



Vegetation Classification and Distribution Mapping Report

Navajo National Monument

Natural Resource Technical Report NPS/SCPN/NRTR—2010/298



ON THE COVER

Views of vegetation-mapping plots, Navajo National Monument. Photos by Dave Wegner, EMI.

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Acronyms

ac	acres
BOR	U.S. Bureau of Reclamation
cm	centimeter(s)
F	Fahrenheit
FGDC	Federal Geographic Data Committee
ft	foot/feet
GAP	Gap Analysis Program
GIS	geographic information system
GPS	global positioning system
ha	hectare(s)
I&M	Inventory & Monitoring
in	inch(es)
km	kilometer(s)
m	meter(s)
mi	mile(s)
MMU	minimum mapping unit
NAVA	Navajo National Monument
NPS	National Park Service
NVC	National Vegetation Classification
NVCS	National Vegetation Classification Standard
SCPN	Southern Colorado Plateau Network
TNC	The Nature Conservancy
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VMP	Vegetation Mapping Program

Abstract

Navajo National Monument (NAVA) encompasses approximately 244 ha (602 ac) in northeast Arizona, and lies wholly within the Navajo Reservation. Its vegetation is represented by roughly 357 species of vascular plants in a limited set of communities. In 2005, a project was initiated to map the vegetation and develop a classification for the plant communities in the study area. This report documents those efforts.

The NAVA vegetation inventory was conducted in accordance with the following protocols and standards specified by the USGS-NPS Vegetation Mapping Program:

Nationally-defined standards

- National Vegetation Classification Standard
- Spatial Data Transfer Standard
- Metadata Standard
- Positional Accuracy
- Taxonomy

Additional program-defined standards

- Classification Accuracy
- Minimum Mapping Unit

A multi-year program was initiated to complete the vegetation mapping at Navajo National Monument, consisting of two major tasks. Phase I was the development of a classification system. Phase II was the production of a digital vegetation map.

Field data collected in 2005 were used as base information for vegetation classification. The described types fit into the National Vegetation Classification Standard (NVCS). To classify vegetation, we used 49 plots collected by Daniela Roth and David Remucal of the Navajo Natural Heritage Program, and Dave Wegner of Environmental Management International (EMI). In addition, 56 informal field observations, collected during the 2005 field season, were also consulted. These plots were compared to existing NVC types and assigned an appropriate type. From the plant alliances and associations assigned from the field data, we derived 32 vegetation map units. An additional two map units represent rivers/streams and roads/facilities.

To produce the digital map, we used 1:12,000-scale, true-color aerial photography acquired over several days in June 2004, in addition to the 2005 field plots. Both avenues were used to interpret the vegetation. All 34 map units were developed and directly cross-walked or matched to corresponding plant associations and land-use classes. All of the interpreted and remotely sensed data were converted to Geographic Information System (GIS) databases using ArcGIS© software. Draft maps were printed, reviewed, and revised.

Products developed for Navajo National Monument are described and presented in this report and stored on the accompanying CD. They include

- a final report that details the methods and results for this project
- a spatial database containing digital vegetation map, plots, accuracy assessment, and flight-line index layers
- digital photos of each vegetation type, along with representative ground photos and miscellaneous park views
- a list of associations present in the mapping area
- Federal Geographic Data Committee-compliant metadata for all spatial database coverages and field data

In addition, NAVA received copies of

- 9 × 9-inch aerial photos
- uncompressed individual digital orthophotos and a compressed compilation of digital orthophotos
- digital data files and hard-copy data sheets of the vegetation field plots and accuracy-assessment sites
- hard-copy, paper vegetation maps

For more information on the NVC standards, please go to the Federal Geographic Data Committee, National Vegetation Classification Standard website, <http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation>. More information on NVC associations in the U.S. can be found at NatureServe's website, <http://www.natureserve.org>. The U.S. Bureau of Reclamation offers numerous services and programs, and may be visited at <http://www.usbr.gov>.

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We would be remiss if we did not also acknowledge the efforts of both Mike Story and Karl Brown, National Vegetation Mapping Program, who have been managing these park vegetation mapping projects for so long now. Along with Mike and Karl are the many other scientists who produced the original protocols, and those who have been in the field applying these techniques to projects for many years. These previous efforts have raised the bar each time. We have learned much from the earlier projects and it is our distinct pleasure to have added to them. New technologies and lessons learned have, we hope, produced a finer product.

1 Introduction

1.1 Background

1.1.1 USGS-NPS Vegetation Mapping Program

In 1994, the U.S. Geological Survey (USGS) and National Park Service (NPS) formed a partnership to map U.S. national parks using the National Vegetation Classification (NVC) (TNC and ESRI 1994a). The goals of the USGS-NPS Vegetation Mapping Program (VMP) are to provide baseline ecological data for park resource managers, create data in a regional and national context, and provide opportunities for future inventory, monitoring, and research activities (FGDC 1997, Grossman et al. 1998, <http://biology.usgs.gov/npsveg/index.html>).

Central to fulfilling the goals of this national program is the use of the NVC as the standard vegetation classification. This classification is based upon current vegetation; uses a systematic approach to classify vegetation communities across environmental continuums; emphasizes natural and existing vegetation; uses a combined physiognomic-floristic hierarchy; identifies vegetation units based on both qualitative and quantitative data; and is appropriate for mapping at multiple scales.

The use of NVC and mapping protocols facilitates effective resource stewardship by ensuring compatibility and widespread use of the information throughout the NPS as well as by other federal and state agencies. These vegetation maps and associated information support a wide variety of resource-assessment, park-management, and planning needs, and provide a structure for framing and answering critical scientific questions about vegetation communities and their relationship to environmental processes across the landscape.

The NVC has primarily been developed and implemented by The Nature Conservancy (TNC) and the network of Natural Heritage Programs over the past 20 years (Grossman et al. 1998). Currently, the NVC is maintained and updated by NatureServe. Additional support has come from federal agencies, the Federal Geographic Data Committee (FGDC), and the Ecological Society of America. Refinements to the classification occur in the application process, leading to ongoing proposed revisions that are reviewed both locally and nationally. NatureServe has made available

a two-volume publication presenting the standardized classification. This document provides a thorough introduction to the classification, its structure, and the list of vegetation types found across the United States as of April 1997 (Grossman et al. 1998). This publication can be found on the Internet at <http://www.natureserve.org/publications/library.jsp>.

NatureServe has since superseded Volume II (the classification listing) with an online database server that provides regular updates to ecological communities in the U.S. and Canada. NatureServe Explorer® can be found on the Internet at <http://www.natureserve.org/explorer>.

1.1.2 Navajo National Monument vegetation mapping project

The decision to map the vegetation at Navajo National Monument (NAVA) as part of the VMP was made in response to the NPS Natural Resources Inventory and Monitoring (I&M) Program Guidelines issued in 1992. The vegetation mapping portion of the I&M program recognizes the need for the parks to spatially analyze vegetation at a scale that is fine enough to facilitate the prediction of outcomes relative to various management issues.

In 2005, the Southern Colorado Plateau Network (SCPN) initiated this project by requesting the U.S. Bureau of Reclamation's Remote Sensing and Geographic Information Group to undertake mapping of NAVA.

Our objectives were to produce final products consistent with the following standards mandated by the USGS-NPS National Vegetation Mapping Program:

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

The products derived from these efforts include:

Spatial data

- Aerial photography
- Map classification/descriptions
- Spatial database of vegetation communities
- Hard-copy maps of vegetation communities
- Metadata for spatial databases

Vegetation information

- Vegetation classification
- Formal description for each vegetation class
- Ground photos of vegetation classes
- Field data in database format

1.2 Scope of work

Vegetation at NAVA was mapped and classified through a combination of new field data and aerial photointerpretation. The protocols and standards used are described in the USGS-NPS program documents (TNC and ESRI (1994b) for small parks. In 2005, the SCPN contracted the U.S. Bureau of Reclamation (BOR) to map approximately 1,000 ha (~2,400 acres) of NAVA and a 0.5-km environs buffer. However, field reconnaissance included only the area within the park boundary.

1.3 The National Vegetation Classification Standard

In 1994, the VMP adopted the U.S. National Vegetation Classification (TNC and ESRI 1994a and

1994b, Grossman et al. 1998) as a basis for the *a priori* definition of vegetation units to be inventoried. The FGDC adopted a modified version of the upper (physiognomic) levels as a federal standard (FGDC-STD-005; FGDC 1997), hereafter termed the National Vegetation Classification Standard (NVCS).[†] The NVCS established a federal standard for a complete taxonomic treatment of vegetation in the U.S. at physiognomic levels. It also established conceptual taxonomic levels for the floristic units of alliance and association, largely following the NVC, but did not offer a taxonomic treatment for the floristic levels because of the immense scope of establishing robust floristic units for the entire U.S. Table 1.3 identifies the seven levels of the NVC and depicts their placement in the hierarchical relationship (Maybury 1999).

The FGDC standard requires that federally funded vegetation classification efforts collect data in a manner that enables cross-walking the data to the NVCS (i.e., the physiognomic levels) and sharing among agencies, but does not require that agencies use that standard for internal mission needs. NatureServe maintains a treatment of floristic units (alliances and associations) that, though not a federal standard, is used for classification and mapping units by the VMP whenever feasible. For purposes of this document, the federal standard (FGDC 1997) is denoted as the NVCS; the NVC will refer exclusively to NatureServe's treat-

[†] The VMP standards refer to the National Vegetation Classification Standard (also NVCS). Because of nomenclatural and acronym confusion with the federal (FGDC) National Vegetation Classification Standard, the VMP no longer uses this term.

Table 1.3. Summary of the National Vegetation Classification Standard hierarchical approach.

Level	Primary basis for classification	Example
Class	Structure of vegetation	Woodland
Subclass	Leaf phenology	Evergreen woodland
Group	Leaf types, corresponding to climate	Temperate or subpolar needle-leaved evergreen woodland
Subgroup	Relative human impact (natural/semi-natural, or cultural)	Natural/semi-natural
Formation	Additional physiognomic and environmental factors, including hydrology	Saturated temperate or subpolar needle-leaved evergreen woodland
Alliance	Dominant/diagnostic species of the uppermost or dominant stratum	Longleaf pine (slash pine, pond pine) saturated woodland alliance
Association	Additional dominant/diagnostic species from any strata	Longleaf pine/little gallberry/carolina wiregrass woodland

Source: Maybury 1999.

ment for vegetation floristic units treatment (alliances and associations only).

Alliances and associations are based on both the dominant (greatest-canopy-cover) species in the upper strata of a stand and on diagnostic species (those consistently found in some land-cover types but not others). Associations are the most specific classification, and are hierarchically subsumed in alliances. Typically, each association is included in only one alliance, while each alliance may include many associations. Alliance names are generally based on the dominant/diagnostic species in the uppermost stratum of the vegetation, though up to four species may be used, if necessary, to define the type. Associations define distinct plant compositions that repeat across the landscape, and are generally named using both the dominant species in the uppermost stratum of the vegetation and one or more dominant species in lower strata (or a diagnostic species in any stratum). Documentation from NatureServe (2005) describes the naming conventions and syntax for all NVC names:

- A hyphen with a space on either side (-) separates names of species occurring in the same stratum.
- A slash with a space on either side (/) separates names of species occurring in different strata.
- Species that occur in the uppermost stratum are listed first, followed successively by those in lower strata.
- Order of species names generally reflects decreasing levels of dominance, constancy, or indicator value.
- Parentheses around a species name indicate the species is less consistently found either in all associations of an alliance, or in all occurrences of an association.
- Association names include the dominant species of the significant strata, followed by the class in which they are classified (e.g., Forest, Woodland, or Herbaceous).
- Alliance names also include the classification type (e.g., Forest, Woodland, or Herbaceous), but are followed by the word “Alliance” to distinguish them from associations.

The species nomenclature for all alliances and associations follows Kartesz (1999).

Examples of association names from NAVA:

- *Atriplex canescens* / *Sporobolus airoides* Shrubland
- *Quercus gambelii* / *Symphoricarpos oreophilus* Shrubland
- *Pinus edulis* - *Juniperus osteosperma* / *Shepherdia rotundifolia* Woodland

Examples of alliance names from NAVA:

- *Atriplex canescens* Shrubland Alliance
- *Quercus gambelii* Shrubland Alliance
- *Pinus edulis* - (*Juniperus* spp.) Woodland Alliance

For more information on the NVC, see the USGS-NPS Vegetation Mapping Program standards (<http://biology.usgs.gov/npsveg/standards.html>) or Grossman et al. (1998).

In addition to the NVC, NatureServe has created a standardized Ecological Systems Classification for describing sites, based on both vegetation and the ecological processes that drive it. Ecological systems are mid-scale biological communities that occur in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding. They are not conceptually a unit within the NVC, but are rather a vegetation mapping concept. However, NVC associations occur within ecological systems. An association may occur in any number of ecological systems, limited only by the range of ecological settings in which that association occurs. Ecological systems are broad-scale, and can embody any number of highly specific associations that might be found in a particular setting.

1.4 Natural Heritage Program methodology and element ranking

The Arizona Natural Heritage Program’s Heritage Data Management System (HDMS) is a member of the NatureServe Network of Natural Heritage Programs and Conservation Data Centers. These programs and data centers are located in all U.S. states and Canadian provinces. Each program serves as that state’s biological-diversity data center, gathering information and field observations to help develop national and statewide conservation priorities.

The multi-disciplinary team of scientists, planners, and information managers at the heritage programs uses a standardized methodology to gather information on the rare, threatened, and

endangered species and significant plant communities that occur in each state. The species and plant communities for which each program maintains data are referred to as “elements of natural diversity” or, simply, “elements.” Life history, status, and locational data are regularly updated in a comprehensive shared data system. Sources of element data include published and unpublished literature, museum and herbaria labels, and field surveys conducted by knowledgeable naturalists, experts, agency personnel, and the heritage program staff of botanists, ecologists, and zoologists.

1.4.1 The Natural Heritage ranking system

The cornerstone of natural heritage methodology is the use of a standardized element-imperilment ranking system. Ranking species and ecological communities according to their imperilment status provides guidance for where natural heritage programs should focus their information-gathering activities and provides data users with a con-

cise, meaningful decisionmaking tool.

To determine the status of an element within Arizona, HDMS gathers information on plants, animals, and plant communities. Each of these elements of natural diversity is assigned a rank that indicates its relative degree of imperilment on a five-point scale (1 = critically imperiled, 5 = demonstrably secure). The criteria used to define the element-imperilment rank are number of occurrences, size of population, and quality of population. The primary criterion is the number of occurrences (i.e., the number of known distinct localities or populations). This factor is weighted more heavily than other factors because an element found in only one place is more imperiled than something found in, say, 21 places. Also important are the size of the geographic range, the number of individuals, the trends in both population and distribution, identifiable threats, and the number of protected occurrences.

Table 1.4.1. Definition of natural heritage imperilment ranks.

Rank	Status	Scale/Description
G1/S1	Critically imperiled	Globally/state because of rarity (5 or fewer occurrences in the world/state; or 1,000 or fewer individuals), or because some factor of its biology makes it especially vulnerable to extinction.
G2/S2	Imperiled	Globally/state because of rarity (6–20 occurrences, or 1,000–3,000 individuals), or because other factors demonstrably make it very vulnerable to extinction throughout its range.
G3/S3	Vulnerable	Through its range or found locally in a restricted range (21–100 occurrences, or 3,000–10,000 individuals).
G4/S4	Apparently secure	Globally/state, though it may be quite rare in parts of its range, especially at the periphery. Usually more than 100 occurrences and 10,000 individuals.
G5/S5	Demonstrably secure	Globally/state, though it may be quite rare in parts of its range, especially at the periphery.
GX/SX	Presumed extinct	Globally, or extirpated within the state.
G#?		Indicates uncertainty about an assigned global rank.
GU/SU		Unable to assign rank due to lack of available information.
GQ		Indicates uncertainty about taxonomic status.
GH/SH		Historically known, but usually not verified for an extended period of time.
G#T#		Trinomial rank (T) is used for subspecies or varieties. These taxa are ranked on the same criteria as G1–G5.
SA		Accidental in the state.
SE		Exotic species.
SNR		Needs review.
SR		Reported to occur in the state but unverified.
S?		Unranked. Some evidence that species may be imperiled, but awaiting formal rarity ranking.

Note: Where two numbers appear in a state or global rank (for example, S2S3), the actual rank of the element is uncertain, but falls within the stated range.

Element-imperilment ranks are assigned both in terms of the element's degree of imperilment within Arizona (its state-, or S-rank) and the element's imperilment over its entire range (its global-, or G-rank). Taken together, these two ranks indicate an element's degree of imperilment. For example, the gray catbird (*Dumetella carolinensis*), thought to be secure in northern North America, but critically imperiled in Arizona, is ranked G5 S1 (globally secure, but critically imperiled in this state). The little princess agave (*Agave parviflora*) is ranked G3 S3 (vulnerable both in the state and globally). Further, Santa Rita mountain yellowshow (*Amoreuxia gonzalezii*) is ranked G1 S1 (critically imperiled both in the state and globally). HDMS actively collects, maps, and electronically processes specific occurrence information for animal and plant species considered extremely imperiled-to-vulnerable in the state (S1–S3). Certain elements are “watchlisted,” meaning that specific occurrence data are periodically analyzed to determine whether more active tracking is warranted. A complete description of each natural heritage rank is provided in Table 1.4.1.

1.5 Project area

1.5.1 Location and regional setting

Navajo National Monument lies in northeast Arizona and completely within the Navajo Indian Reservation. The monument comprises three separate units. The Inscription House unit (16 ha; 39 acres) lies within Coconino County, while the Betatakin (164 ha; 406 acres) and Keet Seel units (64 ha; 158 acres) are in Navajo County. U.S. Highway 160, to the south, provides access to all units. The closest town is Kayenta, about 42 km (26 mi) from the Betatakin and Keet Seel units and about 84 km (52 mi) from the Inscription House unit (Figure 1.5.1). Park headquarters are located within the Betatakin unit, on the Shonto Plateau.

1.5.2 Climate and weather

With elevations ranging from 1,646 to 2,225 m (5,400–7,300 ft) in NAVA's three administrative units, winters can be cold, snowy, and windy. Summers are warm-to-hot, with average temperatures in the low-to-mid 80s (°F) and a record

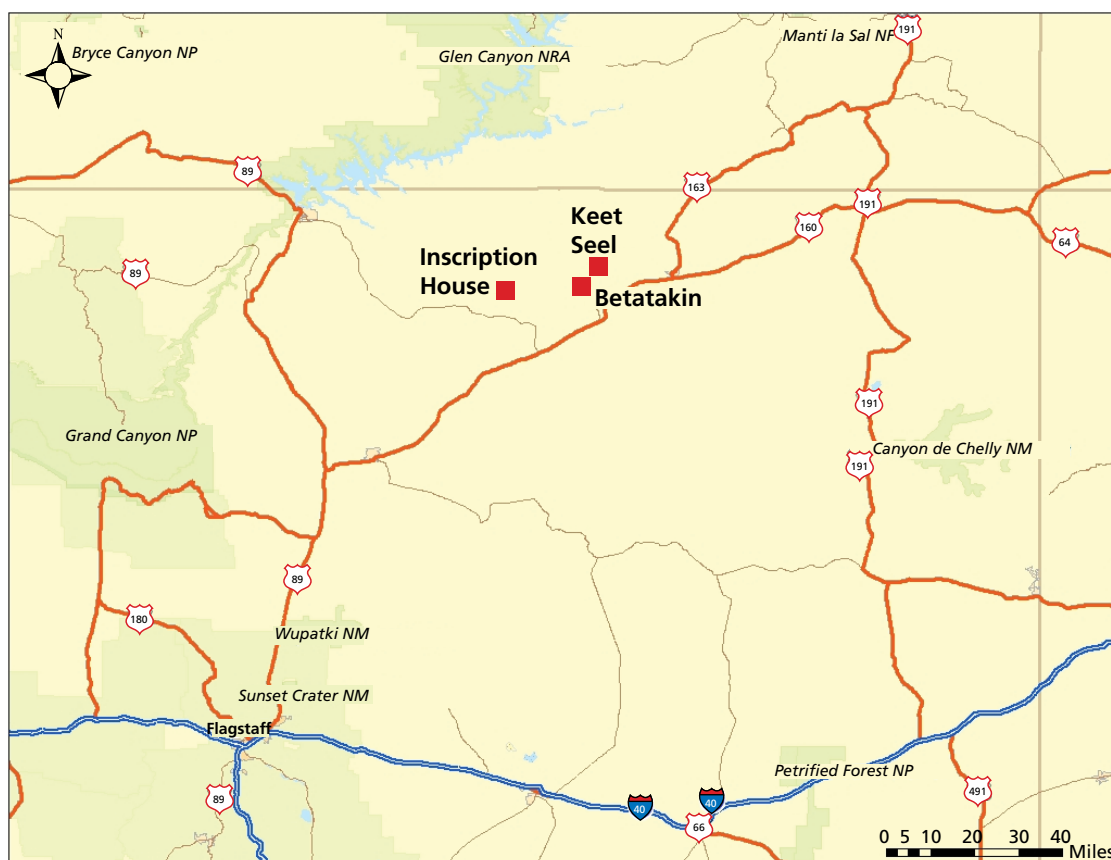
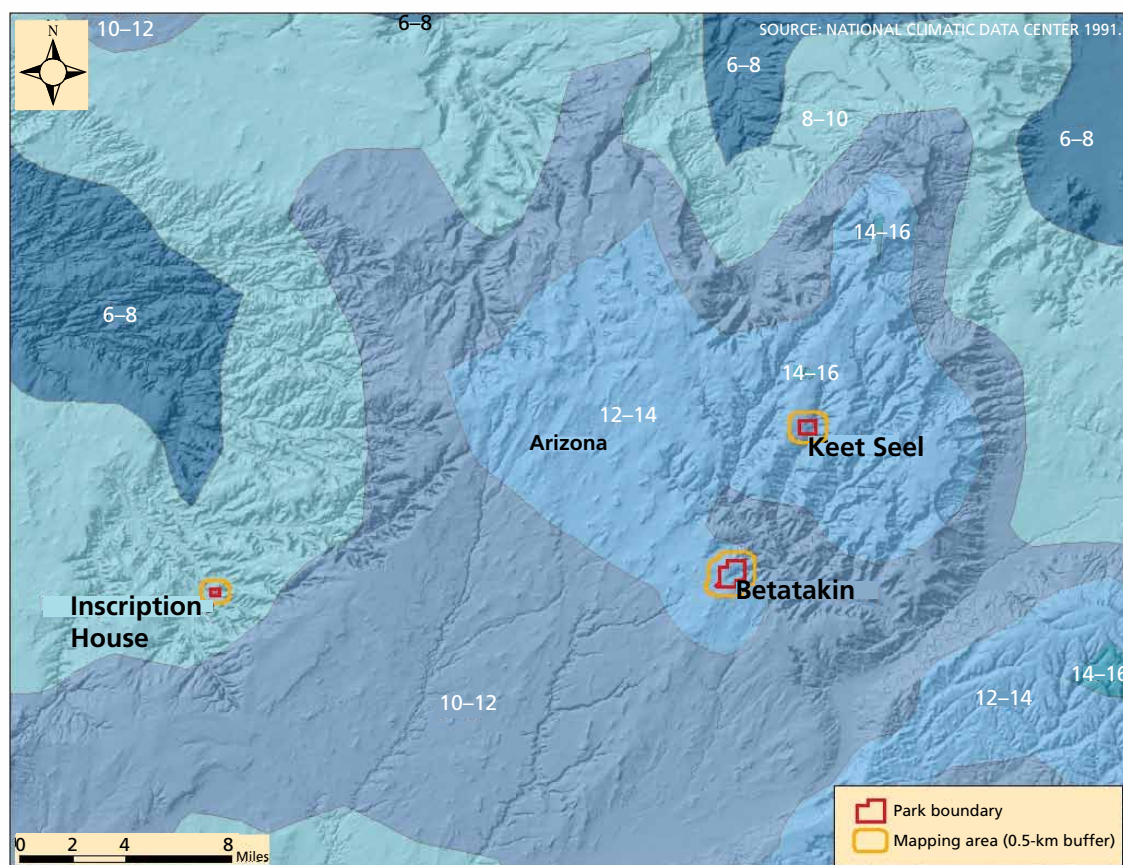


Figure 1.5.1. Location map for Navajo National Monument.

Figure 1.5.2.
Precipitation
(in) for
northern
Arizona,
1961–1990.



high of 101°F. The warmest month is July, with an average high temperature of 85°F and low temperature of 58°F. The coldest months are typically December and January, with average lows of 21–22°F, and a record low of –14°F (<http://www.weather.gov/climate/xmacis.php?wfo=fgz>). Thunderstorms in July and August bring rain, wind, and flash-flooding in the canyons. Spring and fall can be pleasant, but occasionally blustery. Average precipitation (snowmelt and rain) is 30–36 cm (12–14 in) per year for the Betatakin and Keet Seel units and 20–26 cm (8–10 in) per year for the Inscription House unit (NCDC 1991; Figure 1.5.2). The frost-free season ranges from 107 to 213 days, with an average of 155 days (Brotherston et al. 1983).

1.5.3 Topography

The study areas are located in the Four Corners region, between the mountains of Colorado and Utah and the low deserts of Arizona and New Mexico. The area is part of the Colorado Plateau Semi-Desert physiographic province. The mapping area is in the Navajo Canyonlands section containing the Shonto Plateau, which surrounds the canyon systems that make up Navajo Na-

tional Monument. Geomorphic processes once active in this area are evident in the deep canyon formations, the result of plateau dissection. Volcanic mountains exist in this section, but block-fault structural mountain ranges do not. Major landforms include canyonlands, plateaus, plains, and hills (<http://www.fs.fed.us/land/pubs/ecoregions/ch36.html>) (Figure 1.5.3). The road leading to park headquarters follows the Organ Rock Monocline, which lies north of U.S. Highway 160 and tilts the Navajo Sandstone layers that lie beneath Black Mesa sharply up, exposing them as the Shonto Plateau and Skeleton Mesa.

To the south of the mapping area is Black Mesa, a prominent mesa that extends well to the south. The Keet Seel structures lie at the head of Keet Seel Canyon, and the Betatakin structures above Laguna Creek. Inscription House is located at the headwaters of Navajo Creek. Both the Betatakin and Keet Seel structures are part of Tsegi Canyon. Laguna Creek meets with the Chinle Wash, eventually draining into the San Juan River at Mexican Hat, Utah. Navajo Creek drains into Lake Powell to the north. All eventually become part of the greater Colorado River drainage. Elevations for the Betatakin mapping area range from 2,011

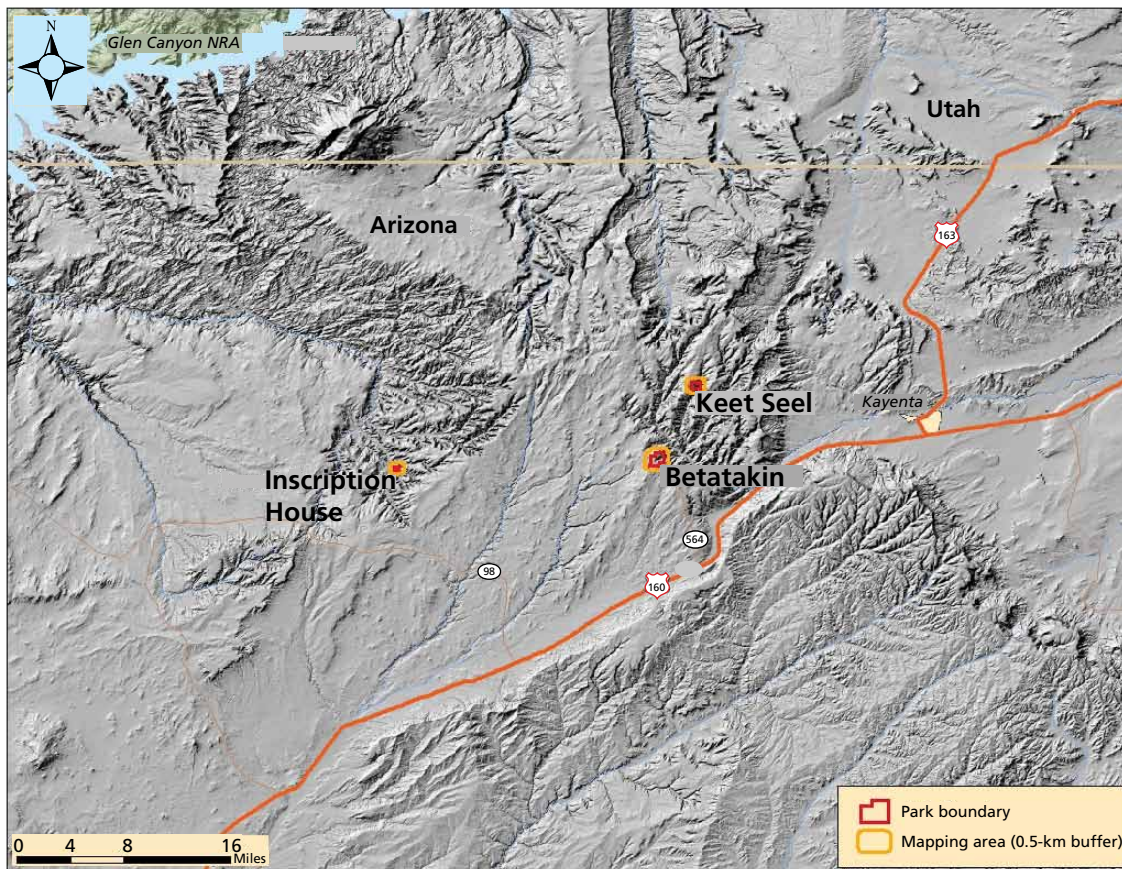


Figure 1.5.3. Topography of Navajo National Monument and surrounding region.

to 2,221 m (6,600–7,286 ft). Keet Seel elevations range from 2,011 to 2,317 m (6,600–7,600 ft). Inscription House is considerably lower, ranging from 1,661 to 2,011 m (5,450–6,600 ft).

1.5.4 Geology

Various geological formations intersect the three units of NAVA (Figure 1.5.4). However, Navajo Sandstone, part of the Glen Canyon Group, is by far the most common formation in each unit. The color is characteristic, and varies from reddish-orange to grayish-orange throughout its range. The Navajo Sandstone forms tall, vertical cliffs in all three units, and has incorporated huge sand dunes of Jurassic and/or Triassic age, though the actual dating of the Navajo Sandstone remains unclear (<http://3dparks.wr.usgs.gov/coloradoplateau/lexicon/navajo.htm>). At the base of the cliffs, one finds a variety of talus accumulations. Occasional pink and grey lenses of freshwater limestone are interbedded with the Navajo Sandstone. These limestone lenses were probably formed by ephemeral ponds in interdunal areas. The highest hills near the visitor center at Betatakin are capped with these freshwater limestones.

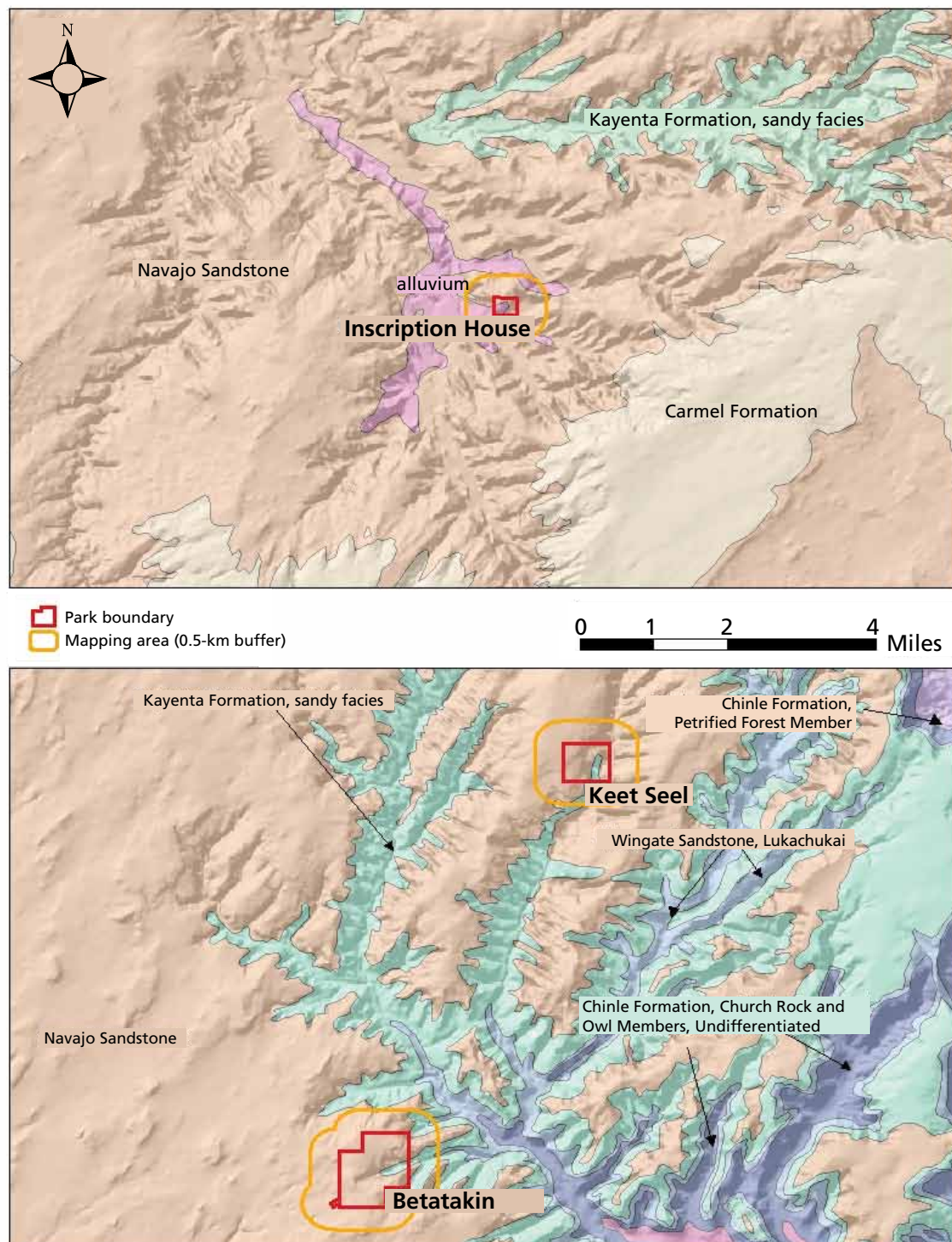
The valley bottoms have various types of quaternary deposits. Both Keet Seel and Nitsin canyons are deeply eroded; Betatakin Canyon is less so.

Underlying the Navajo Sandstone is the Kayenta Formation, which is deeply eroded and is characteristic of the entire Tsegi Canyon (Brotherson et al 1978). In the vicinity of NAVA, this formation varies in thickness from 0 to 38 m (0–125 ft). The Kayenta Formation is mostly sandstone, with some interbedded shale and, occasionally, limestones and conglomerate. Outcrops of this formation may be seen below the Betatakin structures and along the trail to Keet Seel (Vandiver 1936).

Below the Kayenta Formation is the Wingate Sandstone, which is another formation derived from ancient dune fields. The Lukachukai Member of the Wingate Formation is represented in the park. This formation may be observed below the Betatakin structures and in the Tsegi and Navajo canyons (Vandiver 1936).

Below the Wingate Formation is the Chinle Formation, well-known throughout the Southwest for its characteristic shrinking and swelling. There are two dominant members of the Chinle

Figure 1.5.4.
Geologic formations in
the immediate
vicinity
of Navajo
National
Monument.



present in the park; the upper Church Rock Member overlies the Owl Rock Member. A small portion of the lower Petrified Forest Member is visible above the Tsegi Hotel. The Church Rock Member is the uppermost member of the Chinle Formation. It is uniformly brownish-red, and composed of siltstone, mudstone, and thin-to-medium beds of very fine-grained sandstone and silty sandstone. The Owl Creek Member is composed of reddish-brown siltstone and mudstone, in addition to lesser amounts of claystone and limestone. These beds will typically form ledges and cuestas due to their resistance to erosion (Beaumont and Dixon 1964).

The Navajo, Kayenta, and Wingate formations collectively form the Glen Canyon Group. Only the Navajo Sandstone is visible at the Inscription House structures.

The alluvial deposition and erosion of Tsegi Canyon has been described by Hack (1945) as encompassing three distinct periods: the Jeddito Formation (pre-3500 BC), overlaid by the Tsegi Formation (3500 BC–1300 AD), in turn overlaid by the Naja Formation (1450–1880 AD). An erosional environment has occurred since the late 1880s. Vandiver (1936) reported that as recently as the late 1800s, there may have been swamps and lakes in the Marsh Pass area (at the confluence of Tsegi Canyon and Long House Valley [Laguna Creek]) that have since been drained. Reports by Gregory (1917) and Rothman (1991), recounting stories told by the Richard Wetherill family, also confirmed the accounts of a chain of lagoons that were later drained by arroyo-downcutting in the early 1900s. Vandiver also reported an

extensive series of lakes in both Tsegi (*sic*) and Keet Seel canyons. Sands, gravels and clays have been deposited in regular beds up to 18 m [60 ft] or more in thickness. The trail leading from Be-

tatakin to Keet Seel shows a remarkable development of this formation. The remains of plants and pollen together with the presence of fresh water shells buried in these beds have led geologists to believe that lakes were depositing their sediments from the Pleistocene to Recent times.

These Pleistocene formations typically cover the Wingate Formation and, occasionally, the Chinle Formation.

In the Tsegi Canyon area, the Organ Rock Monocline extends from a point just north of the San Juan River, in southern Utah, to about 48 km (30 mi) southeast of Tsegi Canyon (Beaumont and Dixon 1964). North of the monocline is the Tsegi Syncline, which plunges southward.

1.5.5 Wildlife

Various fauna inhabit the region around NAVA. Table 1.5.5 shows the various faunal types that the U.S. Forest Service has identified as occurring in the Colorado Plateau Semi-Desert Province, which encompasses Arizona, New Mexico, and Utah, and covers approximately 195,000 km² (USFS 2005).



Figure 1.5.5.
Horned lizard.

Table 1.5.5. Common fauna of the Colorado Plateau Semi-Desert Province.

Mammals	mule deer, mountain lion, coyote, bobcat, elk, pronghorn, blacktail jackrabbit, Colorado chipmunk, rock squirrel, wood rat, white-footed mouse, cliff chipmunk, cottontail, porcupine, gray fox, ringtail, spotted skunk
Birds	Resident: bushtit, pinyon jay, plain titmouse, black-chinned hummingbird, Woodhouse's jay, red-tailed hawk, golden eagle, red-shafted flicker, rock wren Summering: chipping sparrow, nighthawk, black-throated gray warbler, northern cliff swallow, lark sparrow, mourning dove Wintering: pink-sided junco, Shufeldt's junco, gray-headed junco, red-backed junco, Rocky Mountain nuthatch, mountain bluebird, robin, Steller's jay, turkey
Reptiles	horned lizard (see Figure 1.5.5), collared lizard, rattlesnake

Additional descriptions of regional wildlife were provided by Woodbury (1963), who reported an extensive list of animal species including birds, reptiles, mammals, and invertebrates. Brotherson and Fairchild (1977) also included a list of birds, mammals, reptiles, and amphibians in their report. More recent work by Mikesic (2004) and Haymond and Sherwin (2005) reported on inventories of reptile, amphibian, and mammal species.

1.5.6 Vegetation

The vegetation within the project area has been classified as a number of different types, depending upon the scale and the author. At broad, regional scales, using the ecoregion concepts of Omernik (1987) and Bailey (1995), NAVA is described as either Arizona/New Mexico Plateau ecoregion *sensu* Omernik (1987) (Figure 1.5.6-1) or the Navajo Canyonlands section of the Colorado Plateau Semi-Desert Province ecoregion, *sensu* Bailey (1995) (Figure 1.5.6-2; see box), (<http://www.nationalatlas.com/natlas>). Bailey's map was created at a scale of 1:7,500,000; therefore, at the scale of this project, the boundaries of the ecoregions must be considered to be estimates. Kearny and Peebles (1969) described most of northeastern Arizona, except for higher mountains and mesas, as Great Basin Microphyll Desert. The Inscription House unit fits this description, while the Betatakin and Keet Seel units are more similar to the Western Xeric Evergreen Forest Type, and perhaps include a relict portion of the Northern Mesic Evergreen Forest type.

A more detailed map of Arizona (Arizona GAP Analysis) shows the Betatakin and Keet Seel units in the Great Basin Conifer Woodland-Pinyon Juniper Series, with the Inscription House unit divided between the Great Basin Desert Scrub-Mixed Scrub Series, the Great Basin Scrub-Mixed Bunch-grass Series, and the Plains-(Shrub-Grass) Disclimax Series) (Figure 1.5.6-3) (<http://sdrsnet.snr.arizona.edu/index.php?page=datamenu&lib=0&sublib=5>). Another regional map, developed by Brown et al. (1983; Figure 1.5.6-4), shows the Betatakin and Keet Seel units within the Great Basin Conifer Woodland type, with the Inscription House unit within the Great Basin Desert Scrub type. The Great Basin Conifer Woodland has

only the Pinyon-Juniper Series. The Great Basin Scrub type has a number of series types, including shadscale, sagebrush, blackbrush, winterfat, mixed scrub, and saltbush.

Previous botanical investigations include Flowers (1963) and Woodbury (1963). Flowers briefly described the dominant flora in and around Betatakin Canyon, but the focus of the book was the lichens and mosses of Betatakin Canyon and vicinity. Woodbury (1963) provided an overview and recommendations for interpretive topics.

More detailed investigations were conducted during the 1970s and 1980s, primarily by J. D. Brotherson and S. R. Rushforth. Brotherson et al. (1978), who studied the flora of NAVA, reported 293 species representing 177 genera, 68 families, and 12 plant communities. The flora was physiognomically divided as follows: Forbs, 60%; Shrubs, 16%; Grasses, 12%; and Trees, 5%. By far the greatest diversity was found in Betatakin Canyon, with 223 species observed and, of those, 123 specific to the canyon. Brotherson et al. attributed this greater species diversity to the habitat variability of the canyon, and the amount of time that area has excluded grazing and other anthropogenic disturbances. The 12 communities identified are listed in Table 1.5.6, along with their locations and abundance.

Table 1.5.6. Vegetative communities (associations) encountered within the boundaries of Navajo National Monument and the percent of area they occupy.

Vegetation type	% of area covered		
	Inscription House	Keet Seel	Betatakin
Streamside-tree	1.5	12.6	
Slickrock-scattered shrub	35.0	12.6	
Atriplex-grass	25.9	0.2	
Talus slope	11.3	9.3	
Mixed weed		13.5	
Pinyon-juniper mixed shrub	26.0	59.6	43.5
Oak		4.8	2.4
Hanging garden		Trace	Trace
Pinyon-juniper sage			49.9
Pinyon-juniper grass			3.1
Douglas fir			0.1
Aspen			7

Source: Brotherson et al. 1978



Figure 1.5.6-1. Regional view of Omernik's ecoregions.

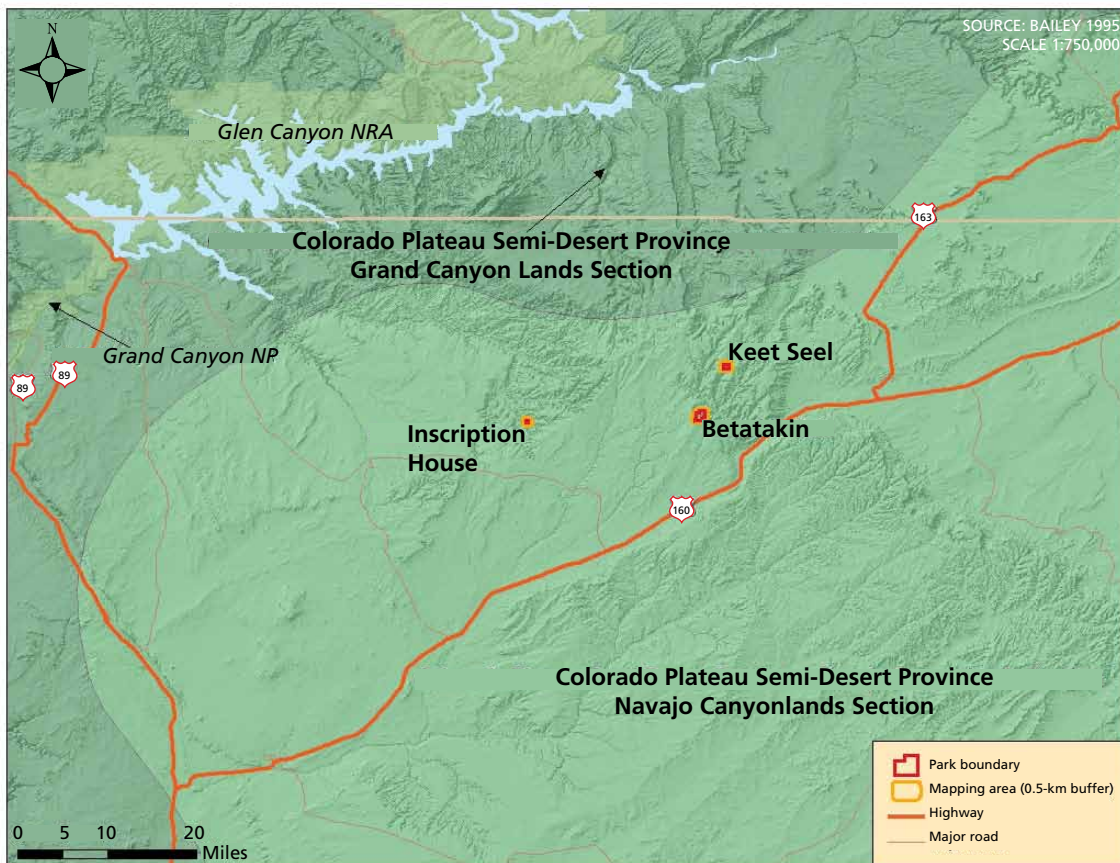


Figure 1.5.6-2. Regional view of Bailey's ecoregions.

