-PJAB)

Photo credit: NPS

W-PJAB Map Class Statistics

Type	Association
Frequency	Project polygons = 4
Area	Project area = 6.2 hectares / 15.3 acres
Average Size	Project polygons = 1.5 hectares / 3.8 acres
Proportion	1.9% of mapping area

Ecological System
Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

Association
Pinus edulis - Juniperus osteosperma / Artemisia bigelovii Woodland [CEGL002118]

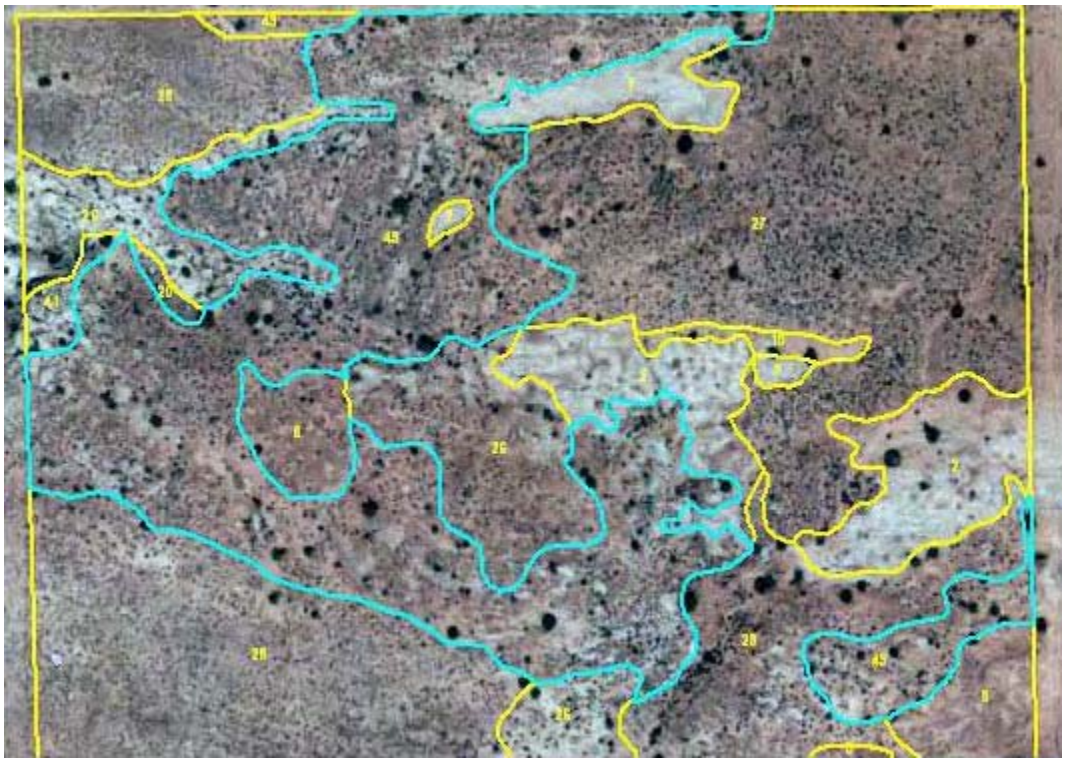
Common species
Juniperus osteosperma *Pinus edulis*
Artemisia bigelovii *Pursia stansburiana*

Distribution/Ecology/Composition
This map class occurs in the Cajon and Hackberry units of HOVE. It is best developed in areas of thin soils, mostly near canyon rims. The woodland canopy tends to be open, as sites for tree

establishment are limited to cracks in the sandstone. Utah juniper tend to be more common than pinyon pine. Pursh's cliffrose is the most abundant associated shrub; other shrubs commonly present include Mormon-tea, yucca, skunkbush, snakeweed and horsebrush. The herbaceous layer tends to be sparse.

Interpretation

The W-PJAB map class occurs in medium, irregularly shaped polygons on level to rolling ground with shallow soils. The signature is a matrix of gray to dark gray color interrupted by dots and patches of lighter gray representing small bedrock exposures. Shrubs are visible as regularly-spaced darker gray dots. Ragged dark green specks of various sizes represent juniper trees. In some polygons the shrub signature is dominant; in others, the tree signature is dominant. Adjacent polygons may be mapped as various shrub or woodland types.