Ecoregions of Navajo National Monument

Ecoregions (Omernik 1987)

Ecoregion Code: 22

Name: Arizona/New Mexico Plateau

Description: The Arizona/New Mexico Plateau represents a large transitional region between the semiarid grasslands and low-relief tablelands of the Southwestern Tablelands ecoregion in the east, the drier shrublands and woodland covered higher relief tablelands of the Colorado Plateau in the north, and the lower, hotter, less-vegetated Mojave Basin and Range in the west and Chihuahuan Desert in the south. Higher, more forest-covered, mountainous ecoregions border the region on the northeast and southwest. Local relief in the region varies from a few meters on plains and mesa tops to well over 300 m along tableland side slopes.

Ecoregions (Bailey 1995)

Domain: Dry Domain

Division: Tropical/Subtropical Steppe Division

Province: Colorado Plateau Semi-Desert Province

Land-surface form: The Colorado Plateau Province consists of tablelands with moderate-to-considerable relief in Arizona, New Mexico, and Utah. Elevations of the plateau tops range from 5,000 to 7,000 ft (1,500–2,100 m), with local relief ranging from 500 to more than 3,000 ft (150–900 m) in some of the deeper canyons that dissect the plateaus, such as the Grand Canyon of the Colorado River. In some areas, volcanic mountains rise 1,000 to 3,000 ft (300–900 m) above the plateau surface. Stream valleys are narrow and widely spaced. The Colorado River, which crosses the northern part of the province, is the region's only large stream. Many other streams flow year-round, but the volume of water fluctuates considerably.

Vegetation: Vegetational zones are conspicuous but lack uniformity. In the lowest zone, there are arid grasslands, but the shortgrass sod seldom covers the ground completely, leaving many bare areas. Xeric shrubs often grow in open stands among the grasses, and sagebrush is dominant over extensive areas. A profusion of annuals and perennials blooms during the summer rainy season. At low elevations in the south, several kinds of cactus and yucca are common. Cottonwoods and, more rarely, other trees grow along some of the permanent streams.

The woodland zone is the most extensive, dominated by open stands of two-needle pinyon pine and several species of juniper, often termed a pygmy forest. Between the trees, the ground is sparsely covered by grama, other grasses, herbs, and various shrubs, such as big sagebrush and alderleaf cercocarpus.

The montane zone extends over considerable areas on the high plateaus and mountains, but it is much smaller in area than the pinyon-juniper zone. Vegetation in the montane zone varies considerably from area to area. In the south, especially in Arizona, ponderosa pine is the dominant forest tree. Douglas-fir is associated with ponderosa pine or else grows in more sheltered locations or at higher elevations. In Utah, by contrast, lodgepole pine and aspen are dominant.

Section: Navajo Canyonlands Section

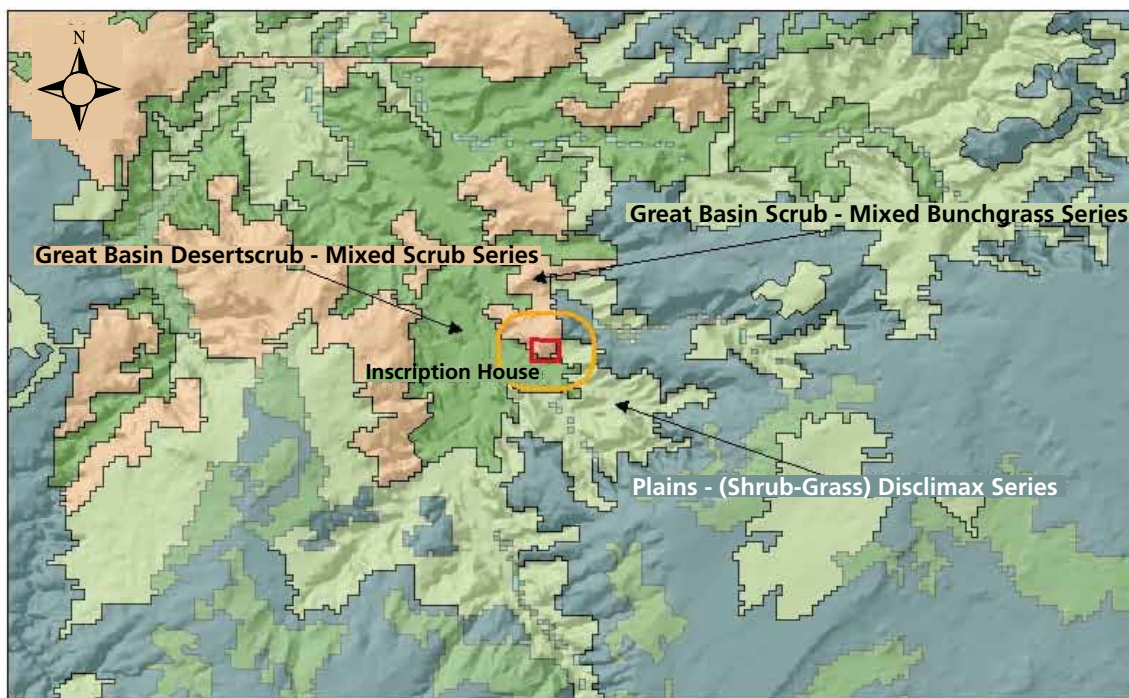


Figure 1.5.6-3.
Arizona
GAP analysis
vegetation
map
surrounding
the NAVA area.

Park boundary
 Mapping area (0.5-km buffer)

0 1 2 4 Miles

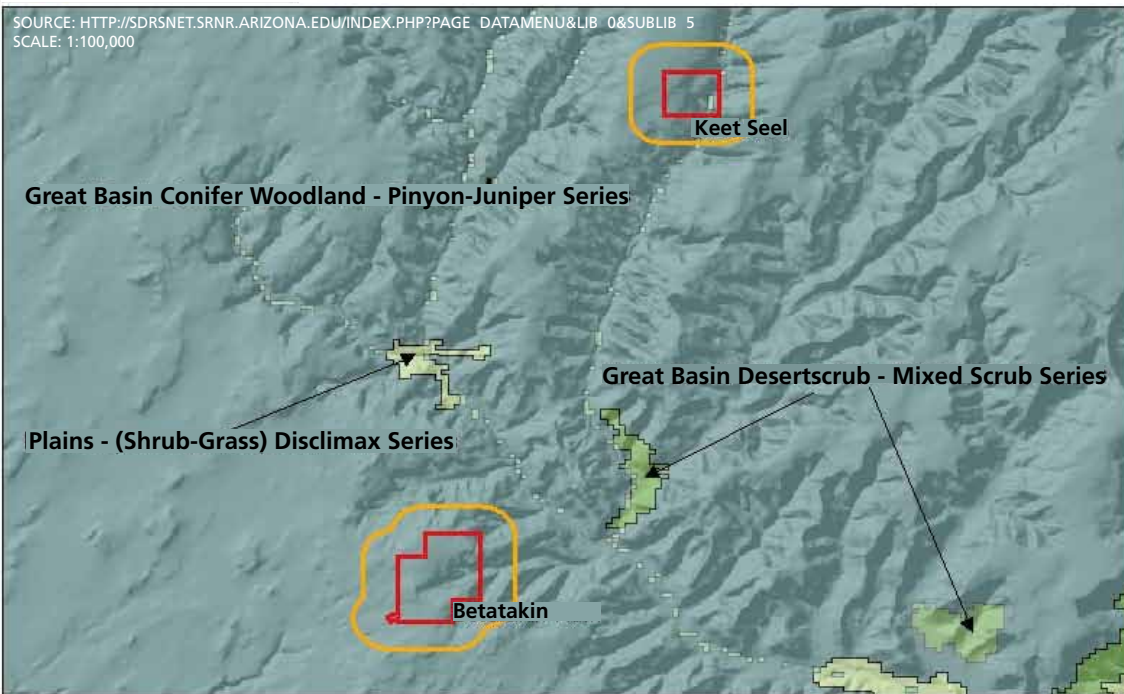
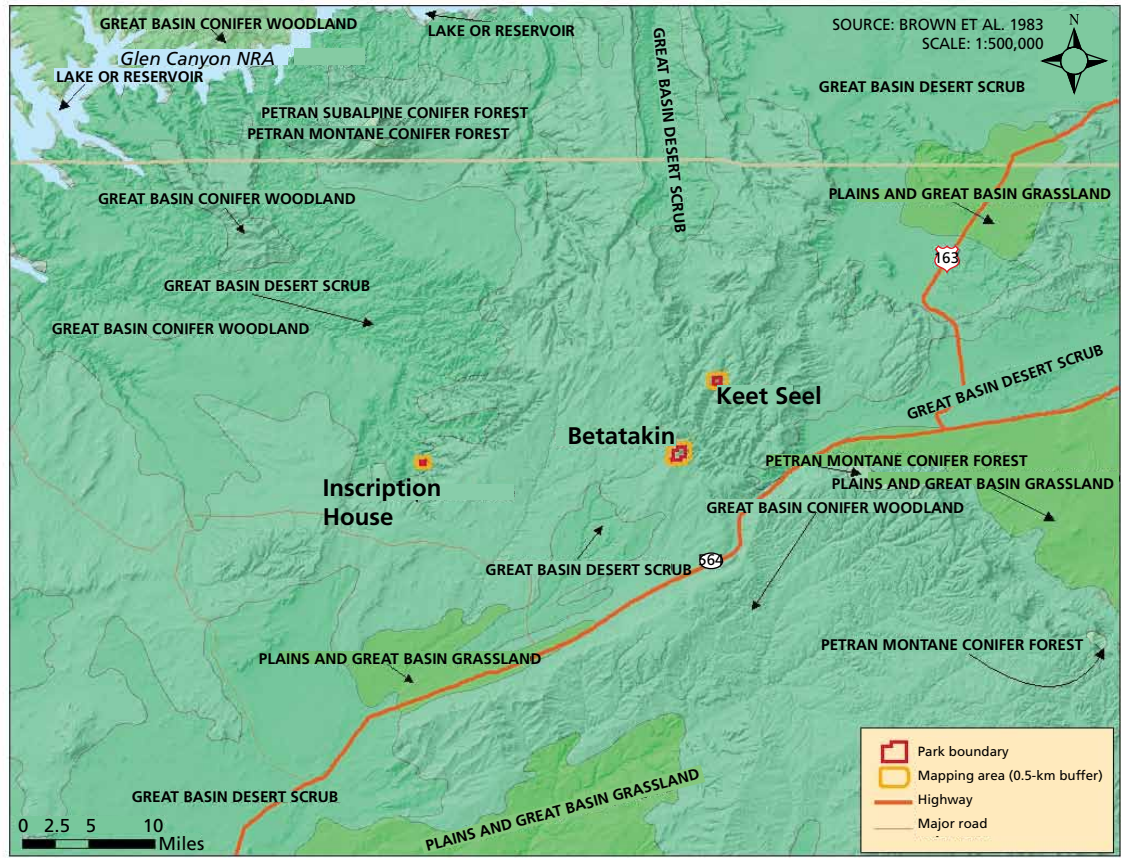


Figure 1.5.6-4. A regional view of the Brown, Lowe, and Pace's Biotic Communities of the Southwest map.



Subsequent to the Brotherson investigations was a thesis by Holiday (1998), who described the vegetation of Tsegi Canyon, and described and mapped portions of Wildcat Canyon, Lower Tsegi Canyon, and Upper Tsegi Canyon. The upper canyon section she described includes the Betatakin mapping portion of this project. Holiday conducted an inventory of plant species in addition to defining and mapping vegetation assemblages. She described nine vegetation types, as follows: *Pseudotsuga* canyon sides, *Populus tremuloides* creek bottoms, Pinyon/juniper areas, *Quercus* terraces, *Atriplex/Artemisia* terraces, *Juncus* marshland, *Betula* creek bottom, *Gutierrezia* stream bottom vegetation, and *Puccinellia* badland vegetation. Of these vegetation assemblages, the pinyon/juniper, *Populus tremuloides* creek bottoms, the *Betula* creek bottom, and the *Pseudotsuga* canyon sides intersect with the mapping area for this project at the Betatakin unit. Holiday's descriptions included dominant and sub-dominant species; she also discussed the seeps present.

A vascular-plant inventory was conducted in 2001–2002 by Roth (2004), who reported 357 species inventoried from all three units. This represented an increase of 64 species over the Brotherson et al. (1978) report. Thirty of these species were exotic, 16 were included in the Southwest Exotic Plant Mapping Program (see <http://www.invasiveweeds.com/mapping/welcome.html>), and 3 were rare.

Of particular interest in regard to park vegetation is a relict population of Douglas-fir found within the Betatakin unit. This population of Douglas-fir is part of a community of mountain-type vegetation in a predominantly desert-type vegetation. Brotherson et al. (1978, 1983) attributed its presence to favorable moisture regimes created by the canyon geology and Navajo Sandstone hydrology.

2 Methods

The methods used to produce a vegetation map for a park of restricted size, such as NAVA, are different than those used to map larger parks. NAVA falls into the “medium park” category, defined as 1–100 km². For larger “medium parks,” the sampling area is the entire park, with data points collected using a stratified approach. Because NAVA is at the small end of the “medium park” category, however, we collected observation points throughout the park. This process is described in more detail below.

2.1 Planning and scoping

On May 11, 2005, a general planning and scoping meeting was held at Hubbell Trading Post National Historic Site to discuss the vegetation-mapping needs of El Morro National Monument, Hubbell Trading Post NHS, and Navajo National Monument. Topics of discussion included:

- Project background
- National program standards
- Unit overviews
- Task overviews
 - Compilation and preparation of existing data
 - Preliminary classification and data review
 - Data collection
 - Map classification
 - Available photographs
 - Information database
 - Local descriptions
 - Metadata
 - Map production
- Field season

2.2 Responsibilities and deliverables

The BOR assumed the primary responsibility for all the tasks for this project, with the exception of field-data collection, which was contracted to EMI and the Navajo Nation Natural Heritage Program. Products include a full report, metadata, and distribution of the data and information to the appropriate NPS offices and websites. The data will be made available through the USGS website, <http://biology.usgs.gov/npsveg/>. The data and report have been reviewed and accepted by the Southern Colorado Plateau Network; the NAVA superintendent; and internal BOR peer review.

2.3 Preliminary data collection and review of existing information

No preliminary data were collected in association with the NAVA vegetation mapping project. This project was not the first to examine, report, and/or map vegetation at NAVA. Most recently, Roth (2004) conducted a floristic inventory of the Inscription House unit and an exotic and rare plant inventory in the Betatakin and Keet Seel units. Holiday (1998) conducted a floristic study and mapped vegetation assemblages of Tsegi Canyon, which encompasses a portion of the Betatakin unit. Studies conducted in the late 1970s and early 1980s by Brotherson et. al. (1977, 1978, 1983) examined vascular plants, lichens, and selected fauna of NAVA. Each of the existing reports mentioned above was reviewed to gain further insight into the ecology of NAVA and aid in the mapping of vegetation on a landscape scale.

2.4 Field survey

A field survey was conducted during several visits between August 29 and October 15, 2005, to verify signatures and collect vegetation association data. Given the small size of NAVA and the consequently low probability of finding new associations, formalized data collection was foregone in favor of an abbreviated protocol. During data collection, an “Observation Point” form, identical to the data collection form used for accuracy assessment at larger parks, was used. This form includes sufficient data for an existing vegetation association to be assigned. A copy of this form is included on the DVD associated with this report.

Prior to the field visit, all polygons (see below) were assigned a numeric ID. The field crew attempted to visit the center of each polygon and used the polygon ID as the observation point number. When possible, one photograph was taken in each of the four cardinal directions from each observation point. Not all polygons received a visit. Polygons outside park boundaries were not abundantly sampled due to access and time constraints. The crew concentrated their time on the largest and most ecologically interesting polygons within and adjacent to the park boundary. Some important areas at Inscription House were missed due to difficult terrain and consequent restrictions on time.

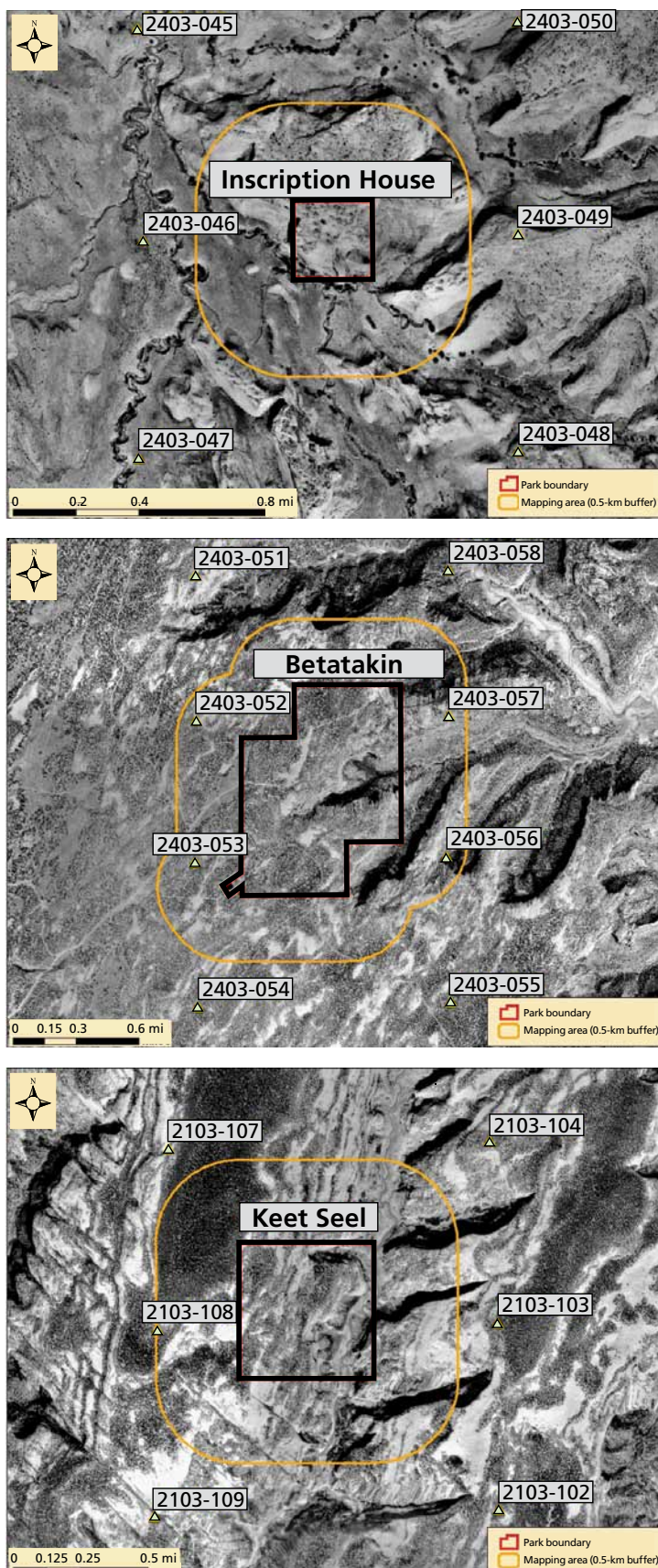


Figure 2.5. Aerial photograph flight lines for NAVA vegetation mapping project.

2.5 Aerial photography

All aerial photography was collected for Keet Seel on June 6, 2004, and for Inscription House and Betatakin on June 17, 2004, at a scale of 1:12,000, in natural color. The aerial photography collected for NAVA was part of a regionwide USDA–NPS contract for a number of other SCPN park units. Six photographs cover Inscription House and there are eight each for Keet Seel and Betatakin. Flight lines for all park units are shown in Figure 2.5.

2.6 Photointerpretation

Photointerpretation was done using 9×9-in, 1:12,000-scale, true-color photographs. Mylar overlays placed on each aerial photo allowed the project team to make notes and delineate polygons. At this stage of interpretation, a stereoscope was used to help identify photosignatures and three-dimensional features; these features were then manually transferred to the orthophoto basemap. Finally, in order to ensure completeness and accuracy, digital-transfer specialists reviewed all of the interpreted orthophotos for consistency and recommended changes where necessary. After all of the obvious vegetation and land-use classes were delineated, the second stage was begun.

2.7 Map units and polygon attribution

The map units delineated on the orthophotos were derived from the NVC classification as constrained by the limitations of the photography. After the initial determination of preliminary map units, the photointerpreters started their work. Photointerpretation included vegetation context and structure. Four attributes were included: map unit, height, density, and coverage pattern. The structural categories and codes are listed in Table 2.7-1. A look-up table for the map unit names is included in Appendix A.

A number of attributes for each polygon are stored in the associated table within the GIS database. Many of these attributes were derived from the photointerpretation; others were calculated or cross-walked from other classifications. Table 2.7-2 shows all of the attributes and their sources. Anderson Level 1 and 2 codes are also included, in order to allow for a more regional perspective on the vegetation types. The names associated with each of the Anderson Level codes are included in a lookup table found in Appen-

Table 2.7-1. Structural categories for vegetation photointerpretation.

Code	Height
1	<1 m
2	1–5 m
3	5–15 m
4	15–30 m
5	>30 m
Coverage density	
1	Closed canopy/Continuous: 75–100%
2	Discontinuous: 50–75%
3	Dispersed: 25–50%
4	Sparse: <25%
Coverage patterns	
1	Evenly dispersed
2	Clumped/Bunched
3	Gradational/Transitional
4	Alternating

Table 2.7-2. Polygon attribute items and descriptions used in the NAVA spatial database.

Attribute	Description
AREA*	Surface area of the polygon in m ²
PERIMETER*	Perimeter of the polygon in m
NAVA_VEG*	Unique internal polygon coding
NAVA_VEG_ID*	Unique internal polygon coding
VEGCODE	Final map unit codes (BOR-derived, project-specific)
VEG_NAME	Final map unit names (BOR-derived, NVC-defined, project-specific)
HEIGHT	Height range of the dominant vegetation layer. Height classes: <1 m, 1–5 m, 5–15 m, 15–30 m, >30 m
DENSITY	Density of the tallest strata. Density classes: <25%, 25–50%, 50–75%, >75%
PATTERN	Vegetation pattern within the polygon. Vegetation pattern classes: Evenly dispersed, Clumped/bunched, Gradational, Alternating
VEG_DETERM	Primary source information used for polygon classification (i.e., Field Plot, Field Notes, Photointerpretation).
AND_LEV1	Land Use and Land Cover Classification System (USGS, Anderson et al. 1976) Level 1
AND_LEV2	Land Use and Land Cover Classification System (USGS, Anderson et al. 1976) Level 2
EL_CODE_1	Ecological Systems Classification Code - NatureServe Ecological Classification
EL_CODE_2	Ecological Systems Classification Code - NatureServe Ecological Classification
EL_CODE_3	Ecological Systems Classification Code - NatureServe Ecological Classification
ACRES	Area in acres
HECTARES	Area in hectares

(*ArcInfo© default items)

dix A. This lookup table also includes ecological system codes and names and the complete NVCS hierarchy for each type. The three EL_codes in the database reflect the one-to-many relationships that may exist when cross-walking the map units to ecological systems. Finally, acres and hectares for each polygon were calculated using XTools Pro for ArcGis Desktop (www.xtoolspro.com).

2.8 Field photographs

The GPS-located vegetation plots collected by the field crew were instrumental to the photointerpretive effort, as they provided the team with a good idea of what the signatures of the individual map units should look like. In addition, the four photographs collected at each plot not only helped the team to identify the immediate area, but also provided a “look” at the areas surrounding the vegetation plot, which were sometimes part of different map units (in several instances, those photos were not available for use in this report). Also useful to the team were comments made in the field by the field crew that referenced specific polygons rather than specific geographic coordinates (see Appendix B).

2.9 Digital transfer

The digital transfer process involved taking the interpreted line work from the photointerpretation (see Section 2.6) and rendering it into a comprehensive digital network of attributed polygons. To accomplish this, the team created an ArcInfo® GIS database using in-house protocols. The actual transfer of information from the interpreted orthophotos to a digital, georeferenced format involved scanning, rasterizing, vectorizing, cleaning, building topology, and labeling each polygon.

The scanning technique involved a multi-step process in which the Mylar overlay sheets produced by the photointerpreters were scanned into digital form. The resultant digital image files (.tif) were then converted from raster images to vector files using the ArcMap extension, ArcScan®. The vector files were then georeferenced to the matching digital versions of the orthophotos. The essential goal of georeferencing was to match the control points (the UTM grid) marked on the orthophotos to the same ones in the digital images. In this manner, the transfer was 1-to-1.

After the overlay sheets were scanned and registered to geographic coordinates, all erroneous information, such as dangling lines, was removed.

Following this “cleaning” process, we joined existing lines into polygons by building topology in the GIS program. The resulting polygons were then edge-matched with those from adjacent orthophotos. Finally, labels were created for each polygon, and attribute information was added to them. Through this process, one final coverage, or spatial database, was created for the entire project.

2.10 Plot data management and classification analysis

2.10.1 Plot data management

Following the field season, all field observations were entered into a database for future access during the vegetation classification process. Specific anomalies of the data collected are discussed in detail in Appendix B.

2.10.2 Vegetation classification

A review of each observation point collected, in conjunction with a comparison to known vegetation associations within the NVC, allowed the team to assign a vegetation name to each point and, by proxy, to each polygon that intersected the point. Polygons that did not receive a field visit were assigned to a map unit based upon field notes and photointerpretation. All polygons outside the park boundary that were not contiguous with polygons within the park were assigned a map unit based upon photointerpretation.

2.11 Map verification

For all NPS vegetation mapping projects, some form of map verification is required. The larger parks usually require some sort of stratified random sample to derive a statistically valid statement regarding the accuracy of the entire map and of each map unit. Although NAVA is a medium-sized park by document standards, it is only barely so. Because of its small size, the network and park agreed to forgo the formalized accuracy assessment in favor of existing and planned field visits. For the purposes of a park the size of NAVA, a representative sample across the park should suffice to establish an assumption of 100% accuracy. There are 277 polygons within the project boundary. Forty-nine field plots and an additional 56 informal field references were collected for map verification. These points provide a non-statistical assumption of close to 100% accuracy.

3 Results

3.1 Field data collection

Data from a total of 49 field plots were collected during the 2005 field season. Of those 49 field plots, five (4, 5, 6, 28, 41) had no geographic coordinates associated with them. Extreme topographic relief, such as that found in box canyons and near cliffs, makes it difficult for GPS units to detect the number of satellites necessary for calculating geographic location, especially during certain hours of the day. However, because three of the five plots (4, 28, 41) were directly associated with a polygon feature, information related to them could still be utilized through the link with the polygon ID number. The remaining two plots (5, 6) described hanging-garden vegetation communities located on cliffs that were difficult to discern on the aerial photography. Geographic coordinates were calculated and assigned to these points, and are reflected in the associated plots shapefile. Several field plots (19, 20, 21, 22, 23, 24, 37, 39) had incorrect UTM coordinates due to GPS error. For these plots, field-plot locations were moved to the center of the polygon referenced by the field crew. UTM coordinates were then calculated for the new locations; these are reflected in the associated plots shapefile. Original UTM coordinates are still included as entered into the database containing field-plot information. Field-plot locations are shown in Figure 3.1.

In addition to the 49 field plots, 56 informal observations were collected and entered into the database. These informal observations referenced polygons similar to those that had already been sampled by a field plot (e.g., polygon 1 was similar to polygon 23). No geographic coordinates are associated with the informal observations; only a polygon number is referenced. For more details, see Appendix B.

3.2 Vegetation classification

To gain information on the potential NVC classifications that might occur in the NAVA project boundary, the project team used a report prepared by NatureServe that listed the potential types that might exist in the area. These were types that existed in the NVC at the time and which local experts were reasonably certain would occur in the park. The analysis of the field plots collected for this effort identified some of those types as well as others not on the preliminary list compiled from NatureServe (Table 3.2) (Appendix C).

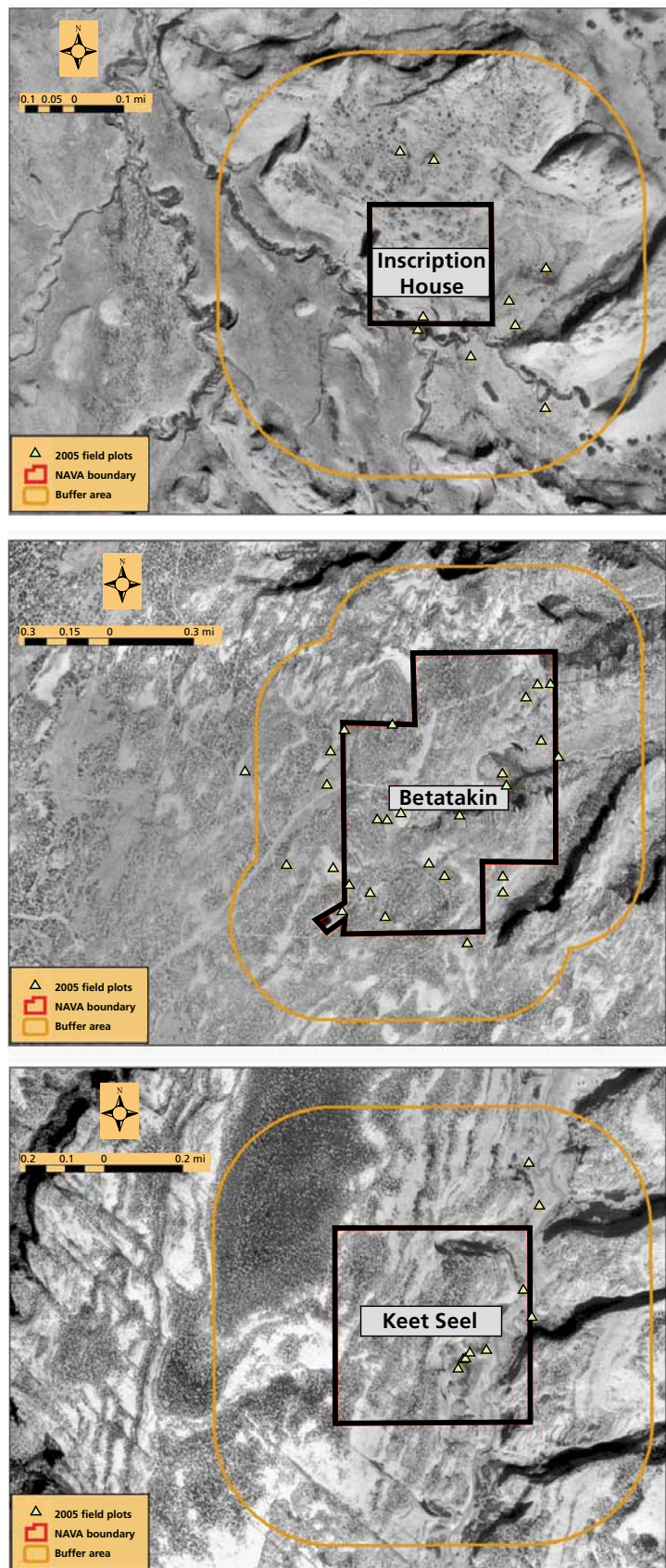


Figure 3.1. Vegetation field-plot locations within NAVA project area.

Using the methods described above, the vegetation-plot data collected in 2005 were classified into 37 distinct vegetation types based on species composition, structure, and environmental characteristics (Table 3.2). Of the 37 distinct vegetation types, 13 types were classified for the project area, but were not supported by formal plots. These 13 types were either referenced by the field crew through informal comments or identified on aerial photos during the mapping phase. The undocumented types were:

- *Artemisia tridentata* ssp. *wyomingensis* Shrubland Alliance
- *Atriplex canescens* Shrubland Alliance
- *Elaeagnus angustifolia* Semi-natural Woodland Alliance
- *Ericameria nauseosa* Shrubland Alliance
- North American Warm Desert Bedrock Cliff and Outcrop
- *Pinus edulis* - (*Juniperus* spp.) Woodland Alliance
- *Populus tremuloides* Temporarily Flooded Forest Alliance
- *Prunus virginiana* Shrubland Alliance
- *Pseudotsuga menziesii* Forest Alliance
- *Pseudotsuga menziesii* / *Acer negundo* Forest
- *Quercus gambelii* Shrubland Alliance

Of the 37 vegetation classifications, 35 are recognized NVC types, while two additional classifications are not official NVC types. One of those two classifications (Invasive Annual and Biennial Forbland Alliance) represented areas dominated by weedy herbaceous species. Similar vegetation assemblages are believed to occur in most park areas in other regions. The other non-NVC vegetation type (*Quercus gambelii* / *Ribes* spp. Shrubland) was represented by three plots, and may be considered a local type specific to the park. Some of the field data collected was only sufficient to classify types to the alliance level.

3.3 Map units

Not all of the alliances and associations in Table 3.2 directly correspond to a map class (unit), because the photointerpreter was unable to identify and delineate unique signatures for each association. In addition, in several cases, alliances and associations only seemed to occur below the minimum mapping unit (MMU) size (<0.5 ha). Alliances and

associations that were below the MMU and could not be identified using the aerial photography were included with the next-most-dominant adjacent vegetation type. Three specific alliances or associations that were not mapped were:

- *Aquilegia micrantha* - *Mimulus eastwoodiae* Herbaceous Vegetation
- *Eleocharis palustris* Seasonally Flooded Herbaceous Alliance
- *Hesperostipa comata* - *Bouteloua gracilis* Herbaceous Alliance

Thirty-four map units represent the vegetation types of NAVA's three units. Two map units are non-vegetated types (Roads / Facilities and Rivers / Streams. One map unit, Sandstone Sparsely Vegetated Alliance, represents specific sandstone communities characterized by little vegetation. Two map units are not existing NVC types, but are proposed types for the NAVA project area: Invasive Annual and Biennial Forbland and *Quercus gambelii* / *Ribes* spp. Shrubland.

3.4 Vegetation alliances and associations

The following descriptions of vegetation types were derived from two sources. The NatureServe Ecological Communities website (www.natureserve.org/explorer), which details all aspects of either the alliance or the association, was the source for the global descriptions. These descriptions have been modified to include either local classification comments, local vegetation summaries, or both.

The local descriptions, which describe the local condition for each type, were written in association with the data collected during this project; they may or may not match the global descriptions. In most cases, vegetation types are described to the association level. However, if the data and the sites were difficult to unequivocally assign to an association, only the alliance level is described. These comments and summaries provide new information that may or may not be included in further reviews of the salient types by NatureServe. In some cases, the NatureServe classification confidence was weak and the only description available is the local description (e.g., Sandstone Sparsely Vegetated Alliance).

Table 3.2. Vegetation alliances and associations/map units in NAVA, including map unit number, park units in which they occur, number of sampling plots or the use of informal observation, frequency of polygons and total area in hectares and acres.

Vegetation type	Alliances and associations/Map units			Project Area (Park + Environs)				Park Area (Park only)			
		Map Unit	Park unit(s)	# of Plots	Frequency	Hectares	Acres	# of Plots	Frequency	Hectares	Acres
Herbaceous	<i>Aquilegia micrantha</i> - <i>Mimulus eastwoodiae</i> Herbaceous Vegetation ¹	–	B	1	–	–	–	1	–	–	–
	<i>Eleocharis palustris</i> Seasonally Flooded Herbaceous Alliance ¹	–	IH	1	–	–	–	1	–	–	–
	<i>Hesperostipa comata</i> - <i>Bouteloua gracilis</i> Herbaceous Alliance ¹	–	IH	1	–	–	–	0	–	–	–
	<i>Hesperostipa comata</i> - <i>Achnatherum hymenoides</i> Herbaceous Vegetation	10	IH	1	1	0.2	0.5	0	0	0	0
Shrubland	<i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> Shrubland Alliance	3	–	10 ²	3	4.9	12.2	0	0	0	0
	<i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> / <i>Hesperostipa comata</i> Colorado Plateau Shrubland	2	B	1	1	0.6	1.5	10 ²	1	0.3	0.7
	<i>Atriplex canescens</i> Shrubland Alliance	5	–	10 ²	1	5.6	13.9	10 ²	1	0.5	1.1
	<i>Atriplex canescens</i> / <i>Sporobolus airoides</i> Shrubland	4	IH	1	1	0.1	0.2	1	1	0.1	0.2
	<i>Ericameria nauseosa</i> Shrubland Alliance	9	–	10 ²	3	3.3	8.2	0	0	0	0
	<i>Ericameria nauseosa</i> / <i>Bromus tectorum</i> Semi-natural Shrubland	7	IH, KS	2	8	28.1	69.4	1	4	6.5	16
	<i>Ericameria nauseosa</i> Sand Deposit Sparse Shrubland	8	IH	1	4	32.0	79.2	0	0	0	0
	<i>Prunus virginiana</i> Shrubland Alliance	24	–	10 ²	1	2.7	6.6	0	0	0	0
	<i>Quercus gambelii</i> Shrubland Alliance	30	–	10 ²	16	26.0	64.4	10 ²	3	1.5	3.6
	<i>Quercus gambelii</i> / <i>Symphoricarpos oreophilus</i> Shrubland	29	B	1	2	8.9	22.0	1	1	7.3	18
	<i>Tamarix</i> spp. Semi-natural Temporarily Flooded Shrubland Alliance	34	IH	1	5	7.9	19.5	10 ²	1	0.9	2.2
Woodland	<i>Acer negundo</i> / Disturbed understory Woodland	1	KS	1	1	0.1	0.2	10 ²	1	0	0.1
	<i>Elaeagnus angustifolia</i> Semi-natural Woodland Alliance	6	–	10 ²	3	0.5	1.2	0	0	0	0
	<i>Juniperus osteosperma</i> / <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> Woodland	12	B	1	1	2.4	5.9	1	1	2.4	5.9
	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance	14	–	10 ²	46	295.9	731.2	10 ²	14	58.6	144.7
	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Amelanchier utahensis</i> Woodland	15	IH	1	2	5.0	12.3	10 ²	2	0.8	1.9
	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland	16	All	8	11	41.7	102.9	5	7	22.3	55.1

Table 3.2. Vegetation alliances and associations/map units in NAVA, cont.

Vegetation type	Alliances and associations/Map units	Map Unit	Park unit(s)	Project Area (Park + Environs)				Park Area (Park only)			
				# of Plots	Frequency	Hectares	Acres	# of Plots	Frequency	Hectares	Acres
Woodland	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Opuntia fragilis</i> Woodland	17	B	1	1	1.2	3.0	1	1	1.2	3
	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Purshia tridentata</i> Woodland	20	B	1	2	8.0	19.7	0	0	0	0
	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Shepherdia rotundifolia</i> Woodland	18	B, KS	4	8	50.1	123.9	1	4	8.2	20.3
	<i>Pinus edulis</i> - <i>Juniperus</i> spp. / <i>Artemisia tridentata</i> (ssp. <i>wyomingensis</i> , ssp. <i>vaseyana</i>) Woodland	19	B, KS	7	20	182.8	451.8	4	9	69	170.4
	<i>Populus deltoides</i> (ssp. <i>wislizeni</i> , ssp. <i>monilifera</i>) / <i>Salix exigua</i> Woodland	21	KS	1	1	0.3	0.9	1	1	0.3	0.9
	<i>Pseudotsuga menziesii</i> / <i>Acer negundo</i> Woodland	25	–	IO ²	1	0.2	0.4	0	0	0	0
Forest	<i>Populus tremuloides</i> Temporarily Flooded Forest Alliance	23	–	IO ²	1	3.4	8.4	IO ²	1	0.3	0.8
	<i>Populus tremuloides</i> / <i>Quercus gambelii</i> / <i>Symphoricarpos oreophilus</i> Forest	22	B	1	2	2.0	4.9	1	1	1.4	3.4
	<i>Pseudotsuga menziesii</i> Forest Alliance	27	–	IO ²	6	47.1	116.5	IO ²	3	5.5	13.6
	<i>Pseudotsuga menziesii</i> / <i>Quercus gambelii</i> Forest	26	B	1	9	19.3	47.8	1	3	6	14.9
Sparse	North American Warm Desert Bedrock Cliff and Outcrop	13	–	IO ²	17	43.1	106.4	IO ²	5	14.8	36.6
Sparse	Sandstone Sparsely Vegetated Alliance	33	B	1	87	154.2	381.0	1	23	25.3	62.4
Other	Invasive Annual and Biennial Forbland Alliance (proposed name)	11	B, KS	3	6	7.9	19.5	1	4	2.2	5.4
	<i>Quercus gambelii</i> / <i>Ribes</i> spp. Shrubland (proposed name)	28	KS	3	3	2.9	7.2	3	3	2.8	6.8
	Rivers / Streams	31	–	IO ²	1	2.9	7.1	IO ²	1	0.8	2
	Roads / Facilities	32	–	IO ²	2	7.9	19.6	IO ²	2	5	12.4
Total				277	999.2	2,469.4					

¹These alliances/associations were not assigned to a to a map unit because the photointerpreter was unable to identify and delineate unique signatures for them.

²IO - informal observations

Note: In the descriptions that follow, the only information specific to Navajo National Monument appears under “Local description” and “Plots.” All other information is part of a general, “global” description of a given alliance or association. This global information was provided by NatureServe. All photos are courtesy D. Wegner, EMI.

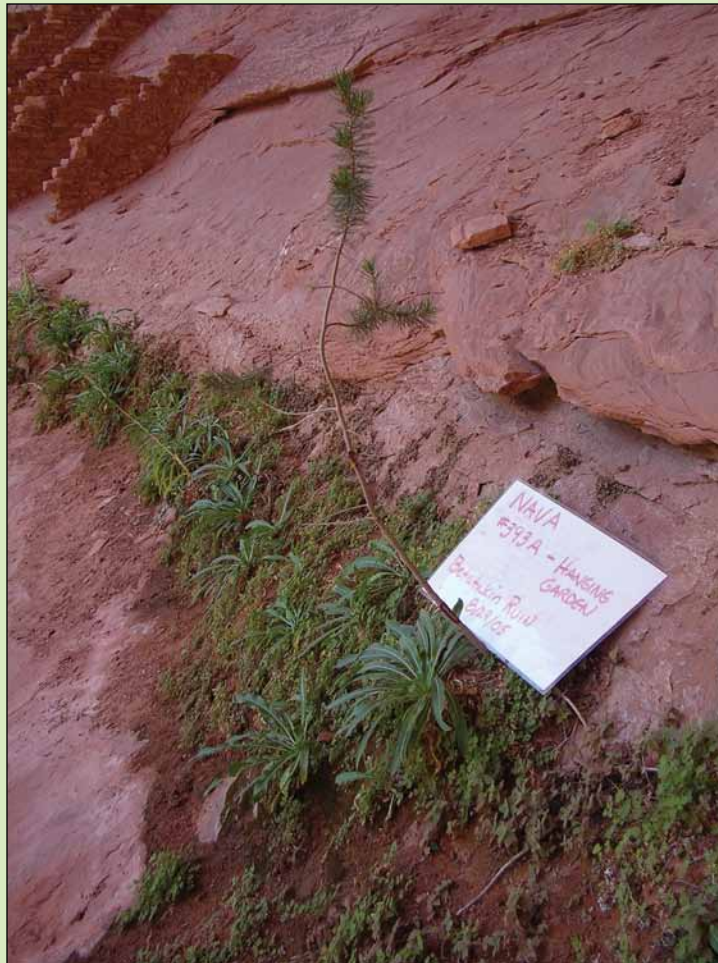


Figure 3.4.1.1. *Aquilegia micrantha* - *Mimulus eastwoodiae* Herbaceous Vegetation.