Example of the photo signature for map class W-PJAB (#49) from the Cajon Unit.

Map Class 50
Rio Grande Cottonwood / Rabbitbrush Woodland
(W-PDEN)

Photo credit: NPS

W-PDEN Map Class Statistics

Type	Association
Frequency	Project polygons = 2
Area	Project area = 0.1 hectares / 0.3 acres
Average Size	Project polygons = 0.06 hectares / 0.2 acres
Proportion	<<1% of mapping area

Ecological System
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland

Association
*Populus deltoides (*ssp. *wislizeni,* ssp. *monilifera) / Artemisia tridentata* Woodland [CEGL005966]

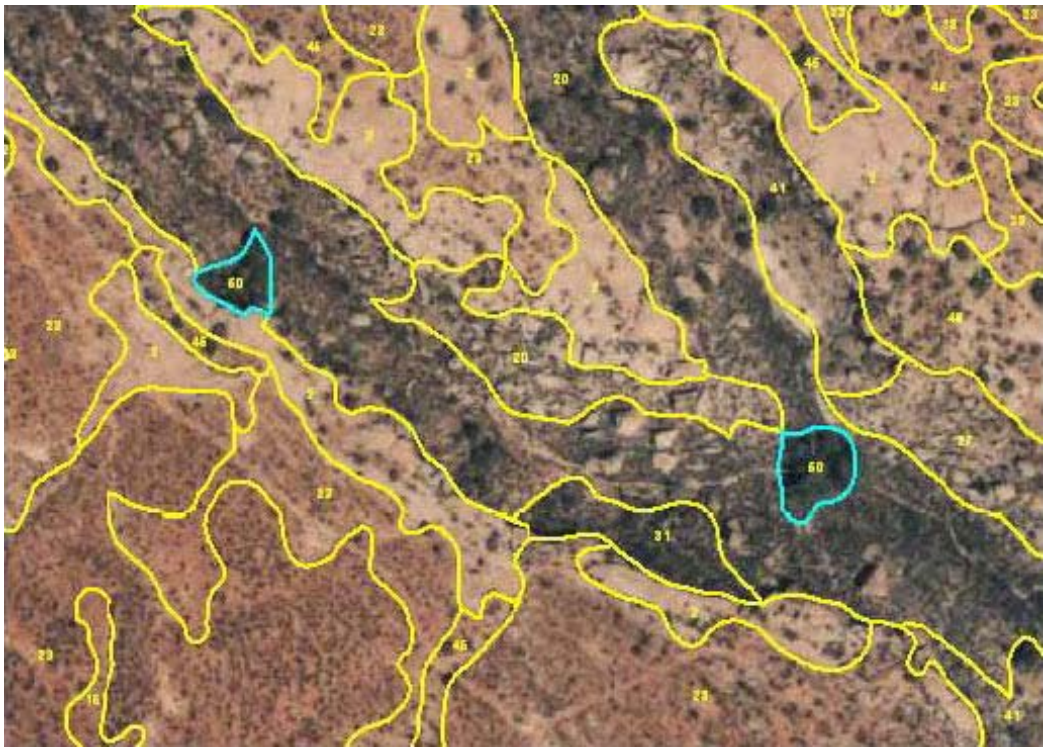
Common species
Populus deltoides ssp. *wislizeni*
Artemisia tridentata ssp. *tridentata*
Ericameria nauseosa
Bromus tectorum

Distribution/Ecology/Composition

This map class is restricted to canyon bottom sites within the Square Tower Unit of HOVE. Stands tend to be perched on the sides of the canyon and therefore somewhat isolated from the water table. They probably originated at the site of springs whose flow has greatly diminished or disappeared in recent decades. The canopy consists of mature Rio Grande cottonwood trees, with an open understory of scattered rubber rabbitbrush and basin big sagebrush. Cheatgrass may be abundant.