3.4.1 Herbaceous vegetation

3.4.1.1 *Aquilegia micrantha* - *Mimulus eastwoodiae* Herbaceous Vegetation

Translated name: Mancos columbine - Eastwood's monkeyflower Herbaceous Vegetation

Unique identifier: CEG002729

Classification approach: International Vegetation Classification (IVC)

Summary: These wetland communities are scattered throughout the canyons of the Colorado Plateau in Utah, northern Arizona, and western Colorado, where groundwater emerges from cracks, crevices, alcoves, and ledges in cliffs to create permanently moist seeps. Hanging gardens form exclusively in sedimentary rocks; the best-developed examples occur in massive, bedded sandstones of eolian origin, such as Navajo, Wingate, Cedar Mesa, and Entrada sandstones. Water chemistry is variable, ranging from potable to calcareous to saline. The structure of these communities ranges from a simple crack in a vertical cliff face supporting a narrow line of herbaceous vegetation to deep, shaded alcoves supporting different plant assemblages on the back wall and on the wet colluvial floor of the alcove. Elevations range from 1,250 to 1,890 m (4,100–6,200 ft), and aspect is not important in determining stand distribution. Soils are typically poorly developed sandy loams and

generally are saturated throughout the growing season. The dominant species within the seep are generally forbs, ferns, and graminoids; however, shrubs and trees sometimes form a margin sheltering the gardens. The forb component includes a number of rare and endemic species. Characteristic forbs include *Adiantum capillus-veneris*, *Aquilegia micrantha*, *Mimulus eastwoodiae*, *Cirsium* spp., *Epipactis gigantea*, *Platanthera zothecina* (= *Habenaria zothecina*), *Zigadenus vaginatus*, *Maianthemum stellatum*, *Primula specuicola*, *Solidago velutina* (= *Solidago sparsiflora*), and *Dodecatheon pulchellum*. Graminoids tend to be more variable from stand to stand; common species include *Juncus ensifolius*, *Calamagrostis scopulorum*, *Agrostis gigantea*, *Schizachyrium scoparium*, *Carex aurea*, and *Carex curatorum*. The woody species that occur on the margins of these wetlands are also variable and may include *Populus* spp., *Pinus edulis*, *Juniperus scopulorum*, *Rhus trilobata*, *Toxicodendron rydbergii*, *Clematis ligusticifolia*, *Cercocarpus intricatus*, *Ericameria nauseosa*, and *Cercocarpus montanus*.

Classification confidence: 1–Strong

Classification comments: This association is part of a complex of herbaceous communities collectively known as hanging gardens. Few systematic studies of these communities have been completed (e.g., Welsh and Toft 1981, Welsh 1989, Fowler 1995), and even fewer quantitative data are available, partly because stands can be difficult or dangerous to access. The National Park Service has undertaken systematic surveys of vegetation, particularly spring and seep communities, throughout the Colorado Plateau (Springer et al. 2006). As more data become available, the various hanging garden associations should be revisited. John Spence, botanist at Glen Canyon National Recreation Area, is reported to be in the process of publishing a comprehensive study and classification of hanging gardens in the Colorado Plateau (J. Spence pers. comm. 2005).

Vegetation hierarchy

Formation class	V	Herbaceous Vegetation
Formation subclass	V.B	Perennial forb vegetation
Formation group	V.B.2	Temperate or subpolar perennial forb vegetation
Formation subgroup	V.B.2.N	Natural/Semi-natural temperate or subpolar perennial forb vegetation
Formation name	V.B.2.N.f	Saturated temperate perennial forb vegetation
Alliance name	<i>Aquilegia micrantha</i> Saturated Hanging Garden Herbaceous Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES304.764	Colorado Plateau Hanging Garden

Global status: G2G3 (14Nov2005)

Rounded global status: G2–Imperiled

Reasons: This association tends to be undersampled because many stands are located on inaccessible vertical cliffs.

U.S. distribution: AZ, CO, UT

Global distribution: United States

Global range: This association is restricted to massive sandstone cliffs and slopes in canyons of the Colorado Plateau in western Colorado, northern Arizona, and southeastern Utah.

Wetland indicator: Y

Dynamics: The availability of water from a seep and the gradual building of soil caught and held by the moist rock surface are key to this association's survival. This association in general is vulnerable to changes and fluctuations in water availability due to drought.

Local vegetation summary: Information from only one field plot (VMP.NAVA-05) was sampled during the field-sampling effort (Figure 3.4.1.2). The plot was located in the Betatakin unit of NAVA, near what is locally known as the Betatakin Gardens. At the location of the plot, three vegetated terraces were present on a semi-vertical sandstone wall, with evidence of water from a seep source. The hanging garden was observed at 2,033 m (6,670 ft) in elevation, on a slope of 45° and an aspect of 170°. The majority of ground cover was composed of bedrock, with small amounts of large rock, moss, and litter/duff were present where bedrock did not dominate. No ferns were observed in the area. Soil texture was identified as a well-drained, sandy soil. Associated vegetation of this alliance included *Pseudotsuga menziesii* (Douglas fir) (seedling) (<1%), *Mimulus eastwoodiae* (Eastwood's monkeyflower), *Poa fendleriana* (muttongrass), *Polypogon interruptus* (ditch rabbitsfoot grass), *Aquilegia micrantha* (Mancos columbine), and *Platanthera zothecina* (alcove bog orchid). The herbaceous stratum accounted for less than 5% total cover of the plot and was of an average height of less than 0.5 m (1.6 ft).

An additional field plot (VMP.NAVA-06) was observed in the Keet Seel unit and described as a hanging-garden vegetation type, as well. This plot was assigned a preliminary association name in the field of *Mimulus eastwoodiae* Herbaceous Vegetation due to the lack of *Aquilegia micrantha*. Through further analysis, it seems appropriate to lump this plot into this association and refer to it as an environmental variation of the documented NVC type. The graminoid stratum had an associated cover of 15–25%. The forb stratum had an associated cover of 5–15%. Associated species observed at this field plot included *Prunus munsoniana* (wild goose plum) (<1%), *Carex pellita* (woolly sedge), *Poa pratensis* (Kentucky bluegrass), *Poa fendleriana*, *Mimulus eastwoodiae*, and *Maianthemum stellatum* (starry false lily of the valley).



Figure 3.4.1.2. *Eleocharis palustris* Seasonally Flooded Herbaceous Alliance.

3.4.1.2 *Eleocharis palustris* Seasonally Flooded Herbaceous Alliance

Translated name: Marsh Spikerush Seasonally Flooded Herbaceous Alliance

Unique identifier: A.1422

Classification approach: International Vegetation Classification (IVC)

Summary: This herbaceous wetland alliance occurs in shallow, mostly still water throughout much of the western United States and central Great Plains, from sea level to alpine elevations. Stands occur on a variety of landforms, including lake margins, stream terraces, floodplains, gravel bars, and wet basins (cienegas). Sites are flat to gently sloping on any aspect. Soils and parent materials are variable, but often highly organic and derived from alluvium. Surface water is typically present for an extended period during the growing season, and the high water table remains high most of the year. The vegetation is characterized by a sparse-to-dense herbaceous layer that is dominated or co-dominated by *Eleocharis palustris*, a facultative wetland species. Because of the variety of habitats where this alliance occurs, associated species are diverse. Characteristic associates include several species of *Carex*, *Juncus*, and *Scirpus*, most notably *Carex praegracilis* and *Juncus balticus*. Other important graminoids are *Phalaris arundinacea* (= *Phalaroides arundinacea*), *Spartina pectinata*, *Panicum virgatum*, *Deschampsia caespitosa*, *Distichlis spicata*, and *Muhlenbergia asperifolia*. Forb cover is also variable, and may include *Sparganium angustifolium*, *Lemna* spp., *Potamogeton* spp., *Berula erecta*, *Rorippa nasturtium-aquaticum*, *Pedicularis groenlandica*, *Rhodiola integrifolia*, *Caltha leptosepala*, *Mentha arvensis*, *Rumex crispus*, *Iris missouriensis*, and *Ranunculus cymbalaria*. Diagnostic of this herbaceous wetland alliance is the dominance or co-dominance of *Eleocharis palustris* and the presence of surface water for extended periods during the growing season.

Vegetation hierarchy

Formation class	V	Herbaceous Vegetation
Formation subclass	V.A	Perennial graminoid vegetation
Formation group	V.A.5	Temperate or subpolar grassland
Formation subgroup	V.A.5.N	Natural/Semi-natural temperate or subpolar grassland
Formation name	V.A.5.N.k	Seasonally flooded temperate or subpolar grassland

U.S. distribution: AZ, CA, CO, ID, MT, NE, NM, NV? OR, SD, UT, WA, WY

Canadian province distribution: AB, BC, SK

Global distribution: Canada, Mexico, United States

Global range: This alliance occurs from Oregon to Montana and Alberta, Canada, south to California, Arizona, and New Mexico. The alliance is expected to occur in eastern Washington.

Vegetation summary: Plant associations within this alliance are classified as seasonally flooded, temperate or subpolar grasslands. *Eleocharis palustris*, a facultative wetland species, dominates the graminoid stratum. Cover ranges from sparse to quite dense (10–80%). *Eleocharis palustris* plant associations occur within a wide elevational range, and the species composition can be quite variable. In the Great Plains stands, co-occurring species often include *Phalaris arundinacea* (= *Phalaroides arundinacea*), *Juncus balticus*, *Carex praegracilis*, *Schoenoplectus pungens* (= *Scirpus pungens*), *Panicum virgatum*, *Carex pellita* (= *Carex lanuginosa*), *Spartina pectinata*, and *Schoenoplectus americanus* (= *Scirpus americanus*). Forb cover can also include *Sparganium angustifolium*, *Lemna* spp., and *Potamogeton* spp. (Kittel et al. 1999). *Distichlis spicata* and *Muhlenbergia asperifolia* co-dominate the graminoid layer in cienegas (Arizona and New Mexico). Forb cover is composed of *Berula erecta* and *Rorippa nasturtium-aquaticum*, especially in stands with deep water (Cross 1991).

At higher, montane elevations, other graminoids present include *Carex aquatilis*, *Carex utriculata*, *Carex buxbaumii*, *Eleocharis rostellata*, and *Deschampsia caespitosa*. Forb cover is typically low, but can be up to 25% in some stands. Common forb species include *Pedicularis groenlandica*, *Rhodiola integrifolia*, and *Caltha leptosepala* (Hansen et al. 1995, Kittel et al. 1999).

Crowe and Clausnitzer (1997) stated that *Eleocharis palustris* is an aggressive species, typically excluding other species from establishing. In the Oregon stands, associated forbs include *Mentha arvensis*, *Rumex crispus*, *Iris missouriensis*, and *Ranunculus cymbalaria*.

Vegetation structure summary: This alliance is characterized by a rhizomatous perennial that dominates the graminoid stratum (up to 70% cover). The forb layer is sparse (0–20%) and contains both aquatic and terrestrial species.

Wetland indicator: Y

Environmental summary: Plant associations included in this alliance are conspicuous, common emergent associations that occur in shallow, mostly still water throughout the western United States. Elevation ranges from sea level in California to 3,050 m (~10,000 ft) in Colorado. Stands occur on a variety of landforms, including lake margins, stream terraces, floodplains, gravel bars, and wet basins (cienegas). Stands occur on sites that are flat, 1% slope with all aspects (Crowe and Clausnitzer 1997). Soils vary from histosols to entisols. High-elevation stands consistently occur on organic (highly sapric) soils, or on a thick, organic horizon that overlays fine-to-coarse alluvial material. Lower-elevation stands occur on fresh alluvial deposits of fine-textured loamy sands, clays, and sandy clays (Kittel et al. 1999). Soil reaction is often alkaline (Hansen et al. 1988). All sites are saturated throughout much of the growing season. Oregon stands are located on soils derived from volcanic (andesite, basalt) or sedimentary parent materials (Crowe and Clausnitzer 1997).

At higher elevations, *Carex aquatilis* or *Carex utriculata* meadows and *Salix wolfii* or *Salix planifolia* shrublands occur within the riparian mosaic. At lower elevations, *Schoenoplectus pungens* often occurs within the stream channel, while wet meadow prairies of *Panicum virgatum* and *Sorghastrum nutans* occupy the immediate streambanks and low floodplains.

Dynamics: At lower elevations, *Eleocharis palustris* plant associations occur well within the active channel and are inundated annually. These early seral communities colonize backwater eddies and shallow edges of slow moving reaches of small and larger rivers. The stands are probably ephemeral, as the eddies and river edges are scoured out each year during high spring flows (Kittel et al. 1999). These communities have also been described as early seral stages by Padgett et al. (1989). Padgett et al. (1989) describe light-colored soils for the sites, indicating an early phase of soil development. Kovalchik (1987) reports that the lower-elevation plant associations within this alliance frequently form seral communities in ponded sites between stream rehabilitation structures, such as loose rock check dams.

In the montane zone, associations within this alliance occur in ponded sites on faster-moving streams. If siltation occurs, sites may become dominated by *Carex utriculata*. At higher elevations, the associations appear to be stable. Stands occur near seeps on soils with deep organic layers, often sapric, and are saturated throughout the growing season.

Crowe and Clausnitzer (1997) stated that *Eleocharis palustris* is of little to no forage value to livestock and wild ungulates. On seasonally drier sites, ungulate trampling may cause this species to increase (Snyder 1992 as cited in Crowe and Clausnitzer 1997). However, this species does provide seed forage and cover to ducks and geese (Kovalchik 1987).

Local vegetation summary: Information from only one field plot (VMP.NAVA-21) represented this wetland alliance in the NAVA project area (Figure 3.4.1.3). The plot was located in the Inscription House unit, along the trail from the Inscription House to Owl House. The plot represents a historic wetland formed by an Anasazi dam and is documented as occurring at 1,660 m (5,446 ft), on nearly flat ground with an aspect of 70°. Litter/duff accounted for the majority of the ground cover (90%). Standing water and bare soil accounted for the remainder of the percent ground cover (10%). The soil was identified as a silt loam soil texture. *Eleocharis palustris* (common spikerush) was the dominant species, with an estimated cover of 85–95% and height of less than 0.5 m (1.6 ft). *Xanthium strumarium* (rough cocklebur) and *Polygonum aviculare* (prostrate knotweed) were also present in small amounts (1–5%).



Figure 3.4.1.3. *Hesperostipa comata* - *Bouteloua gracilis* Herbaceous Alliance.

3.4.1.3 *Hesperostipa comata* - *Bouteloua gracilis* Herbaceous Alliance

Translated name: Needle-and-Thread - Blue Grama Herbaceous Alliance

Unique identifier: A.1234

Classification approach: International Vegetation Classification (IVC)

Summary: This alliance is widespread across upland sites in the northern Great Plains. Its communities tend to be the climax communities on fertile dry-mesic sites across much of its range. It is dominated by mid- and shortgrass species; woody species do not regularly achieve prominence. Few of the species exceed 1 m, while many, including *Bouteloua gracilis*, do not exceed 50 cm. The most abundant species are *Hesperostipa comata* (= *Stipa comata*) and *Bouteloua gracilis*. On more mesic sites, *Hesperostipa comata* is predominant, while on areas that are drier or subject to light grazing, *Bouteloua gracilis* takes precedence. Other graminoid species commonly found in communities of this alliance are *Aristida purpurea* var. *longiseta* (= *Aristida longiseta*), *Carex duriuscula* (= *Carex eleocharis*), *Carex filifolia*, *Koeleria macrantha*, *Nassella viridula*, and *Pascopyrum smithii*. Sites in the southern half of the range of this alliance may have significant amounts of *Bouteloua curtipendula*. Forbs are common but not usually abundant. Forb species regularly found are *Artemisia frigida*, *Gaura coccinea*, *Gutierrezia sarothrae* (= *Gutierrezia diversifolia*), *Liatris punctata*,

Sphaeralcea coccinea (= *Malvastrum coccineum*), *Phlox hoodii*, and *Sphaeralcea coccinea*. The club-moss, *Selaginella densa*, is present in many stands in this alliance. Scattered shrubs are sometimes present. These include *Prunus virginiana*, *Rhus aromatica*, and *Symphoricarpos occidentalis*. In the western and southwestern portions of its range, *Cercocarpus montanus* may be found where this alliance occurs on slopes.

Communities in this alliance are found on flat-to-moderately steep topography. The soils are sandy loam, loam, or sometimes clay loam. They are often well-developed and derived from either glacial deposits or sometimes limestone or sandstone (Hanson and Whitman 1938, Coupland 1950, Hanson 1955).

Classification comments: Communities in this alliance can be confused with communities of the *Bouteloua gracilis* Herbaceous Alliance (A.1282), especially in Wyoming. More classification work is needed to clarify the concept boundaries between stands in this alliance.

Vegetation hierarchy

Formation class	V	Herbaceous Vegetation
Formation subclass	V.A	Perennial graminoid vegetation
Formation group	V.A.5	Temperate or subpolar grassland
Formation subgroup	V.A.5.N	Natural/Semi-natural temperate or subpolar grassland
Formation name	V.A.5.N.c	Medium-tall sod temperate or subpolar grassland

U.S. distribution: CO, KS, MT, ND, NE, SD, WY

Canadian province distribution: AB, MB, SK

Global distribution: Canada, United States

Global range: This alliance is found in the western Great Plains, from western Kansas to North Dakota, west into Colorado, Wyoming, and Montana. The alliance also extends north into Canada in Saskatchewan, Manitoba, and probably Alberta.

Vegetation summary: These grasslands are widespread across upland sites in the northern Great Plains. Communities tend to be the late seral communities on fertile dry-mesic sites across much of its range (Tolstead 1941, Hansen et al. 1984). It is dominated by mid- and shortgrass species; woody species do not regularly achieve prominence. Few of the species exceed 1 m (3.3 ft) while many, including *Bouteloua gracilis*, do not exceed 50 cm. The most abundant species are *Hesperostipa comata* (= *Stipa comata*) and *Bouteloua gracilis*. On more mesic sites *Hesperostipa comata* is predominant, while on areas that are drier or subject to light grazing *Bouteloua gracilis* takes precedence. Other graminoid species that are commonly found in communities of this alliance are *Aristida purpurea* var. *longiseta* (= *Aristida longiseta*), *Carex duriuscula* (= *Carex eleocharis*), *Carex filifolia*, *Carex inops* ssp. *heliophila*, *Koeleria macrantha*, *Nassella viridula*, *Pascopyrum smithii* or *Poa secunda*. Sites in the southern half of the range of this alliance may have significant amounts of *Bouteloua curtipendula*. Forbs are common but not usually abundant (<10% cover). Forb species regularly found are *Antennaria parvifolia*, *Artemisia frigida*, *Allium textile*, *Eriogonum umbellatum*, *Gaura coccinea*, *Heterotheca villosa*, *Liatris punctata*, *Sphaeralcea coccinea* (= *Malvastrum coccineum*), *Phlox hoodii*, *Packera fendleri* (= *Senecio fendleri*), and *Sphaeralcea coccinea*. The clubmoss, *Selaginella densa*, is present in many stands in this alliance (Coupland 1950, DeVelice and Lesica 1993, Hansen et al. 1984). Scattered shrubs and dwarf-shrubs are sometimes present. These may include *Artemisia frigida*, *Gutierrezia* spp., *Krascheninnikovia lanata*, *Prunus virginiana*, *Rhus trilobata*, *Rosa* spp., and *Symphoricarpos occidentalis*. In the western and southwestern portions of its range, *Cercocarpus montanus* may be found where this alliance occurs on slopes (Hanson 1955).

Wetland indicator: N

Environmental summary: Grasslands included in this alliance are common in the west-central

and northwestern Great Plains. Elevations range from 600 to 2,350 m. Climate is temperate, continental, and semi-arid-to-subhumid. Mean annual precipitation ranges from 25 to 50 cm. The year-to-year variation is great, in both total annual precipitation and the proportion of precipitation occurring in the winter and spring versus summer.

Stands typically occur on upland sites in rolling plains, breaks, foothills, plateaus, xeric montane parklands, and in smaller forest openings in mountains. Sites are flat-to-moderately steep slopes on any aspect. Soils are shallow-to-moderately deep, non-saline, often calcareous and alkaline, with sandy loam, loam, or sometimes clay loam texture. Mountain substrates are typically coarser colluvial soils. Parent materials often include limestone, sandstone, or shale with glacial deposits in the northern Great Plains, and colluvium derived from granite, gneiss, and schist in the mountains.

Adjacent stands in the plains are often grasslands dominated by *Pascopyrum smithii* in mesic bottomlands, *Bouteloua gracilis* in xeric plains, and *Festuca idahoensis* in the mountains; shrublands dominated by *Artemisia tridentata*, *Ribes* spp., or *Rhus trilobata*; and woodlands dominated by *Pinus edulis*, *Pinus flexilis*, *Pinus ponderosa* or *Juniperus* spp.

Dynamics: These mixed grasslands occur in the subhumid/semi-arid steppes of the western Great Plains, where high variability of seasonal and annual precipitation allows both short and mid grasses to co-exist (Coupland 1992). *Hesperostipa comata* will decline with overgrazing, leaving the more grazing-tolerant *Bouteloua gracilis* to dominate (Laurenroth et al. 1994, Smoliak 1965, Smoliak et al. 1972). Fire also can change the species composition of these grasslands. Burning generally kills or severely damages *Hesperostipa comata* plants. After fire, regeneration of this non-rhizomatous bunchgrass is through seed, and may take many years to reach pre-fire densities (FEIS 1998). Burning *Bouteloua gracilis* during the growing season will top-kill the plant, but the rhizomes are usually unharmed and quickly regrow (FEIS 1998). *Bouteloua gracilis* is usually unharmed by fires in years with above-normal winter and spring precipitation (soil moisture prevents lethal soil temperatures), but it can be severely damaged by fires that occur during drought years (FEIS 1998). Exotic species, such as *Taraxacum officinale*, *Medicago sativa*, *Melilotus officinalis*, or *Salsola kali*, are present in some stands.

Local vegetation summary: This alliance is described by one plot (VMP.NAVA-23), which was found in the Inscription House unit (Figure 3.4.1.4). The plot was sampled at an elevation of 1,802 m (5,912 ft), with a minor slope and an aspect of 310° on the upper third of the slope. The soil texture was identified as a well-drained, sandy soil. Cryptobiotic crust was abundant (95%), representing the majority of the percent ground cover. The graminoid stratum cover was estimated at 25–35%, with a height of 0.5–1.0 m (1.6–3.3 ft). Dominant graminoids found in the plot included *Hesperostipa comata* ssp. *comata* (needle-and-thread), *Bouteloua gracilis* (blue grama), *Muhlenbergia wrightii* (spike muhly), and *Poa fendleriana*. Associated forbs of this alliance included *Sclerocactus parviflorus* ssp. *terrae-canyonae* (smallflower fishhook cactus) and *Oenothera pallida* (pale evening-primrose) (1–5%). The dwarf-shrub stratum was composed of *Eriogonum microthecum* (slender buckwheat) and *Gutierrezia sarothrae* (broom snakeweed) (1–5%) as the dominant species. Other associated species occurring in trace amounts (<1%) included *Juniperus osteosperma* (Utah juniper), *Artemisia nova* (black sagebrush), and *Cercocarpus intricatus* (littleleaf mountain mahogany).



Figure 3.4.1.4. *Hesperostipa comata* - *Achnatherum hymenoides* Herbaceous Vegetation.

3.4.1.4 *Hesperostipa comata* - *Achnatherum hymenoides* Herbaceous Vegetation

Translated name: Needle-and-Thread - Indian Ricegrass Herbaceous Vegetation

Common name: Needle-and-Thread - Indian Ricegrass Mixedgrass Prairie

Unique identifier: CEG001703

Classification approach: International Vegetation Classification (IVC)

Summary: This grassland association has been described from western Colorado and south-central Wyoming. Stands develop on benches, plateaus, and ridges ranging in elevation from 1,550 to 2,560 m (5,085–8,400 ft). The stands recorded in northwestern Colorado resulted from burning sagebrush shrublands on sandy soils. Slopes are gentle-to-moderately steep, and may be oriented to any aspect. Soils tend to be well-drained, deep, and sandy, although they may be derived from a variety of sources. The unvegetated ground surface is mostly covered by litter and bare ground. This grassland occurs in small-to-medium-sized patches, often in sagebrush shrublands that have burned. Total vegetation cover often does not exceed 40%, and may be as low as 20%. *Hesperostipa comata* and *Achnatherum hymenoides* co-dominate the vegetation, and *Pascopyrum smithii* and *Elymus elymoides* are common secondary species. Forbs have moderate diversity but are inconsistent among sites; common species include *Phlox hoodii*, *Eriogonum flavum*, and *Sphaeralcea coccinea*. Scattered shrubs are often present, including *Artemisia tridentata* ssp. *wyomingensis*, *Krascheninnikovia lanata*, *Gutierrezia sarothrae*, and *Ericameria nauseosa*. Other species sometimes present with low cover include *Cerastium arvense*, *Carex* spp., *Symphotrichum laeve* (= *Aster laevis*), *Achillea millefolium*, *Equisetum laevigatum*, *Iva axillaris*, *Taraxacum officinale*, *Poa palustris*, and *Penstemon confertus*.

Classification confidence: 2–Moderate

Classification comments: This grassland needs to be rechecked against the *Oryzopsis hymenoides*

- *Stipa comata* montane grassland in Baker (1984), and a thorough comparison is needed between the information on this association and the descriptions of other grassland types in the region. Sparse stands or those with significant *Bouteloua gracilis* may be difficult to separate from *Artemisia frigida* - (*Bouteloua gracilis*, *Achnatherum hymenoides*, *Poa secunda*) - Lichens Rocky Mesa Dwarf-shrubland (CEGL002344). Co-dominance by *Achnatherum hymenoides* distinguishes this association from *Hesperostipa comata* Great Basin Herbaceous Vegetation (CEGL001705) that is widespread in the Great Basin and Colorado Plateau.

Vegetation hierarchy

Formation class	V	Herbaceous Vegetation
Formation subclass	V.A	Perennial graminoid vegetation
Formation group	V.A.5	Temperate or subpolar grassland
Formation subgroup	V.A.5.N	Natural/Semi-natural temperate or subpolar grassland
Formation name	V.A.5.N.d	Medium-tall bunch temperate or subpolar grassland
Alliance name	<i>Hesperostipa comata</i> Bunch Herbaceous Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES303.817	Western Great Plains Foothill and Piedmont Grassland
CES304.787	Inter-Mountain

Global status: G2? (30Nov1998)

Rounded global status: G2–Imperiled

Reasons: The G2 portion of the rank is based on a limited known range and few known stands. The “?” portion of the rank indicates the strong uncertainty over the distribution of this association and its relationship to *Hesperostipa comata* types named from other areas.

U.S. distribution: CO, UT, WY

Global distribution: United States

Global range: This type has been described from western Colorado and the Great Divide Basin of south-central Wyoming. Other basins in south-central and southwestern Wyoming are similar in climate and geology, and this association may well extend over a wide area of the two states.

Wetland indicator: N

Local vegetation summary: This association was described by one field plot (VMP.NAVA-25), located in the Inscription House unit (Figure 3.4.1.6.). The plot was sampled at an elevation of 1,794 m (5,886 ft), with a minor slope (<1°) and an aspect of 10° in an area with deep soil with junipers and ephedra islands. The soil texture was identified as a well-drained, sandy soil. Ground cover was dominated by cryptograms (80%). Bare soil, litter/duff, and wood accounted for the remainder of the percent ground cover. The graminoid stratum had an estimated vegetation cover of 35–45%, with a height of 0.5–1.0 m (1.6–3.3 ft). Dominant graminoids consisted of *Hesperostipa comata* ssp. *comata*, *Achnatherum hymenoides* (Indian ricegrass), *Bouteloua gracilis*, and *Vulpia octoflora* (six-weeks fescue). The dwarf-shrub stratum (5–15%) consisted primarily of *Ephedra cutleri* (Cutler’s jointfir). The short-shrub stratum (1–5%) consisted of *Yucca angustissima* var. *toftiae* (narrowleaf yucca). Associated species with the forb stratum (5–15%) included *Chamaesyce glyptosperma* (rib-seed sandmat) and *Oenothera pallida* (pale evening-primrose).



Figure 3.4.2.1. *Artemisia tridentata* ssp. *wyomingensis* Shrubland Alliance.

3.4.2 Shrubland vegetation

3.4.2.1 *Artemisia tridentata* ssp. *wyomingensis* Shrubland Alliance

Translated name: Wyoming Big Sagebrush Shrubland Alliance

Unique identifier: A.832

Classification approach: International Vegetation Classification (IVC)

Summary: This broadly distributed alliance is found on dry steppes in the western United States and southwestern Canada. It occurs primarily west of the Continental Divide; however, this description is also based on the vegetation in western North Dakota and eastern Montana. This alliance occurs on flat-to-steeply sloping sites with southerly aspects. Sites with little slope tend to have deep soils, while those with steeper slopes have shallow-to-moderately deep soils. Soil texture is loamy sand, loam, sandy loam, or clay loam. Shrubs are conspicuous in this alliance, but herbaceous species usually have equal or greater cover. The vegetation included in this alliance is characterized by a somewhat sparse-to-moderately dense (20–70% cover) shrub layer that is dominated (or co-dominated with at least 40% relative cover in mixed stands) by *Artemisia tridentata* ssp. *wyomingensis*. *Atriplex confertifolia*, *Artemisia frigida*, *Purshia tridentata*, and *Krascheninnikovia lanata* are common associates. The herbaceous stratum can be diverse and have sparse-to-moderate cover, but perennial graminoids typically total <20% cover. *Pseudoroegneria spicata* is one of the most common species. *Bouteloua curtipendula*, *Bouteloua gracilis*, *Bromus japonicus* (especially on disturbed areas), *Carex filifolia*, *Koeleria macrantha*, and *Hesperostipa comata* (= *Stipa comata*) are common but rarely dominant. Forbs include *Achillea millefolium*, *Camelina microcarpa*, *Gutierrezia sarothrae*, *Sphaeralcea coccinea*, *Opuntia* spp., and *Phlox* spp. Mosses and lichens, such as *Selaginella densa*, may occur on bare ground. Diagnostic of this alliance is the *Artemisia tridentata* ssp. *wyomingensis*-dominated shrub layer that lacks a significant perennial graminoid layer (<20% cover) or has over 40% total cover of shrubs.

Classification comments: Currently, this alliance includes stands in North Dakota that are attributed to the *Artemisia tridentata* Shrubland Alliance (A.829). In the Midwest, the difference between these two alliances is not well understood. It is likely that plants identified as *Artemisia tridentata* are actually *Artemisia tridentata* ssp. *wyomingensis*. After further review, it may be that only one of the two alliances will be listed for the Midwest. The *Artemisia tridentata* Shrub Herbaceous Alliance (A.1521), which has a sparse shrub cover and many stands on floodplains, may be confused with this alliance in the Midwest. Some stands in the *Sarcobatus vermiculatus* Intermittently Flooded Shrub Herbaceous Alliance (A.1554) may be similar (USFS 1992).

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.4	Microphyllous evergreen shrubland
Formation subgroup	III.A.4.N	Natural/Semi-natural microphyllous evergreen shrubland
Formation name	III.A.4.N.a	Lowland microphyllous evergreen shrubland

U.S. distribution: CA, CO, ID, MT, ND, NV, OR, UT, WA, WY

Canadian province distribution: BC

Global distribution: Canada, United States

Global range: This alliance occurs from northeastern California and eastern Oregon across the northern Great Basin, Utah, and dry habitats of the Rocky Mountains to the northern Great Plains of Montana, Wyoming, and North and South Dakota. Associations are also reported from the intermountain parks of Colorado, and from British Columbia, Canada. The alliance has not been reported from either Arizona or New Mexico, but may occur there.

Vegetation summary: This broadly distributed alliance is found on dry steppes in the western United States and southwestern Canada. The vegetation included in this alliance is characterized by a somewhat sparse-to-moderately dense (20–70% cover) shrub layer that is dominated (or co-dominated with at least 40% relative cover in mixed stands) by *Artemisia tridentata* ssp. *wyomingensis*. The shrub stratum is typically 0.3–0.7 m tall, although in Washington and western Idaho it may be up to 2 m in height. *Atriplex confertifolia*, *Artemisia frigida*, *Sarcobatus vermiculatus*, *Ericameria* spp., *Chrysothamnus* spp., and *Krascheninnikovia lanata* are common associates. Locally, *Purshia tridentata*, *Peraphyllum ramosissimum*, or *Gutierrezia sarothrae* may also be common. The herbaceous layer has relatively sparse-to-moderate cover and is often dominated by perennial graminoids (<20% cover) that occupy patches in the shrub matrix. In arid, far-western stands, the understory may be depauperate and is usually dominated by *Poa secunda*, *Elymus elymoides*, and scattered annuals (Hironaka et al. 1983). From central Idaho eastward, *Pseudoroegneria spicata* is the most common associate. Other locally abundant grass associates include *Hesperostipa comata* (= *Stipa comata*), *Achnatherum thurberianum* (= *Stipa thurberiana*), *Elymus lanceolatus*, *Carex filifolia*, *Bouteloua curtipendula*, *Bouteloua gracilis*, *Koeleria macrantha*, *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Leymus ambiguus*, and *Pascopyrum smithii*. Forbs form a minor and highly variable portion of this vegetation. Recurrent species include *Achillea millefolium*, *Camelina microcarpa*, *Balsamorhiza sagittata*, *Sphaeralcea coccinea*, *Erigeron* spp., *Opuntia* spp., and *Phlox* spp. Mosses and lichens, such as *Selaginella densa* and *Tortula ruralis*, may occur on bare ground, and in Washington and Idaho, stands may cover up to 50% of the ground surface. Diagnostic of this alliance is the *Artemisia tridentata* ssp. *wyomingensis*-dominated shrub layer that lacks a significant perennial graminoid layer (<20% cover) or has over 40% total cover of shrubs.

Vegetation structure summary: The vegetation in this alliance is characterized by a moderate-to-dense (25–70%) cover of microphyllous evergreen shrubs, usually 0.5–1 m in height. Cespitose graminoids are usually prominent, often matching the shrubs in height and cover. Forb species may be frequent, but usually contribute little canopy cover. With increasing summer rain in the eastern portion of the range, there is a corresponding increase in the abundance of sod-forming grasses as

compared to bunch grasses. There may be significant cover on the ground surface by mosses and lichens, or a cryptogamic soil crust.

Wetland indicator: N

Environmental summary: The plant associations in this alliance are widely distributed throughout the northern and eastern Great Basin and occur as far east as the Dakotas. Climate ranges from arid in the western Great Basin to subhumid in the northern plains. The amount and reliability of growing-season moisture increase eastward and with increasing elevation. These shrublands occur from less than 1,000 m elevation in the Columbia Basin and northern Great Plains to over 2,500 m in the Rocky Mountains and Great Basin ranges. The alliance occurs on flat-to-steeply sloping upland sites on a wide variety of landform positions, including alluvial fans and terraces, toeslopes, lower and middle slopes, draws, badly eroded badland slopes, and foothills. Sites with little slope tend to have deep soils, while those with steeper slopes have shallow-to-moderately deep soils (USFS 1992). Sloping sites tend to have southerly aspects. Soil texture is loamy sand, loam, sandy loam, or clay loam (Hansen and Hoffman 1988), and there is often a significant amount of coarse fragment in the soil profile. Hironaka et al. (1983) reported that most of their *Artemisia tridentata* ssp. *wyomingensis* habitat types occurred on calcareous soils, often with some form of a cemented duripan or silica-hardpan at about 1 m in depth.

In eastern Idaho and western Wyoming, *Artemisia tridentata* ssp. *wyomingensis* occupies somewhat dry, low-elevation sites, while *Artemisia tridentata* ssp. *tridentata* or *Artemisia cana* occupy deep alluvial soils of drainage bottoms at low elevation, and *Artemisia tridentata* ssp. *vaseyana* occupies cooler, moister, upland sites at higher elevations. In addition to *Artemisia tridentata* and *Artemisia cana*, other associated vegetation types include *Atriplex confertifolia*, *Ericameria* spp. or *Chrysothamnus* spp. shrublands, *Populus tremuloides*, *Pinus ponderosa*, *Pinus contorta*, *Abies grandis*, or *Pseudotsuga menziesii* forests, *Pinus-Juniperus* woodlands, or mesic herbaceous communities.

Dynamics: Complex ecological interactions between fire regimes, grazing history, and climate patterns result in equally complex patterns of species structure and composition in *Artemisia tridentata*. These present corresponding difficulties in the classification of these shrublands, which have been compounded by the influence of human settlement and agricultural patterns. What follows is a summary of some of the influences of altered fire regimes, and grazing history on *Artemisia tridentata* shrublands and shrub herbaceous vegetation.

Artemisia tridentata ssp. *wyomingensis* shrublands may represent either drier or more disturbed examples of the *Artemisia tridentata* ssp. *wyomingensis* shrubland and shrub herbaceous alliances. Shrub densities typically increase with overgrazing of the bunchgrass component or with increasing summer drought (West 1984). There is considerable debate over whether present shrub-dominated stands are actually degraded “steppe” (e.g., Shrub Herbaceous physiognomy), and if the stands will return to steppe with changes in grazing and fire management. *Artemisia tridentata* is inhibited by fire, and excessive grazing may decrease fire frequency due to consumption of herbaceous forage, resulting in increased shrub density. Conversely, invasion by non-native annual grasses (e.g., *Bromus tectorum* or *Bromus japonicus*) may increase fire frequency sufficiently to eliminate the shrubs from the stands (Hironaka et al. 1983). With a change in fire frequency, species composition will be altered, as well (West 1984). With a high fire frequency, every 2–5 years, perennial grasses and shrubs are eliminated and non-native annual grasses dominate. At fire-return intervals of 10–30 years, short-lived resprouting shrubs, such as *Chrysothamnus* or *Tetradymia* spp., dominate. At fire intervals of 30–70 years, a mixture of perennial bunch grasses and shrubs is maintained. Finally, in the complete absence of fire, deep-rooted shrubs, such as *Artemisia tridentata*, become the theoretical dominants.

Local vegetation summary: This type occurs at Betatakin and Inscription House environs.

3.4.2.2 *Artemisia tridentata* ssp. *wyomingensis* / *Hesperostipa comata* Colorado Plateau Shrubland

Translated name: Wyoming Big Sagebrush / Needle-and-Thread Colorado Plateau Shrubland

Unique identifier: Cegl002761

Classification approach: International Vegetation Classification (IVC)

Summary: This shrubland association occurs on deep soils on the slopes and summits of plateaus, ridges, hills, and mesas throughout the Colorado Plateau in eastern Utah and western Colorado. The type is likely to occur in southwestern Wyoming, as well. Elevations range from 1,450 to 2,419 m (4,750–7,940 ft). Slopes are level-to-moderately steep (0–50%). Substrates include eolian sands, loess, and landslide deposits; most often, soils are not residual but develop from these secondary sources. In sparsely vegetated stands, there is usually an abundance of exposed soil on the ground surface, whereas in denser stands litter covers most of the ground. Total vegetation cover ranges from 25 to 75%, dominated by *Artemisia tridentata* ssp. *wyomingensis*. Other shrubs provide little additional cover but may include *Chrysothamnus viscidiflorus*, *Gutierrezia sarothrae*, *Leptodactylon pungens*, *Opuntia polyacantha*, and *Yucca harrimaniae*. *Hesperostipa comata* dominates the sparse-to-moderately dense herbaceous layer. Other grass species present depend on the soil texture, with *Achnatherum hymenoides*, *Elymus elymoides*, and *Koeleria macrantha* more common on sandy soils, and *Pleuraphis jamesii*, *Bouteloua gracilis*, and *Poa fendleriana* more common on silty soils. Forbs provide little total cover but may include *Arenaria fendleri*, *Calochortus gunnisonii*, *Lepidium montanum*, *Linum lewisii*, *Phlox hoodii*, *Penstemon teucroides*, and *Sphaeralcea coccinea*. *Bromus tectorum* may be co-dominant in heavily disturbed sites. Scattered young *Juniperus osteosperma* and *Pinus edulis* trees are often present. Cryptobiotic soil crusts are common in this type, but development is uneven and tends to be sparse in sites that have been grazed by domestic livestock.

Classification confidence: 1–Strong

Classification comments: A similar association, *Artemisia tridentata* ssp. *wyomingensis* / *Hesperostipa comata* Shrubland (CEGL001051), describes a shrubland type of the Columbia River Basin of Oregon and Washington and the Snake River Plain of Idaho that is restricted to dry calcareous hardpan sites. However, little is known of the specifics of this association and its possible relationship to the Colorado Plateau shrubland. Baker's (1984) concept of the *Artemisia tridentata* ssp. *wyomingensis* / *Stipa comata* Association includes both the Colorado and Columbia Basin/Snake River Plain communities. As more data become available, and especially as the range of the Colorado Plateau shrubland type is better known, these two associations should be revisited and compared to justify their separation.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.4	Microphyllous evergreen shrubland
Formation subgroup	III.A.4.N	Natural/Semi-natural microphyllous evergreen shrubland
Formation name	III.A.4.N.a	Lowland microphyllous evergreen shrubland
Alliance name	<i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> Shrubland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES304.777	Inter-Mountain Basins Big Sagebrush Shrubland

Global status: GNR (12Apr2005)

Rounded global status: GNR-Not Yet Ranked

U.S. distribution: CO, UT, WY?

Global distribution: United States

Wetland indicator: N

Dynamics: This association is subject to periodic fire. When burned, it generally converts to a grassland dominated by *Hesperostipa comata* and *Achnatherum hymenoides* (see *Hesperostipa comata* - *Achnatherum hymenoides* Herbaceous Vegetation, CEG001703). Without additional disturbance, sagebrush will generally re-invade and regain canopy dominance within 20–50 years. This association is also subject to invasion by cheatgrass when grazed heavily, and in these stands, fire will generally convert the community more or less permanently to *Bromus tectorum* Semi-natural Herbaceous Vegetation (CEGL003019).

Local vegetation summary: This association was described by one field plot (VMP.NAVA-26) occurring in the Betatakin unit. The association was sampled at an elevation of 2,211 m (7,254 ft) with a minor slope (<2°) and an aspect of 260°. Ground cover was dominated by cryptograms (80%). The remainder of the ground cover was composed of bare soil (3%), litter/duff (10%), wood (5%), and moss (2%). The soil texture was identified as a moderately-to-well-drained, loamy sand. The short shrub stratum was estimated to have a shrub cover of 35–45%, with a height of 0.5–1.0 m (1.6–3.3 ft) and dominated by *Artemisia tridentata*. The dwarf-shrub stratum (5–15%) consisted of *Gutierrezia sarothrae* (broom snakeweed) and *Chrysothamnus Greenei* (Greene's rabbitbrush). Associated species of the graminoid (15–25%) and forb (5–15%) strata include *Hesperostipa comata* ssp. *comata*, *Bouteloua gracilis*, *Elymus elymoides* ssp. *elymoides* (squirreltail), *Cordylanthus parviflorus* (purple bird's-beak), *Artemisia carruthii* (Carruth's sagewort), and *Chenopodium fremontii* (Fremont's goosefoot). *Pinus edulis* seedlings were also present in trace amounts.

3.4.2.3 *Atriplex canescens* Shrubland Alliance

Translated name: Fourwing Saltbush Shrubland Alliance

Unique identifier: A.869

Classification approach: International Vegetation Classification (IVC)

Summary: This alliance occurs primarily in arid and semi-arid areas of the southwestern U.S., from western Texas to southern and eastern California and into Chihuahua, Mexico. It is also found in the western Great Plains to the Great Basin from western Kansas, Colorado, and Wyoming to Utah, Nevada, and eastern Oregon. Associations in this alliance vary throughout the range and occur in a variety of environmental settings. In western Texas, this alliance occupies alkaline flats, depressions among gypsum ridges, and saline or sandy soils. Overall, shrublands in this alliance occur on lowland and upland sites with elevation ranging from 75 m below sea level to 2,400 m. Lowland sites include alluvial flats, drainage terraces, playas, washes, and interdune basins. Upland sites include bluffs and gentle-to-moderately steep, sandy or rocky slopes. Stands occur on all aspects. Soils are variable, with depths ranging from shallow to moderately deep, and texture ranging from sand to loam to clay. The lowland sites may be moderately saline or alkaline. Bare ground usually dominates the ground surface. Francis (1986) described stands in northwestern New Mexico with approximately 80% bare soils and 15% litter. In the Great Basin/Mojave Desert transition zone, Beatley (1993) found these shrublands occurred within a mosaic of *Atriplex confertifolia*- or *Lycium andersonii* - *Grayia spinosa*-dominated shrublands, and were associated with sandy soils. Adjacent vegetation includes *Bouteloua gracilis*-dominated uplands in the Great Plains to various desert shrublands in the southern deserts.