Interpretation

Map class W-PDEN occurs in very small, irregular or rounded polygons. Most polygons are smaller than the project minimum mapping unit (0.5 ha), but were mapped because of their distinctive signature and biological value. The signature is a very dark green, with an irregular texture created by the cottonwood tree crowns. Adjacent polygons are mapped as Basin Big Sagebrush Shrubland (#20).



Example of the photo signature for map class W-PDEN (#50) from the Square Tower Unit.

Map Class 51
Rio Grande Cottonwood / Coyote Willow Woodland
(W-PDSE)

Photo credit: NPS

W-PFSE Map Class Statistics

Type	Association
Frequency	Project polygons = 2
Area	Project area = 0.3 hectares / 0.7 acres
Average Size	Project polygons = 0.1 hectares / 0.3 acres
Proportion	0.1% of mapping area

Ecological System
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)

Associations
*Populus deltoides (*ssp. *wislizeni*, ssp. *monilifera) / Salix exigua* Woodland [CEGL002685]

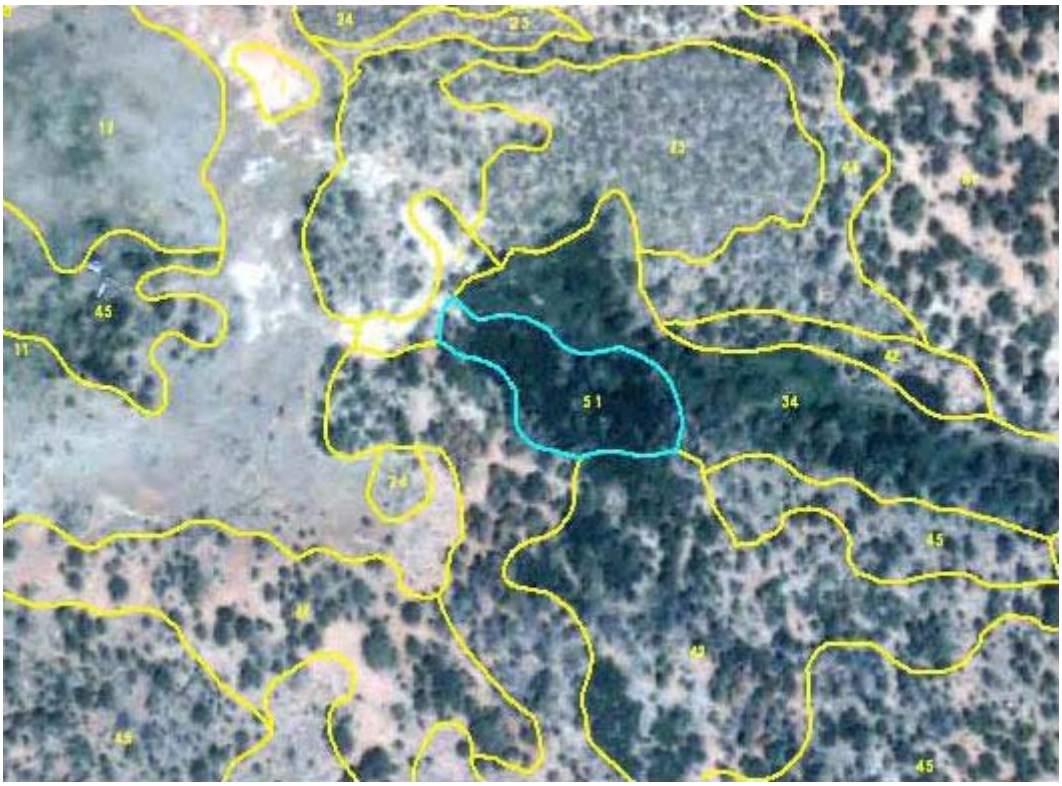
Common species
Populus deltoides ssp. *wislizeni*
Salix exigua
Cercocarpus montanus
Purshia tridentata

Distribution/Ecology/Composition

This Map Class occurs only within the Cutthroat Castle and Goodman Point units of HOVE. It is further limited to drainages where the water table remains high throughout the growing season, such as the base of pour-offs. Mature Rio Grande cottonwood form the canopy; the understory consists of a mix of riparian and upland shrubs. Coyote willow tends to dominate where water is closer to the surface, whereas mountain mahogany, Pursh's cliffrose, and pinyon pine are more common on the fringes of the community.