Stands typically have a sparse-to-moderately dense (10–60% cover) short-shrub canopy (approximately 1.5 m tall) that is dominated by the facultative, deciduous, xeromorphic shrub *Atriplex canescens*, with bare ground usually dominating the ground surface. Associated shrubs may include *Artemisia bigelovii*, *Artemisia tridentata*, *Ephedra viridis*, *Krascheninnikovia lanata*, *Purshia stansburiana* (= *Purshia mexicana* var. *stansburiana*), *Psoralea polydenius*, *Parthenium confertum*, *Sarcobatus vermiculatus*, and species of *Chrysothamnus*, *Ericameria*, and *Lycium*. Dwarf shrubs, such as *Gutierrezia sarothrae* or *Eriogonum* spp., may be common in some stands. The sparse-to-moderately dense graminoid layer (1–60% cover) is typically dominated by warm-season, medium-tall, and short grasses. The species present depend on geographic range of the grasses and past land use. Species may include *Bouteloua gracilis*, *Distichlis spicata*, *Elymus elymoides*, *Hesperostipa comata*, *Pleuraphis jamesii* (= *Hilaria jamesii*), *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Muhlenbergia porteri*, *Scleropogon brevifolius*, *Pascopyrum smithii*, and *Sporobolus* spp. Forb cover is generally sparse, but annual forbs, such as *Calycoseris parryi*, may be abundant in wet years. Common forbs include species of *Sphaeralcea*, *Dalea*, *Cymopterus*, *Chenopodium*, *Kochia*, *Iva*, *Picradeniopsis*, and *Ratibida*. Cacti from the genus *Opuntia* are associated species in some stands. Trees are typically not present, but occasionally scattered *Juniperus* spp. occur. Very little is known about the expression of this alliance in the Midwest.

Classification comments: Shrublands in this alliance can grade into grasslands dominated by *Sporobolus airoides* or *Pleuraphis mutica*, or occur within a matrix of other desert shrublands. Further review of this alliance is necessary before comparisons can be made with other vegetation types. Some of the stands referenced, such as in Francis (1986), may not have enough vegetation cover to be classified as shrublands.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.5	Extremely xeromorphic evergreen shrubland
Formation subgroup	III.A.5.N	Natural/Semi-natural extremely xeromorphic evergreen shrubland
Formation name	III.A.5.N.b	Facultatively deciduous extremely xeromorphic subdesert shrubland

U.S. distribution: AZ, CA, CO, KS, NM, NV, OR, TX, UT, WY

Global distribution: Mexico, United States

Global range: Shrublands included in this alliance occur primarily in arid and semi-arid areas of the southwestern U.S. from west Texas to southern and eastern California and into Chihuahua, Mexico. They also are found in the western Great Plains to the Great Basin, from western Kansas, Colorado, and Wyoming to Utah, Nevada, and eastern Oregon.

Wetland indicator: N

Dynamics: *Atriplex canescens* is tolerant of saline or alkaline soils, but is not restricted to those soils. Therefore, it is not a reliable indicator of those conditions (USFS 1937). This shrub is considered good forage for deer and many classes of livestock because it is highly nutritious and palatable (USFS 1937).

Local vegetation summary: This type occurs at Inscription House and its environs.



Figure 3.4.2.4. *Atriplex canescens* / *Sporobolus airoides* Shrubland.

3.4.2.4 *Atriplex canescens* / *Sporobolus airoides* Shrubland

Translated name: Fourwing Saltbush / Alkali Sacaton Shrubland

Unique identifier: CEGl.001291

Classification approach: International Vegetation Classification (IVC)

Summary: This shrubland occurs in the northern Chihuahuan Desert, extending into the Trans-Pecos of Texas, southwestern Great Plains, and Colorado Plateau. Stands are found in washes, floodplains, and on alluvial flats, extending up lower slopes of alluvial fans or bajadas. Sites are level-to-gently sloping. Substrates are typically moderately deep, alkaline, calcareous, fine-textured soils or calcareous sands. Cover of bare soil can be high (>50%). The association is characterized by an open-to-moderately dense (10–50% cover), short-shrub layer dominated by *Atriplex canescens* with a perennial graminoid layer dominated by *Sporobolus airoides*. The shrub layer has greater cover than the herbaceous layer, which may include other scattered shrubs and dwarf shrubs, such as *Artemisia filifolia*, *Atriplex confertifolia*, *Atriplex obovata*, *Chrysothamnus viscidiflorus*, *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Isocoma pluriflora*, *Krascheninnikovia lanata*, *Lycium* spp., *Opuntia* spp., *Prosopis glandulosa*, and *Sarcobatus vermiculatus*. Associated herbaceous species, such as *Achnatherum hymenoides*, *Elymus elymoides*, *Pascopyrum smithii*, *Pleuraphis jamesii*, *Sphaeralcea coccinea*, *Sporobolus cryptandrus*, *Sporobolus nealleyi*, and *Suaeda* spp., may be present. *Bouteloua gracilis* cover is minor and inconsistent. Diagnostic of this *Atriplex canescens*-dominated shrubland is a *Sporobolus airoides*-dominated herbaceous layer. Introduced species, such as *Salsola kali*, *Bromus tectorum*, or *Marrubium vulgare*, may be common.

Classification confidence: 2–Moderate

Classification comments: Stands with relatively low cover of *Atriplex canescens* (10–25%) are included in this association because the shrub density is often variable within stands, but species

composition and ecological processes do not change significantly. There are several similar as-associations that vary according to the abundance of different co-dominants, especially graminoids. Rangewide review of these types is needed to clarify their extent.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.5	Extremely xeromorphic evergreen shrubland
Formation subgroup	III.A.5.N	Natural/Semi-natural extremely xeromorphic evergreen shrubland
Formation name	III.A.5.N.b	Facultatively deciduous extremely xeromorphic subdesert shrubland
Alliance name	<i>Atriplex canescens</i> Shrubland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES302.017	Chihuahuan Mixed Salt Desert Scrub
CES304.784	Inter-Mountain Basins Mixed Salt Desert Scrub

Global status: G5? (09Nov2005)

Rounded global status: G5–Secure

Reasons: Although this type is widespread, it usually occurs in relatively small patches. Both of the diagnostic species are resistant to moderate grazing, but this association has likely been converted to semi-natural shrublands in heavily grazed areas.

U.S. distribution: AZ, CA, CO, NM, NV? TX, UT

Global distribution: Mexico? United States

Global range: This shrubland occurs in the northern Chihuahuan Desert, extending into Trans-Pecos Texas, the southwestern Great Plains, and Colorado Plateau in Colorado, New Mexico, Arizona, and Utah. It is reported from California and likely also occurs in Nevada and Mexico.

Wetland indicator: N

Environmental summary: This shrubland occurs on alkaline sites in washes, floodplains, and on alluvial flats, extending up lower slopes of alluvial fans or bajadas. Elevation ranges from 915 to 1,890 m (3,000–6,200 ft). Sites are level-to-gently sloping (1–5%), and soils are typically moderately deep, alkaline, calcareous, and fine-textured, such as silt loam, loamy clay, or clay (Francis 1986, Shaw et al. 1989, Muldavin et al. 2000b), although some sites in active floodplains may be sandy. Cover of bare soil may be high (>50%) (Francis 1986). Evidence of overland flow and erosion (e.g., gullies, rills, plant pedestalling) is common (SCS n.d.).

Dynamics: Both *Atriplex canescens* and *Sporobolus airoides* are widespread species in semi-arid and arid western North America. Both are able to tolerate moderately high alkalinity or salinity and finer-textured soils with poor drainage, but they are not restricted to these soils and can be found growing on sand (USFS 1937). Most stands occur on sites that, although located in floodplains or valley floors, flood only rarely. *Atriplex canescens* has an extensive root system and is very drought-tolerant. It is very palatable and especially valuable winter forage but can be severely damaged by over-utilization (USFS 1937). *Sporobolus airoides* produces abundant, long-lived seeds that enable it to fully occupy and dominate favorable sites. It is deep-rooted and produces abundant coarse forage that is best utilized during the growing season (USFS 1937).

Local vegetation summary: This association is described by one field plot (VMP.NAVA-07) (Fig-

ure 3.4.2.4). The field plot is located in the Inscription House unit, at the base of Inscription House, on a bench. The plot was sampled at an elevation of 1,662 m (5,453 ft) with a slope of 4° and aspect of 230°. Ground cover was composed of cryptograms (50%), sand (20%), bare soil (8%), litter/duff (10%), wood (10%), large rocks (1%), and pottery shards (1%). The soil texture was identified as rapidly draining sandy clay. The short-shrub stratum was dominated by *Atriplex canescens*, covering 5–15% of the plot with a height of 1.0 to 2.0 m (3.3–6.6 ft). The cover for the dwarf shrub, *Gutierrezia microcephala* (threadleaf snakeweed), ranged from 1 to 5%. The herbaceous stratum had a total vegetation cover of 45–55%, with a height of 0.5–1.0 m (1.6–3.3 ft). Associated species in the herbaceous stratum included *Sporobolus airoides* (alkali sacaton), *Bromus tectorum* (cheatgrass), *Bouteloua barbata* (sixweeks grama), *Sporobolus cryptandrus* (sand dropseed), *Opuntia phaeacantha* (tulip pricklypear), *Astragalus lentiginosus* var. *palans* (freckled milkvetch), *Erodium cicutarium* (redstem stork's bill), and *Tribulus terrestris* (puncturevine).

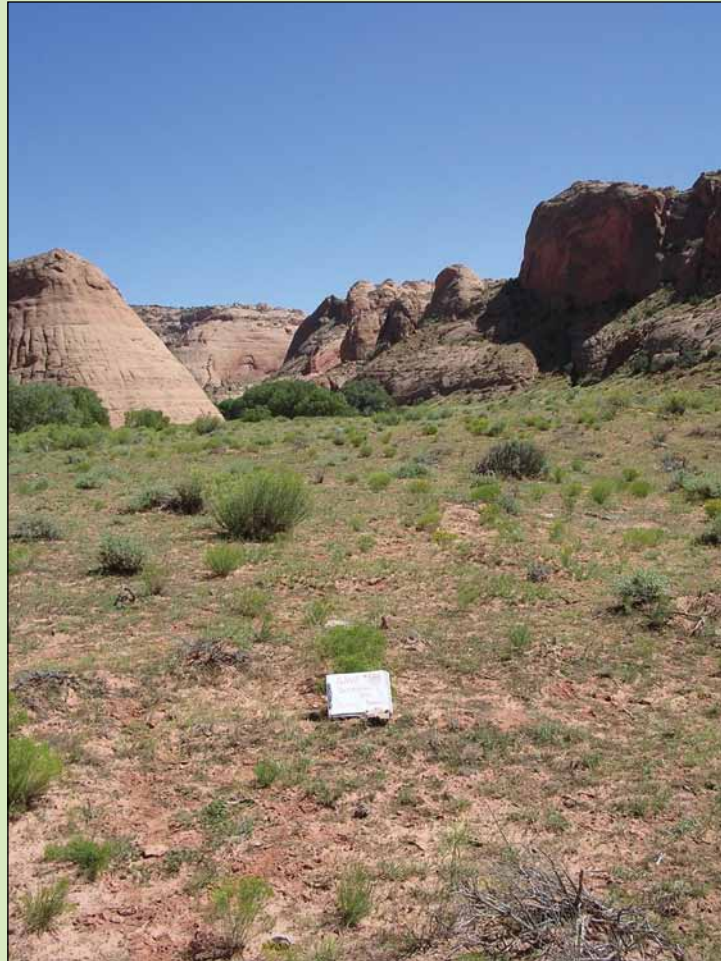


Figure 3.4.2.5. *Ericameria nauseosa* Shrubland Alliance.

3.4.2.5 *Ericameria nauseosa* Shrubland Alliance

Translated name: Rubber Rabbitbrush Shrubland Alliance

Unique identifier: A.835

Classification approach: International Vegetation Classification (IVC)

Summary: This alliance includes both natural and semi-natural stands from localized areas across the northern Great Plains and throughout the western U.S. Naturally occurring stands have been described from areas of partially stabilized sands, in a region of actively moving dune deposits, from 1,525 to 1,800 m in elevation in southeastern Idaho and in other areas of high natural disturbance, such as on steep colluvial slopes, along drainages, or in floodplains. Natural stands in the dune systems of southern Idaho occur in very specific environments, roughly 30–210 m windward from the pioneer vegetation type, *Leymus flavescens* Herbaceous Vegetation (CEGL001563). These sand deposits have generally been stable for approximately 40 years. The soils are sand, from a few cm to over 4 m deep, left behind as the dunes advance. Stands on the Colorado Plateau occur in a variety of habitats, such as gentle or steep slopes, dunes, and washes. Elevations range from 1,220–1,800 m. Substrates may be eolian, alluvial, colluvial, or derived from sandstone residuum. Soils are variable but are generally well-drained and coarse-textured. The semi-natural stands included in this alliance are seral shrubland communities resulting from overgrazing by livestock, road build-

ing, or other cultural disturbance of typically grass-dominated communities.

The vegetation is characterized by an open-to-moderately dense short-shrub layer (15–60% cover) that is dominated by *Ericameria nauseosa*. Depending on geography, associated shrubs may include scattered *Artemisia tridentata*, *Artemisia filifolia*, *Chrysothamnus viscidiflorus*, *Gutierrezia sarothrae*, *Rhus trilobata*, *Opuntia* spp., *Prunus virginiana*, *Symphoricarpos occidentalis*, and *Yucca* spp. The herbaceous layer can vary from moderately dense and dominated by graminoids to absent. Common native grasses include *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Bouteloua* spp., *Elymus trachycaulus* ssp. *trachycaulus*, *Leymus flavescens* (= *Elymus flavescens*), *Pascopyrum smithii*, *Pleuraphis jamesii*, *Pseudoroegneria spicata*, and *Sporobolus cryptandrus*. Native forbs generally have low cover, but may include species such as *Psoralidium lanceolatum* (= *Psoralea lanceolatum*), *Machaeranthera canescens* (= *Aster canescens*), *Lygodesmia grandiflora*, and *Phacelia hastata* (= *Phacelia leucophylla*). Disturbed stands typically have high cover of introduced annual *Bromus* species such as *Bromus tectorum*, *Bromus japonicus*, and *Bromus rubens*. Introduced forbs may include *Melilotus officinalis*, *Salsola kali*, and *Bassia scoparia* (= *Kochia scoparia*). Figure 3.4.2.5 shows this alliance occurring in NAVA.

Classification comments: This alliance's concept has been recently expanded to include semi-natural vegetation. More classification information is needed to fully describe this alliance throughout its range of distribution.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.4	Microphyllous evergreen shrubland
Formation subgroup	III.A.4.N	Natural/Semi-natural microphyllous evergreen shrubland
Formation name	III.A.4.N.a	Lowland microphyllous evergreen shrubland

U.S. distribution: AZ, CO, ID, MT, ND, NV, SD, UT

Global distribution: United States

Global range: This alliance includes shrublands from localized areas across the northern Great Plains and throughout the western U.S.

Vegetation structure summary: Vegetation included in this alliance has a moderately dense (40–60% cover) short-shrub layer less than 2 m tall. The herbaceous layer is relatively sparse (20–30% cover) and is usually less than 0.5 m tall. It is co-dominated by perennial grasses and forbs. Annual graminoids and forbs are seasonally present.

Wetland indicator: N

Dynamics: In southern Idaho, this shrubland is the second seral stage of five vegetation types found on this dune complex. The types are found in bands that transverse to the direction of dune movement. The width of the vegetation bands is quite consistent throughout the sandhills area, and each band advances across the landscape at about the same rate as the dune advancement. This association has an approximate duration on a given deposit of 10–70 years. Semi-natural stands have largely been overlooked in the classification literature. Daubenmire (1970) described *Ericameria nauseosa*-dominated stands (to 40% cover) from the steppes of eastern Washington as the second level of degeneration of the *Bromus tectorum* zootic climax (when overgrazing by livestock continues after perennial grasses are replaced by *Bromus tectorum*).

Local vegetation summary: This type occurs at Keet Seel and Inscription House environs.



Figure 3.4.2.6. *Ericameria nauseosa* / *Bromus tectorum* Semi-natural Shrubland.

3.4.2.6 *Ericameria nauseosa* / *Bromus tectorum* Semi-natural Shrubland

Translated name: Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland

Unique identifier: CEGl002937

Classification approach: International Vegetation Classification (IVC)

Summary: This shrubland association occurs in disturbed situations at moderate altitudes in the Colorado Plateau. It has been documented from sites in northwestern Colorado and southern Utah. Most stands are the result of fire having burned sagebrush or other types of shrublands, but some derive from other forms of disturbance, including grazing. Elevations range from 1,220 to 2,085 m (4,000–6,840 ft), and sites occur on gentle-to-steep slopes. Soils are variable, but most stands occur on well-drained, sandy loams that are often rocky. Total vegetation cover is relatively sparse to moderately dense, depending primarily on the density of cheatgrass in any given year. The shrub canopy is open, consisting of *Ericameria nauseosa* with up to 40% cover. Scattered individuals of other shrub species, such as *Artemisia tridentata*, *Rhus trilobata*, *Atriplex canescens*, and *Atriplex confertifolia* may be present. The herbaceous layer contains many species but is overwhelmingly dominated by *Bromus tectorum*. Relict native herbaceous grasses include *Elymus elymoides*, *Achnatherum hymenoides*, *Poa fendleriana*, and *Sporobolus cryptandrus*. Native herbaceous species are also common but contribute only sparse cover; these may include *Cleome lutea*, *Eriogonum inflatum*, and *Heterotheca villosa*. Weedy forbs are more abundant in most stands, including *Descurainia pinnata*, *Lappula occidentalis*, and *Salsola tragus*.

Classification confidence: 2–Moderate

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.4	Microphyllous evergreen shrubland
Formation subgroup	III.A.4.N	Natural/Semi-natural microphyllous evergreen shrubland
Formation name	III.A.4.N.a	Lowland microphyllous evergreen shrubland
Alliance name	<i>Ericameria nauseosa</i> Shrubland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES304.781	Inter-Mountain Basins Wash
CES304.788	Inter-Mountain Basins Semi-Desert Shrub-Steppe

Global status: GNR (14Aug2001)

Rounded global status: GNR–Not Yet Ranked

U.S. distribution: CO, UT

Global distribution: United States

Global range: This association has currently only been described from Zion National Park in southwestern Utah, but is likely more widespread throughout the western U.S. in disturbed areas.

Wetland indicator: N

Local vegetation summary: Two plots (VMP.NAVA-11, 18) sampled in the Inscription House and Keet Steel units described this herbaceous association (Figure 3.4.2.6). The plot elevations ranged from 1,675 to 2,066 m (5,495–6,778 ft), with 0–1° slopes and an aspect of 12°. The soil textures differed slightly, with one plot having silty loam texture and the other plot identified as a sandy loam soil texture. The tall-shrub stratum ranged in total coverage from 1 to 15%, with an average height of 1.0–2.0 m (3.3–6.6 ft). *Ericameria nauseosa* ssp. *nauseosa* var. *nauseosa* was the dominant shrub, with *Ribes cereum* (wax currant) and *Atriplex canescens* (fourwing saltbush) occurring in trace amounts. A short-shrub stratum was present in one of the plots with a cover range of 15–25%. *Gutierrezia sarothrae* and *Chrysothamnus viscidiflorus* (yellow rabbitbrush) were the associated short shrubs. The herbaceous stratum ranged in cover from 5 to 97.5% for the two plots. Associated species in the herbaceous stratum included *Sporobolus contractus* (spike dropseed), *Bromus tectorum*, *Sporobolus cryptandrus*, *Ambrosia acanthicarpa* (flatspine burr ragweed), *Descurainia pinnata* (western tansymustard), *Sisymbrium altissimum* (tall tumbledmustard), and *Portulaca oleracea* (little hogweed).



Figure 3.4.2.7. *Ericameria nauseosa* Sand Deposit Sparse Shrubland.

3.4.2.7 *Ericameria nauseosa* Sand Deposit Sparse Shrubland

Translated name: Rubber Rabbitbrush Sand Deposit Sparse Shrubland

Unique identifier: CEGl002980

Classification approach: International Vegetation Classification (IVC)

Summary: This association occurs on sandsheets and dune systems in southern Utah, northeastern Arizona, and western Colorado, but is likely more common in similar habitats throughout the interior western U.S. *Ericameria nauseosa* is most likely to dominate a community where there has been chronic or severe disturbance, such as grazing, fire, or, in rare instances, flooding. Elevation ranges from 1,430 to 2,000 m (4,700–6,560 ft). At Zion National Park, a stand was described from a colluvial slope below a sandstone cliff. In other areas, this type occurs on sand dunes and sandsheets in flatter areas, such as floodplains, stream terraces, and valley floors. Sites are generally gentle-to-moderately sloping, but range from flat to steep and may occur on any aspect. Soils are sandy and may be derived from local sandstone, eolian sands, or alluvium. This association is characterized by a typically sparse short-shrub layer (5–20% cover, ranging up to 30%) dominated by *Ericameria nauseosa* (at least half the cover). Other shrubs or dwarf shrubs are often present and may include *Artemisia bigelovii*, *Atriplex* spp., *Chrysothamnus viscidiflorus*, *Ephedra torreyana*, *Eriogonum corymbosum*, *Ipomopsis congesta*, *Gutierrezia sarothrae*, *Opuntia polyacantha*, or *Yucca elata* var. *utahensis*. The herbaceous layer is generally sparse and is dominated by perennial graminoids, such as *Achnatherum hymenoides*, *Aristida purpurea*, *Hesperostipa comata*, *Muhlenbergia pungens*, and *Sporobolus* spp. Forb associates may include *Chamaesyce glyptosperma*, *Cirsium* spp., *Heterotheca villosa*, *Penstemon palmeri*, *Phacelia heterophylla*, *Sphaeralcea coccinea*, *Streptanthella longirostris*, and *Sophora stenophylla*.

Classification confidence: 2–Moderate

Classification comments: This association is distinguished as much by its setting as its floristics,

and is floristically fairly diverse.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.4	Microphyllous evergreen shrubland
Formation subgroup	III.A.4.N	Natural/Semi-natural microphyllous evergreen shrubland
Formation name	III.A.4.N.a	Lowland microphyllous evergreen shrubland
Alliance name	<i>Ericameria nauseosa</i> Shrubland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES304.775	Inter-Mountain Basins Active and Stabilized Dune
CES304.793	Southern Colorado Plateau Sand Shrubland

Global status: GNR (22Jan2002)

Rounded global status: GNR–Not Yet Ranked

U.S. distribution: AZ, CO, UT

Global distribution: United States

Global range: This association has been described from southern Utah, northeastern Arizona, and western Colorado but is likely more common in similar habitats throughout the interior western U.S.

Wetland indicator: N

Dynamics: The sandy substrate is an important environmental variable, whether created by active eolian processes or from sandstone residuum. *Ericameria nauseosa* is a common species in sandy habitats.

Local vegetation summary: One field plot (VMP.NAVA-47) described this association (Figure 3.4.2.7). The plot was located in the Inscription House unit, at an elevation of 1,668 m (5,472 ft) with a 5% slope. Ground cover was dominated by sand (85%). The soil texture was identified as a moderately to well-drained silt loam. *Ericameria nauseosa* was the dominant shrub and represented the dominant stratum with a cover of 1–5% and height of 2–5 m (6.6–16.4 ft). Other shrubs present in low amounts (1–5%) included *Atriplex canescens* and *Gutierrezia sarothrae*. The herbaceous stratum ranged from 1 to 5% in cover and consisted of *Sporobolus cryptandrus* (<1%), *Sporobolus airoides* (<1%), *Monroa squarrosa* (false buffalograss) (<1%), *Erodium cicutarium* (redstem stork's bill), *Ambrosia acanthicarpa*, *Chamaesyce glyptosperma* (ribseed sandmat), and *Ambrosia acanthicarpa*.

3.4.2.8 *Prunus virginiana* Shrubland Alliance

Translated name: Choke Cherry Shrubland Alliance

Unique identifier: A.919

Classification approach: International Vegetation Classification (IVC)

Summary: This alliance occurs in scattered locations at low-to-mid elevations of the western U.S. Sites typically occur along streams, rivers, lakes, and ponds, and on terraces. It also is found in canyons or steep gullies and along arroyos. Elevations range from 716 m to about 1,600 m in Montana, Wyoming, and Colorado, and up to 2,440 m in Nevada. In some places, the alliance occurs on side slopes of hillsides, immediately below a seep or spring. Some examples of this alliance have been placed into an intermittently or temporarily flooded hydrologic regime. Soils are usually well-developed, older, and well-drained, formed in shallow-to-deep alluvial deposits. These soils have higher fertility and afford good rooting depth. Textures range from silt to sandy loams, often becoming skeletal at depth. *Prunus virginiana* can tolerate weakly saline soils, but is intolerant of poor drainage and prolonged flooding. This alliance is characterized by a tall, dense layer of shrubs, primarily of *Prunus virginiana*. In the absence of disturbance, this species can form dense, monotypic thickets. With grazing or browsing disturbance, stands become more open, allowing other shrubs to become common, including *Symphoricarpos occidentalis*, *Rosa woodsii*, *Ribes aureum*, and, in Oregon, *Sambucus caerulea*. The woody vine, *Toxicodendron rydbergii*, is present in most stands, as are the forbs, *Maianthemum stellatum* and *Galium triflorum*. The herbaceous layer is typically not abundant, although stands with an open shrub canopy typically have a component of weedy forbs and graminoids. A few scattered *Juniperus scopulorum* also occur.

Classification comments: The occurrence of *Prunus virginiana* is reported in most literature as being associated with moist soil to semi-riparian conditions. This alliance might be better placed in an intermittently flooded or temporarily flooded formation.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.B	Deciduous shrubland
Formation group	III.B.2	Cold-deciduous shrubland
Formation subgroup	III.B.2.N	Natural/Semi-natural cold-deciduous shrubland
Formation name	III.B.2.N.a	Temperate cold-deciduous shrubland

U.S. distribution: CO, ID, MT, NV, OR, SD, WA, WY

Global distribution: Canada, United States

Global range: This alliance has been described from the northwestern Great Plains, including Colorado, Wyoming, and Montana. It also is found in low-to-mid-elevation foothill areas of Idaho, Nevada, Washington, and Oregon.

Vegetation structure summary: These are moderately tall, broad-leaved deciduous shrublands, typically with a closed canopy. Undisturbed stands are very dense thickets, almost impossible to walk through. There is usually a shorter shrub layer, also composed of deciduous species. Herbaceous species are not abundant, except in more open stands.

Wetland indicator: N

Dynamics: In Nevada, these communities are considered “marginal” riparian types and represent succession away from riparian conditions (Manning and Padgett 1995). In Montana, *Prunus virginiana* communities may be grazing-induced successional stages of the *Fraxinus pennsylvanica* / *Prunus virginiana* community type (Hansen et al. 1995). Both *Prunus virginiana* and *Symphoricarpos occidentalis* are tolerant of fire and will usually sprout after fires and grow into even denser

stands. Dense stands of *Prunus virginiana* may preclude use by livestock, while open stands may provide adequate grazing opportunities. However, if grazed for the entire season the strongly rhizomatous *Rosa woodsii* and non-native grasses may become established (Manning and Padgett 1995, Hansen et al. 1988).

Local vegetation summary: No formal field plots described this alliance. One informal field note (VMP.NAVA-54) referenced this polygon, in the Keet Steel unit, as occurring in the mouth of a side canyon perpendicular to the major stream in the area. No other similar signatures were found within the NAVA project area. No additional vegetation information was provided by the informal field reference.



Figure 3.4.2.9. *Quercus gambelii* Shrubland Alliance.

3.4.2.9 *Quercus gambelii* Shrubland Alliance

Translated name: Gambel Oak Shrubland Alliance

Unique identifier: A.920

Classification approach: International Vegetation Classification (IVC)

Summary: This alliance contains shrublands dominated by *Quercus gambelii*. In western Texas, this alliance includes montane shrublands, 1–2 m tall, often forming dense thickets at the bases of ledges and bordering talus slopes at 5,000–8,300 ft of elevation. In Texas occurrences, associated species can include *Holodiscus dumosus* and *Symphoricarpos oreophilus*. Additional species found in associations of this alliance include *Cercocarpus montanus*, *Carex geyeri*, *Amelanchier alnifolia*, *Amelanchier utahensis*, *Artemisia tridentata*, *Carex inops*, *Paxistima myrsinites*, *Robinia neomexicana*, and *Symphoricarpos rotundifolius*.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.B	Deciduous shrubland
Formation group	III.B.2	Cold-deciduous shrubland
Formation subgroup	III.B.2.N	Natural/Semi-natural cold-deciduous shrubland
Formation name	III.B.2.N.a	Temperate cold-deciduous shrubland

U.S. distribution: AZ, CO, NM, TX, UT

Global distribution: Mexico? United States

Global range: Shrublands included in this alliance occur in lower montane and canyon habitats throughout southern and western Colorado, Utah, Arizona, New Mexico, western Texas, and likely northern Mexico and south-central Wyoming.

Vegetation summary: Shrublands included in this alliance occur in the lower montane zone in the southern Rocky Mountains, Wasatch Plateau, and Uinta Mountains; and in mesas, desert mountains, and canyons in the Chihuahuan and Sonoran deserts, Colorado Plateau, and southern plains. Stands have a moderately dense-to-dense, woody layer that is typically 2–5 m tall but can also occur as 1-m-tall clumps to small trees over 5 m tall. The canopy is dominated by the broad-leaved, deciduous shrub, *Quercus gambelii*, which occasionally reaches small-tree size. Stands range from dense thickets with little understory to relatively mesic mixed shrublands with a rich understory of shrubs, grasses, and forbs. These shrubs often have a patchy distribution with grass growing in between. Scattered trees are occasionally present in stands and typically include species of *Pinus* or *Juniperus*. Characteristic shrubs that may co-occur include *Amelanchier alnifolia*, *Amelanchier utahensis*, *Artemisia tridentata*, *Cercocarpus montanus*, *Ptelea trifoliata*, *Prunus virginiana*, *Robinia neomexicana*, *Rosa* spp., *Symphoricarpos oreophilus*, and *Symphoricarpos rotundifolius*. The herbaceous layer is sparse-to-moderately dense, ranging from 1 to 40% cover. Perennial graminoids are the most abundant species, particularly *Bouteloua curtipendula*, *Bouteloua eriopoda*, *Bouteloua gracilis*, *Aristida* spp., *Carex inops*, *Carex geyeri*, *Elymus arizonicus*, *Eragrostis* spp., *Festuca* spp., *Koeleria macrantha*, *Muhlenbergia* spp., and *Hesperostipa* spp. Many forb and fern species can occur, but none have much cover. Commonly present forbs include *Achillea millefolium*, *Artemisia* spp., *Geranium* spp., *Maianthemum stellatum*, *Thalictrum fendleri*, and *Vicia americana*. Ferns include species of *Cheilanthes* and *Woodsia*. Annual grasses and forbs are seasonally present. Figure 3.4.2.9 depicts this alliance occurring in NAVA.

Vegetation structure summary: Vegetation in this shrubland alliance is characterized by a moderately dense cover of broad-leaved, deciduous shrubs. The graminoid layer is sparse-to-moderately dense and dominated by medium-tall bunch grasses. The forb layer is generally sparse but may have high species diversity. Annual grasses and forbs are seasonally present.

Wetland indicator: N

Environmental summary: Shrublands included in this alliance occur in the foothills and lower slopes of isolated desert mountain ranges, mesas, and canyons from Nevada to western Texas, as well as in the lower montane zone of the southern Rocky Mountains, Uinta Mountains, and Wasatch Plateau. Elevations range from 1,550 to 2,950 m. Climate is semi-arid. Summers are generally hot and winters range from mild with cold periods and occasional snows in the southern part of its range to extended periods of freezing temperatures in the northern part. The seasonality of precipitation varies, but most of the 35–70 cm mean annual precipitation occurs during the growing season. Stands typically occur on nearly level to steep (to 80%) rocky slopes on upper slopes and ridgetops, but some stands occur in canyon bottoms and along drainages. Aspect does not seem important except in the southern range extent, where stands are restricted to the more mesic north slopes. Soils are generally deep, coarse-textured, and well-drained. Soil texture is

typically a cobbly and gravelly loamy sand and gravelly loams, but the alliance also occurs on well-drained clay soil. Parent materials are varied and include quartzite, monzonite, shale, and alluvium. Adjacent vegetation at higher elevations is typically conifer woodlands or forests dominated by *Pinus ponderosa*, *Pinus contorta*, or *Pseudotsuga menziesii*, but *Populus tremuloides* forests are also common in the northern part of its range. Adjacent vegetation below these stands is often medium-tall grasslands in southeastern Colorado or shrublands dominated by *Artemisia* spp. in western Colorado.

Dynamics: The distribution of *Quercus gambelii* was studied by Neilson and Wullstein (1983) in respect to climatic patterns. They found the species to be limited by seedling mortality from severe spring frosts and summer drought. The northern extent of the species is in alignment with the winter polar front that runs along the boundary between southern Wyoming and Colorado and Utah. Its western range limit aligns with the westward extent of summer moisture from the Arizona monsoon, which approximates the western Arizona border. Reproducing stands in northern Utah that exist north of the summer monsoon moisture are restricted to more mesic sites. Seedling recruitment is more common in the southern part of its range than the northern (Neilson and Wullstein 1983).

Quercus gambelii is a fire-adapted species (Clary 1992). The root systems are well-developed and draw moisture from a large volume of soil, allowing for rapid resprouting after fire. Muldavin and others (1998b) reported that after a severe fire in the Organ Mountains of southwestern New Mexico, *Quercus gambelii* resprouted into a dense thicket that excluded both herbaceous understory and conifer species. They suggested that frequent, small, cool fires would favor the establishment of conifers and maintain an herbaceous understory. *Quercus gambelii* shrubs also resprout vigorously after stems are killed with almost all herbicides or removed by chaining or cut for firewood (Clary 1992). Altered fire regimes, fuelwood harvest, and grazing by livestock have significant impacts to the quality of sites. More study is needed to understand and manage these shrublands ecologically.

Local vegetation summary: This type occurs at Betatakin and Keet Seel environs.



Figure 3.4.2.10. *Quercus gambelii* / *Symphoricarpos oreophilus* Shrubland.

3.4.2.10 *Quercus gambelii* / *Symphoricarpos oreophilus* Shrubland

Translated name: Gambel Oak / Mountain Snowberry Shrubland

Unique identifier: C EGL001117

Classification approach: International Vegetation Classification (IVC)

Summary: This plant association is found in foothills, plateaus, and mountains from western Texas to southern and western Colorado and throughout Utah, and likely occurs in northern Arizona. Elevation ranges from 1,750 to 2,745 m (6,000–8,600 ft). This type is a mesic upland and non-obligate riparian community. Some stands appear to be transitional between riparian areas and drier upland communities, such as *Artemisia* spp. This type occurs on cool, moist sites, such as along drainages in canyons and steep draws in more xeric areas, and as a mesic upland shrubland forming extensive stands on cooler northern slopes. Substrates are typically deep, well-drained, sandy loam to clay loam derived from alluvium or colluvium. The vegetation is characterized by an open-to-closed, typically tall-shrub layer (2–5 m tall) dominated by *Quercus gambelii* (Gambel oak). The understory is composed of a short-shrub layer dominated by *Symphoricarpos oreophilus* or a closely related local *Symphoricarpos* species, such as *Symphoricarpos rotundifolius* or *Symphoricarpos palmeri*. Other mesic shrubs may be present, including *Amelanchier* spp., *Prunus virginiana*, *Robinia neomexicana*, and *Brickellia* sp. In some stands, the *Quercus gambelii* develop into small trees that form a tree canopy. These “woodlands” are included in this association because their floristic composition is identical to the tall shrublands. In other stands, the oak is mostly under 2 m tall, forming a short-shrub layer. The herbaceous layer is sparse-to-moderately dense, depending on density of woody canopy, and is often dominated by graminoids, such as species of *Achnatherum*, *Bromus*, *Elymus*, *Poa*, and *Koeleria*. Common forbs include *Vicia americana*, *Thalictrum fendleri*, and *Achillea millefolium*. Occasionally, tree species are present in the overstory, including *Pinus ponderosa*, *Juniperus scopulorum*, and *Pseudotsuga menziesii*. Introduced

graminoids, such as *Bromus inermis* and *Poa pratensis*, are often common in stands that have been disturbed by heavy livestock grazing.

Classification confidence: 2–Moderate

Classification comments: This plant association is similar to other montane Gambel oak shrublands, except for the co-dominance of *Symphoricarpos oreophilus* with only minor amounts (<10% cover) of *Amelanchier utahensis*, *Artemisia tridentata*, or *Cercocarpus montanus*.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.B	Deciduous shrubland
Formation group	III.B.2	Cold-deciduous shrubland
Formation subgroup	III.B.2.N	Natural/Semi-natural cold-deciduous shrubland
Formation name	III.B.2.N.a	Temperate cold-deciduous shrubland
Alliance name	<i>Quercus gambelii</i> Shrubland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES303.664	Southwestern Great Plains Canyon
CES305.796	Madrean Pine-Oak Forest and Woodland
CES306.818	Rocky Mountain Gambel Oak-Mixed Montane Shrubland

Global status: G5 (23Feb1994)

Rounded global status: G5–Secure

U.S. distribution: AZ, CO, NM, TX, UT

Global distribution: United States

Global range: This shrubland association is reported from foothills, plateaus, and mountains of western Texas to southern and western Colorado and Utah, and likely occurs in Arizona.

Wetland indicator: N

Dynamics: Fire is important in maintaining montane shrublands, as burning eliminates *Juniperus osteosperma*, *Juniperus scopulorum*, and *Pinus edulis* trees, but not the more fire-adapted shrub species. *Quercus gambelii* is a fire-adapted species with a well-developed root system that draws moisture from a large volume of soil, allowing for rapid resprouting after fire (Clary 1992). Muldavin et al. (1998b) reported that after a severe fire in the Organ Mountains of southwestern New Mexico, *Quercus gambelii* resprouted into a dense thicket that excluded both herbaceous understory and conifer species. *Symphoricarpos oreophilus*, tolerant of fire, is usually undamaged by low-severity fire, and will resprout if the above-ground parts are burned. However, it is considered a weak sprouter and may take longer to recover from a burn than *Quercus gambelii* (up to 15 years after a severe fire) (Wright et al. 1979, Crane 1982). At Mesa Verde National Park, most of which has burned in the past 30 years, stands of *Pinus edulis* - *Juniperus* spp. / *Quercus gambelii* Woodland (CEGL000791) persist only in the unburned parts of the park and have the appearance of oak shrublands that have been invaded by pinyon and juniper.

Local vegetation summary: This association was described by one field plot (VMP.NAVA-13) located in the Betatakin unit, and represented a *Quercus gambelii* bottomland (Figure 3.4.2.10). The sampled plot was on a toe slope at an elevation of 2,133 m (6,998 ft) with a 10° slope and an aspect of 60°. Ground cover was composed of litter/duff (89%), wood (10%), and bare soil (1%). The soil texture was identified as a well-drained sandy loam. *Quercus gambelii* dominated the canopy

with a height ranging from 5 to 10 m (16.4–32.8 ft). The subcanopy ranged in height from 2 to 5 m (6.6–16.4 ft), with a cover class of 25–35%. Subcanopy species consisted of *Amelanchier utahensis* (Utah serviceberry) and *Prunus virginiana*. The tall-shrub stratum was 1–2 m (3.3–6.6 ft) in height, with a cover range of 15–25%. Tall-shrub species consisted of *Quercus gambelii* and *Rosa woodsii* (Woods' rose). Other species associated with this association included *Symphoricarpos oreophilus* (mountain snowberry), *Poa fendleriana*, *Thalictrum fendleri* (Fendler's meadow-rue), *Maianthemum stellatum* (starry false lily of the valley), and *Clematis ligusticifolia* (western white clematis).



Figure 3.4.2.11. *Tamarix* spp. Semi-natural Temporarily Flooded Shrubland Alliance.

3.4.2.11 *Tamarix* spp. Semi-natural Temporarily Flooded Shrubland Alliance

Translated name: Salt-cedar species Semi-natural Temporarily Flooded Shrubland Alliance

Unique identifier: A.842

Classification approach: International Vegetation Classification (IVC)

Summary: This alliance is composed of shrublands that form moderately dense-to-dense thickets on banks of larger streams, rivers, and playas across the western Great Plains, interior and southwestern U.S., and northern Mexico. Stands are dominated by introduced species of *Tamarix*, including *T. ramosissima*, *T. chinensis*, *T. gallica*, and *T. parviflora*. Introduced from the Mediterranean, *Tamarix* spp. have become naturalized in various sites, including salt flats, springs, and especially along streams and regulated rivers, often replacing *Salix* or *Prosopis* spp. shrublands or other native vegetation. A remnant herbaceous layer may be present, depending on the age and density of the shrub layer. These species have become a critical nuisance along most large rivers in the semi-arid western U.S. Because of the difficulty associated with its removal, *Tamarix* spp. may have irreversibly changed the vegetation along many rivers.

Classification comments: This broadly defined alliance is composed of many diverse *Tamarix* spp.-dominated vegetation communities from a wide variety of environments. Common species of *Tamarix* include *T. ramosissima*, *T. chinensis*, and *T. parviflora*, but other species are reported from the western U.S., such as *T. africana*, *T. aphylla*, *T. aralensis*, *T. canariensis*, *T. gallica*, and *T. tetragyna* (Kartesz 1999). Powell (1988) reported that *Tamarix* spp. are a critical nuisance, most notably along the Rio Grande and Pecos River. Muldavin et al. (2000a) described eight community types that will be reviewed as possible USNVC associations. Currently, the sole USNVC tamarix association, *Tamarix* spp. Temporarily Flooded Shrubland (CEGL003114), is equally broadly defined.

Local classification comments: One field plot (VMP.NAVA-10) described this alliance, which was

sampled as occurring in the Inscription House unit. No component associations of the alliance adequately described the vegetation occurring in the field. A proposed association name for this field plot is *Tamarix* spp. / *Elaeagnus angustifolia* Semi-natural Woodland. Due to the minimal amount of data, the plot was only classified and mapped to the alliance level to correspond with an existing NVC.

Vegetation hierarchy

Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.4	Microphyllous evergreen shrubland
Formation subgroup	III.A.4.N	Natural/Semi-natural microphyllous evergreen shrubland
Formation name	III.A.4.N.c	Temporarily flooded microphyllous shrubland

Global distribution: Mexico, United States

Global range: This semi-natural shrubland alliance is found along drainages in the semi-arid western Great Plains, interior western and southwestern U.S., and northern Mexico, from central and eastern Montana south to Colorado, western Oklahoma, and Texas west to California.

Vegetation summary: This semi-natural shrubland alliance occurs along streams, rivers and playas where it forms a moderate to dense tall-shrub layer that is solely or strongly dominated by species of *Tamarix* including *Tamarix ramosissima*, *Tamarix chinensis*, *Tamarix gallica*, and *Tamarix parviflora*. Other shrubs may include species of *Salix* (especially *Salix exigua*) and *Prosopis*, *Rhus trilobata*, and *Sarcobatus vermiculatus*, but with low cover (if shrub species are co-dominant, then the stand is classified as a natural shrubland). Scattered *Acer negundo*, *Salix amygdaloides*, *Populus* spp., or *Elaeagnus angustifolia* trees may also be present. Depending on stand age and density of the shrub layer, an herbaceous layer may be present. Associated species include *Distichlis spicata*, *Sporobolus airoides*, and introduced forage species, such as *Agrostis gigantea*, *Agrostis stolonifera*, and *Poa pratensis*. Introduced herbaceous species, such as *Polypogon monspeliensis*, *Conyza canadensis*, *Lepidium latifolium*, and others have been reported from shrublands in this association.

Wetland indicator: Y

Environmental summary: The riparian shrublands included in this alliance occur across the western Great Plains, interior western and southwestern U.S., and northern Mexico. These widespread shrublands are common along larger streams, rivers, and around playas. Elevation ranges from 75 m below sea level to 1,860 m. *Tamarix* spp. have become naturalized in various sites, including riverbanks, floodplains, basins, sandbars, side channels, springs, salt flats, and other saline habitats. Stands grow especially well along regulated rivers where flood-regenerated native species of *Populus* are declining. Substrates are commonly thin sandy loam soil over alluvial deposits of sand, gravel, or cobbles.

Dynamics: *Tamarix* spp. are highly competitive shrubs that have invaded many riparian and wetland environments in the western U.S. Hansen et al. (1995) reported that these shrubs are extremely drought- and salt-tolerant, produce prolific, wind-dispersed seeds over much of the growing season, can resprout after burning or cutting, and, if kept moist, buried or broken branches will develop adventitious roots and grow. Stands seem to favor disturbed and flow-regulated rivers, but establish well in pristine areas, too. Under optimum conditions, riparian areas can be converted to a dense thicket in less than 10 years (Hansen et al. 1995). Once established, stands are extremely difficult to eradicate, requiring cutting and herbicide application on stumps to prevent resprouting (Smith 1989).