Interpretation

The W-PDSE map class appears as very small, rounded to somewhat elongated polygons in the heads of canyons. The signature is a uniform, very dark green or mottled dark and lighter green, with an irregular texture created by the cottonwood crowns. No bare ground is visible.



Example of the photo signature for map class W-PDSE (#51) from the Goodman Point Unit.

Map Class 2
Slickrock (unvegetated)
(G-SLIC)

Photo credit: NPS

G-SLIC Map Class Statistics

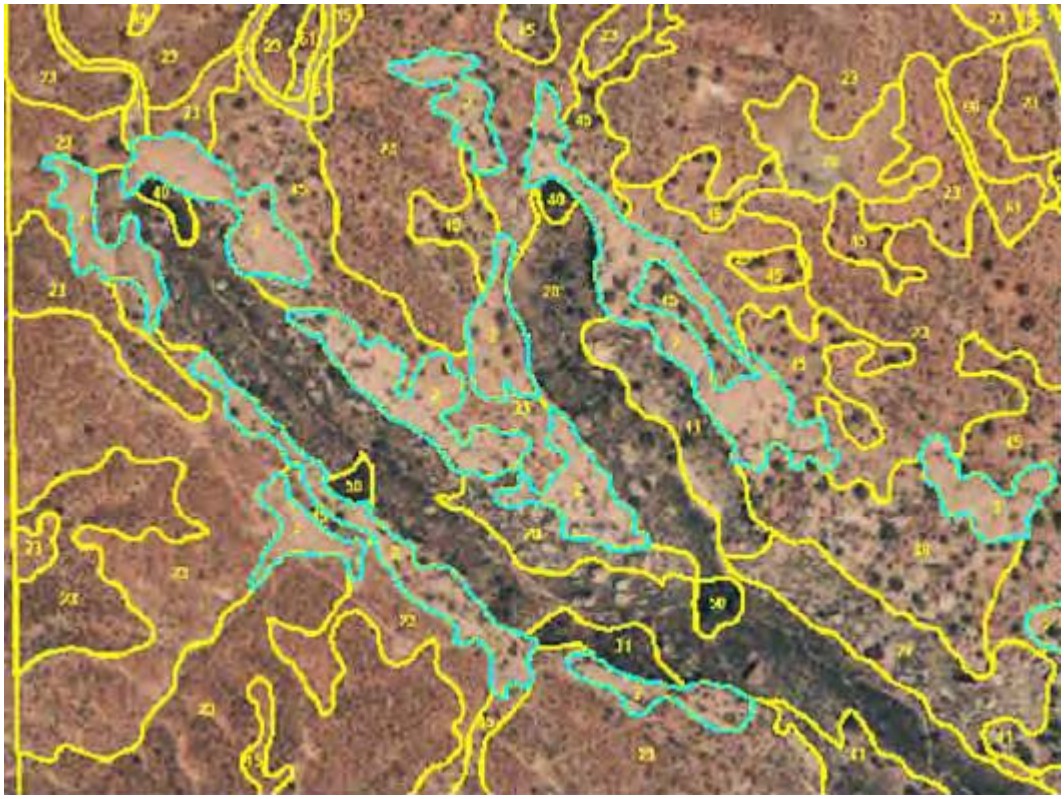
Type	Geologic
Frequency	Project polygons = 54
Area	Project area = 10.1 hectares / 25.1 acres
Average Size	Project polygons = 0.2 hectares / 0.5 acres
Proportion	3.1% of mapping area

Distribution

Small areas of unvegetated sandstone occur in all HOVE management units except Cutthroat Castle. Polygons tend to follow the rims of canyons where soils are thin, although a few cap low rises within the units. Vegetation is sparse, limited to cracks in the bedrock or small depressions where soil collects. Lichens cover much of the rock surface.