Local vegetation summary: One field plot (VMP.NAVA-10) described this alliance, which was sampled as occurring in the Inscription House unit (Figure 3.4.2.11). The plot was sampled at

an elevation of 1,684 m with a minor slope and an aspect of 260° in a riparian ravine zone below Inscription House. Ground cover was composed of sand (60%), bare soil (27%), litter/duff (3%), wood (3%), water (5%), and large rocks (2%). The soil texture was identified as a moderately well-drained, sandy clay. Significant erosion and debris flow were present on site. The canopy was dominated by *Elaeagnus angustifolia* (Russian olive) and *Tamarix ramosissima* (saltcedar), with a height of 5.0–10.0 m (16.4–32.8 ft) and cover range of 25–35%. Additional species associated with this alliance included *Ericameria nauseosa* (<1%), *Scirpus pungens* (common threesquare) (5–15%), *Eleocharis palustris* (5–15%), *Hordeum jubatum* (foxtail barley) (5–15%), *Xanthium strumarium* (<1%), *Salix exigua* (narrowleaf willow) (1–5%), and *Salix gooddingii* (Goodding's willow) (1–5%).

3.4.3 Woodland vegetation

3.4.3.1 *Acer negundo* / Disturbed Understory Woodland

Translated name: Box-elder / Disturbed Understory Woodland

Unique identifier: CEG002693

Classification approach: International Vegetation Classification (IVC)

Summary: This riparian association is found in the Colorado Plateau and other areas of the southwestern U.S. on upper alluvial terraces below 2,015 m (6,600 ft) in elevation. Sites are on gentle slopes or flat areas near permanent or temporary streams but are rarely flooded because of their location on high, abandoned stream terraces. Soils are usually sandy. This type has an open-to-moderately closed (10–80%) tree canopy and moderate-to-dense total vegetation cover. The tree canopy of this association is open-to-moderately closed and 5–15 m tall. The dominant tree species is *Acer negundo* with scattered *Acer glabrum*, *Juniperus osteosperma*, or *Juniperus scopulorum*. There is a sparse shrub layer up to 2 m tall with *Artemisia tridentata*, *Ericameria nauseosa*, *Fraxinus anomala*, *Rhus trilobata*, *Ribes cereum*, *Tamarix ramosissima*, and (in the south) *Quercus gambelii*. Herbaceous cover and species composition are variable. The herbaceous stratum may be sparse or dominated by native and introduced species typically found in disturbed areas. *Bromus tectorum* is common. Other typical species are *Heterotheca villosa*, *Poa pratensis*, *Sisymbrium altissimum*, *Lepidium latifolium*, *Taraxacum officinale*, and *Verbascum thapsus*.

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II.B	Deciduous woodland
Formation group	II.B.2	Cold-deciduous woodland
Formation subgroup	II.B.2.N	Natural/Semi-natural cold-deciduous woodland
Formation name	II.B.2.N.b	Temporarily flooded cold-deciduous woodland
Alliance name	<i>Acer negundo</i> Temporarily Flooded Woodland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES306.821	Rocky Mountain Lower Montane Riparian Woodland and Shrubland

Global status: GNR (14Aug2001)

Rounded global status: GNR–Not Yet Ranked

U.S. distribution: CO, UT

Global distribution: United States

Global range: This association has been sampled in the Colorado Plateau from northwestern Colorado to southwestern Utah and is likely widespread elsewhere in the southwestern U.S.

Wetland indicator: Y

Environmental summary: This association is found on flat-to-gently sloping riparian sites near permanent or temporary streams below 2,015 m (6,600 ft) in elevation. Sites are usually found on terraces several meters above the active floodplain and below the steeper upland slopes on any aspect. They rarely flood. Soils are usually sandy alluvium and can range from well-drained to poorly drained. The ground surface is largely covered by large rocks, litter, downed wood, or bare soil.

Dynamics: The shade provided by the tree canopy and proximity to water make stands of this association attractive to domestic livestock and wildlife. The subsequent grazing, trampling, brows-

ing, and importation of weed seeds can be significant disturbances in this association and are likely instruments in shaping its composition.

Local vegetation summary: One field plot (VMP.NAVA-09) described this association as occurring in the Keet Steel unit. The plot was sampled at an elevation of 2,074 m (6,804 ft) with a 5% slope and aspect of 230° in a frequently washed-out stream-bottom channel. Ground cover was composed of bare soil (56%), litter/duff (2%), wood (2%), water (5%), large rocks (10%), and sand (25%). The soil texture was identified as a moderately well-drained silt loam soil texture. The canopy stratum consisted of *Acer negundo* with a height of 2.0–5.0 m (6.6–16.4 ft) and cover of less than 1%. Shrubs present in the plot included *Senecio flaccidus* var. *flaccidus* (<1%) and *Gutierrezia sarothrae* (1–5%). Graminoids cover ranged from 15 to 25%, consisting of *Bromus tectorum* and *Poa interior*. Forb cover ranged from 25 to 35% and included the species *Conyza canadensis*, *Taraxacum officinale*, *Erodium cicutarium*, and *Ranunculus cymbalaria*.

3.4.3.2 *Elaeagnus angustifolia* Semi-natural Woodland Alliance

Translated name: Russian-olive Semi-natural Woodland Alliance

Unique identifier: A.3566

Classification approach: International Vegetation Classification (IVC)

Summary: This widespread Russian-olive woodland alliance is found in the northern Great Plains, Utah, and probably throughout much of the western U.S. and adjacent Canada. It is a naturalized type that has been widely planted in hedgerows for windbreaks. It has since spread to a variety of native habitats, particularly more mesic ones, such as near streams and rivers. In South Dakota's Badlands National Park, this type occupies a portion of shoreline along the White River, upstream of a highway bridge (Von Loh et al. 1999). In Ouray National Wildlife Refuge in Utah, these woodlands are found in the floodplain along the Green River and in upland basins and drainages. Stands tend to be small and linear. The vegetation is dominated by *Elaeagnus angustifolia*, with a variety of native and introduced species in the shrub and herbaceous layers. Associated species have not been characterized. In a stand in Badlands National Park, *Elaeagnus angustifolia* is dominant. Canopy closure approaches 40–50%, about equal to the tall-shrub cover provided by *Salix exigua*. *Amorpha fruticosa* and *Pascopyrum smithii* make up the short-shrub and herbaceous cover, which are less than 10%. At Ouray National Wildlife Refuge in Utah, tree canopies were denser to (80% cover) and had remnant *Populus fremontii* trees (to 10% cover). Other than a few native grasses (*Sporobolus airoides*, *Distichlis spicata*, and *Hordeum jubatum*) and *Atriplex patula* in the herbaceous layer, the understory was dominated by introduced species, both in the moderately dense-to-dense tall-shrub layer (*Tamarix ramosissima*) and in the herbaceous layer (*Lepidium latifolium*, *Descurainia sophia*, and *Bassia scoparia* (= *Kochia scoparia*)).

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II.B	Deciduous woodland
Formation group	II.B.2	Cold-deciduous woodland
Formation subgroup	II.B.2.N	Natural/Semi-natural cold-deciduous woodland
Formation name	II.B.2.N.a	Cold-deciduous woodland

Global distribution: United States

Global range: This alliance is found in Utah, Colorado, North Dakota, and South Dakota.

Wetland indicator: N

Local classification summary: This alliance was not supported with either a formal field plot or field notes. Photointerpretation of several small polygons in the Inscription House unit identified the potential for this alliance. The nearest associated field plot (VMP.NAVA-10) contained both *Tamarix* spp. and *Elaeagnus angustifolia* as the dominants in the canopy. The polygons mapped as this alliance appeared to have been part of the riverine system historically. The polygons contain a linear cluster of trees, which seem to correspond to the signature of *Elaeagnus angustifolia*. It would seem reasonable to also map these few polygons as the *Tamarix* spp. Semi-natural Temporarily Flooded Shrubland Alliance, which has been previously described in this report.

Local vegetation summary: No field information was collected for this potential NAVA alliance. Refer to the local vegetation summary for the *Tamarix* spp. Semi-natural Temporarily Flooded Shrubland Alliance for a similar vegetation description.



Figure 3.4.3.3. *Juniperus osteosperma* / *Artemisia tridentata* ssp. *wyomingensis* Woodland.

3.4.3.3 *Juniperus osteosperma* / *Artemisia tridentata* ssp. *wyomingensis* Woodland

Translated name: Utah Juniper / Wyoming Big Sagebrush Woodland

Unique identifier: CEGl000730

Classification approach: International Vegetation Classification (IVC)

Summary: 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 1,220 to 2,260 m (4,000–7,400 ft). 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* (= *Hilaria 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*.

Classification confidence: 2–Moderate

<i>Vegetation hierarchy</i>		
Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	<i>Juniperus osteosperma</i> Woodland Alliance	
<i>Ecological systems placement</i>		
Ecological system unique ID		Ecological system name
CES304.767		Colorado Plateau Pinyon-Juniper Woodland
CES306.955		Rocky Mountain Foothill Limber Pine-Juniper Woodland

Global status: G5? (01Feb1996)

Rounded global status: G5–Secure

Wetland indicator: N

Dynamics: Fires in this association are thought to be infrequent because smaller *Juniperus osteosperma* and *Artemisia tridentata* are easily killed by burns and do not resprout (Barney and Frischknecht 1974, Everett 1987). In addition, many stands have an open canopy with insufficient understory to carry fire. *Artemisia tridentata* will re-establish relatively quickly (about 10–20 years) if a seed source is nearby (Barney and Frischknecht 1974, Bunting 1987). However, *Juniperus osteosperma* is relatively slow to recover following fire, and sagebrush may dominate the sites for decades (Jameson et al. 1962). If fire-return intervals are more frequent than 10 years, then *Artemisia tridentata* has difficulty recovering (Bunting 1987, Everett 1987). This community may be increasing in extent by invading adjacent grasslands and steppe because of reduction of fire frequency due to fire suppression and fine-fuels removal by grazing livestock that would allow fires to spread (Johnson and Payne 1968). Fire, drought, and competition with grasses are thought to have kept *Juniperus* spp. communities restricted to rocky areas that do not burn frequently (Wright et al. 1979).

Local vegetation summary: One field plot (VMP.NAVA-12) described this association (Figure 26). The field plot was located in the Betatakin unit at an elevation of 2,023 m (6,637 ft), with a 35° slope and 82° aspect. Ground cover consisted of cryptograms (45%), sand (45%), litter/duff (5%), and wood (5%). The soil texture was indentified as being a well-drained, sandy soil. *Juniperus osteosperma* represented the canopy layer with a height of 2.0–5.0 m (6.6–16.4 ft) and a cover range of 5–15%. Tall-shrub species *Artemisia tridentata* and *Atriplex canescens* were present at a height of 1.0–2.0 m (3.3–6.6 ft) and a cover range of 25–35%. Other associated shrubs present in lesser quantities included *Tetradymia canescens* (1–5%), *Opuntia erinacea* (1–5%), and *Artemisia campestris* (1–5%). Associated graminoids (5–15%) included *Bouteloua gracilis*, *Hesperostipa comata* ssp. *comata*, and *Vulpia octoflora*. Associated forbs (1–5%) included *Cordylanthus parviflorus* and *Plantago patagonica*.

3.4.3.4 *Pinus edulis* - (*Juniperus* spp.) Woodland Alliance

Translated name: Two-needle Pinyon - (Juniper species) Woodland Alliance

Unique identifier: A.516

Classification approach: International Vegetation Classification (IVC)

Summary: *Pinus edulis*-dominated woodlands occur in the mountains, plateaus, and canyons of Colorado, Utah, Arizona, and New Mexico, in the westernmost tip of the Oklahoma panhandle, and possibly in western Texas. The climate of the region is semi-arid with drought not uncommon. Stands typically occur on nearly level-to-steep (to 80%), rocky slopes on hillsides and ridgetops. Aspect does not seem important except in elevational extremes for a given latitude where low-elevation stands are restricted to the more mesic north slopes; canyons and high-elevation stands occur on south aspects. Sites are typically dry with shallow, rocky, calcareous, and alkaline soils. Other sites include eroded “badlands,” lava flows, scree slopes, and deep sands. The understory ranges from a relatively rich mixture of evergreen and/or deciduous shrubs, to a sparse-to-moderately dense herbaceous layer dominated by perennial grasses (with or without shrubs), to no vegetation at all. Most commonly, the understory is sparse and has a patchy distribution in the openings between tree crowns. Associated species can include *Juniperus monosperma*, *Juniperus osteosperma*, *Juniperus deppeana*, *Juniperus coahuilensis* (= *Juniperus erythrocarpa*), *Quercus arizonica*, *Cercocarpus montanus*, *Cercocarpus ledifolius*, *Arctostaphylos pungens*, *Artemisia tridentata*, *Rhus trilobata*, *Bouteloua gracilis*, *Andropogon hallii*, *Festuca arizonica*, *Muhlenbergia dubia*, and others.

Classification comments: *Pinus edulis* forest stands are not well-differentiated from woodland stands. They occur on less-xeric sites within woodlands, such as on north aspects and at higher-elevation sites. Only one association currently exists, and more work is needed to clarify the differences between these two alliances.

The literature often describes *Pinus edulis* and *Juniperus* spp. vegetation types as one woodland type (P/J woodland). Both *Pinus edulis*-dominated associations and those co-dominated with *Juniperus* spp. are included in this alliance. More work is needed to clarify boundaries between this alliance and the *Juniperus* spp. alliances that may have scattered *Pinus edulis* trees. Also, a sparsely vegetated alliance may need to be developed because some *Pinus edulis* stands do not have enough cover to be classified as woodlands. See Francis (1986) for examples.

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	<i>Juniperus osteosperma</i> Woodland Alliance	

U.S. distribution: AZ, CA, CO, NM, NV, OK, TX, UT, WY

Global distribution: United States

Global range: Stands included in this woodland alliance are common on the Colorado Plateau and extend north into the Uinta Mountains, south into the northern mountains of the Sonoran and Chihuahuan deserts, and east to lower montane zone of the southern Rocky Mountains. The alliance is also found on mesas and breaks of the southern Great Plains as far as the panhandle of Oklahoma and into western Texas.

Wetland indicator: N

Dynamics: *Pinus edulis* is extremely drought-tolerant and slow-growing (Little 1987, Powell 1988). It is also non-sprouting and may be killed by fire (Wright et al. 1979). The effect of a fire on a stand is largely dependent on the tree height and density, fine-fuel load on the ground, weather conditions, and season (Dwyer and Pieper 1967, Wright et al. 1979). Trees are more vulnerable in open stands where fires frequently occur in the spring, the relative humidity is low, wind speeds are over 10–20 mph, and there are adequate fine fuels to carry fire (Wright et al. 1979). Under other conditions, burns tend to be spotty with low tree mortality. Large trees are generally not killed unless fine fuels, such as tumbleweeds, have accumulated beneath the tree to provide ladder fuels for the fire to reach the crown (Jameson 1962). Closed-canopy stands rarely burn because they typically do not have enough understory or wind to carry a fire (Wright et al. 1979).

Although *Pinus edulis* is drought-tolerant, prolonged droughts will weaken trees and promote mortality by secondary agents. Periodic die-offs of pinyon pine caused by insects, such as the pinyon ips beetle (*Ips confusus*), or fungal agents, such as blackstain root-rot (*Leptographium wagneri*), tend to be correlated with droughts (Anhold 2005). These mortality events may be localized or widespread but can result in 50–90% mortality of *Pinus edulis* (Harrington and Cobb 1988).

Climatic and other factors have resulted in denser and expanded pinyon-juniper stands throughout the Colorado Plateau and Great Basin. Denser stands are more susceptible to attack by insects and disease (Anhold 2005). In addition, altered fire regimes, tree-cutting for fencing or firewood, and improper grazing by livestock have significant impacts on the quality of sites. Grazing by livestock can modify the fire regime by removing the fine fuels that carry fire. Fire, livestock grazing, and trampling by recreationalists and vehicles disturb cryptogamic soil crusts that help maintain soil structure, reduce soil erosion, provide habitat for plants, and preserve biological diversity (Ladyman and Muldavin 1996). More study is needed to understand and manage these woodlands ecologically.

Local vegetation summary: This type occurs at every unit and environs.



Figure 3.4.3.5. *Pinus edulis* - *Juniperus osteosperma* / *Amelanchier utahensis* Woodland.

3.4.3.5 *Pinus edulis* - *Juniperus osteosperma* / *Amelanchier utahensis* Woodland

Translated name: Two-needle Pinyon - Utah Juniper / Utah Serviceberry Woodland

Unique identifier: CEG002329

Classification approach: International Vegetation Classification (IVC)

Summary: This association is characteristic of rocky slopes in western Colorado. Stands in northwestern Colorado are at lower elevations (1,528–1,950 m) and tend to occur on northerly aspects. Stands in central and southern Colorado occur at higher elevations (2481–2510 m) and have southerly aspects. Stands throughout the range may be on gentle-to-steep slopes (7–160%). Soils are rapidly drained but texture and parent materials vary from clay to sandy loam and from marine shale to sandstone and granite. The unvegetated ground surface is composed primarily of exposed bedrock, rocks, gravel, and bare ground. This woodland association has an open-to-relatively closed tree canopy and sparse to dense total vegetation cover. *Juniperus osteosperma* and *Pinus edulis* comprise the tree canopy but individually do not exceed 25% cover. There is a tall-shrub stratum with up to 25% cover dominated by *Amelanchier utahensis*. Other shrubs that may be present with low cover include *Artemisia tridentata*, *Cercocarpus montanus*, *Fraxinus anomala*, *Ephedra viridis*, *Fendlera rupicola*, *Quercus gambelii*, *Rhus trilobata*, and *Symphoricarpos oreophilus*. Dwarf shrubs may include *Yucca harrimaniae*, *Gutierrezia sarothrae*, and *Chrysothamnus viscidiflorus*. The herbaceous layer has sparse-to-low cover and contains graminoids such as *Achnatherum hymenoides*, *Carex geyeri*, *Leymus salinus*, and *Poa fendleriana*, and forbs such as *Antennaria parvifolia*, *Erigeron peregrinus*, *Eriogonum ovalifolium*, *Heterotheca villosa*, *Lathyrus lanszwertii*, *Lepidium montanum*, *Phlox austromontana*, and *Streptanthella longirostris*. Disturbed stands may contain *Bromus tectorum*.

Classification confidence: 2–Moderate

Classification comments: *Amelanchier utahensis* is a common constituent of plant

communities on rocky slopes in the Colorado Plateau. There is some overlap with *Pinus edulis* - *Juniperus osteosperma* / (*Shepherdia rotundifolia*, *Amelanchier utahensis*) Wooded Shrubland (CEGL002334), and as more information becomes available, woodlands with *Amelanchier utahensis* as a significant component should be re-analyzed.

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon-Juniper Woodland
CES306.955	Rocky Mountain Foothill Limber Pine-Juniper Woodland

Global status: GNR (11Jan2005)

Rounded global status: GNR–Not Yet Ranked

U.S. distribution: CO

Global distribution: United States

Global range: This association is found in the Colorado Plateau and central Rocky Mountains of western Colorado.

Wetland indicator: N

Local vegetation summary: This association was described by one field plot (VMP.NAVA-22) located in the Inscription House unit (Figure 27). The association was sampled halfway up a canyon slot at an elevation of 1,773 m (5,817 ft) with a slope of 30–40° and aspect of 110°. Ground cover consisted of bare soil (10%), bedrock (40%), litter/duff (5%), wood (5%), cryptogram (10%), small rocks (10%), and large rocks (20%). The soil texture was identified as a rapidly drained, loamy sand. The canopy consisted of both *Pinus edulis* and *Juniperus osteosperma*, with a cover of 1–5% and canopy height of 2.0–5.0 m (6.6–16.4 ft). Tall shrubs (15–25%) consisted of *Quercus turbinella*, *Amelanchier utahensis*, and *Rhus trilobata* var. *simplicifolia*. Short-shrub (5–15%) species included *Cercocarpus intricatus* and *Artemisia nova*. Dwarf-shrub species (1–5%) included *Gutierrezia sarothrae* and *Yucca angustissima* var. *toftiae*. Herbaceous understory species were present in small amounts (<5%) and consisted of *Bouteloua gracilis*, *Bouteloua curtipendula*, *Achnatherum hymenoides*, *Echinocereus triglochidiatus*, and *Astragalus lentiginosus*.



Figure 3.4.3.6. *Pinus edulis* - *Juniperus osteosperma* / *Cercocarpus intricatus* Woodland.

3.4.3.6 *Pinus edulis* - *Juniperus osteosperma* / *Cercocarpus intricatus* Woodland

Translated name: Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland

Unique identifier: CEGl000779

Classification approach: International Vegetation Classification (IVC)

Summary: This woodland association occurs on dry, sandstone ridgetops, mesa edges, outcrops, and colluvial slopes at moderate elevations of 1,585–2,470 m (5,200–8,100 ft) on the Colorado Plateau and in extreme northwestern Colorado, adjacent Utah, and possibly Wyoming. South and southwest aspects are common, and slopes can be variable in steepness. Exposed bedrock and large rock may cover over 50% of the stand, with vegetation growing in the cracks. These sandstone-derived soils are generally poorly developed, coarse-textured, and skeletal. Bare soil is common. The vegetation is characterized by a short (2–10 m), open tree canopy (10–25% cover) co-dominated by *Pinus edulis* and *Juniperus osteosperma*, and by the dominance of *Cercocarpus intricatus* in the relatively sparse short-shrub layer (10–25% cover). *Pinus edulis* and *Juniperus osteosperma* vary in cover between 1 and 15%, though higher covers are possible. The shrubs *Amelanchier utahensis*, *Arctostaphylos patula*, *Gutierrezia sarothrae*, *Mahonia fremontii*, *Quercus gambelii*, or *Yucca* spp. are often present in many stands. Herbaceous cover is sparse (<5% cover) and is composed of scattered forbs and grasses, such as species of *Cryptantha*, *Penstemon*, and *Opuntia*, *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Bouteloua gracilis*, *Elymus elymoides*, *Pleuraphis jamesii*, and *Poa fendleriana*.

Classification confidence: 2–Moderate

Classification comments: Compare this association with *Juniperus osteosperma* / *Cercocarpus intricatus* Woodland (CEGL000733) which is very similar, but lacks *Pinus edulis*.

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES304.765	Colorado Plateau Mixed Bedrock Canyon and Tableland
CES304.766	Colorado Plateau Pinyon-Juniper Shrubland
CES304.767	Colorado Plateau Pinyon-Juniper Woodland

Global status: G3 (30Dec2000)

Rounded global status: G3–Vulnerable

Reasons: This plant association is limited to a small geographic area and is documented from a narrow elevational band on sandstone substrates in extreme northwestern Colorado and possibly adjacent Utah. There are 11 documented stands in Colorado, with size ranging from 4 to 450 ac. Although most occurrences are considered in good-to-excellent condition, those in excellent condition tend to be small. Grazing and woodcutting are the primary threats where stands are accessible.

U.S. distribution: CO, UT, WY

Global distribution: United States

Global range: This plant association is found on the Colorado Plateau and in extreme northwestern Colorado, adjacent Utah, and possibly Wyoming.

Wetland indicator: N

Dynamics: Fire is not frequent because open tree and shrub canopies and lack of continuous fine fuels prevent its spread.

Local vegetation summary: This association was the most commonly documented in the NAVA project area, based on the field plot data (Figure 28). A total of eight field plots (VMP.NAVA-36, 37, 38, 39, 40, 41, 44, 45) were sampled in the Betatakin and Inscription House units. In addition, two plots (VMP.NAVA-42, 43) were sampled just outside the Keet Seel project area in the Skeleton Mesa region, with the intention of representing vegetation that is not easily accessed in Keet Seel. The two plots in the Skeleton Mesa area represented vegetation on a slope and an exposed area. This association may be described as a sandstone community and was often sparse in vegetation. Vegetation often was patchy in nature (i.e., vegetation islands) and existed in areas where soil accumulates. Bedrock was the dominant ground cover item for the majority of the plots sampled. Soil texture was identified as sand, sandy clay, loamy sand, and silt loam. Elevation of the sampled plots ranged from 1,813 to 2,221 m (5,948–7,287 ft), slope from 2 to 20% and all encompassing aspects.

The canopy stratum is dominated by *Pinus edulis*, *Juniperus osteosperma*, and sometimes *Fendlera rupicola*, with heights ranging from 1.0 to 10.0 m (3.3–32.8 ft) and cover range of 1–15%. Shrub species observed in the field plots included *Cercocarpus intricatus*, *Artemisia dracunculus*, *Ephedra viridis*, *Shepherdia rotundifolia*, *Artemisia bigelovii*, *Chrysothamnus pulchellus*, *Gutierrezia saro-*

thrae, and *Artemisia nova*, with strata coverages ranging from 1 to 15%. Associated herbaceous species included *Vulpia octoflora*, *Poa fendleriana*, *Bouteloua gracilis*, *Sporobolus cryptandrus*, *Achnatherum hymenoides*, *Bromus tectorum*, *Yucca angustissima*, *Eriogonum umbellatum*, *Escobaria vivipara* var. *vivipara*, *Opuntia erinacea*, *Vulpia octoflora*, *Arenaria eastwoodiae*, *Opuntia polyacantha*, *Opuntia phaeacantha*, *Arenaria eastwoodiae*, *Tradescantia occidentalis*, *Artemisia ludoviciana*, and *Ipomopsis* sp., with strata coverages ranging from 1 to 15%.



Figure 3.4.3.7. *Pinus edulis* - *Juniperus osteosperma* / *Opuntia fragilis* Woodland.

3.4.3.7 *Pinus edulis* - *Juniperus osteosperma* / *Opuntia fragilis* Woodland

Translated name: Two-needle Pinyon - Utah Juniper / Brittle Prickly-pear Woodland

Unique identifier: CEG002374

Classification approach: International Vegetation Classification (IVC)

Summary: This rare, open woodland association is currently documented only from Capitol Reef National Park in southeastern Utah; this summary is derived from plots sampled in the park in 2003 and 2004. It is restricted to eolian deposits on benches and valley floors on sites that slope gently (5–15%), occur between 2,067 and 2,298 m in elevation, and are oriented to southeastern aspects. Sand and litter cover most of the unvegetated surface, although biological soil crusts provide up to 40% cover. Parent materials include Wingate and Navajo sandstone eroded and redeposited as eolian sands. Soils are rapidly drained sands, sandy loams, and loamy sands. Total vegetation cover generally does not exceed 50%, and is characterized by an open canopy, typically 2–10 m tall, of *Pinus edulis* and *Juniperus osteosperma* that range in cover from 15 to 40%, and an understory dominated by *Opuntia fragilis* that ranges in cover from 15 to 55%. Associated shrubs include *Picrothamnus desertorum* (= *Artemisia spinescens*) and *Ericameria nauseosa*. The herbaceous layer is diverse in terms of species composition and provides sparse-to-moderate cover. Common

graminoids include *Achnatherum hymenoides*, *Bouteloua gracilis*, and *Muhlenbergia pungens*. Forbs typically provide less than 1% total cover per species.

Classification confidence: 3–Weak

Classification comments: This association has only been described from Capitol Reef National Park. Until further inventory is completed, there is no global information.

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon-Juniper Woodland

Global status: GNR (23Mar2005)

Rounded global status: GNR–Not Yet Ranked

U.S. distribution: UT

Global distribution: United States

Global range: This association has been documented only from scattered sites throughout Capitol Reef National Park in southeastern Utah.

Wetland indicator: N

Dynamics: Unlike some other associations in which *Opuntia* spp. are dominant, this association has not been affected by domestic livestock grazing. It is restricted to well-drained eolian sands.

Local vegetation summary: This association is described by one field plot (VMP.NAVA-48) in the Betatakin unit (Figure 29). The association was sampled on a side slope at an elevation of 2,228 m (7,310 ft) with a 15° degree slope and 60° aspect. Ground cover consisted of bare soil (30%), bedrock (5%), litter/duff (1%), wood (5%), cryptograms (40%), small rocks (1%), large rocks (1%), and sand (15%). The soil texture was identified as a well-drained, loamy sand. The canopy was dominated by *Pinus edulis* and *Juniperus osteosperma* with a height of 2.0–5.0 m (6.6–16.4 ft) and cover ranging from 5 to 15%. Tall shrubs (5–15%) consisted of *Fendlera rupicola* and *Purshia tridentata*. Short shrubs (5–15%) consisted of *Ephedra viridis* and *Shepherdia rotundifolia*. Dwarf shrubs (5–15%) consisted of *Gutierrezia sarothrae* and *Opuntia fragilis*. The herbaceous stratum consisted of a sparse (<1%) cover of forbs consisting of *Heterotheca villosa*, *Descurainia pinnata*, and *Cryptantha* sp.



Figure 3.4.3.8. *Pinus edulis* - *Juniperus osteosperma* / *Shepherdia rotundifolia* Woodland.

3.4.3.8 *Pinus edulis* - *Juniperus osteosperma* / *Shepherdia rotundifolia* Woodland

Translated name: Two-needle Pinyon - Utah Juniper / Roundleaf Buffaloberry Woodland

Unique identifier: CEGl002335

Classification approach: International Vegetation Classification (IVC)

Summary: This woodland association occurs in two distinct situations: At Natural Bridges National Monument and Capitol Reef National Park, stands of this type occupy rolling uplands on eolian, alluvial, or residual red sandy silt soils, often in a mosaic with *Pinus edulis* - *Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland (CEGL000776) and *Pinus edulis* - *Juniperus osteosperma* / Sparse Understory Woodland (CEGL002148). In addition, at Capitol Reef and Canyonlands national parks, stands occur on warm, dry, moderately steep lower slopes where sandstone colluvium overlies slopes of Chinle or Organ Rock shales. Elevations range from 1,445 to 2,273 m (4,740–7,460 ft). Because this is a relatively xeric woodland, bare soil and rocks may cover up to 70% of the unvegetated surface. Soils vary depending on substrate, including sandy loams, sandy clays, and silt loams. This woodland association is locally common in the Colorado Plateau of southern Utah. Total vegetation cover ranges between 15 and 80%. *Juniperus osteosperma* and *Pinus edulis* form a canopy 2–5 m tall and with 10–60% cover. The understory is

characterized by a shrub layer dominated by *Shepherdia rotundifolia*. Other shrubs present may include *Artemisia tridentata* ssp. *wyomingensis*, *Mahonia fremontii*, *Artemisia nova*, and *Gutierrezia sarothrae*. Herbaceous species generally have low total cover and vary from site to site. Cryptobiotic soils may have significant cover in sites derived from loess.

Classification confidence: 2–Moderate

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon-Juniper Woodland

Global status: GNR (12Jan2005)

Rounded global status: GNR–Not Yet Ranked

U.S. distribution: NM, UT

Global distribution: United States

Global range: This association has been documented from southern Utah. It may also occur in northern New Mexico.

Wetland indicator: N

Dynamics: This association occupies ecological sites that, outside of the range of *Shepherdia rotundifolia*, are occupied by pinyon-juniper/serviceberry and pinyon-juniper/Wyoming sagebrush woodland types. The shrubs occupy microsites with elevated soil moisture, either because of gully-ing of the soil or because of colluvial sandstone blocks concentrating precipitation.

Local vegetation summary: This association was described by four field plots (Figure 30). Three of the field plots (VMP.NAVA-1, 3, 4) are located in the Betatakin unit; the other field plot (VMP.NAVA-2) was sampled in the Keet Seel unit. Elevation of the sampled plots ranged from 2,033 to 2,193 m (6,670–7,195 ft) with slopes ranging from 15 to 40%. Sand and silt loam textures were the identified soils. Bedrock and bare soil were the dominant ground cover types. The canopy stratum was dominated by *Pinus edulis* and *Juniperus osteosperma*, with heights ranging from 1.0 to 5.0 m (3.6–16.4 ft) and cover from 5 to 25%. *Fendlera rupicola* also was observed in the canopy at times, with an associated cover of 5–15%. The shrub stratum ranged from 5 to 25% and included such species as *Ephedra viridis*, *Shepherdia rotundifolia*, *Atriplex canescens*, *Yucca angustissima*, *Purshia stansburiana*, *Cercocarpus intricatus*, *Artemisia nova*, *Artemisia frigida*, *Opuntia erinacea*, and *Gutierrezia sarothrae*. The graminoid stratum ranged in cover from 5 to 35% and included *Bouteloua gracilis*, *Hesperostipa comata* ssp. *comata*, *Poa fendleriana*, *Achnatherum hymenoides*, *Bromus tectorum*, *Psilostrophe sparsiflora*, and *Sphaeralcea parvifolia*.



Figure 3.4.3.9. *Pinus edulis* - *Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland.

3.4.3.9 *Pinus edulis* - *Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland

Translated name: Two-needle Pinyon - Juniper species / (Wyoming Big Sagebrush, Mountain Big Sagebrush) Woodland

Unique identifier: CEG000776

Classification approach: International Vegetation Classification (IVC)

Summary: 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 1,465 to 2,500 m (4,800–8,200 ft). 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 to 50% cover) that is co-dominated 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) dominates a 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*, 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* (= *Oryzopsis 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.

Classification confidence: 1–Strong

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon-Juniper Woodland
CES306.835	Southern Rocky Mountain Pinyon-Juniper Woodland

Global status: G5 (01Feb1996)

Rounded global status: G5–Secure

U.S. distribution: AZ, CA, CO, NM, NV, UT

Global distribution: United States

Global range: 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.

Wetland indicator: N

Dynamics: Stuever and Hayden (1997) described two phases of this plant community: a *Juniperus osteosperma* and a *Juniperus monosperma* phase. Both are restricted by geographic range, and where the *Juniperus* spp. are sympatric, *J. osteosperma* generally occurs at high elevations. Fires in this association are thought to be infrequent because *Pinus edulis*, *Juniperus osteosperma*, *Juniperus monosperma*, and *Artemisia tridentata* are killed by burns and do not resprout (Wright et al. 1979). *Artemisia tridentata* will re-establish relatively quickly (about 10–20 years) if a seed source is nearby (Bunting 1987). However, *Pinus edulis*, *Juniperus osteosperma*, and *Juniperus monosperma* are relatively slow to recover following fire, and sagebrush may dominate the sites for decades (Jameson et al. 1962, Erdman 1970). If fire-return intervals are more frequent than 10 years, then *Artemisia tridentata* has difficulty recovering (Bunting 1987, Everett 1987).

Local vegetation summary: This is the second-most documented association by field plots for the NAVA project area (Figure 31). A total of eight field plots (VMP.NAVA- 27 to 34) described this association locally. Seven of the eight field plots were located in the Betatakin unit. The remaining field plot was sampled in the Skeleton Mesa area near Keet Seel, on a ridgetop. Sample locations ranged in elevation from 2,193 to 2,234 m (7,195–7,329 ft) with slopes ranging from 0 to 10% with aspects ranging in all directions. The canopy stratum was dominated by *Pinus edulis* and *Juniperus osteosperma* with stand height ranging from 1.0 to 10 m (3.3–32.8 ft) and a cover of 1–25%. The dominant shrub of this association was *Artemisia tridentata*, with cover range of 5–45%. Other associated species of this alliance included *Fendlera rupicola*, *Purshia stansburiana*, *Gutierrezia sarothrae*, and *Opuntia fragilis*. The herbaceous stratum overall was sparse, with cover ranging from 1 to 15%. Associated herbaceous species include *Poa fendleriana*, *Ipomopsis aggregata*, *Cordylanthus parviflorus*, *Opuntia erinacea*, *Descurainia pinnata*, *Bouteloua gracilis*, *Vulpia octoflora*, *Bromus tectorum*, *Elymus elymoides* ssp. *elymoides*, and *Hymenopappus filifolius*.



Figure 3.4.3.10. *Pinus edulis* - *Juniperus osteosperma* / *Purshia tridentata* Woodland.

3.4.3.10 *Pinus edulis* - *Juniperus osteosperma* / *Purshia tridentata* Woodland

Translated name: Two-needle Pinyon - Utah Juniper / Antelope Bitterbrush Woodland

Common name: Two-Needle Pinyon / Bitterbrush

Unique identifier: CEGLO00789

Classification approach: International Vegetation Classification (IVC)

Summary: This association is common at middle elevations of the pinyon-juniper woodland zone in western Colorado and northwestern New Mexico. Sites occupy ridges, scarps, and mesas with generally gentle-to-moderate slopes. Elevations range from 1,800 to 2,330 m (5,900–7,645 ft) and aspect is variable. Soils are often coarse and rocky, may be shallow, and sometimes contain outcrops of the underlying sandstone or limestone. This association is characterized by a mixed canopy of *Pinus edulis* and *Juniperus* spp., with a shrub layer dominated by *Purshia tridentata*. Canopy cover ranges from 10% in the beetle- and fungus-affected woodlands of southwestern Colorado to around 50% in the mountains of northern New Mexico. The canopy sometimes includes arborescent *Quercus gambelii* in the southern part of the range. The shrub layer may consist almost entirely of *Purshia tridentata* with between 5 and 25% cover, or more often is mixed with other shrubs that have at least 1% cover, including *Amelanchier utahensis*, *Artemisia tridentata*, *Artemisia nova*,

Cercocarpus montanus, *Ephedra viridis*, *Opuntia polyacantha*, *Ribes cereum*, and *Yucca baccata*. Graminoids are well-represented-to-abundant; common species include *Pseudoroegneria spicata*, *Poa fendleriana*, *Koeleria macrantha*, *Carex rossii*, and *Piptatherum micranthum*. The forb component of the understory is often diverse but rarely contributes significantly to the overall vegetation cover. Species noted as occurring in this community include *Astragalus scopulorum*, *Eriogonum jamesii*, *Eriogonum racemosum*, *Penstemon linarioides* ssp. *coloradoensis*, *Petradoria pumila*, *Phlox* spp., and *Stenotus acaulis*.

Classification confidence: 1–Strong

Classification comments: Some stands of this association in northwestern Colorado have a shrub layer that is co-dominated by *Artemisia nova* and *Purshia tridentata*. The classification of these stands may need to be revisited to determine whether they are a better fit with the concept of this association or with *Pinus edulis* - *Juniperus osteosperma* / *Artemisia nova* Woodland (CEGL002331).

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES304.766	Colorado Plateau Pinyon-Juniper Shrubland
CES304.767	Colorado Plateau Pinyon-Juniper Woodland
CES306.835	Southern Rocky Mountain Pinyon-Juniper Woodland

Global status: G5 (01Feb1996)

Rounded global status: G5–Secure

U.S. distribution: CO, NM

Global distribution: United States

Global range: This association is documented from the Sandia and Jemez ranges in New Mexico, from Mesa Verde in southwestern Colorado, and from Dinosaur National Monument in northwestern Colorado.

Wetland indicator: N

Dynamics: At Mesa Verde National Park, this association is limited to the southern mesatops that have not burned in the last 200 years. Before 1980, it was much more widespread within the park. Blackstain root-rot (a fungus) and a major *Ips* beetle infestation have devastated pinyon trees in southwestern Colorado and southeastern Utah since 1999, reducing populations in some areas by more than 90%. This has converted some stands of this association to a de facto *Juniperus osteosperma* / *Purshia tridentata* woodland association, although *Pinus edulis* seedlings commonly occur in the herbaceous stratum. *Purshia tridentata* shrubs are often heavily browsed by deer and elk.

Local vegetation summary: This association was described by one field plot (VMP.NAVA-49) located in the Betatakin unit (Figure 32). The association was sampled at 2,200 m (7,218 ft), with a

slope of 10° and aspect of 110°. Ground cover consisted of bare soil (20%), bedrock (10%), litter/duff (3%), wood (5%), moss (2%), cryptograms (40%), lichen (5%), large rocks (5%), and sand (10%). The soil texture was identified as a rapidly drained loamy sand. The canopy layer consisted of *Pinus edulis* and *Juniperus osteosperma*, with a height of 2.0–5.0 m (6.6–16.4 ft) and cover of 25–35%. Tall shrubs (15–25%) consisted of *Purshia tridentata* and *Quercus gambelii*. Additional species associated with this association included *Artemisia tridentata* and *Gutierrezia sarothrae*. The herbaceous strata consisted only of a trace of vegetation (<1%) and included the species *Bouteloua gracilis*, *Poa fendleriana*, *Cryptantha* sp., and *Cordylanthus parviflorus*.

3.4.3.11 *Populus deltoides* (ssp. *wislizeni*, ssp. *monilifera*) / *Salix exigua* Woodland

Translated name: (Rio Grande Cottonwood, Plains Cottonwood) / Coyote Willow Woodland

Unique identifier: Cegl002685

Classification approach: International Vegetation Classification (IVC)

Summary: 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 in Colorado, North Dakota, Nebraska, Oklahoma, South Dakota, and Texas. This association occurs in wide river corridors that have low-gradient and primarily sandy/gravelly beds (becoming cobbly with increasing gradients). Elevations range from 1,380 to 1,980 m (4,525–6,500 ft). The type is most often found proximal to perennial rivers on low sidebars and streambanks near stream bankfull levels (discharge ratios close to one). 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 five 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 co-dominate. Herbaceous cover is abundant, particularly among graminoids, and numerous (23) native wetland indicators can be present, such as *Schoenoplectus pungens* (= *Scirpus 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%).

Classification confidence: 1–Strong

Classification comments: 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) described a cottonwood/coyote willow mapping unit with four structural subtypes for the middle Rio Grande. Dick-Peddie (1993) referred 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.

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II.B	Deciduous woodland
Formation group	II.B.2	Cold-deciduous woodland
Formation subgroup	II.B.2.N	Natural/Semi-natural cold-deciduous woodland
Formation name	II.B.2.N.b	Temporarily flooded cold-deciduous woodland
Alliance name	<i>Populus deltoides</i> Temporarily Flooded Woodland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES302.748	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
CES303.658	Northwestern Great Plains Canyon
CES303.678	Western Great Plains Floodplain

Global status: G3 (01Dec2000)

Rounded global status: G3–Vulnerable

Reasons: 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.

U.S. distribution: CO, ND, NE, NM, OK, SD, TX, UT

Global distribution: United States

Global range: 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 in Colorado, North Dakota, Nebraska, Oklahoma, South Dakota, and Texas.

Wetland indicator: Y

Local vegetation summary: This association was described by one field plot (VMP.NAVA-08) located in the Keet Seel unit, in a drainage area where evidence of monsoonal flows occur. The elevation of the field plot was 2,034 m (6,673 ft) with a 5% slope and aspect of 135°. Ground cover consisted of sand (60%), bare soil (10%), litter/duff (20%), wood (5%), and small rocks (5%). The soil texture was identified as a moderately to well-drained sandy clay soil. *Populus deltoides* ssp. *wislizeni* was the only species present in the canopy stratum, with a height of 15.0–20.0 m (49.2–65.6 ft) and cover of 35–45%. The tall-shrub stratum (35–45%) consisted of *Salix exigua* and *Salix lucida* ssp. *lasiandra*. *Ericameria nauseosa* ssp. *nauseosa* var. *nauseosa* made up the short-shrub stratum (1–5%). The graminoid stratum (15–25%) primarily consisted of *Muhlenbergia andina* and *Juncus tenuis*. Forbs were present in smaller amounts (5–15%) included the species *Artemisia ludoviciana* and *Conyza canadensis*.

3.4.3.12 *Pseudotsuga menziesii* / *Acer negundo* Woodland

Translated name: Douglas-fir / Box-elder Woodland

Unique identifier: CEG002754

Classification approach: International Vegetation Classification (IVC)

Summary: This mixed-canopy woodland association has been documented from cold, narrow, high-gradient tributary canyons in Dinosaur National Monument in northwestern Colorado. Elevations range from 1,600 to 2,000 m (5,250–6,560 ft). Sites are rocky and subject to periodic flash flooding. The canopy consists of *Pseudotsuga menziesii* with a subcanopy of *Acer negundo*. Other tree species present include *Populus angustifolia* and *Juniperus scopulorum*. The shrub layer is variable but may include *Amelanchier utahensis*, *Prunus virginiana*, *Rosa woodsii*, and *Rhus trilobata*. Herbaceous species have minimal cover.

Classification confidence: 3–Weak

Local classification summary: This association has no associated vegetation data. This association represents one polygon in the entire mapping project area, which is referenced by an informal field observation.

Vegetation hierarchy

Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.b	Conical-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	<i>Pseudotsuga menziesii</i> Woodland Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES306.825	Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland

Global status: GNR (12Apr2005)

Rounded global status: GNR–Not Yet Ranked

U.S. distribution: CO, UT

Global distribution: United States

Global range: This association has only been documented from Dinosaur National Monument in northwestern Colorado.

Wetland indicator: N

Local vegetation summary: This association is referenced as occurring in Keet Seel through an informal field reference. No associated vegetation field data exists.

3.4.4 Forest vegetation

3.4.4.1 *Populus tremuloides* Temporarily Flooded Forest Alliance

Translated name: Quaking Aspen Temporarily Flooded Forest Alliance

Unique identifier: A.300

Classification approach: International Vegetation Classification (IVC)

Summary: This alliance contains a number of communities found from the Great Lakes to the western and southwestern United States. Most stands of this alliance are found in riparian zones. Some may be near lakes where the ground is flooded or saturated for a short time in the spring. The moderate-to-closed tree canopy is dominated by *Populus tremuloides*, sometimes with *Populus balsamifera* co-dominant. More-open stands have a prominent shrub layer containing species such as *Alnus incana*, *Cornus sericea*, and *Salix* spp.