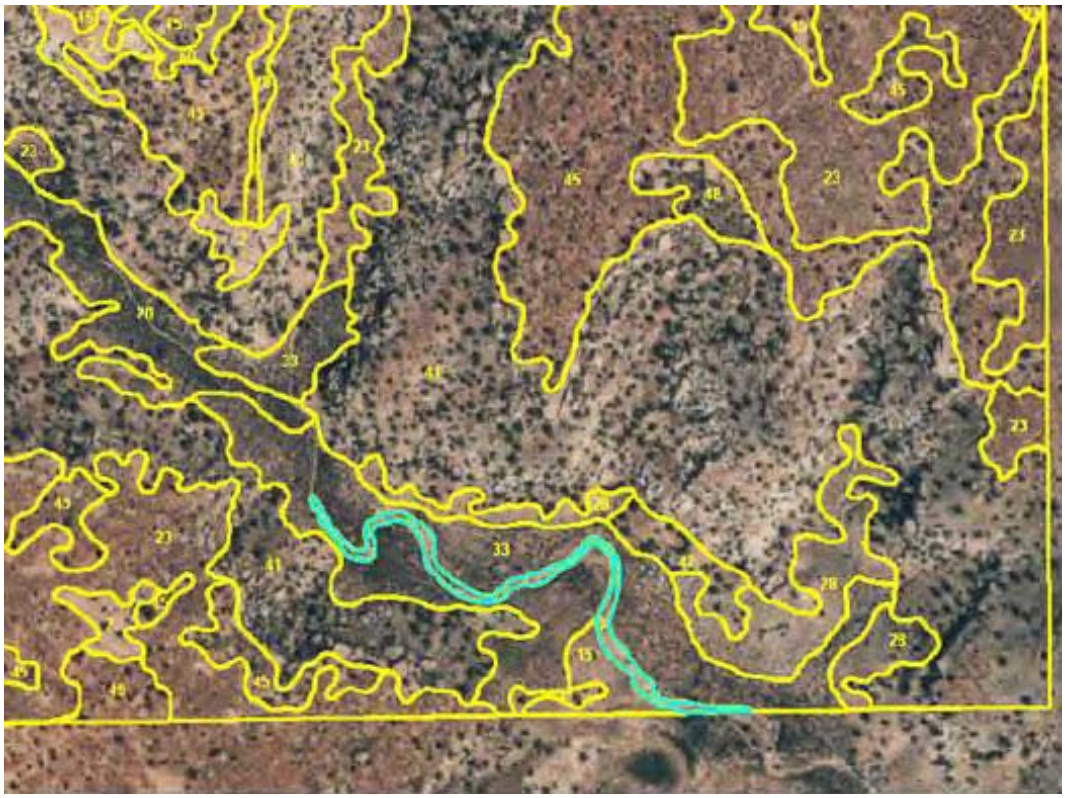
Interpretation

Polygons of this map class are generally elongated polygons following canyon rims. Most are relatively small. The signature is either a light pink, gray or tan with little texture evident. Some polygons may have scattered dark specks representing dwarfed shrubs or trees.



Example of the photo signature for map class G-SLIC (#2) from Square Tower Unit.

Map Class 3
Unvegetated Wash
(G-WASH)



Example of the photo signature for map class G-WASH (#3) from Square Tower Unit.

G-WASH Map Class Statistics

Type	Geologic
Frequency	Project polygons = 3
Area	Project area = 0.6 hectares / 1.5 acres
Average Size	Project polygons = 0.2 hectares / 0.5 acres
Proportion	0.2% of mapping area

Distribution

Polygons of this map class in most HOVE management units are too small to map; only Goodman Point and Square Tower have polygons large enough to map. All polygons are located in canyon bottoms.

Interpretation

Polygons of this map class are very small, narrow, and either straight or sinuous, depending on the shape of the drainage. The color is a very light tan with a smooth texture.

Map Class 60
Roads
(L-ROAD)

Example of the photo signature for map class L-ROAD (#60) from the Hackberry Unit.