Classification comments: Clarification is needed as to why some associations were included in this alliance instead of the seasonally flooded alliance. Stands in this alliance also had wetland soils (gleyed, hydric, organic muck) as well as better-drained, upland soils. It is not clear if the *Populus tremuloides* - *Populus balsamifera* alliances also included *Populus balsamifera* ssp. *trichocarpa* or just *Populus balsamifera* ssp. *balsamifera*. Little information was available on stands occurring in the northern Great Plains and western Great Lakes areas. Also, the sole reference cited for *Populus tremuloides* Canyon Formation Forest (CEGL000576) does not mention *Populus tremuloides*. Stands in California need association-level description.

Vegetation hierarchy

Formation class	I	Forest
Formation subclass	I.B	Deciduous forest
Formation group	I.B.2	Cold-deciduous forest
Formation subgroup	I.B.2.N	Natural/Semi-natural cold-deciduous forest
Formation name	I.B.2.N.d	Temporarily flooded cold-deciduous forest

U.S. distribution: CA, CO, ID, ME, MI, MN, MT, ND, NH, NM, NV, OR, UT, VT, WA, WI

Canadian province distribution: AB, MB, NB, ON, QC, SK

Global distribution: Canada, United States

Global range: Forests included in this alliance have been described from across the western and southwestern U.S. and northern Great Plains. They extend into the western Great Lakes area from California to Michigan. Its northern extent is in Canada in Saskatchewan, Manitoba, and Ontario.

Vegetation summary: Vegetation included in this widespread forest alliance occurs in temporarily flooded sites in the western U.S. to the western Great Lakes area. Stands have a somewhat closed-to-closed canopy of trees 5–20 m tall, dominated or co-dominated by the cold-deciduous, broad-leaved tree, *Populus tremuloides*. Other broad-leaved trees, such as *Populus balsamifera* ssp. *trichocarpa*, *Populus balsamifera* ssp. *balsamifera*, *Quercus macrocarpa*, and *Betula papyrifera*, may be present to co-dominant, depending on geography and topography. Several species of conifer trees may also be present in the tree canopy. Conifers include *Abies concolor*, *Abies lasiocarpa*, *Picea engelmannii*, *Picea pungens*, *Pinus contorta*, *Pinus ponderosa*, and *Pseudotsuga menziesii*. Conifer species may contribute up to 25% of the tree canopy before the stand is reclassified as a mixed stand. Because of the open-growth form of *Populus tremuloides*, enough light can penetrate for lush understory development, depending on available soil moisture and other factors. The understory structure may be complex, with multiple shrub and herbaceous layers, or simple, with just an herbaceous layer. In the western U.S., common tree associates include *Populus balsamifera* ssp. *trichocarpa* in the northern Rocky Mountains (Cooper and Heidel 1997). One or more of the conifer trees listed above are often scattered in the canopy or understory of stands occurring in

the montane and subalpine zones. If present, the tall-shrub layer may be dominated by *Quercus gambelii*, *Amelanchier alnifolia*, *Alnus incana*, *Betula occidentalis*, *Betula nana*, *Prunus virginiana*, or *Salix* species, such as *Salix bebbiana*, *Salix drummondiana*, *Salix monticola*, or many others. Common short shrubs include *Cornus sericea*, *Ribes montigenum*, *Rosa woodsii*, *Symphoricarpos albus*, and *Symphoricarpos oreophilus*. The dwarf shrubs *Mahonia repens* and *Vaccinium myrtillus* are common. The herbaceous layer may be lush and diverse, dominated by graminoids or tall forbs. Other common graminoids may include *Bromus ciliatus*, *Bromus carinatus*, *Calamagrostis canadensis*, *Carex siccata* (= *Carex foenea*), *Carex hoodii*, *Elymus glaucus*, *Elymus trachycaulus*, and *Festuca thurberi*. Forbs may include *Achillea millefolium*, *Eucephalus engelmannii* (= *Aster engelmannii*), *Delphinium X occidentale*, *Equisetum arvense*, *Fragaria virginiana*, *Geranium richardsonii*, *Ligusticum porteri*, *Maianthemum stellatum*, *Mertensia arizonica*, *Osmorhiza occidentalis*, *Senecio bigelovii* var. *bigelovii*, *Thalictrum occidentale*, *Veratrum californicum*, and many others. Exotic grasses, such as the perennial *Poa pratensis* and the annual *Bromus tectorum*, are often common in stands disturbed by grazing. In the northern Great Plains and western Great Lakes areas, these stands have a moderate-to-closed tree canopy dominated by *Populus tremuloides* with *Populus balsamifera* co-dominant. More-open stands have a prominent shrub layer containing species such as *Alnus incana*, *Cornus sericea*, and *Salix* spp. Little information was available for stands in the northern Great Plains and midwestern U.S.

Vegetation structure summary: Vegetation included in this alliance has a moderately dense-to-dense tree canopy dominated by cold-deciduous broad-leaved trees (5–20 m tall). Evergreen needle-leaved trees may be present, but do not co-dominate the tree canopy. The understory is variable. Sparse-to-dense, tall- and short-shrub layers may be present and are typically dominated by deciduous, broad-leaved species; however, a scale-leaved short shrub dominates the understory of some stands. Sparse-to-dense, tall or short herbaceous layers may also be present and may be dominated by perennial forbs or graminoids.

Wetland indicator: Y

Environmental summary: Forests included in this alliance occur extensively in the western U.S. and northern Great Plains, and extend into the western Great Lakes area. Elevations range from 600 to 3,230 m. Climate is temperate, with a relatively long growing season, typically cold winters, and, often, deep snow. Mean annual precipitation is greater than 38 cm and typically greater than 50 cm, except in semi-arid environments. Most of these temporarily flooded stands are found in riparian zones. Some may occur near lakes where the ground is flooded or saturated for a short time in the spring or on upland slopes below seepage areas. Distribution of these forests is primarily limited by adequate soil moisture required to meet its high evapotranspiration demand (Mueggler 1988). Secondarily, its range is limited by the length of the growing season or low temperatures (Mueggler 1988). Topography is variable. Sites are typically gently sloping but also include steep slopes near upland seeps. Aspect varies according to the limiting factors. Stands at high elevations or northern latitudes are restricted by cold temperatures and found on warmer southern aspects. At lower elevations and southern latitudes, stands are restricted by lack of moisture and are found on cooler northern aspects and mesic microsites. The soils are typically deep and well-developed, with rock often absent from the soil. Soils are typically mesic or hydric, poorly drained, and fine-textured, consisting of silts and clays, often with an organic surface layer. Many are gleyed and would be classified as wetland soils. However, because of the alluvial soils are coarser, soil texture ranges from clay to sandy loams. Parent materials are variable and may include sedimentary, metamorphic, or igneous rocks, but these forests appear to grow best on limestone, basalt, and calcareous or neutral shales (Mueggler 1988).

Dynamics: Stands in this alliance often originate and likely are maintained by stand-replacing disturbances, such as crown fire, disease, and windthrow, or clearcutting by humans and beaver. The stems of these thin-barked, clonal trees are easily killed by ground fires. They can quickly and vigorously resprout in densities of up to 30,000 stems per hectare (Knight 1994). Stands are favored by fire in the conifer zone (Mueggler 1988). The stems are relatively short-lived (100–150 years),

and individual stands will succeed to longer-lived conifer forest if undisturbed. With adequate disturbance, a clone may live many centuries. Although *Populus tremuloides* produces abundant seeds, seedling survival is rare because the long, warm, moist conditions required to establish are rare in the habitats where it occurs.

Local vegetation summary: This type occurs at Keet Seel and its environs.



Figure 3.4.4.2. *Populus tremuloides* / *Quercus gambelii* / *Symphoricarpos oreophilus* Forest.

3.4.4.2 *Populus tremuloides* / *Quercus gambelii* / *Symphoricarpos oreophilus* Forest

Translated name: Quaking Aspen / Gambel Oak / Mountain Snowberry Forest

Unique identifier: CEG000598

Classification approach: International Vegetation Classification (IVC)

Summary: This deciduous forest is known from central New Mexico, the southwestern Colorado Plateau, and southern Rocky Mountains, where it occurs along drainages on plateaus and in draws on mountain slopes. Elevations range from 2,240 to 2,538 m. Stands occur along intermittent streams on moderately steep-to-steep slopes with southwestern to northwestern aspects. Soils tend to be relatively shallow, finer-textured loams derived from alluvium and residuum from volcanic or sedimentary rocks. Litter covers much of the ground surface. The vegetation is characterized by a moderately dense-to-dense tree canopy dominated by *Populus tremuloides*. *Quercus gambelii* dominates the tall-shrub layer (>10% cover) and may be present in the tree canopy. *Symphoricarpos oreophilus* or *Symphoricarpos rotundifolius* form the short-shrub layer (>10% cover) with several other shrub species. Additional tall, short, and dwarf shrubs provide low-to-moderate cover and include *Amelanchier alnifolia*, *Mahonia repens*, *Paxistima myrsinites*, *Prunus virginiana*, *Pseudotsuga menziesii* seedlings, and *Rosa woodsii*. The herbaceous layer is generally sparse, but may be

moderately dense, and is usually a diverse mixture of grasses and forbs. Forb species may include *Achillea millefolium*, *Galium boreale*, *Geranium* sp., *Heracleum maximum*, *Lathyrus lanszwertii*, *Ligusticum porteri*, *Maianthemum stellatum*, *Pedicularis procera*, *Senecio eremophilus*, *Solidago velutina*, *Thalictrum fendleri*, and *Vicia americana*. Common graminoids include *Bromus anomalus*, *Bromus porteri*, *Carex geyeri*, *Festuca thurberi*, and the introduced perennial *Poa pratensis*.

Classification confidence: 2–Moderate

Classification comments: This poorly known association is reported from only two locations and needs additional classification work to further define the type and its range.

Vegetation hierarchy

Formation class	I	Forest
Formation subclass	I.B	Deciduous forest
Formation group	I.B.2	Cold-deciduous forest
Formation subgroup	I.B.2.N	Natural/Semi-natural cold-deciduous forest
Formation name	I.B.2.N.d	Temporarily flooded cold-deciduous forest
Alliance name	<i>Populus tremuloides</i> Temporarily Flooded Forest Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES306.813	Rocky Mountain Aspen Forest and Woodland
CES306.833	Rocky Mountain Subalpine-Montane Riparian Woodland

Global status: GNR (01Feb1996)

rounded global status: GNR–Not Yet Ranked

U.S. distribution: CO, NM, UT

Global distribution: United States

Global range: This deciduous forest association is known from the Sacramento Mountains of central New Mexico, the southwestern Colorado Plateau, and southern Rocky Mountains in western Colorado.

Wetland indicator: Y

Local vegetation summary: This association was represented by one field plot (VMP.NAVA-46) located in the Betatakin unit (Figure 33). The association was sampled at an elevation of 2,021 m (6,631 ft) with a slope of less than 5% and an aspect of 320°. Ground cover consisted of litter/duff (80%), bare soil (5%), wood (10%), and sand (5%). Soil texture was identified as a well-drained, sandy soil. The tallest stratum was composed of emergent *Populus tremuloides* with a height of 20–35 m (65.6–114.8 ft) and cover of 15–25%. The main canopy level was slightly shorter, with a height of 15–20 m (49.2–65.6) and covers of 65–75%, composed solely of *Populus tremuloides*. A tall shrub stratum (5–15%) was dominated by *Cornus sericea* ssp. *sericea*. The dwarf-shrub stratum (5–15%) was composed of *Toxicodendron radicans*. The herbaceous stratum (65–75%) was primarily composed of forbs with a height of 0.5–1.0 m (1.6–3.3 ft). Species associated with the herbaceous stratum included *Equisetum hyemale*, *Thalictrum fendleri*, *Clematis ligusticifolia*, and *Agropyron trachycaulum*. *Populus tremuloides* were also present in the understory in the form of seedlings with an associated cover of 25–35%.

3.4.4.3 *Pseudotsuga menziesii* Forest Alliance

Translated name: Douglas-fir Forest Alliance

Unique identifier: A.157

Classification approach: International Vegetation Classification (IVC)

Summary: This alliance includes evergreen forests dominated by *Pseudotsuga menziesii* occurring from Vancouver Island south through the Cascades and Coastal Ranges of northern California, through the Great Basin and Rocky Mountains, to extreme western Texas and northern Mexico. In the Pacific ranges, the dominant species is *Pseudotsuga menziesii* var. *menziesii*, while *Pseudotsuga menziesii* var. *glauca* is the dominant in forests of the Rocky Mountains, south to Mexico. Currently, this alliance includes 49 associations occurring in 12 states or provinces. Associated species vary with geographic location but can include in the canopy/subcanopy *Arbutus menziesii*, *Acer circinatum*, *Acer glabrum*, *Acer grandidentatum*, *Amelanchier alnifolia*, *Quercus arizonica*, *Quercus gambelii*, *Quercus hypoleucoides*, and *Quercus rugosa*. Typical shrubs and herbs include *Arctostaphylos patula*, *Arctostaphylos uva-ursi*, *Arnica cordifolia*, *Bromus ciliatus*, *Calamagrostis rubescens*, *Carex geyeri*, *Festuca arizonica*, *Festuca occidentalis*, *Gaultheria shallon*, *Holodiscus discolor*, *Jamesia americana*, *Juniperus communis*, *Juniperus osteosperma*, *Linnaea borealis*, *Mahonia aquifolium* (= *Mahonia piperiana*), *Mahonia repens*, *Muhlenbergia montana*, *Muhlenbergia virescens*, *Osmorhiza berteroi*, *Paxistima myrsinites*, *Physocarpus malvaceus*, *Purshia tridentata*, *Spiraea betulifolia*, *Symphoricarpos albus*, *Symphoricarpos occidentalis*, *Symphoricarpos oreophilus*, *Thalictrum occidentale*, *Vaccinium caespitosum*, *Vaccinium membranaceum*, and *Viola adunca*. In western Texas, this alliance is restricted to upper canyons and slopes at high elevations of 1,830–2,440 m (6,000–8,000 ft) in the mountains of the Trans-Pecos, where important associates include *Pinus ponderosa* var. *scopulorum*, *Pinus strobiformis* (Guadalupe Mountains), and *Cupressus arizonica* (Chisos Mountains).

Classification comments: This alliance is derived from a series concept, where the presence of *Pseudotsuga menziesii* is diagnostic if other more shade-tolerant conifers are absent (presumes dominance of *Pseudotsuga menziesii* if some form of disturbance or extreme edaphic conditions do not limit its regeneration). In the Pacific ranges, the dominant taxon is *Pseudotsuga menziesii* var. *menziesii*, while *Pseudotsuga menziesii* var. *glauca* is the dominant in forests of the Rocky Mountains south into Mexico.

Vegetation hierarchy

Formation class	I	Forest
Formation subclass	I.A	Evergreen forest
Formation group	I.A.8	Temperate or subpolar needle-leaved evergreen forest
Formation subgroup	I.A.8.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen forest
Formation name	I.A.8.N.c	Conical-crowned temperate or subpolar needle-leaved evergreen forest

U.S. distribution: AZ, CA, CO, ID, MT, NM, OR, TX, UT, WA, WY

Canadian province distribution: AB, BC

Global distribution: Canada, Mexico, United States

Global range: This montane and coastal alliance includes evergreen forests dominated by *Pseudotsuga menziesii* occurring from Vancouver Island south through the Cascades and Coast ranges of northern California, through the Rocky Mountains of Montana, Colorado, and Alberta, the Nevada–Utah and Arizona–New Mexico mountains, to extreme western Texas and northern Mexico.

Vegetation summary: This alliance includes evergreen forests dominated by *Pseudotsuga menziesii* occurring in mountain ranges of the western U.S., as well as northern Mexico, and western Texas. In the Pacific ranges, the dominant species is *Pseudotsuga menziesii* var. *menziesii*, while *Pseudotsuga*

menziesii var. *glauca* is the dominant in forests of the Rocky Mountains, south to Mexico. On the east side of the Cascades and east into the northern and southern Rocky Mountains, these forests are dominated by *Pseudotsuga menziesii* in the canopy and almost always in the tree regeneration layer. *Pinus ponderosa* is an important seral species occurring in many associations, either as older seral remnants or co-dominating in the canopy. Other trees that can be present-to-abundant (typically seral) include *Larix occidentalis* in the northern Rockies, *Populus tremuloides* (in the southern Rockies and south into New Mexico and Arizona), *Pinus strobiformis* (in New Mexico and Arizona), and *Pinus contorta* (throughout much of the alliance's range). Species of *Abies* and *Picea* do not commonly occur in this alliance, but are present in some stands. Understories in *Pseudotsuga menziesii* forests are varied; many associations have well-developed shrub layers, varying in height from <2 m (typically) up to 5 m. Dominant species in some associations in the northern Rockies include *Acer glabrum*, *Linnaea borealis*, *Paxistima myrsinites*, *Physocarpus malvaceus*, *Symphoricarpos albus*, *Symphoricarpos oreophilus*, *Spiraea betulifolia*, *Vaccinium caespitosum*, and *Vaccinium membranaceum*. Further south, other shrubs become the dominant or diagnostic species, such as *Acer grandidentatum*, *Amelanchier alnifolia*, *Arctostaphylos patula*, *Jamesia americana*, *Physocarpus monogynus*, *Quercus arizonica*, *Quercus gambelii*, *Quercus rugosa*, *Quercus X pauciloba*, and *Quercus hypoleucoides*. *Arctostaphylos uva-ursi* and *Mahonia repens* are present to important throughout the range.

The herbaceous layer can be sparse, or if the shrub layer is not abundant, can be relatively species-rich, usually graminoid-dominated. Important or dominant species include the graminoids *Bromus ciliatus*, *Calamagrostis rubescens*, *Carex geyeri*, *Carex rossii*, *Festuca arizonica*, *Festuca occidentalis*, *Bromus ciliatus*, *Luzula parviflora*, *Muhlenbergia montana*, and *Muhlenbergia virescens*; and the forbs *Arnica cordifolia*, *Osmorhiza berteroi*, *Thalictrum occidentale*, *Viola adunca*, and species of many other genera, including *Lathyrus*, *Penstemon*, *Erigeron*, *Lupinus*, *Fragaria*, *Vicia*, *Arenaria*, *Galium*, and others.

In the low-elevation forests of western Washington and Oregon (west of the Cascade crest), the canopy is semi-open-to-closed. *Pseudotsuga menziesii* dominates, with little or no *Tsuga heterophylla* or *Thuja plicata*. *Abies grandis* is co-dominant on some sites, and *Pinus contorta* can also co-dominate. *Salix scouleriana* and *Arbutus menziesii* are common but subordinate. There is a well-developed understory of deciduous or evergreen shrubs, or graminoids. *Holodiscus discolor*, *Symphoricarpos albus*, or *Rosa gymnocarpa* are typical dominant species and diagnostic. Other shrubs that may be important include *Gaultheria shallon*, *Rhododendron macrophyllum*, *Vaccinium ovatum*, *Mahonia aquifolium* (= *Mahonia piperiana*), *Mahonia nervosa*, *Corylus cornuta*, and *Symphoricarpos mollis*. In the herbaceous layer, *Festuca occidentalis* and *Melica subulata* are diagnostic species, often dominant or co-dominant. *Bromus vulgaris*, *Festuca subuliflora*, and *Elymus glaucus* are also very common.

Vegetation structure summary: These forests are characterized by a multi-tiered, needle-leaved evergreen tree canopy up to 50 m high, with between 60 and 100% cover. A sparse subcanopy of cold-deciduous or evergreen trees is often present, particularly in northwestern coastal stands. Downed wood may also be abundant in older stands. Shrub cover is dominated by ericaceous or cold-deciduous species and can be dense. The herbaceous understory is composed of either shade-tolerant forbs and ferns in the northern Rockies and Pacific Northwest, or mesophytic-to-xerophytic forbs and grasses in drier stands.

Wetland indicator: N

Environmental summary: Forest associations within this alliance occur in two major distributions. The first is along the northwest Pacific slope in low-elevation valleys of western Oregon and Washington, in scattered dry sites of the Olympics and western Cascades, and along the eastern slope of the Oregon and Washington Cascades. The second is in the Rocky Mountains, extending from the Okanogan Highlands and Blue Mountains of eastern Washington and Oregon south and east into the mountains of the Great Basin and into the Rocky Mountains from Montana south

into northern Mexico.

The Pacific Northwest region has mild winter temperatures, cool-to-hot summers, and receives 75–250 cm of annual precipitation in a Mediterranean pattern of winter rain followed by summer drought. The majority of the precipitation falls as rain, but snowfall can be abundant at montane elevations. These forests occur along low- to moderate-elevation (0–1,300 m) mountain slopes and valley margins, with an increasing affinity for moist topographic positions away from the coast and southward. They occupy sites where soil drought is induced by site features (shallow soils, sunny aspect) or local rainshadow effects that lessen precipitation. Generally, these forests are in drier sites or zones than *Pseudotsuga menziesii* - *Abies grandis* forests, but moister sites or zones than *Pinus ponderosa* - *Pseudotsuga menziesii* woodlands. Contiguous vegetation is often *Quercus* spp. woodlands and savannas, chaparral, or annual grasslands at the xeric margin, and closed *Sequoia sempervirens* or *Tsuga heterophylla* forests at the mesic margin.

In the Rocky Mountains, *Pseudotsuga menziesii* forests occur under a comparatively drier and more continental climate regime, and at higher elevations than in the Pacific Northwest. Elevations range from less than 1,000 m in the northern Rocky Mountains to nearly 2,900 m in the southern Rockies and plateaus of the southwestern U.S. Lower-elevation stands typically occupy protected northern exposures or mesic ravines and canyons, often on steep slopes. At higher elevations, these forests occur primarily on southerly aspects or ridgetops. Annual precipitation ranges from 50 to 100 cm, with moderate snowfall and a greater proportion falling during the growing season. Monsoonal summer rains contribute a significant proportion of the annual precipitation in Arizona, New Mexico, and Colorado. Adjacent vegetation is typically dominated by *Pinus ponderosa* or *Pinus flexilis* on drier, warmer sites; *Picea* spp. on moister sites; and *Abies concolor* or *Abies lasiocarpa* at higher, cooler sites. Montane grasslands and meadows may also occur in patches within these forests or on adjacent dry slopes.

Soils are highly variable across the range of this alliance and derived from diverse parent materials. *Pseudotsuga menziesii* forests are reported by most studies (Pfister et al. 1977, Steele et al. 1981, Mauk and Henderson 1984, Lillybridge et al. 1995) to show no particular affinities to geologic substrates. Rock types can include marine sediments in northern California and Oregon, glacial deposits in the Puget Sound, extrusive volcanics in the Cascades and Columbia Basin, and sedimentary rocks in the central and southern Rockies and the Colorado Plateau. The soils are typically slightly acidic (pH 5.0–6.0), well-drained, and well-aerated. They can be derived from moderately deep colluvium or shallow-jointed bedrock, and are usually gravelly or rocky.

Dynamics: Successional relationships in this alliance are complex. *Pseudotsuga menziesii* is less shade-tolerant than many northern or montane trees, such as *Tsuga heterophylla*, *Abies concolor*, *Picea engelmannii*, or *Thuja plicata*, and seedlings compete poorly in deep shade. At drier locales, seedlings may be favored by moderate shading, such as by a canopy of *Pinus ponderosa*, which helps to minimize drought stress. In some locations, much of these forests have been logged or burned during European settlement, and present-day stands are second-growth forests dating from fire, logging, or other stand-replacing disturbances (Mauk and Henderson 1984, Chappell et al. 1997). *Pseudotsuga menziesii* forests were probably subject to a moderate severity fire regime in pre-settlement times, with fire-return intervals of 30–100 years. Many of the important tree species in these forests are fire-adapted (*Populus tremuloides*, *Pinus ponderosa*, *Pinus contorta*, *Larix occidentalis*) (Pfister et al. 1977), and fire-induced reproduction of *Pinus ponderosa* can result in its continued co-dominance in *Pseudotsuga menziesii* forests (Steele et al. 1981). Seeds of the shrub, *Ceanothus velutinus*, can remain dormant in forest stands for 200 years (Steele et al. 1981) and germinate abundantly after fire, competitively suppressing conifer seedlings. Some stands may have higher tree-stem density than historically, due largely to fire suppression. Fire suppression has also led to the succession of *Pinus ponderosa* woodlands or *Quercus* spp. woodlands to *Pseudotsuga menziesii* forests.

Local vegetation summary: This type occurs at Keet Seel and its environs.

3.4.4.4 *Pseudotsuga menziesii* / *Quercus gambelii* Forest

Translated name: Douglas-fir / Gambel Oak Forest

Unique identifier: CEG.L000452

Classification approach: International Vegetation Classification (IVC)

Summary: This forest association occurs on mountains and plateaus from Colorado to Trans-Pecos Texas, west into Arizona and Utah. Elevation ranges from 1,370 to 2,870 m (4,500–9,400 ft). Stands are found along drainages, lower and middle slopes, steep upper slopes, and ridgetops. Aspects are variable. This forest occurs as both a non-obligate riparian community on the outer margins of riparian areas in desert canyons and steep draws, and as an upland forest forming extensive stands on typically north-facing hillslopes (southern aspects at higher elevations). Soils vary, but are often shallow and rocky, ranging from sandy loams to clay. The surface is generally largely covered with a thin layer of litter. Parent materials include fractured limestone, sandstone, basalt and andesite. The vegetation is characterized by a relatively sparse-to-moderately dense evergreen tree canopy dominated by *Pseudotsuga menziesii*, sometimes with scattered large *Pinus ponderosa*, *Pinus strobiformis*, *Pinus edulis*, or *Juniperus* spp. (especially on drier sites). *Abies concolor* is typically not present. *Quercus gambelii* dominates both the subcanopy (tree form, if present) and the moderately dense tall-shrub layer that consists of dense clumps of oak. *Quercus gambelii* must have at least 5% cover, but there is frequently over 25%. At higher elevations, the *Quercus gambelii* are more tree-like and *Symphoricarpos oreophilus* will be present with significant cover in the short-shrub layer. At lower elevations, scattered *Pinus edulis*, *Juniperus osteosperma*, or *Juniperus deppeana* are often present. Other common shrub species, depending on geographic location, may include *Acer glabrum*, *Arctostaphylos patula*, *Amelanchier* spp., *Cercocarpus montanus*, *Holodiscus dumosus*, *Mahonia repens*, *Paxistima myrsinites*, *Prunus virginiana*, *Ribes cereum*, *Robinia neomexicana*, and *Rosa woodsii*. The generally sparse herbaceous layer is composed of mostly graminoids with scattered forbs but ranges to moderately dense and diverse. Associated graminoids may include *Bromus* spp., *Carex rossii*, *Festuca arizonica*, *Koeleria macrantha*, *Muhlenbergia montana*, *Muhlenbergia virescens*, and *Poa fendleriana*. Common forbs include *Achillea millefolium*, *Lathyrus lanszwertii* var. *leucanthus*, *Thalictrum fendleri*, and *Vicia americana*. The shrub layer has equal or greater cover than graminoids. This open conifer forest transitions to *Quercus gambelii* woodlands in drier sites and at lower elevations.

Classification confidence: 2–Moderate

Classification comments: Within the habitat type literature, there are four phases mentioned: *Festuca arizonica* phase, *Holodiscus dumosus* phase, *Muhlenbergia virescens* phase (all defined by having at least 5% cover of both *Quercus gambelii* and the nominal species), and *Quercus gambelii* (typic) phase, defined by a undeveloped herbaceous layer (Alexander et al. 1984, Alexander et al. 1987, DeVelice et al. 1986, Fitzhugh et al. 1987, Johnston 1987, Larson and Moir 1987, Muldavin et al. 1996, Stuever and Hayden 1997b). Three similar USNVC *Pseudotsuga menziesii* associations use these phase species as the nominal species. These phases represent “intermediate” vegetation. Review of these associations is needed to clarify relationships between associations.

Vegetation hierarchy

Formation class	I	Forest
Formation subclass	I.A	Evergreen forest
Formation group	I.A.8	Temperate or subpolar needle-leaved evergreen forest
Formation subgroup	I.A.8.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen forest
Formation name	I.A.8.N.c	Conical-crowned temperate or subpolar needle-leaved evergreen forest
Alliance name	<i>Pseudotsuga menziesii</i> Forest Alliance	

Ecological systems placement

Ecological system unique ID	Ecological system name
CES306.823	Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland

Global status: G5 (23Feb1994)

Rounded global status: G5–Secure

U.S. distribution: AZ, CO, NM, TX, UT

Global distribution: United States

Global range: This *Pseudotsuga menziesii* forest association occurs in the southern Rocky Mountains and southwestern U.S. and is found on foothills, mountains, and plateaus from Colorado to Trans-Pecos Texas, west to Arizona and Utah.

Wetland indicator: N

Dynamics: This association represents mid- to late-seral forests that are dominated by *Pseudotsuga menziesii* with the diagnostic *Quercus gambelii*-dominated understory. Large, often fire-scarred *Pinus ponderosa* trees may be present to co-dominant in the canopy, but do not reproduce (Alexander et al. 1984, DeVelice et al. 1986).

Local vegetation summary: This association was represented by one field plot (VMP.NAVA-35) located at the base of a secluded large cliff area in the Betatakin unit. The elevation of the sampled plot is approximately 2,158 m (7,080 ft) with a 25% slope and an aspect of 10°. Ground cover consisted of bare soil (40%), bedrock (25%), litter/duff (5%), wood (5%), small rocks (10%), large rocks (10%), and sand (5%). *Pseudotsuga menziesii* was the dominant species of the emergent stratum with a height of 10–15 m and an associated cover of 1–5%. The subcanopy consisted of *Quercus gambelii*, *Pinus edulis*, and *Juniperus osteosperma* with a height of 2.0–5.0 m (6.6–16.4 ft) and cover of 15–25%. The tall shrub stratum (15–25%) was composed of *Cercocarpus intricatus* and *Shepherdia rotundifolia*. Additional shrub species associated with this alliance included *Ephedra viridis*, *Gutierrezia sarothrae*, *Yucca baccata*, and *Yucca angustissima*. Associated herbaceous species included *Poa fendleriana*, *Bromus tectorum*, *Hesperostipa comata* ssp. *comata*, and *Stephanomeria minor* var. *minor*.

3.4.5 Sparse vegetation

3.4.5.1 North American Warm Desert Bedrock Cliff and Outcrop

Scientific name: North American Warm Desert Bedrock Cliff and Outcrop

Unique identifier: CES302.745

Classification confidence: 2–Moderate

Summary: This ecological system is found from subalpine to foothill elevations and includes barren and sparsely vegetated landscapes (generally <10% plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. Also included are unstable scree and talus slopes that typically occur below cliff faces. Species present are diverse and may include *Bursera microphylla*, *Fouquieria splendens*, *Nolina bigelovii*, *Opuntia bigelovii*, and other desert species, especially succulents. Lichens are predominant lifeforms in some areas. May include a variety of desert shrublands less than 2 ha (5 acres) in size from adjacent areas. Land areas classified as this alliance may contain species associated with the surrounding local alliances and associations. Vegetation cover generally can be described as being sparse or non-existent. When vegetation is present, it is often clumped together in areas of soil accumulation, but still representing sparse vegetation cover overall. This alliance generally contains more consistent vegetation cover than the North American Warm Desert Bedrock Cliff and Outcrop Alliance.

Classification approach: International Terrestrial Ecological Systems Classification (ITESC)

Land cover class: Barren

Spatial pattern: Large patch

Natural/Seminal: Yes

Vegetated (>10% vascular cover): No

Upland: Yes

Local vegetation summary: This alliance was present at each of the three NAVA units.



Figure 3.4.5.2. Sandstone Sparsely Vegetated Alliance.

3.4.5.2 Sandstone Sparsely Vegetated Alliance

Translated name: Sandstone Sparsely Vegetated Alliance

Unique identifier: A.2568

Classification approach: International Vegetation Classification (IVC)

Vegetation hierarchy

Formation class	VII	Sparse Vegetation
Formation subclass	VII.B	Boulder, gravel, cobble, or talus sparse vegetation
Formation group	VII.B.2	Sparsely vegetated rock flats
Formation subgroup	VII.B.2.N	Natural/Semi-natural sparsely vegetated rock flats
Formation name	VII.B.2.N.a	Boulder fields

Global distribution: United States

Global range: This alliance is found in Arizona.

Wetland indicator: N

Local vegetation summary: One field plot (VMP.NAVA-20) described this alliance (Figure 34). Associated vegetation from the field plot included *Pinus edulis*, *Gutierrezia sarothrae*, and *Tradescantia occidentalis*, all of which were in trace amounts (<1%).



Figure 3.4.6.1. Invasive Annual and Biennial Forbland Alliance (proposed name)

3.4.6 Non-NVC types (proposed local alliances or associations)

3.4.6.1 Invasive Annual and Biennial Forbland Alliance (proposed name)

Local vegetation description: This proposed alliance was described by three field plots (VMP. NAVA-17, 19, 24) (Figure 35). Two of the field plots were located in Keet Seel and one in the Betatakin unit. The field plots sampled ranged in elevation from 2,050 to 2,201 m. All three plots were on minor slopes of less than 5%. Disturbance of the soil was evident in each plot from either anthropogenic activities (i.e., facilities construction), grazing, or hydrologic processes. Soil textures ranged from a silt loam (2 plots) to loamy sand. The herbaceous stratum were all dominated by forbs of less than 0.5 meter in height. Forb coverages ranged from 35 to 85% in the three plots. Dominant forb species included *Amaranthus blitoides*, *Salsola tragus*, *Cleome serrulata*, *Erodium cicutarium*, *Portulaca oleracea*, *Descurainia pinnata*, and *Sisymbrium altissimum*. Additional associated species include *Ribes cereum*, *Rosa woodsii*, *Senecio flaccidus* var. *flaccidus*, *Gutierrezia sarothrae*, *Monroa squarrosa*, and *Bromus tectorum*.

3.4.6.2 *Quercus gambelii* / *Ribes* spp. Shrubland (proposed name)

Local vegetation summary: This proposed association was described by three field plots (VMP. NAVA -14, 15, 16), all located in the Keet Seel unit. The sampled plots ranged in elevation from 1,980 to 2,053 m (6,496–6,736 ft). All plots were of an east aspect (80–90°) and were on minor slopes (<10%). All three field plots were identified as a moderately to well-drained silt loam soil texture. *Quercus gambelii* was the dominant species in the canopy stratum, ranging in height from 2.0 to 5.0 m (6.6–16.4 ft), with cover ranging from 5 to 65%. *Ribes cereum* and *Ribes leptanthum* are the associated tall shrubs of this proposed association, with a height range of 1.0–2.0 m (3.3–6.6 ft) and cover range of 5–25%. *Ribes cereum* is only present in one plot, whereas *Ribes leptanthum* is present in all three plots. The graminoid stratum cover ranged from 1 to 85% cover with *Bromus tectorum* as the dominant species. The forb stratum ranged in cover from 1 to 25%. Associated forb species included *Descurainia pinnata*, *Senecio flaccidus* var. *flaccidus*, *Ambrosia acanthicarpa*, *Sisymbrium altissimum*, *Mirabilis oxybaphoides*, *Solanum jamesii*, and *Salsola tragus*.

3.5 Photographic database

When possible, digital photographs were taken at the center of each field point in each of the four cardinal directions. The photographs were labeled with the polygon number that was assigned on the field maps. In addition, four extra photographs, providing various views of the monument, were taken. A total of 84 digital photographs were supplied with the database, of which 4 are landscape views not associated with the field points. All photographs, except for the miscellaneous four, are linked to the Microsoft Access database with the field observation data.

3.6 Photointerpretation and map units

Map units for the NAVA vegetation mapping project have either a one-to-one or a many-to-one relationship of vegetated associations to map units. When possible, polygons were mapped to the association level. Most commonly, association-level mapping occurred when a field plot was located within a polygon representing a delineated area with a unique signature. The remainder of the polygons (which either did not have an associated field point or for which the photointerpreter could not identify a signature that corresponded with field plot data) were mapped to the alliance level. Polygons mapped to the alliance level represent several vegetation associations combined into one map unit because of the difficulty of distinguishing similar associations on an aerial photograph. A total of 34 map units were established for the NAVA project, as described in earlier sections and listed in Table 3.3-1. Two of the 34 map-unit classes are considered to be non-vegetated.

3.7 Vegetation map

A total of 999 ha (2,469 acres) comprising NAVA and its environs was mapped. The area mapped within the park boundary was 244 ha (602 acres). Thirty-four map units were used to describe the landscape. Of these, two were non-vegetated map units. Of all the map units, the one that occurred most frequently within the entire mapping area was *Pinus edulis* - (*Juniperus* spp.) Woodland Alliance, with 46 polygons ranging in size from 0.1 to 48 ha (0.35–119.3 acres). The most abundant map unit in terms of area was also *Pinus edulis* - (*Juniperus* spp.) Woodland Alliance, representing a total of 296 ha (731 acres), or about 30% of the project area, with a mean

polygon size of 6 ha (~16 acres).

The individual map unit statistics reveal much more than just the mean area. Often, the mean area for each map unit is highly skewed. For example, many small polygons may represent a large portion of the overall frequency of occurrence, yet only a few large polygons may comprise the greatest area. In this case, the mean size of a particular map unit could lead to an overestimate of the size and distribution of the specific map unit polygons. Other summary statistics should be considered, in addition to the mean, to develop a more accurate picture of the distribution and frequency of occurrence of map units.

The several vegetation codes that describe each polygon are one particularly useful attribute of the vegetation map. Project-specific vegetation codes that include considerable local detail were developed for this mapping effort. Those codes were also cross-walked to several others that will allow for analysis at various scales and perspectives. These include two Anderson type land cover codes (levels 1 and 2) and the ecological system codes. Using these items, one can then link to external databases that may supplement the information provided here.

The utility of these maps extends from the very basic to the very involved. A basic application of the vegetation maps is to determine how much of an area of a specific map class represents under certain topographical constraints, in order to determine potential habitat of a certain species of concern. Such a question could easily and quickly be answered through a combination of queries. At a more sophisticated level, the maps could be used as an input into landscape models of fuel loadings or invasive species. A large portion of the utility of the vegetation map depends upon the sophistication and imagination of the user or investigator. For more advanced investigations, one might expect the need for a GIS analyst. The vegetation map for each unit is shown in Figures 3.7-1 (Betatakin), 3.7-2 (Inscription House), and 3.7-3 (Keet Seel).

Navajo National Monument Vegetation Map Betatakin Ruin

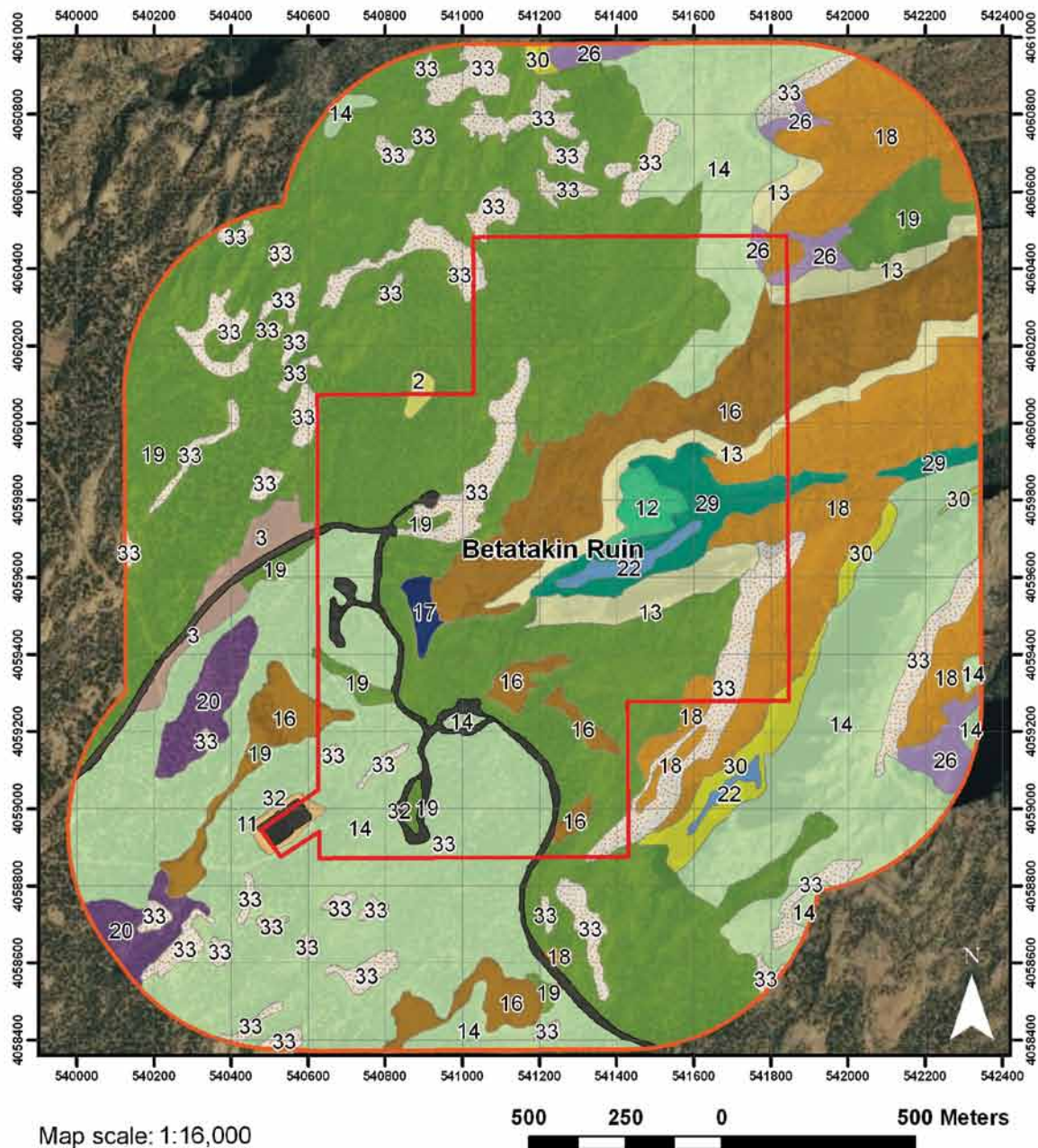


Figure 3.7-1. Navajo National Monument Vegetation Map, Betatakin unit.

Map-unit codes and names

-  2, Wyoming Big Sagebrush / Needle-and-Thread Colorado Plateau Shrubland
-  3, Wyoming Big Sagebrush Shrubland Alliance
-  11, Invasive Annual and Biennial Forbland Alliance
-  12, Utah Juniper / Wyoming Big Sagebrush Woodland
-  13, North American Warm Desert Bedrock Cliff and Outcrop
-  14, Two-needle Pinyon - (Juniper species) Woodland Alliance
-  16, Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland
-  17, Two-needle Pinyon - Utah Juniper / Brittle Prickly-pear Woodland
-  18, Two-needle Pinyon - Utah Juniper / Roundleaf Buffaloberry Woodland
-  19, Two-needle Pinyon - Juniper species / (Wyoming Big Sagebrush, Mountain Big Sagebrush) Woodland
-  20, Two-needle Pinyon - Utah Juniper / Antelope Bitterbrush Woodland
-  22, Quaking Aspen / Gambel Oak / Mountain Snowberry Forest
-  26, Douglas-fir / Gambel Oak Forest
-  29, Gambel Oak / Mountain Snowberry Shrubland
-  30, Gambel Oak Shrubland Alliance
-  32, Road/Facilities
-  33, Sandstone Sparsely Vegetated Alliance
-  Park Boundary
-  Buffer Area

Vegetation map produced from the interpretation of 1:12,000 color aerial photography acquired in June 2004. Vegetation classification determined from field plots collected in 2005. Background image - I3 Imagery Prime World 2D.

Geographic coordinate system: NAD 83
Projected coordinate system: UTM Zone 12

Map produced by BOR-RSGIG

Navajo National Monument Vegetation Map Inscription House

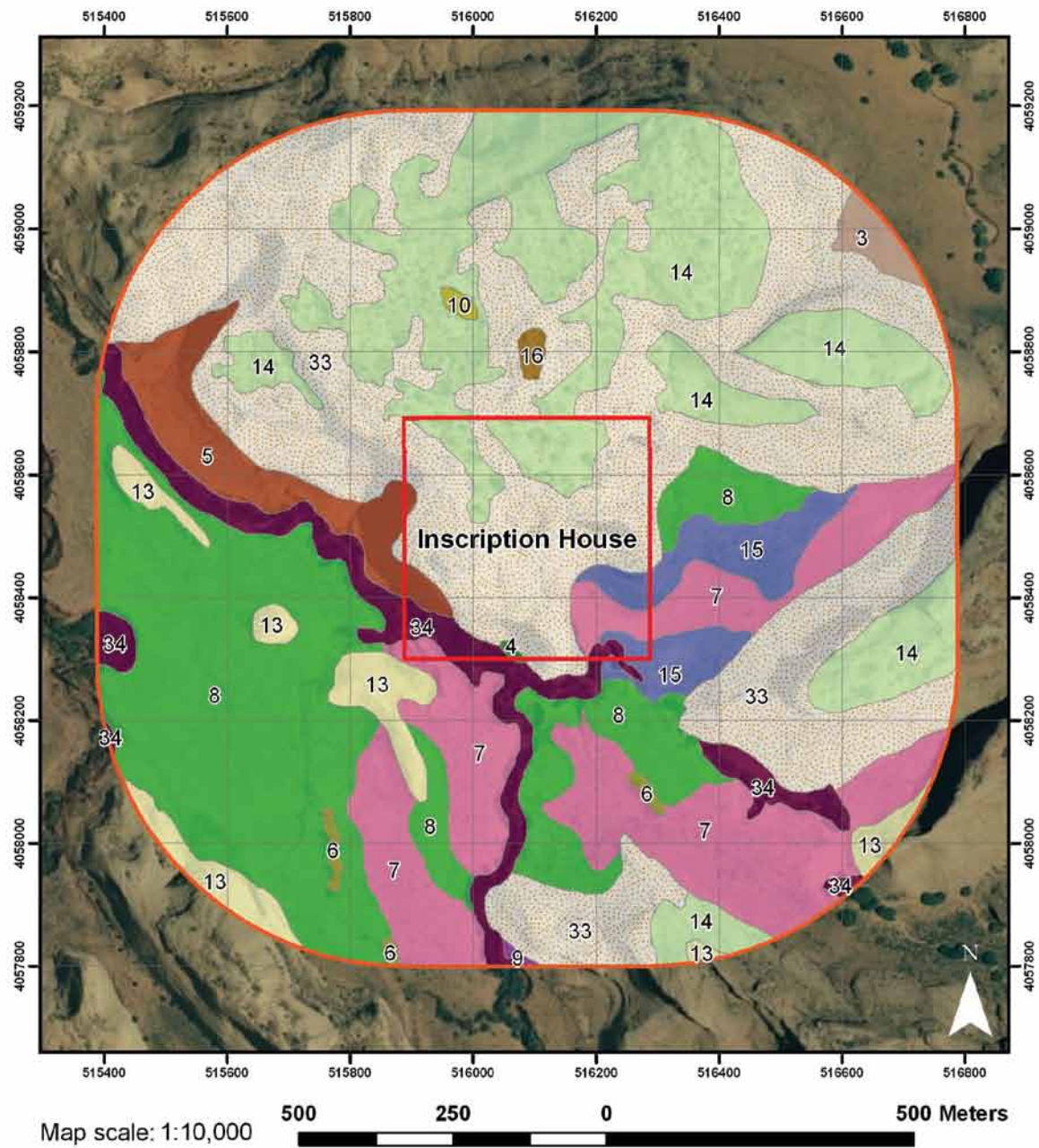


Figure 3.7-2. Navajo National Monument Vegetation Map, Inscription House unit.

Map-unit codes and names

-  3, Wyoming Big Sagebrush Shrubland Alliance
-  4, Fourwing Saltbush / Alkali Sacaton Shrubland
-  5, Fourwing Saltbush Shrubland Alliance
-  6, Russian-olive Semi-natural Woodland Alliance
-  7, Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland
-  8, Rubber Rabbitbrush Sand Deposit Sparse Shrubland
-  9, Rubber Rabbitbrush Shrubland Alliance
-  10, Needle-and-Thread - Indian Ricegrass Herbaceous Vegetation
-  13, North American Warm Desert Bedrock Cliff and Outcrop
-  14, Two-needle Pinyon - (Juniper species) Woodland Alliance
-  15, Two-needle Pinyon - Utah Juniper / Utah Serviceberry Woodland
-  16, Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland
-  33, Sandstone Sparsely Vegetated Alliance
-  34, Salt-cedar species Semi-natural Temporarily Flooded Shrubland Alliance
-  Park Boundary
-  Buffer Area

Vegetation map produced from the interpretation of 1:12,000 color aerial photography acquired in June 2004. Vegetation classification determined from field plots collected in 2005. Background image - I3 Imagery Prime World 2D.

Geographic coordinate system: NAD 83
Projected coordinate system: UTM Zone 12

Map produced by BOR-RSGIG

Navajo National Monument Vegetation Map Keet Seel

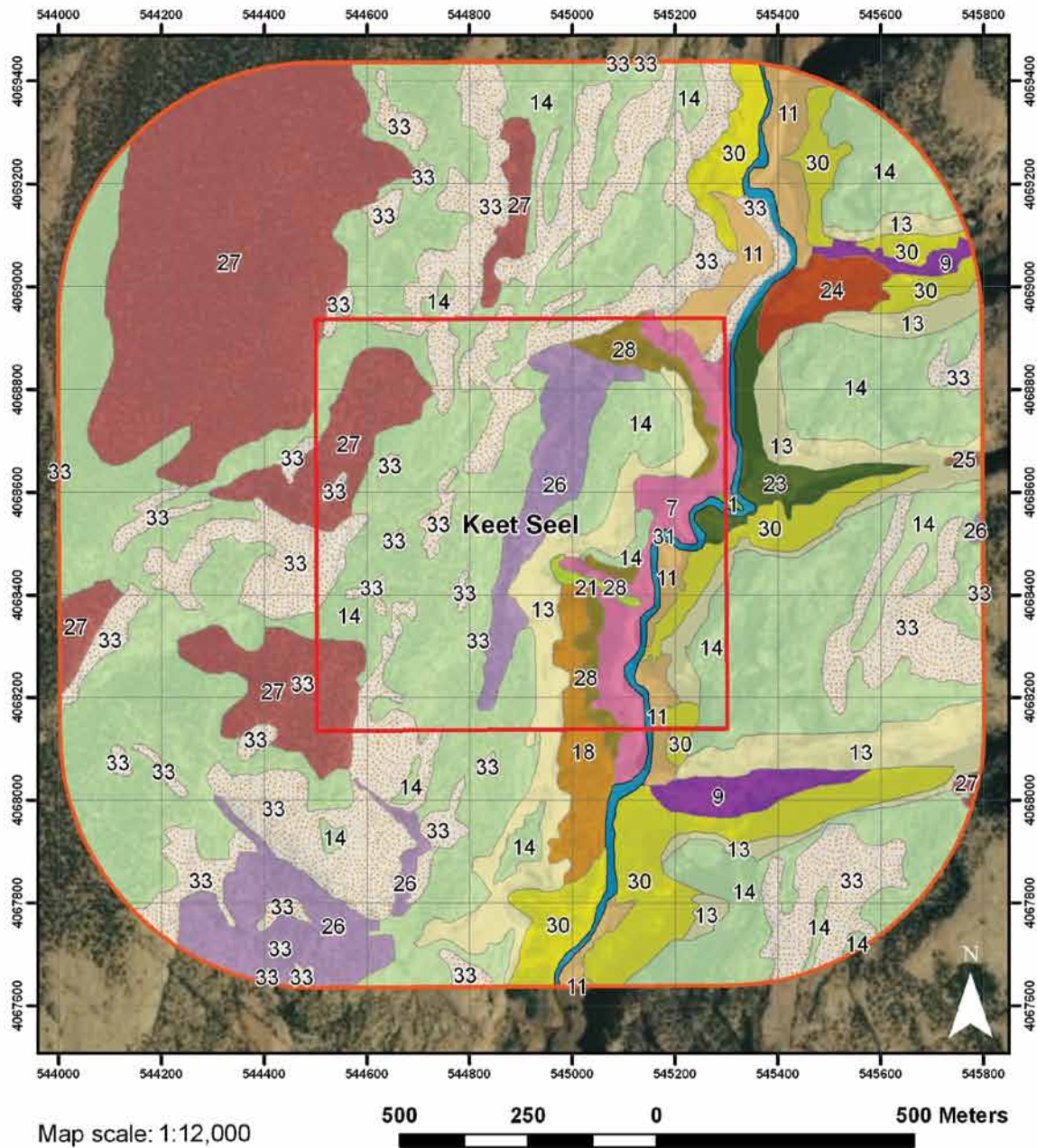


Figure 3.7-3. Navajo National Monument Vegetation Map, Keet Seel unit.

Map-unit codes and names

-  1, Box-elder / Disturbed Understory Woodland
-  7, Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland
-  9, Rubber Rabbitbrush Shrubland Alliance
-  11, Invasive Annual and Biennial Forbland Alliance
-  13, North American Warm Desert Bedrock Cliff and Outcrop
-  14, Two-needle Pinyon - (Juniper species) Woodland Alliance
-  18, Two-needle Pinyon - Utah Juniper / Roundleaf Buffaloberry Woodland
-  21, (Rio Grande Cottonwood, Plains Cottonwood) / Coyote Willow Woodland
-  23, Quaking Aspen Temporarily Flooded Forest Alliance
-  24, Choke Cherry Shrubland Alliance
-  25, Douglas-fir / Box-elder Woodland
-  26, Douglas-fir / Gambel Oak Forest
-  27, Douglas-fir Forest Alliance
-  28, Gambel Oak / Gooseberry Shrubland
-  30, Gambel Oak Shrubland Alliance
-  31, River/Stream
-  33, Sandstone Sparsely Vegetated Alliance
-  Park Boundary
-  Buffer Area

Vegetation map produced from the interpretation of 1:12,000 color aerial photography acquired in June 2004. Vegetation classification determined from field plots collected in 2005. Background image - I3 Imagery Prime World 2D.

Geographic coordinate system: NAD 83
Projected coordinate system: UTM Zone 12

Map produced by BOR-RSGIG

4 Discussion

4.1 NVC classification

The vegetation at NAVA is fairly diverse, in large part because the park is composed of three separate units. The distance between the Inscription House unit from Betatakin and Keet Seel is approximately 84 km (52 mi.). Elevation also varies between the three units. Inscription House is the lowest in elevation, ranging from 1,661 to 2,012 m (5,450–6,600 ft). The other two units range in elevation from 2,012 to 2,316 m (6,600–7,600 ft). Each unit is composed of complex topography ranging from riparian corridors to mesa uplands.

NVC vegetation types were assigned using the field plots collected in 2005 and the preliminary list of potential NVC classifications for the area. The field plots were placed opportunistically within preliminary polygon boundaries created through photointerpretation. Field plot locations were selected to adequately represent the vegetation of the polygon and/or to further discriminate between more than one vegetation type within a polygon.

The 49 field plots and 56 informal observations collected during this project cover the area inside park boundaries fairly extensively; areas outside the park were less extensively sampled. On the aerial photography, several polygons located in the buffer area either had unique signatures that did not correspond to signatures supported by field data or had non-distinct signatures. These polygons were only classified and mapped to the alliance level, and remain tentative until further field inquiries are made.

In most cases, vegetation communities sampled by the field plots adequately corresponded with existing NVC association types. Corresponding NVC associations were not always described as occurring in the state of Arizona, but were still chosen as the “best-fitting” existing NVC vegetation type. As additional vegetation surveys are expanded geographically, existing association extents are expected to expand.

In a few cases, plots did not fit neatly into an existing NVC association. In these cases, the field crew used two requirements to determine whether or not a new local vegetation association should be proposed: (1) the community had to deviate enough from either the community composition or environmental conditions of es-

tablished community types to make inclusion in those types problematic, and (2) the community had to be either known to occur elsewhere, either in NAVA or the Navajo Nation, or thought to be highly likely to occur elsewhere (Appendix B). In the event that the two requirements were not met, an existing NVC type that fit closest was used.

For the NAVA project, a total of five local associations were initially proposed by the field crew, representing nine field plots. The proposed vegetation types were:

1. Sandstone Slickrock Shallow Soil Sparse Vegetation
2. *Tamarix* spp. - *Elaeagnus angustifolia* Semi-natural Woodland
3. *Mimulus eastwoodiae* Herbaceous Vegetation
4. *Quercus gambelii* / *Ribes* spp. Woodland
5. Invasive annual and biennial forbland

After further review of the field plot information and the existing potentially occurring classifications for NAVA in the NVC, items 1–3 above were aggregated to the following existing NVC alliances:

- Sandstone Sparsely Vegetated Alliance
- *Tamarix* spp. Semi-natural Temporarily Flooded Shrubland Alliance
- *Aquilegia micrantha* - *Mimulus eastwoodiae* Herbaceous Vegetation

Items 4 and 5 above remained as local proposed names because they were documented in several field plots across NAVA.

Not all investigators will agree with all of the designations outlined in this report, and all are invited to submit their comments to NatureServe, which will ultimately decide upon inclusion, exclusion, or modification to the NVC.

4.2 Global rarity

Only associations were matched to their global rarity. Of these, all but three were either G5 (Secure) or GNR (Not yet ranked). A total of nine associations described for NAVA have yet to receive a ranking. Two associations were ranked at the G3 (Vulnerable) level: *Pinus edulis* - *Juniperus osteosperma* / *Cercocarpus intricatus* Woodland

and *Populus deltoides* (ssp. *wislizeni*, ssp. *monilifera*) / *Salix exigua* Woodland. One association, *Hesperostipa comata* - *Achnatherum hymenoides* Herbaceous Vegetation, is ranked at the G2 (Imperiled) level in NAVA.

4.3 Non-native species

Non-native species exist in each of NAVA's three units, as documented by Roth (2004). Occurrences of non-native species within plots were documented on the field plot forms and in the database for future management consideration.

4.4 Photointerpretation and map units

Ordinarily, the mapping of small parks allows for the luxury of visiting every polygon during the field-sampling operation. However, because NAVA encompasses three distinct units, separated both geographically and topographically, access issues (i.e., topography) and time limitations meant that not every polygon could be visited in the field. The NAVA map units have a one-to-one correspondence with either NVC alliances or associations, in addition to a one-to-many correspondence with NVC associations.

When possible, polygons were attributed with a single NVC association. These polygons had either a field plot located within the polygon or corresponded with a signature from an existing field plot at another location. In large polygons, which may have included several plots describing more than one association, the polygon was mapped to the alliance level if the representative signatures could not be delineated on the aerial photograph. This was most often the case in forested or woodland areas dominated by *Pinus edulis* and *Juniperus osteosperma*.

One association described by the field-sampling effort, *Aquilegia micrantha* - *Mimulus eastwoodiae* Herbaceous Vegetation, could not be mapped due to the project's minimum mapping unit guidelines. This association was documented and described as occurring in NAVA, but was not specifically mapped or represented by a unique map class unit on the vegetation map. Furthermore, this association is often not detectable on aerial photography due to its location on cliff faces.

5 References

- Alexander, B. G., Jr., E. L. Fitzhugh, F. Ronco, Jr., and J. A. Ludwig. 1987. A classification of forest habitat types of the northern portion of the Cibola National Forest, NM. General Technical Report RM-143. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 35 pp.
- Alexander, B. G., Jr., F. Ronco, Jr., A. S. White, and J. A. Ludwig. 1984. Douglas-fir habitat types of northern Arizona. General Technical Report RM-108. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 13 pp.
- 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 conference, May 11–12, 2005, St. George, Ut.
- Bailey, R.G. 1995. Description 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 pp. with separate map at 1:7,500,000.
- Baker, W. L. 1984. A preliminary classification of the natural vegetation of Colorado. *Great Basin Naturalist* 44(4):647–676.
- 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.
- 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.
- Beaumont, E. C., and G. H. Dixon. 1964. The geology of the Kayenta and Chilchinbito quadrangles, Navajo Co., Az. USGS Pub. 1202-A.
- Brotherson, J. D., and J. Fairchild. 1977. Ecological studies at Navajo National Monument, Part I. National Park Service, Southwest Region. 100+ pp.
- Brotherson, J. D., G. Nebeker, M. Skougard, and J. Fairchild. 1978. Plants of Navajo National Monument. *Great Basin Naturalist* 38(1):19–30.
- Brotherson, J. D., S. R. Rushforth, W. E. Evenson, J. R. Johansen, and C. Morden. 1983. Population dynamics and age relationships of eight tree species in Navajo National Monument, Arizona. *Journal of Range Management* 36:250–256.
- Brown, D. E., C. H. Lowe, and C. P. Pase. 1983. Biotic communities of the Southwest. Map, 1:1,000,000 scale. General Technical Report RM-78. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
- 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*, January 13–16, 1986, Reno, Nevada. General Technical Report INT-215. USDA Forest Service, Intermountain Research Station, Ogden, Utah.
- 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 Washington, and Portland, Oregon. 177 pp.
- Clary, W. P. 1992. Ecology and values of Gambel oak woodlands. Pages 87–95 *in* *Ecology and management of oak and associated woodlands*. General Technical Report RM-218. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 224 pp.
- Cooper, S. V., and B. L. Heidel. 1997. Population status and ecology of trembling aspen and black cottonwood communities on the Blackfeet Indian Reservation. Prepared for the Blackfeet Nation Fish and Wildlife Department and the U.S. Fish and Wildlife Service by Montana Natural Heritage Program, Helena, Montana.
- Coupland, R. T. 1950. Ecology of mixed prairie in Canada. *Ecological Monographs* 20(4):271–315.

- Coupland, R. T. 1992. Mixed prairie. Pages 151–182 in R. T. Coupland, ed., *Natural grasslands introduction and Western Hemisphere. Ecosystems of the world*, Volume 8A. Amsterdam: Elsevier Publishing Company.
- Crane, M. F. 1982. Fire ecology of Rocky Mountain Region forest habitat types. USDA Forest Service final report. 272 pp.
- Cross, A. F. 1991. Vegetation of two southeastern Arizona desert marshes. *Madrono* 38(3):185–194.
- Crowe, E. A., and R. R. Clausnitzer. 1997. Mid-montane wetland plant associations of the Malheur, Umatilla, and Wallowa-Whitman national forests. Technical Paper R6-NR-ECOL-TP-22-97. USDA Forest Service, Pacific Northwest Region.
- Daubenmire, R. F. 1970. Steppe vegetation of Washington. Technical Bulletin No. 62. Washington State University Agricultural Experiment Station. 131 pp.
- DeVelice, R. L., and P. Lesica. 1993. Plant community classification for vegetation on BLM lands, Pryor Mountains, Carbon County, Montana. Helena, Mont.: Montana Natural Heritage Program. 78 pp.
- DeVelice, R. L., J. A. Ludwig, W. H. Moir, and F. Ronco, Jr. 1986. A classification of forest habitat types of northern New Mexico and southern Colorado. General Technical Report RM-131. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 59 pp.
- Dick-Peddie, W. A. 1993. New Mexico vegetation: Past, present, and future. Albuquerque: University of New Mexico Press. 244 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.
- 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.
- 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*, January 13–16, 1986, Reno, Nevada. General Technical Report INT-215. USDA Forest Service, Intermountain Research Station, Ogden, Utah.
- FEIS (Fire Effects Information System). 1998. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. <http://www.fs.fed.us/database/feis/>.
- FGDC (Federal Geographic Data Committee). 1997. FGDC vegetation classification and information standards. Reston, Virginia. <http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation>
- . 1998a. FGDC spatial data transfer standard. Reston, Virginia. http://www.fgdc.gov/standards/projects/FGDC-standards-projects/SDTS/sdts_point.
- . 1998b. FGDC content standard for digital geospatial metadata. Reston, Virginia. <http://www.fgdc.gov/metadata/csdlgm>.
- Fitzhugh, E. L., W. H. Moir, J. A. Ludwig, and F. Ronco, Jr. 1987. Forest habitat types in the Apache, Gila, and part of the Cibola national forests. General Technical Report RM-145. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 116 pp.
- Flowers, S. 1963. The lichen and moss flora of Betatakin Canyon and vicinity, Navajo National Monument, Arizona. University of Utah Institute of Environmental Biological Research.
- Francis, R. E. 1986. Phyto-edaphic communities of the Upper Rio Puerco Watershed, New Mexico. Research Paper RM-272. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 73 pp.
- Fowler, J. F. 1995. Biogeography of hanging gardens on the Colorado Plateau. PhD dissertation, University of Wyoming, Laramie, Wyoming. 209 pp. plus abstract, appendices.
- Gregory, H. E. 1917. Geology of the Navajo Country. USGS Professional Paper 93. 161 pp.
- Grossman, D. H., D. Faber-Langendoen, A. W. 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 Standard. Arlington, Va.: The Nature Conservancy.
- Hack, J.T. 1945. Recent geology of the Tsegi Canyon. Appendix I in R. L. Beals, G. W. Brainerd, and W. Smith, Archaeological studies in northeast Arizona. Berkeley: University of California Press.
- 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. General Technical Report RM-157. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 68 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. General Technical Report RM-113. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 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. Miscellaneous Publication No. 54. Montana Forest and Conservation Experiment Station, School of Forestry, University of Montana, Missoula. 646 pp. + posters.
- Hansen, P. L., S. W. Chadde, and R. D. Pfister. 1988. Riparian dominance types of Montana. University of Montana Miscellaneous Publication 49. Montana Forest and Conservation Experiment Station, School of Forestry, University of Montana, Missoula. 411 pp.
- Hanson, H. C. 1955. Characteristics of the *Stipa comata*-*Bouteloua gracilis*-*Bouteloua curtipendula* association in northern Colorado. Ecology 36(2):269-280.
- Hanson, H. C., and W. Whitman. 1938. Characteristics of major grassland types in western North Dakota. Ecological Monographs 8:58-114.
- Harrington, T. C., and F. W. Cobb, Jr., eds. 1988. Leptographium root diseases on conifers. St. Paul, Minn.: The American Phytopathological Society Press. 149 pp.
- Haymond, S., and R. E. Sherwin. 2005. Final report for 2003 and 2004 mammal inventories on selected National Park Service, Southern Colorado Plateau Network parks: Navajo National Monument. Navajo Nation Department of Fish and Wildlife. Report on file, National Park Service, Southern Colorado Plateau Network, Flagstaff, Arizona.
- 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, N.M.
- Hironaka, M., M. A. Fosberg, and A. H. Winward. 1983. Sagebrush-grass habitat types of southern Idaho. Forestry, Wildlife, and Range Experiment Station Bulletin No. 15. University of Idaho, Moscow. 44 pp.
- Holiday, S. 1998. A flora of Tsegi Canyon. MA thesis. Northern Arizona University, Flagstaff.
- 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.
- Johnson, J. R., and G. F. Payne. 1968. Sagebrush reinvasion as affected by some environmental influences. Journal of Range Management 21:209-213.
- 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, Colorado. 429 pp.
- 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 [computer program]. Version 1.0. Chapel Hill, N.C.: North Carolina Botanical Garden.
- Kittel, G., E. Van Wie, M. Damm, R. Rondeau, S. Kettler, and J. Sanderson. 1999. 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.
- Knight, D. H. 1994. Mountains and plains: Ecology of Wyoming landscapes. New Haven, Ct.: Yale University Press. 338 pp.
- Kovalchik, B. L. 1987. Riparian zone associations—Deschutes, Ochoco, Fremont, and Winema national forests. USDA Forest Service Technical Paper 279-87. Pacific Northwest Region, Portland, Oregon. 171 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, N.M.
- Ladyman, J. A. R., and E. Muldavin. 1996. Terrestrial cryptograms of pinyon-juniper woodlands in the Southwestern United States: A review. General Technical Report RM-GTR-280. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 33 pp.
- Lillybridge, T. R., B. L. Kovalchik, C. K. Williams, and B. G. Smith. 1995. Field guide for forested plant associations of the Wenatchee National Forest. General Technical Report PNW-GTR-359. USDA Forest Service, Pacific Northwest Research Station, Portland. Portland, Oregon. 335 pp.
- Little, E. L. 1987. Pinyon trees (*Pinus edulis*) remeasured after 47 years. Pages 65–68 in Proceedings: Pinyon-juniper conference. General Technical Report INT-215. USDA Forest Service, Intermountain Research Station, Ogden, Utah.
- Manning, M. E., and W. G. Padgett. 1995. Riparian community type classification for Humboldt and Toiyabe national forests, Nevada and eastern California. USDA Forest Service, Intermountain Region. 306 pp.
- Mauk, R. L., and J. A. Henderson. 1984. Coniferous forest habitat types of northern Utah. General Technical Report INT-170. USDA Forest Service, Intermountain Research Station, Ogden, Utah. 89 pp.
- Maybury, K. P., ed. 1999. Seeing the forest and the trees: Ecological classification for conservation. Arlington, Va.: The Nature Conservancy.
- Mikesic, D. 2004. Inventory of amphibians and reptiles at Navajo National Monument.
- Navajo Nation Department of Fish and Wildlife. Report on file, National Park Service, Southern Colorado Plateau Network, Flagstaff, Arizona.
- Mueggler, W. F. 1988. Aspen community types of the Intermountain Region. General Technical Report INT-250. USDA Forest Service, Intermountain Research Station, Ogden, Utah. 135 pp.
- Muldavin, E., et al. 1998a. Plant community inventory for Fort Bliss. Unpublished report in preparation by the New Mexico Natural Heritage Program, Albuquerque, N.M.
- Muldavin, E., G. Harper, P. Neville, and Y. Chauvin. 1998b. The vegetation of White Sands Missile Range, New Mexico. Volume II. Vegetation map. Final report for Cooperative Agreement No. 14-16-00-91-233, White Sands Missile Range, U.S. Fish and Wildlife Service. The Nature Conservancy and the University of New Mexico.
- Muldavin, E. H., R. L. DeVelice, and F. Ronco, Jr. 1996. A classification of forest habitat types southern Arizona and portions of the Colorado Plateau. General Technical Report RM-GTR-287. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 130 pp.
- 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.
- 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, Albuquerque. 192 pp.
- NCDC (National Climatic Data Center). 1991. U.S. national 1961–1990 climate normals. Climatology of the United States 81. Asheville, N.C.: National Climatic Data Center.

- NatureServe. 2006. Classification of standard ecological units. July. <http://www.nature-serve.org/explorer/classeco.htm>.
- Neilson, R. P., and L. H. Wullstein. 1983. Biogeography of two southwest American oaks in relation to atmospheric dynamics. *Journal of Biogeography* 10:275–297.
- Omernik, J. M. 1987. Ecoregions of the conterminous United States. Map (scale 1:7,500,000). *Annals of the Association of American Geographers* 77(1):118–125.
- Padgett, W. G., A. P. Youngblood, and A. H. Winward. 1989. Riparian community type classification of Utah and southeastern Idaho. Report R4-ECOL-89-01. USDA Forest Service, Intermountain Research Station, Ogden, Utah. 191 pp.
- Pfister, R. D., B. L. Kovalchik, S. F. Arno, and R. C. Presby. 1977. Forest habitat types of Montana. General Technical Report INT-34. USDA Forest Service, Intermountain Research Station, Ogden, Utah. 174 pp.
- Powell, A. M. 1988. Trees and shrubs of Trans-Pecos Texas, including Big Bend and Guadalupe Mountains national parks. Big Bend Natural History Assoc., Inc. 536 pp.
- Roth, D. R. 2004. Vascular plant inventories at Navajo National Monument, Window Rock, AZ, USA. Navajo Natural Heritage Program, Navajo Nation Department of Fish and Wildlife. Report on file, National Park Service, Southern Colorado Plateau Network, Flagstaff, Arizona.
- Rothman, H. K. 1991. Navajo National Monument: A place and its people. Professional Paper No. 40. Santa Fe, N.M.: National Park Service, Division of History, Southwest Cultural Resources Center.
- SCS (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.
- Shaw, R. B., S. L. Anderson, K. A. Schultz, and V. E. Diersing. 1989. Plant communities, ecological checklist, and species list for the U.S. Army Pinon Canyon Maneuver Site, Colorado. Science Series No. 37, Department of Range Science, Colorado State University, Fort Collins. 71 pp.
- Smith, T. L. 1989. An overview of old-growth forests in Pennsylvania. *Natural Areas Journal* 9:40–44.
- Smoliak, S. 1965. A comparison of ungrazed and lightly grazed *Stipa-Bouteloua* prairie in southeastern Alberta. *Canadian Journal of Plant Science* 45:270–275.
- Smoliak, S. J., J. F. Dormaar, and A. Johnston. 1972. Long-term grazing effects on *Stipa-Bouteloua* prairie soils. *Journal of Range Management* 25:246–251.
- Springer, A., L. E. Stevens, and R. Harms. 2006. Inventory and classification of selected National Park Service springs on the Colorado Plateau. Report on file, National Park Service, Southern Colorado Plateau Network, Flagstaff, Arizona.
- Steele, R., R. D. Pfister, R. A. Ryker, and J. A. Kitams. 1981. Forest habitat types of central Idaho. General Technical Report INT-114. USDA Forest Service, Intermountain Research Station, Ogden, Utah. 138 pp.
- Stuever, M. C., and J. S. Hayden. 1997a. Plant associations of Arizona and New Mexico. Volume 2: Woodlands. Habitat typing guides, USDA Forest Service, Southwestern Region. 196 pp.
- Tolstead, W. L. 1941. Plant communities and secondary succession in south-central South Dakota. *Ecology* 22(3):322–328.
- TNC (The Nature Conservancy) and ESRI (Environmental Research Systems Institute). 1994a. NBS/NPS Vegetation Mapping Program: Field methods for vegetation mapping. Arlington, Virginia. <http://biology.usgs.gov/npsveg/standards.html>.
- . 1994b. NBS/NPS Vegetation Mapping Program: Standardized National Vegetation Classification System. Arlington, Virginia. <http://biology.usgs.gov/npsveg/standards.html>.
- USDA, NRCS. 2005. The PLANTS Database (<http://plants.usda.gov>). National Plant Data Center, Baton Rouge, Louisiana.
- USFS (U.S. Forest Service). 1937. Range plant handbook. Dover Publications Inc., New York. 816 pp.
- . 1992. Draft habitat types of the Little Missouri National Grasslands. Medora and McKenzie ranger districts, Custer National

- Forest. Dickinson, ND.
- . 2005. Colorado Plateau Semi-desert Province (<http://www.fs.fed.us/colorimagemap/images/313.html>).
- USGS (U.S. Geological Survey). 1999. U.S. National Map Accuracy Standards. Reston, VA 20192 (<http://erg.usgs.gov/isb/pubs/factsheets/fs17199.html>)
- Vandiver, V. W. 1936. Geology of Navajo National Monument. Southwest monuments monthly reports. July:46–55.
- Von Loh, J., D. Cogan, D. Faber-Langendoen, D. Crawford, and M. J. Pucherelli. 1999. USGS-NPS Vegetation Mapping Program Badlands National Park, South Dakota (final report). Technical memorandum No. 8260-99-03. U.S. Bureau of Reclamation Technical Service Center, Denver, Colorado.
- 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. Technical memorandum 8260-02-03. U.S. Bureau of Reclamation, Remote Sensing and GIS Group, Denver Federal Center, Denver, Colorado.
- Welsh, S. L. 1989. On the distribution of Utah's hanging gardens. *Great Basin Naturalist* 49(1):1–30.
- Welsh, S. L., and C. A. Toft. 1981. Biotic communities of hanging gardens in southeastern Utah. *National Geographic Society Research Reports* 13:663–681.
- 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.
- Woodbury, A. M. 1963. Biological-ecological aspects of Betatakin Canyon, Navajo National Monument. Misc. Papers. No. 2. Division of Biological Sciences, University of Utah, Salt Lake City.
- 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. General Technical Report INT-58. USDA Forest Service, Intermountain Research Station, Ogden, Utah.

Appendix A: Map Unit Look-up Tables

MAP UNIT	VEG_NAME	NVCS	FM_CLASS	FM_SUBCLAS
Herbaceous vegetation				
10	<i>Hesperostipa comata</i> - <i>Achnatherum hymenoides</i> Herbaceous Vegetation	CEGL001703	V - Herbaceous Vegetation	V.A - Perennial graminoid vegetation
Shrubland vegetation				
3	<i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> Shrubland Alliance	A.832	III - Shrubland	III.A - Evergreen shrubland
2	<i>Artemisia tridentata</i> ssp. <i>wyomengensis</i> / <i>Hesperostipa comata</i> Colorado Plateau Shrubland	CEGL002761	III - Shrubland	III.A - Evergreen shrubland
5	<i>Atriplex canescens</i> Shrubland Alliance	A.869	III - Shrubland	III.A - Evergreen shrubland
4	<i>Atriplex canescens</i> / <i>Sporobolus airoides</i> Shrubland	CEGL001291	III - Shrubland	III.A - Evergreen shrubland
9	<i>Ericameria nauseosa</i> Shrubland Alliance	A.835	III - Shrubland	III.A - Evergreen shrubland
7	<i>Ericameria nauseosa</i> / <i>Bromus tectorum</i> Semi-natural Shrubland	CEGL002937	III - Shrubland	III.A - Evergreen shrubland
8	<i>Ericameria nauseosa</i> Sand Deposit Sparse Shrubland	CEGL002980	III - Shrubland	III.A - Evergreen shrubland
24	<i>Prunus virginiana</i> Shrubland Alliance	A.919	III - Shrubland	III.B - Deciduous shrubland
30	<i>Quercus gambelii</i> Shrubland Alliance	A.920	III - Shrubland	III.B - Deciduous shrubland
29	<i>Quercus gambelii</i> / <i>Symphoricarpos oreophilus</i> Shrubland	CEGL001117	III - Shrubland	III.B - Deciduous shrubland
34	<i>Tamarix</i> spp. Semi-natural Temporarily Flooded Shrubland Alliance	A.842	III - Shrubland	III.A - Evergreen shrubland
Woodland vegetation				
1	<i>Acer negundo</i> / Disturbed Understory Woodland	CEGL002693	II - Woodland	II.B - Deciduous woodland
6	<i>Elaeagnus angustifolia</i> Semi-natural Woodland Alliance	A.3566	II - Woodland	II.B - Deciduous woodland
12	<i>Juniperus osteosperma</i> / <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> Woodland	CEGL000730	II - Woodland	II.A - Evergreen woodland
14	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance	A.516	II - Woodland	II.A - Evergreen woodland
15	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Amelanchier utahensis</i> Woodland	CEGL002329	II - Woodland	II.A - Evergreen woodland
16	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland	CEGL000779	II - Woodland	II.A - Evergreen woodland
17	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Opuntia fragilis</i> Woodland	CEGL002374	II - Woodland	II.A - Evergreen woodland
18	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Shepherdia rotundifolia</i> Woodland	CEGL002335	II - Woodland	II.A - Evergreen woodland
19	<i>Pinus edulis</i> - <i>Juniperus</i> spp. / <i>Artemisia tridentata</i> (ssp. <i>wyomingensis</i> , ssp. <i>vaseyana</i>) Woodland	CEGL000776	II - Woodland	II.A - Evergreen woodland
20	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Purshia tridentata</i> Woodland	CEGL000789	II - Woodland	II.A - Evergreen woodland
21	<i>Populus deltoides</i> (ssp. <i>wislizeni</i> , ssp. <i>monilifera</i>) / <i>Salix exigua</i> Woodland	CEGL002685	II - Woodland	II.B - Deciduous woodland
25	<i>Pseudotsuga menziesii</i> / <i>Acer negundo</i> Woodland	CEGL002754	II - Woodland	II.A - Evergreen woodland

MAP UNIT	VEG_NAME	NVCS	FM_CLASS	FM_SUBCLAS
Forest vegetation				
23	<i>Populus tremuloides</i> Temporarily Flooded Forest Alliance	A.636	I - Forest	I.B - Deciduous forest
Forest vegetation, cont.				
22	<i>Populus tremuloides</i> / <i>Quercus gambelii</i> / <i>Symphoricarpos oreophilus</i> Forest	CEGL000598	I - Forest	I.B - Deciduous forest
27	<i>Pseudotsuga menziesii</i> Forest Alliance	A.157	I - Forest	I.A - Evergreen forest
26	<i>Pseudotsuga menziesii</i> / <i>Quercus gambelii</i> Forest	CEGL000452	I - Forest	I.A - Evergreen forest
Sparse vegetation				
13	North American Warm Desert Bedrock Cliff and Outcrop	CES302.745	N/A	N/A
33	Sandstone Sparsely Vegetated Alliance	A.2568	VII - Sparse Vegetation	VII.B - Boulder, gravel, cobble, or talus sparse vegetation
Non-NVC types (proposed local alliances or associations)				
11	Invasive Annual and Biennial Forbland	N/A		
28	<i>Quercus gambelii</i> / <i>Ribes</i> spp. Shrubland (proposed name)	N/A	III - Shrubland	III.B - Deciduous shrubland
Non-vegetated types				
31	Rivers/Streams	N/A		
32	Roads/Facilities	N/A		

MAP-UNIT	FM_GROUP	FM_SUBGROU
Herbaceous vegetation		
10	V.A.5 - Temperate or subpolar grassland	V.A.5.N - Natural/Semi-natural temperate or subpolar grassland
Shrubland vegetation		
3	III.A.4 - Microphyllous evergreen shrubland	N/A
2	III.A.4 - Microphyllous evergreen shrubland	III.A.4.N - Natural/Semi-natural microphyllous evergreen shrubland
5	III.A.5 - Extremely xeromorphic evergreen shrubland	III.A.5.N - Natural/Semi-natural extremely xeromorphic evergreen shrubland
4	III.A.5 - Extremely xeromorphic evergreen shrubland	III.A.5.N - Natural/Semi-natural extremely xeromorphic evergreen shrubland
9	III.A.4 - Microphyllous evergreen shrubland	III.A.4.N - Natural/Semi-natural microphyllous evergreen shrubland
7	III.A.4 - Microphyllous evergreen shrubland	III.A.4.N - Natural/Semi-natural microphyllous evergreen shrubland
8	III.A.4 - Microphyllous evergreen shrubland	III.A.4.N - Natural/Semi-natural microphyllous evergreen shrubland
24	III.B.2 - Cold-deciduous shrubland	III.B.2.N - Natural/Semi-natural cold-deciduous shrubland
30	III.B.2 - Cold-deciduous shrubland	III.B.2.N - Natural/Semi-natural cold-deciduous shrubland
29	III.B.2 - Cold-deciduous shrubland	III.B.2.N - Natural/Semi-natural cold-deciduous shrubland
34	III.A.4 - Microphyllous evergreen shrubland	III.A.4.N - Natural/Semi-natural microphyllous evergreen shrubland
Woodland vegetation		
1	II.B.2 - Cold-deciduous woodland	II.B.2.N - Natural/Semi-natural cold-deciduous woodland
6	II.B.2 - Cold-deciduous woodland	II.B.2.N - Natural/Semi-natural cold-deciduous woodland
12	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
14	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
15	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
16	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
17	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
18	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
19	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
20	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
21	III.B.2 - Cold-deciduous shrubland	III.B.2.N - Natural/Semi-natural cold-deciduous shrubland
25	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Forest vegetation		
23	I.B.2 - Cold-deciduous forest	I.B.2.N - Natural/Semi-natural cold-deciduous forest
22	I.B.2 - Cold-deciduous forest	I.B.2.N - Natural/Semi-natural cold-deciduous forest
27	I.A.8 - Temperate or subpolar needle-leaved evergreen forest	I.A.8.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen forest
26	I.A.8 - Temperate or subpolar needle-leaved evergreen forest	I.A.8.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen forest
Sparse vegetation		
13	N/A	N/A

MAP- UNIT	FM_GROUP	FM_SUBGROU
<i>Sparse vegetation, cont.</i>		
33	VII.B.2 - Sparsely vegetated rock flats	VII.B.2.N - Natural/Semi-natural sparsely vegetated rock flats
Non-NVC types (proposed local alliances or associations)		
11		
28	III.B.2 - Cold-deciduous shrubland	III.B.2.N - Natural/Semi-natural cold-deciduous shrubland
Non-vegetated types		
31		
32		

MAP UNIT	FORMATION	ALLIANCE
Herbaceous vegetation		
10	V.A.5.N.d - Medium-tall bunch temperate or subpolar grassland	<i>Hesperostipa comata</i> Bunch Herbaceous Alliance
Shrubland vegetation		
3	III.A.4.N - Natural/Semi-natural microphyllous evergreen	<i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> Shrubland Alliance
2	III.A.4.N.a - Lowland microphyllous evergreen shrubland	<i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> Shrubland Alliance
5	III.A.5.N.b - Facultatively deciduous extremely xeromorphic subdesert shrubland	<i>Atriplex canescens</i> Shrubland Alliance
4	III.A.5.N.b - Facultatively deciduous extremely xeromorphic subdesert shrubland	<i>Atriplex canescens</i> Shrubland Alliance
9	III.A.4.N.a - Lowland microphyllous evergreen shrubland	<i>Ericameria nauseosa</i> Shrubland Alliance
7	III.A.4.N.a - Lowland microphyllous evergreen shrubland	<i>Ericameria nauseosa</i> Shrubland Alliance
8	III.A.4.N.a - Lowland microphyllous evergreen shrubland	<i>Ericameria nauseosa</i> Shrubland Alliance
24	III.B.2.N.a - Temperate cold-deciduous shrubland	<i>Prunus virginiana</i> Shrubland Alliance
30	III.B.2.N.a - Temperate cold-deciduous shrubland	<i>Quercus gambelii</i> Shrubland Alliance
29	III.B.2.N.a - Temperate cold-deciduous shrubland	<i>Quercus gambelii</i> Shrubland Alliance
34	III.A.4.N.c - Temporarily flooded microphyllous shrubland	<i>Tamarix</i> spp. Semi-natural Temporarily Flooded Shrubland Alliance
Woodland vegetation		
1	II.B.2.N.b - Temporarily flooded cold-deciduous woodland	<i>Acer negundo</i> Temporarily Flooded Woodland Alliance
6	II.B.2.N.a - Cold-deciduous woodland	<i>Elaeagnus angustifolia</i> Semi-natural Woodland Alliance
12	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Juniperus osteosperma</i> Woodland Alliance
14	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance
15	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance
16	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance
17	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance
18	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance
19	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance
20	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance
21	II.B.2.N.b - Temporarily flooded cold-deciduous woodland	<i>Populus deltoides</i> Temporarily Flooded Woodland Alliance
25	II.A.4.N.b - Conical-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Pseudotsuga menziesii</i> Woodland Alliance
Forest vegetation		
23	I.B.2.N.d - Temporarily flooded cold-deciduous forest	<i>Populus tremuloides</i> Temporarily Flooded Forest Alliance

MAP UNIT	FORMATION	ALLIANCE
<i>Forest vegetation, cont.</i>		
22	I.B.2.N.d - Temporarily flooded cold-deciduous forest	<i>Populus tremuloides</i> Temporarily Flooded Forest Alliance
27	I.A.8.N.c - Conical-crowned temperate or subpolar needle-leaved evergreen forest	<i>Pseudotsuga menziesii</i> Forest Alliance
26	I.A.8.N.c - Conical-crowned temperate or subpolar needle-leaved evergreen forest	<i>Pseudotsuga menziesii</i> Forest Alliance
<i>Sparse vegetation</i>		
13	N/A	North American Warm Desert Bedrock Cliff and Outcrop
33	VII.B.2.N.a - Boulder fields	Sandstone Sparsely Vegetated Alliance
<i>Non-NVC types (proposed local alliances and associations)</i>		
11		
28	III.B.2.N.a - Temperate cold-deciduous shrubland	<i>Quercus gambelii</i> Shrubland Alliance
<i>Non-vegetated types</i>		
31		
32		

MAP UNIT	ASSOCIATION	ECOSYS1_ID	ECOSYS1	ECOSYS2_ID
Herbaceous vegetation				
10	<i>Hesperostipa comata</i> - <i>Achnatherum hymenoides</i> Herbaceous Vegetation	CES303.817	Western Great Plains Foothill and Piedmont Grassland	CES304.787
Shrubland vegetation				
3				
2	<i>Artemisia tridentata</i> ssp. <i>wyomengensis</i> / <i>Hesperostipa comata</i> Colorado Plateau	CES304.777	Inter-Mountain Basins Big Sagebrush Shrubland	
5				
4	<i>Atriplex canescens</i> / <i>Sporobolus airoides</i> Shrubland	CES302.017	Chihuahuan Mixed Salt Desert Scrub	CES304.784
9				
7	<i>Ericameria nauseosa</i> / <i>Bromus tectorum</i> Semi-natural Shrubland	CES304.781	Inter-Mountain Basins Wash	CES304.788
8	<i>Ericameria nauseosa</i> Sand Deposit Sparse Shrubland	CES304.775	Inter-Mountain Basins Active and Stabilized Dune	CES304.793
24				
30				
29	<i>Quercus gambelii</i> / <i>Symphoricarpos oreophilus</i> Shrubland	CES303.664	Southwestern Great Plains Canyon	CES305.796
34				
Woodland vegetation				
1	<i>Acer negundo</i> / Disturbed understory Woodland	CES306.821	Rocky Mountain Lower Montane Riparian Woodland and Shrubland	
6				
12	<i>Juniperus osteosperma</i> / <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> Woodland	CES304.767	Colorado Plateau Pinyon-Juniper Woodland	CES306.955
14				
15	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Amelanchier utahensis</i> Woodland	CES304.767	Colorado Plateau Pinyon-Juniper Woodland	CES306.955
16	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland	CES304.765	Colorado Plateau Mixed Bedrock Canyon and Tableland	CES304.766
17	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Opuntia fragilis</i> Woodland	CES304.767	Colorado Plateau Pinyon-Juniper Woodland	
18	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Shepherdia rotundifolia</i> Woodland	CES304.767	Colorado Plateau Pinyon-Juniper Woodland	
19	<i>Pinus edulis</i> - <i>Juniperus</i> spp. / <i>Artemisia tridentata</i> (ssp. <i>wyomingensis</i> , ssp. <i>vaseyana</i>) Woodland	CES304.767	Colorado Plateau Pinyon-Juniper Woodland	CES306.835
20	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Purshia tridentata</i> Woodland	CES304.766	Colorado Plateau Pinyon-Juniper Shrubland	CES304.767
21	<i>Populus deltoides</i> (ssp. <i>wislizeni</i> , ssp. <i>monilifera</i>) / <i>Salix exigua</i> Woodland	CES302.748	North American Warm Desert Lower Montane Riparian Woodland and Shrubland	CES303.658
25	<i>Pseudotsuga menziesii</i> / <i>Acer negundo</i> Woodland	CES306.825	Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland	
Forest vegetation				
23				

MAP UNIT	ASSOCIATION	ECOSYS1_ID	ECOSYS1	ECOSYS2_ID
22	<i>Populus tremuloides</i> / <i>Quercus gambelii</i> / <i>Symphoricarpos oreophilus</i> Forest	CES306.813	Rocky Mountain Aspen Forest and Woodland	CES306.833
Forest vegetation, cont.				
27				
26	<i>Pseudotsuga menziesii</i> / <i>Quercus gambelii</i> Forest	CES306.823	Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland	
Sparse vegetation				
13				
33				
Non-NVC types (proposed alliances and associations)				
11				
28	N/A	N/A	N/A	
Non-vegetated types				
31				
32				

MAP UNIT	ECOSYS2	ECOSYS3_ID	ECOSYS3	ANDERSON_L	ANDERSON_L
Herbaceous vegetation					
10	Inter-Mountain			3	Rangeland
Shrubland vegetation					
3				3	Rangeland
2				3	Rangeland
5				3	Rangeland
4	Inter-Mountain Basins Mixed Salt Desert Scrub			3	Rangeland
9				3	Rangeland
7	Inter-Mountain Basins Semi-Desert Shrub-Steppe			3	Rangeland
8	Southern Colorado Plateau Sand Shrubland			3	Rangeland
24				3	Rangeland
30				3	Rangeland
29	Madrean Pine-Oak Forest and Woodland	CES306.818	Rocky Mountain Gambel Oak-Mixed Montane Shrubland	3	Rangeland
34				6	Wetland
Woodland vegetation					
1				4	Forest Land
6				4	Forest Land
12	Rocky Mountain Foothill Limber Pine-Juniper Woodland			4	Forest Land
14				4	Forest Land
15	Rocky Mountain Foothill Limber Pine-Juniper Woodland			4	Forest Land
16	Colorado Plateau Pinyon-Juniper Shrubland	CES304.767	Colorado Plateau Pinyon-Juniper Woodland	4	Forest Land
17				4	Forest Land
18				4	Forest Land
19	Southern Rocky Mountain Pinyon-Juniper Woodland			4	Forest Land
20	Colorado Plateau Pinyon-Juniper Woodland	CES306.835	Southern Rocky Mountain Pinyon-Juniper Woodland	4	Forest Land
21	Northwestern Great Plains Canyon	CES303.678	Western Great Plains Floodplain	6	Forest Land
25				4	Forest Land
Forest vegetation					
23				4	Forest Land
22	Rocky Mountain Subalpine-Montane Riparian Woodland			4	Forest Land
27				4	Forest Land
26				4	Forest Land
Sparse vegetation					
13				7	Barren
33				7	Barren

MAP UNIT	ECOSYS2	ECOSYS3_ID	ECOSYS3	ANDERSON_L	ANDERSON_L
Non-NVC types (proposed alliances and associations)					
11				3	Rangeland
28				3	Rangeland
Non-vegetated types					
31				5	Water
32				1	Urban or Built-up Land

MAP-UNIT	ANDERSON_L	GLOBAL_STA	ROUNDED_GL
Herbaceous vegetation			
10	Herbaceous Rangeland	G2? (30Nov1998)	G2 - Imperiled
Shrubland vegetation			
3	Shrub and Brush Rangeland		
2	Shrub and Brush Rangeland	GNR (12Apr2005)	GNR - Not Yet Ranked
5	Shrub and Brush Rangeland		
4	Shrub and Brush Rangeland	G5? (09Nov2005)	G5 - Secure
9	Shrub and Brush Rangeland		
7	Shrub and Brush Rangeland	GNR (14Aug2001)	GNR - Not Yet Ranked
8	Shrub and Brush Rangeland	GNR (22Jan2002)	GNR - Not Yet Ranked
24	Shrub and Brush Rangeland		
30	Shrub and Brush Rangeland		
29	Shrub and Brush Rangeland	G5 (23Feb1994)	G5 - Secure
34	Nonforested Wetland		
Woodland vegetation			
1	Decidious Forest Land	GNR (14Aug2001)	GNR - Not Yet Ranked
6	Decidious Forest Land		
12	Evergreen Forest Land	G5? (01Feb1996)	G5 - Secure
14	Evergreen Forest Land		
15	Evergreen Forest Land	GNR (11Jan2005)	GNR - Not Yet Ranked
16	Evergreen Forest Land	G3 (30Dec2000)	G3 - Vulnerable
17	Evergreen Forest Land	GNR (23Mar2005)	GNR - Not Yet Ranked
18	Evergreen Forest Land	GNR (12Jan2005)	GNR - Not Yet Ranked
19	Evergreen Forest Land	G5 (01Feb1996)	G5 - Secure
20	Evergreen Forest Land	G5 (01Feb1996)	G5 - Secure
21	Forested Wetland	G3 (01Dec2000)	G3 - Vulnerable
25	Evergreen Forest Land	GNR (12Apr2005)	GNR - Not Yet Ranked
Forest vegetation			
23	Decidious Forest Land		
22	Decidious Forest Land	GNR (01Feb1996)	GNR - Not Yet Ranked
27	Evergreen Forest Land		
26	Evergreen Forest Land	G5 (23Feb1994)	G5 - Secure
Sparse vegetation			
13	Bare Exposed Rock		
33	Bare Exposed Rock		
Non-NVC types (proposed alliances and associations)			
11	Herbaceous Rangeland		
28	Shrub and Brush Rangeland	N/A	N/A
Non-vegetated types			
31	Streams and Canals		
32	Transportation, Communications, and Utilities		

Appendix B: Field Plot Metadata

Metadata for fieldwork and data entry for Navajo National Park (NAVA) vegetation mapping data

Prepared by David Remucal

This metadata is provided to explain some of the particularities/anomalies of the data obtained for the vegetation mapping project at NAVA. This data was collected in the fall of 2005 by David Remucal and Dave Wegner, with the assistance of Daniela Roth.

In most cases, communities were matched comfortably with currently described community types. However, in other cases, a new, proposed community name was used. Two requirements had to be met before a new community name was proposed: (1) the community had to deviate enough from either the community composition or environmental conditions of established community types to make inclusion in those types problematic, and (2) the community had to be either known to occur elsewhere (either in NAVA or the Navajo Nation), or thought to be highly likely to occur elsewhere. If condition 1 was met, but not condition 2, then the community was simply named as the closest-fitting established community type, with consideration that missing species were simply absent because of chance, not incompatibility.

The data sheets had one small difference from the database-entry forms: in the data sheets, there was a field titled “Other Comments” not present in the database-entry forms. The information from these records was inserted in the database where deemed most germane. Common substitute fields were the geological comment field, disturbance comments fields, and vegetation comment field, although in some cases, if the information was already represented in one of these or other fields, inclusion was deemed unnecessary.

In some other cases, polygon boundaries were found to be inadequate to describe the on-the-ground observations—understandable in any photointerpretive project. Polygons often had to be split and relabeled. This accounts for the pres-

ence of new polygons, labeled with the suffix “A” in the data.

List of hard-copy data points provided on separate sheets

Several data points are provided in hard-copy that do not have corresponding data sheets. There are two main classes of these data points: (1) data points from Skeleton Mesa, an inaccessible portion of the park in the Keet Seel park area, and (2) data points largely deemed similar enough to other polygons to not need new data.

Skeleton Mesa data points

These points are on top of Skeleton Mesa, which we could not access easily in the allotted time. We took three points from an accessible part of the mesa south of the park lands, labeled with polygon names SME (Skeleton Mesa Exposed), SMR (Skeleton Mesa Ridge) and SMS (Skeleton Mesa Slope). This was done so photointerpreters could potentially use these as model types to determine categorization of these unreached polygons. The following communities were found to apply to these polygon types (each has a data sheet/database entry):

SME: *Pinus edulis* / *Cercocarpus intricatus*
sparse vegetation

SMR: *Pinus edulis* - *Juniperus osteosperma* /
Artemisia tridentata Woodland

SMS: *Pinus edulis* - *Juniperus osteosperma* /
Cercocarpus intricatus Woodland

Dave Wegner divided the polygons into two groups, based on the aerial photography:

Appear to be pinyon/juniper-dominated: Polygons 114, 25, 28, 29, 170, 159, 75, 180, 177.

Appear to be slickrock-dominant, with some vegetation islands: Polygons 64, 82, 91, 97, 117, 90, 20, 78, 144, 143, 147, 153, 166, 190, 194, 195, 205, 224, 199, 196, 163, 171.

Second class of polygons without data sheets

Throughout all parks, several plot codes were found to be similar enough to those of other polygons that notes were just taken on which polygon they most closely resembled and no datasheet was prepared for them. Because many of these notes were written on the side of the polygon maps, the only data recorded, in most cases, was the

location of the site and which polygon was referenced. Information about the presence of certain species was included in cover data. Because a few points in this section were too inaccessible to view, too few notes were taken to warrant a datasheet.

The table in column 2 shows the plot codes in the database with their corresponding polygons.

Miscellaneous notes

In some cases, text-field entries deviated slightly from hard-copy entries. These were intentional in order to correct spelling, plant identification, or to clarify meaning.

A small number of plants could not be successfully identified in the field. In many cases, these identities were later established; other times, identification could only be made to the genus level. Only a few species remained unresolved, and none of these was deemed important to community identification.

Polygon 167, from Dave Wegner's notes, is described as *Pinus edulis*-dominated. This differs from the datasheets taken. The data sheets were chosen as the authoritative source and used for the database.

Plot Code	Polygon
050	200
051	206
052	108
053	109
054	112
055	104
056	222
057	151
058	185
059	204
060	92
061	86
062	83
063	95
064	187
065	129
066	85
067	156
068	155
069	140
070	123
071	123A
072	541
073	449
074	407
075	507
076	399
077	417

Plot Code	Polygon
078	418
079	552
080	544
081	493
082	455
083	499
084	549
085	524
086	529
087	553
088	490
089	474
090	479
091	487
092	409
093	412
094	512
095	355
096	402
097	390
098	419
099	414
100	386
101	485
102	518
103	484
104	585

Appendix C: Alliances and Associations from Field Plots

Plot	Polygon	Alliance or association name
Betatakin		
1	362	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Shepherdia rotundifolia</i> Woodland
3	428	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Shepherdia rotundifolia</i> Woodland
4	483	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Shepherdia rotundifolia</i> Woodland
5	393A	<i>Aquilegia micrantha</i> - <i>Mimulus eastwoodiae</i> Herbaceous Vegetation
12	408	<i>Juniperus osteosperma</i> / <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> Woodland
13	404	<i>Quercus gambelii</i> / <i>Symphoricarpos oreophilus</i> Shrubland
17	498	Invasive Annual and Biennial Forbland
20	491	Sandstone Sparsely Vegetated Alliance
26	392	<i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> / <i>Hesperostipa comata</i> Colorado Plateau Shrubland
27	412	<i>Pinus edulis</i> - <i>Juniperus</i> spp. / <i>Artemisia tridentata</i> (ssp. <i>wyomingensis</i> , ssp. <i>vaseyana</i>) Woodland
28	405	<i>Pinus edulis</i> - <i>Juniperus</i> spp. / <i>Artemisia tridentata</i> (ssp. <i>wyomingensis</i> , ssp. <i>vaseyana</i>) Woodland
29	496	<i>Pinus edulis</i> - <i>Juniperus</i> spp. / <i>Artemisia tridentata</i> (ssp. <i>wyomingensis</i> , ssp. <i>vaseyana</i>) Woodland
30	415	<i>Pinus edulis</i> - <i>Juniperus</i> spp. / <i>Artemisia tridentata</i> (ssp. <i>wyomingensis</i> , ssp. <i>vaseyana</i>) Woodland
31	513	<i>Pinus edulis</i> - <i>Juniperus</i> spp. / <i>Artemisia tridentata</i> (ssp. <i>wyomingensis</i> , ssp. <i>vaseyana</i>) Woodland
33	398	<i>Pinus edulis</i> - <i>Juniperus</i> spp. / <i>Artemisia tridentata</i> (ssp. <i>wyomingensis</i> , ssp. <i>vaseyana</i>) Woodland
34	321a	<i>Pinus edulis</i> - <i>Juniperus</i> spp. / <i>Artemisia tridentata</i> (ssp. <i>wyomingensis</i> , ssp. <i>vaseyana</i>) Woodland
35	n/a	<i>Pseudotsuga menziesii</i> / <i>Quercus gambelii</i> Forest
36	464	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland
39	424	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland
40	442	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland
41	465	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland
44	324	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland
45	393	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland
46	444	<i>Populus tremuloides</i> / <i>Quercus gambelii</i> / <i>Symphoricarpos oreophilus</i> Forest
48	447	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Opuntia fragilis</i> Woodland
49	454	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Purshia tridentata</i> Woodland
Inscription House		
7	476	<i>Atriplex canescens</i> / <i>Sporobolus airoides</i> Shrubland
10	488	<i>Tamarix</i> spp. Semi-natural Temporarily Flooded Shrubland Alliance
11	590	<i>Ericameria nauseosa</i> / <i>Bromus tectorum</i> Semi-natural Shrubland
21	602	<i>Eleocharis palustris</i> Seasonally Flooded Herbaceous Alliance
22	575	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Amelanchier utahensis</i> Woodland
23	551	<i>Hesperostipa comata</i> - <i>Bouteloua gracilis</i> Herbaceous Alliance
25	470	<i>Hesperostipa comata</i> - <i>Achnatherum hymenoides</i> Herbaceous Vegetation

Appendix C: Alliances and associations from field plots, cont.

Plot	Polygon	Alliance or association name
37	548	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland
38	476	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland
47	585	<i>Ericameria nauseosa</i> Sand Deposit Sparse Shrubland
Keet Seel		
2	121B	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Shepherdia rotundifolia</i> Woodland
6	162A	<i>Aquilegia micrantha</i> - <i>Mimulus eastwoodiae</i> Herbaceous Vegetation
8	162	<i>Populus deltoides</i> (ssp. <i>wislizeni</i> , ssp. <i>monilifera</i>) / <i>Salix exigua</i> Woodland
9	121	<i>Acer negundo</i> / Disturbed understory Woodland
14	167	<i>Quercus gambelii</i> / <i>Ribes</i> spp. Shrubland (proposed name)
15	122	<i>Quercus gambelii</i> / <i>Ribes</i> spp. Shrubland (proposed name)
16	161	<i>Quercus gambelii</i> / <i>Ribes</i> spp. Shrubland (proposed name)
18	121A	<i>Ericameria nauseosa</i> / <i>Bromus tectorum</i> Semi-natural Shrubland
19	99	Invasive Annual and Biennial Forbland
24	88	Invasive Annual and Biennial Forbland
32	n/a	<i>Pinus edulis</i> - <i>Juniperus</i> spp. / <i>Artemisia tridentata</i> (ssp. <i>wyomingensis</i> , ssp. <i>vaseyana</i>) Woodland
42	n/a	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland
43	n/a	<i>Pinus edulis</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland

Appendix D. Plant Species List, Navajo National Monument.

Scientific name	Common name	Family	Nativity
<i>Abronia elliptica</i>	fragrant white sand verbena	Nyctaginaceae	N
<i>Abronia fragrans</i>	snowball sand verbena	Nyctaginaceae	N
<i>Acer glabrum</i>	Rocky Mountain maple	Aceraceae	N
<i>Acer negundo</i>	boxelder	Aceraceae	N
<i>Achillea millefolium</i>	common yarrow	Asteraceae	N
<i>Achnatherum hymenoides</i>	Indian ricegrass	Poaceae	N
<i>Adiantum capillus-veneris</i>	common maidenhair	Pteridaceae	N
<i>Agrostis exarata</i>	spike bentgrass	Poaceae	N
<i>Allionia incarnata</i>	trailing windmills	Nyctaginaceae	N
<i>Allium macropetalum</i>	largeflower onion	Liliaceae	N
<i>Alopecurus aequalis</i>	shortawn foxtail	Poaceae	N
<i>Amaranthus albus</i>	prostrate pigweed	Amaranthaceae	N
<i>Amaranthus blitoides</i>	mat amaranth	Amaranthaceae	N
<i>Amaranthus hypochondriacus</i>	Prince-of-Wales feather	Amaranthaceae	E
<i>Amaranthus retroflexus</i>	redroot amaranth	Amaranthaceae	E
<i>Ambrosia acanthicarpa</i>	flatspine burr ragweed	Asteraceae	N
<i>Ambrosia artemisiifolia</i>	annual ragweed	Asteraceae	N
<i>Amelanchier utahensis</i>	Utah serviceberry	Rosaceae	N
<i>Andropogon gerardii</i>	big bluestem	Poaceae	N
<i>Andropogon hallii</i>	sand bluestem	Poaceae	N
<i>Androsace septentrionalis</i>	pygmyflower rockjasmine	Primulaceae	N
<i>Antennaria marginata</i>	whitemargin pussytoes	Asteraceae	N
<i>Antennaria neglecta</i>	field pussytoes	Asteraceae	N
<i>Antennaria parvifolia</i>	small-leaf pussytoes	Asteraceae	N
<i>Apocynum X floribundum</i>	dogbane	Apocynaceae	N
<i>Aquilegia micrantha</i>	Mancos columbine	Ranunculaceae	N
<i>Arabis perennans</i>	perennial rockcress	Brassicaceae	N
<i>Arabis pulchra</i>	beautiful rockcress	Brassicaceae	N
<i>Arceuthobium campylopodum</i>	western dwarf mistletoe	Viscaceae	N
<i>Arctostaphylos pungens</i>	pointleaf manzanita	Ericaceae	N
<i>Arenaria eastwoodiae</i>	Eastwood's sandwort	Caryophyllaceae	N
<i>Aristida arizonica</i>	Arizona threeawn	Poaceae	N
<i>Aristida purpurea</i>	purple threeawn	Poaceae	N
<i>Aristida purpurea</i> var. <i>fendleriana</i>	Fendler's threeawn	Poaceae	N
<i>Artemisia bigelovii</i>	Bigelow sage	Asteraceae	N
<i>Artemisia campestris</i>	field sagewort	Asteraceae	N
<i>Artemisia campestris</i> ssp. <i>borealis</i> var. <i>scouleriana</i>	field sagewort	Asteraceae	N
<i>Artemisia carruthii</i>	Carruth's sagewort	Asteraceae	N
<i>Artemisia dracunculus</i>	false tarragon	Asteraceae	N
<i>Artemisia frigida</i>	prairie sagewort	Asteraceae	N
<i>Artemisia ludoviciana</i>	white sagebrush	Asteraceae	N
<i>Artemisia nova</i>	black sagebrush	Asteraceae	N

Appendix D. Plant species list, Navajo National Monument, cont.

Scientific name	Common name	Family	Nativity
<i>Artemisia tridentata</i>	big sagebrush	Asteraceae	N
<i>Asclepias asperula</i>	spider milkweed	Asclepiadaceae	N
<i>Asclepias subverticillata</i>	horsetail milkweed	Asclepiadaceae	N
<i>Astragalus amphioxys</i>	crescent milkvetch	Fabaceae	N
<i>Astragalus ceramicus</i>	painted milkvetch	Fabaceae	N
<i>Astragalus ceramicus</i> var. <i>ceramicus</i>	painted milkvetch	Fabaceae	N
<i>Astragalus lentiginosus</i>	freckled milkvetch	Fabaceae	N
<i>Astragalus lentiginosus</i> var. <i>palans</i>	freckled milkvetch	Fabaceae	N
<i>Astragalus mollissimus</i> var. <i>thompsoniae</i>	woolly locoweed	Fabaceae	N
<i>Astragalus sesquiflorus</i>	sandstone milkvetch	Fabaceae	N
<i>Astragalus zionis</i>	Zion milkvetch	Fabaceae	N
<i>Atriplex canescens</i>	fourwing saltbush	Chenopodiaceae	N
<i>Betula occidentalis</i>	water birch	Betulaceae	N
<i>Bouteloua barbata</i>	sixweeks grama	Poaceae	N
<i>Bouteloua curtipendula</i>	sideoats grama	Poaceae	N
<i>Bouteloua gracilis</i>	blue grama	Poaceae	N
<i>Brickellia californica</i>	California brickellbush	Asteraceae	N
<i>Brickellia grandiflora</i>	tasselflower brickellbush	Asteraceae	N
<i>Brickellia microphylla</i> var. <i>scabra</i>	rough brickellbush	Asteraceae	N
<i>Bromus carinatus</i>	California brome	Poaceae	N
<i>Bromus ciliatus</i>	fringed brome	Poaceae	N
<i>Bromus marginatus</i>	mountain brome	Poaceae	N
<i>Bromus rubens</i>	red brome	Poaceae	E
<i>Bromus tectorum</i>	cheatgrass	Poaceae	E
<i>Calochortus nuttallii</i>	sego lily	Liliaceae	N
<i>Capsella bursa-pastoris</i>	shepherd's purse	Brassicaceae	E
<i>Carex occidentalis</i>	western sedge	Cyperaceae	N
<i>Carex pellita</i>	woolly sedge	Cyperaceae	N
<i>Carex rossii</i>	Ross' sedge	Cyperaceae	N
<i>Carex vallicola</i>	valley sedge	Cyperaceae	N
<i>Castilleja linariifolia</i>	Wyoming Indian paintbrush	Scrophulariaceae	N
<i>Celtis laevigata</i> var. <i>reticulata</i>	netleaf hackberry	Ulmaceae	N
<i>Centaurium calycosum</i>	Arizona centaury	Gentianaceae	N
<i>Cercocarpus intricatus</i>	littleleaf mountain mahogany	Rosaceae	N
<i>Chaenactis stevioides</i>	Steve's dustymaiden	Asteraceae	N
<i>Chaetopappa ericoides</i>	rose heath	Asteraceae	N
<i>Chamaesaracha coronopus</i>	greenleaf five eyes	Solanaceae	N
<i>Chamaesyce glyptosperma</i>	ribseed sandmat	Euphorbiaceae	N
<i>Chamaesyce micromera</i>	Sonoran sandmat	Euphorbiaceae	N
<i>Chenopodium album</i>	lambsquarters	Chenopodiaceae	N
<i>Chenopodium desiccatum</i>	aridland goosefoot	Chenopodiaceae	N
<i>Chenopodium fremontii</i>	Fremont's goosefoot	Chenopodiaceae	N
<i>Chenopodium glaucum</i>	oakleaf goosefoot	Chenopodiaceae	N
<i>Chenopodium leptophyllum</i>	narrowleaf goosefoot	Chenopodiaceae	N

Appendix D. Plant species list, Navajo National Monument, cont.

Scientific name	Common name	Family	Nativity
<i>Chenopodium pratericola</i>	desert goosefoot	Chenopodiaceae	N
<i>Chorispura tenella</i>	crossflower	Brassicaceae	E
<i>Chrysothamnus depressus</i>	longflower rabbitbrush	Asteraceae	N
<i>Chrysothamnus greenei</i>	Greene's rabbitbrush	Asteraceae	N
<i>Chrysothamnus pulchellus</i>	southwestern rabbitbrush	Asteraceae	N
<i>Chrysothamnus viscidiflorus</i>	yellow rabbitbrush	Asteraceae	N
<i>Cirsium calcareum</i>	Cainville thistle	Asteraceae	N
<i>Cirsium vulgare</i>	bull thistle	Asteraceae	E
<i>Clematis ligusticifolia</i>	western white clematis	Ranunculaceae	N
<i>Cleome serrulata</i>	Rocky Mountain beeplant	Capparaceae	N
<i>Comandra umbellata</i> ssp. <i>pallida</i>	pale bastard toadflax	Santalaceae	N
<i>Conyza canadensis</i>	Canadian horseweed	Asteraceae	N
<i>Cordylanthus wrightii</i>	Wright's bird's beak	Scrophulariaceae	N
<i>Cornus sericea</i> ssp. <i>sericea</i>	redosier dogwood	Cornaceae	N
<i>Corydalis aurea</i>	scrambled eggs	Fumariaceae	N
<i>Cryptantha barbiger</i>	bearded cryptantha	Boraginaceae	N
<i>Cryptantha capitata</i>	capitate cryptantha	Boraginaceae	N
<i>Cryptantha cinerea</i> var. <i>jamesii</i>	James' cryptantha	Boraginaceae	N
<i>Cryptantha confertiflora</i>	basin yellow cryptantha	Boraginaceae	N
<i>Cryptantha crassiseppala</i>	thicksepal cryptantha	Boraginaceae	N
<i>Cryptantha flava</i>	Brenda's yellow cryptantha	Boraginaceae	N
<i>Cryptantha fulvocanescens</i>	tawny cryptantha	Boraginaceae	N
<i>Cryptantha pterocarya</i>	wingnut cryptantha	Boraginaceae	N
<i>Cymopterus newberryi</i>	sweetroot springparsley	Apiaceae	N
<i>Datura wrightii</i>	sacred thorn-apple	Solanaceae	N
<i>Delphinium nuttallianum</i>	two-lobed larkspur	Ranunculaceae	N
<i>Delphinium parishii</i> ssp. <i>parishii</i>	Parish's larkspur	Ranunculaceae	N
<i>Delphinium scaposum</i>	tall mountain larkspur	Ranunculaceae	N
<i>Descurainia pinnata</i>	western tansymustard	Brassicaceae	N
<i>Descurainia sophia</i>	flixweed	Brassicaceae	E
<i>Dracocephalum parviflorum</i>	American dragonhead	Lamiaceae	N
<i>Echinocereus fendleri</i>	pinkflower hedgehog cactus	Cactaceae	N
<i>Echinocereus triglochidiatus</i>	claretcup cactus	Cactaceae	N
<i>Elaeagnus angustifolia</i>	Russian olive	Elaeagnaceae	E
<i>Eleocharis palustris</i>	common spikerush	Cyperaceae	N
<i>Elymus caninus</i>	bearded wheatgrass	Poaceae	E
<i>Elymus elymoides</i> ssp. <i>elymoides</i>	squirreltail	Poaceae	N
<i>Elymus glaucus</i>	blue wildrye	Poaceae	N
<i>Elymus trachycaulus</i> ssp. <i>trachycaulus</i>	slender wheatgrass	Poaceae	N
<i>Ephedra cutleri</i>	Cutler's jointfir	Ephedraceae	N
<i>Ephedra viridis</i>	mormon tea	Ephedraceae	N
<i>Epilobium ciliatum</i>	fringed willowherb	Onagraceae	N
<i>Epilobium hornemannii</i>	Hornemann's willowherb	Onagraceae	N
<i>Equisetum hyemale</i>	scouringrush horsetail	Equisetaceae	N

Appendix D. Plant species list, Navajo National Monument, cont.

Scientific name	Common name	Family	Nativity
<i>Equisetum laevigatum</i>	smooth horsetail	Equisetaceae	N
<i>Eragrostis pectinacea</i>	tufted lovegrass	Poaceae	N
<i>Ericameria nauseosa</i>	rubber rabbitbrush	Asteraceae	N
<i>Ericameria nauseosa</i> ssp. <i>nauseosa</i> var. <i>glabrata</i>	rubber rabbitbrush	Asteraceae	N
<i>Ericameria nauseosa</i> ssp. <i>nauseosa</i> var. <i>nauseosa</i>	rubber rabbitbrush	Asteraceae	N
<i>Erigeron bellidiastrum</i>	western daisy fleabane	Asteraceae	N
<i>Erigeron concinnus</i>	Navajo fleabane	Asteraceae	N
<i>Erigeron divergens</i>	spreading fleabane	Asteraceae	N
<i>Erigeron flagellaris</i>	trailing fleabane	Asteraceae	N
<i>Erigeron glabellus</i>	streamside fleabane	Asteraceae	N
<i>Erigeron speciosus</i>	aspen fleabane	Asteraceae	N
<i>Erigeron speciosus</i> var. <i>macranthus</i>	aspen fleabane	Asteraceae	N
<i>Erigeron utahensis</i>	Utah fleabane	Asteraceae	N
<i>Eriogonum alatum</i>	winged wild buckwheat	Polygonaceae	N
<i>Eriogonum cernuum</i>	nodding wild buckwheat	Polygonaceae	N
<i>Eriogonum corymbosum</i>	crispleaf wild buckwheat	Polygonaceae	N
<i>Eriogonum microthecum</i>	slender wild buckwheat	Polygonaceae	N
<i>Eriogonum umbellatum</i>	sulphur-flower wild buckwheat	Polygonaceae	N
<i>Eriogonum umbellatum</i> var. <i>cognatum</i>	sulphur-flower wild buckwheat	Polygonaceae	N
<i>Erodium cicutarium</i>	redstem stork's bill	Geraniaceae	E
<i>Erysimum capitatum</i> var. <i>capitatum</i>	western wallflower	Brassicaceae	N
<i>Escobaria vivipara</i> var. <i>vivipara</i>	spiny star cactus	Cactaceae	N
<i>Euphorbia brachycera</i>	horned spurge	Euphorbiaceae	N
<i>Euthamia occidentalis</i>	western goldentop	Asteraceae	N
<i>Fallugia paradoxa</i>	Apache plume	Rosaceae	N
<i>Fendlera rupicola</i>	cliff fendlerbush	Hydrangeaceae	N
<i>Forestiera pubescens</i> var. <i>pubescens</i>	stretchberry	Oleaceae	N
<i>Fraxinus anomala</i>	singleleaf ash	Oleaceae	N
<i>Fritillaria atropurpurea</i>	spotted fritillary	Liliaceae	N
<i>Funastrum cynanchoides</i> ssp. <i>cynanchoides</i>	fringed twinevine	Asclepiadaceae	N
<i>Funastrum heterophyllum</i>	Hartweg's twinevine	Asclepiadaceae	N
<i>Gaillardia pinnatifida</i>	red dome blanketflower	Asteraceae	N
<i>Galium aparine</i>	stickywilly	Rubiaceae	N
<i>Galium triflorum</i>	fragrant bedstraw	Rubiaceae	N
<i>Geranium atropurpureum</i>	western purple cranesbill	Geraniaceae	N
<i>Geranium caespitosum</i>	pinewoods geranium	Geraniaceae	N
<i>Gilia leptomeria</i>	sand gilia	Polemoniaceae	N
<i>Gilia scopulorum</i>	rock gilia	Polemoniaceae	N
<i>Gilia subnuda</i>	coral gilia	Polemoniaceae	N
<i>Glyceria striata</i>	fowl mannagrass	Poaceae	E
<i>Gutierrezia microcephala</i>	threadleaf snakeweed	Asteraceae	N
<i>Gutierrezia sarothrae</i>	broom snakeweed	Asteraceae	N

Appendix D. Plant species list, Navajo National Monument, cont.

Scientific name	Common name	Family	Nativity
<i>Heliotropium convolvulaceum</i>	phlox heliotrope	Polemoniaceae	N
<i>Hesperodoria scopulorum</i>	Grand Canyon glowweed	Asteraceae	N
<i>Hesperostipa comata</i> ssp. <i>comata</i>	needle and thread	Poaceae	N
<i>Hesperostipa neomexicana</i>	New Mexico feathergrass	Poaceae	N
<i>Heterotheca villosa</i>	hairy false goldenaster	Asteraceae	N
<i>Heterotheca villosa</i> var. <i>villosa</i>	hairy false goldenaster	Asteraceae	N
<i>Heuchera parvifolia</i>	littleleaf alumroot	Saxifragaceae	N
<i>Heuchera rubescens</i>	pink alumroot	Saxifragaceae	N
<i>Holodiscus dumosus</i>	rockspirea	Rosaceae	N
<i>Hordeum jubatum</i>	foxtail barley	Poaceae	N
<i>Hordeum murinum</i> ssp. <i>glaucum</i>	smooth barley	Poaceae	E
<i>Hordeum murinum</i> ssp. <i>leporinum</i>	leporinum barley	Poaceae	E
<i>Hymenopappus filifolius</i>	fineleaf hymenopappus	Asteraceae	N
<i>Hymenopappus filifolius</i> var. <i>lugens</i>	Idaho hymenopappus	Asteraceae	N
<i>Hymenoxys bigelovii</i>	Bigelow's rubberweed	Asteraceae	N
<i>Hymenoxys richardsonii</i>	pingue rubberweed	Asteraceae	N
<i>Ipomopsis aggregata</i>	scarlet gilia	Polemoniaceae	N
<i>Ipomopsis aggregata</i> ssp. <i>aggregata</i>	scarlet gilia	Polemoniaceae	N
<i>Ipomopsis longiflora</i> ssp. <i>longiflora</i>	flaxflowered ipomopsis	Polemoniaceae	N
<i>Juglans major</i>	Arizona walnut	Juglandaceae	N
<i>Juncus balticus</i>	Baltic rush	Juncaceae	N
<i>Juncus tenuis</i>	poverty rush	Juncaceae	N
<i>Juniperus monosperma</i>	oneseed juniper	Cupressaceae	N
<i>Juniperus osteosperma</i>	Utah juniper	Cupressaceae	N
<i>Kelloggia galioides</i>	milk kelloggia	Rubiaceae	N
<i>Kochia scoparia</i>	Mexican-fireweed	Chenopodiaceae	E
<i>Lactuca serriola</i>	prickly lettuce	Asteraceae	E
<i>Lactuca tatarica</i> var. <i>pulchella</i>	blue lettuce	Asteraceae	E
<i>Lappula occidentalis</i>	flatspine stickseed	Boraginaceae	N
<i>Lappula occidentalis</i> var. <i>occidentalis</i>	flatspine stickseed	Boraginaceae	N
<i>Lathyrus brachycalyx</i>	Bonneville pea	Fabaceae	N
<i>Lathyrus lanszwertii</i> var. <i>leucanthus</i>	Nevada pea	Fabaceae	N
<i>Lepidium montanum</i>	mountain pepperweed	Brassicaceae	N
<i>Lepidium montanum</i> var. <i>jonesii</i>	Jones' pepperweed	Brassicaceae	N
<i>Leptodactylon pungens</i>	granite prickly phlox	Polemoniaceae	N
<i>Lesquerella intermedia</i>	mid bladderpod	Brassicaceae	N
<i>Lesquerella ludoviciana</i>	foothill bladderpod	Brassicaceae	N
<i>Lesquerella rectipes</i>	straight bladderpod	Brassicaceae	N
<i>Linum aristatum</i>	bristle flax	Linaceae	N
<i>Linum perrene</i>	blue flax	Linaceae	N
<i>Lithospermum multiflorum</i>	manyflowered stone seed	Boraginaceae	N
<i>Lupinus argenteus</i>	silvery lupine	Fabaceae	N
<i>Lycium pallidum</i>	pale desert-thorn	Solanaceae	N
<i>Lycurus phleoides</i>	common wolfstail	Poaceae	N

Appendix D. Plant species list, Navajo National Monument, cont.

Scientific name	Common name	Family	Nativity
<i>Machaeranthera canescens</i> ssp. <i>canescens</i> var. <i>incana</i>	hoary tansyaster	Asteraceae	N
<i>Machaeranthera canescens</i> var. <i>glabra</i>	tansyaster	Asteraceae	N
<i>Machaeranthera grindelioides</i>	rayless tansyaster	Asteraceae	N
<i>Machaeranthera grindelioides</i> var. <i>grindelioides</i>	rayless tansyaster	Asteraceae	N
<i>Mahonia repens</i>	creeping barberry	Berberidaceae	N
<i>Maianthemum stellatum</i>	starry false lily of the vally	Liliaceae	N
<i>Malacothrix sonchoides</i>	sowthistle desertdandelion	Asteraceae	N
<i>Medicago sativa</i>	alfalfa	Fabaceae	E
<i>Melilotus officinalis</i> (includes <i>M. alba</i>)	sweetclover	Fabaceae	E
<i>Mentzelia albicaulis</i>	whitestem blazingstar	Loasaceae	N
<i>Mimulus eastwoodiae</i>	Eastwood's monkeyflower	Scrophulariaceae	N
<i>Mirabilis comata</i>	hairy-tuft four o'clock	Nyctaginaceae	N
<i>Mirabilis linearis</i>	narrowleaf four o'clock	Nyctaginaceae	N
<i>Mirabilis multiflora</i>	Colorado four o'clock	Nyctaginaceae	N
<i>Mirabilis oxybaphoides</i>	smooth spreading four o'clock	Nyctaginaceae	N
<i>Monroa squarrosa</i>	false buffalograss	Poaceae	N
<i>Muhlenbergia andina</i>	foxtail muhly	Poaceae	N
<i>Muhlenbergia curtifolia</i>	Utah muhly	Poaceae	N
<i>Muhlenbergia minutissima</i>	annual muhly	Poaceae	N
<i>Muhlenbergia pungens</i>	sandhill muhly	Poaceae	N
<i>Muhlenbergia thurberi</i>	Thurber's muhly	Poaceae	N
<i>Muhlenbergia wrightii</i>	spike muhly	Poaceae	N
<i>Nicotiana attenuata</i>	coyote tobacco	Solanaceae	N
<i>Oenothera albicaulis</i>	whitest evening-primrose	Onagraceae	N
<i>Oenothera caespitosa</i>	tufted evening-primrose	Onagraceae	N
<i>Oenothera caespitosa</i> ssp. <i>macroglottis</i>	tufted evening-primrose	Onagraceae	N
<i>Oenothera elata</i>	Hooker's evening-primrose	Onagraceae	N
<i>Oenothera elata</i> ssp. <i>hookeri</i>	Hooker's evening-primrose	Onagraceae	N
<i>Oenothera longissima</i>	longstem evening-primrose	Onagraceae	N
<i>Oenothera pallida</i>	pale evening-primrose	Onagraceae	N
<i>Oenothera pallida</i> ssp. <i>pallida</i>	pale evening-primrose	Onagraceae	N
<i>Opuntia erinacea</i>	grizzlybear pricklypear	Cactaceae	N
<i>Opuntia fragilis</i>	brittle pricklypear	Cactaceae	N
<i>Opuntia phaeacantha</i>	tulip pricklypear	Cactaceae	N
<i>Opuntia polyacantha</i>	plains pricklypear	Cactaceae	N
<i>Opuntia whipplei</i>	Whipple's cholla	Cactaceae	N
<i>Packera hartiana</i>	Hart's ragwort	Asteraceae	N
<i>Packera multilobata</i>	lobeleaf groundsel	Asteraceae	N
<i>Parietaria pensylvanica</i>	Pennsylvania pellitory	Urticaceae	N
<i>Penstemon ambiguus</i>	gilia beardtongue	Scrophulariaceae	N
<i>Penstemon barbatus</i>	beardlip penstemon	Scrophulariaceae	N
<i>Penstemon comarrhenus</i>	dusty beardtongue	Scrophulariaceae	N

Appendix D. Plant species list, Navajo National Monument, cont.

Scientific name	Common name	Family	Nativity
<i>Penstemon eatonii</i>	Eaton's penstemon	Scrophulariaceae	N
<i>Penstemon rostriflorus</i>	Bridge penstemon	Scrophulariaceae	N
<i>Penstemon virgatus</i>	upright blue beardtongue	Scrophulariaceae	N
<i>Phacelia crenulata</i> var. <i>corrugata</i>	cleftleaf wildheliotrope	Polemoniaceae	N
<i>Phacelia ivesiana</i>	Ives' phacelia	Polemoniaceae	N
<i>Phlox austromontana</i>	mountain phlox	Polemoniaceae	N
<i>Phlox longifolia</i>	longleaf phlox	Polemoniaceae	N
<i>Phoradendron juniperinum</i>	juniper mistletoe	Viscaceae	N
<i>Physalis hederifolia</i>	ivyleaf groundcherry	Solanaceae	N
<i>Physalis hederifolia</i> var. <i>fendleri</i>	Fendler's groundcherry	Solanaceae	N
<i>Pinus edulis</i>	twoneedle pinyon	Pinaceae	N
<i>Piptatherum micranthum</i>	littleseed ricegrass	Poaceae	N
<i>Plantago patagonica</i>	woolly plantain	Plantaginaceae	N
<i>Platanthera zothecina</i>	alcove bog orchid	Orchidaceae	N
<i>Pleuraphis jamesii</i>	galleta grass	Poaceae	N
<i>Poa annua</i>	annual bluegrass	Poaceae	N
<i>Poa fendleriana</i>	muttongrass	Poaceae	N
<i>Poa fendleriana</i> ssp. <i>longiligula</i>	muttongrass	Poaceae	N
<i>Poa nemoralis</i> ssp. <i>interior</i>	inland bluegrass	Poaceae	N
<i>Poa pratensis</i>	Kentucky bluegrass	Poaceae	E
<i>Polygonum aviculare</i>	prostrate knotweed	Polygonaceae	N
<i>Polygonum douglasii</i> ssp. <i>johnstonii</i>	Johnston's knotweed	Polygonaceae	N
<i>Polypogon interruptus</i>	ditch rabbitsfoot grass	Poaceae	N
<i>Polypogon monspeliensis</i>	annual rabbitsfoot grass	Poaceae	E
<i>Polypogon viridis</i>	beardless rabbitsfoot grass	Poaceae	E
<i>Populus angustifolia</i>	narrowleaf cottonwood	Salicaceae	N
<i>Populus deltoides</i> ssp. <i>wislizeni</i>	Rio Grande cottonwood	Salicaceae	N
<i>Populus fremontii</i>	Fremont's cottonwood	Salicaceae	N
<i>Populus tremuloides</i>	quaking aspen	Salicaceae	N
<i>Portulaca halimoides</i>	silkcotton purslane	Portulacaceae	N
<i>Portulaca oleracea</i>	purslane	Portulacaceae	N
<i>Prunus emarginata</i>	bitter cherry	Rosaceae	N
<i>Prunus munsoniana</i>	wild goose plum	Rosaceae	N
<i>Prunus virginiana</i>	chokecherry	Rosaceae	N
<i>Pseudognaphalium luteoalbum</i>	Jersey cudweed	Asteraceae	N
<i>Pseudotsuga menziesii</i>	Douglas-fir	Pinaceae	N
<i>Psilactis asteroides</i>	New Mexico tansyaster	Asteraceae	N
<i>Psilostrophe sparsiflora</i>	greenstem paperflower	Asteraceae	N
<i>Puccinellia nuttalliana</i>	Nuttall's alkaligrass	Poaceae	N
<i>Purshia mexicana</i>	Mexican cliffrose	Rosaceae	N
<i>Purshia stansburiana</i>	Stansbury cliffrose	Rosaceae	N
<i>Purshia tridentata</i>	antelope bitterbrush	Rosaceae	N
<i>Quercus gambelii</i>	Gambel's oak	Fagaceae	N
<i>Quercus havardii</i>	Havard's oak	Fagaceae	N

Appendix D. Plant species list, Navajo National Monument, cont.

Scientific name	Common name	Family	Nativity
<i>Quercus turbinella</i>	Sonoran scrub oak	Fagaceae	N
<i>Ranunculus cymbalaria</i>	alkali buttercup	Ranunculaceae	N
<i>Rhus trilobata</i>	skunkbush sumac	Anacardiaceae	N
<i>Rhus trilobata</i> var. <i>simplicifolia</i>	singleleaf sumac	Anacardiaceae	N
<i>Rhus trilobata</i> var. <i>trilobata</i>	skunkbush sumac	Anacardiaceae	N
<i>Ribes cereum</i>	wax currant	Grossulariaceae	N
<i>Ribes leptanthum</i>	trumpet gooseberry	Grossulariaceae	N
<i>Ribes viscosissimum</i>	sticky currant	Grossulariaceae	N
<i>Rosa woodsii</i>	Woods' rose	Rosaceae	N
<i>Salix exigua</i>	narrowleaf willow	Salicaceae	N
<i>Salix gooddingii</i>	Goodding's willow	Salicaceae	N
<i>Salix lasiolepis</i>	arroyo willow	Salicaceae	N
<i>Salix lucida</i> ssp. <i>