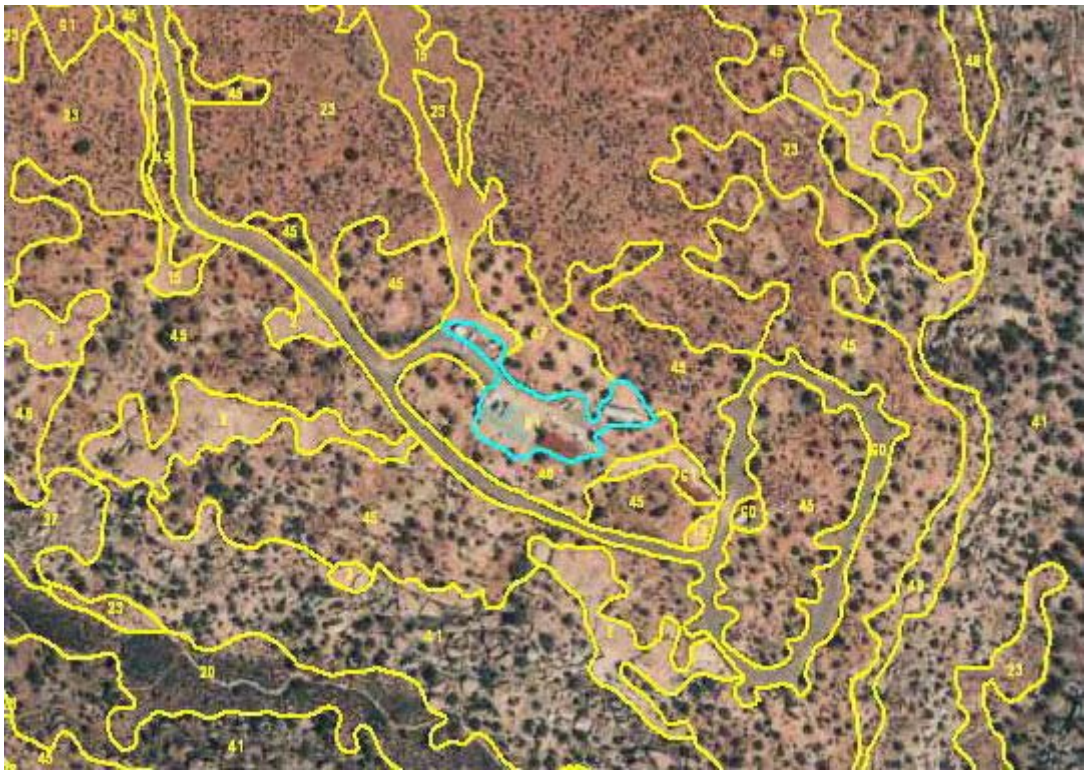
L-ROAD Map Class Statistics

Type	Land Use
Frequency	Project polygons = 6
Area	Project area = 4.2 hectares / 10.5 acres
Average Size	Project polygons = 0.7 hectares / 1.7 acres
Proportion	1.3% of mapping area

Description:

This map class includes all types of roads, including paved Monument roads and dirt access roads. It also includes adjacent related features such as pullouts, ditches, shoulders and road cuts. The typical photo signature is long, narrow sinuous polygons with smooth texture indicating pavement or graded dirt. All units of HOVE except Cajon have roads.

Map Class 61
Monument Facilities
(L-PAFA)



Example of the photo signature for map class L-PAFA (#61) from the Square Tower Unit.

L-PAFA Map Class Statistics

Type	Land Use
Frequency	Project polygons = 7
Area	Project area = 0.7 hectares / 1.7 acres
Average Size	Project polygons = 0.1 hectares / 0.24 acres
Proportion	0.2% of mapping area

Description:

This map class consists of NPS buildings and other facilities (e.g., water tanks, sewage ponds) with associated access roads, parking areas and immediate developed and undeveloped land. The signature combines regularly-shaped structures and natural vegetation. Only the Square Tower Unit has NPS facilities.

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 D-40, April 2008

National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA™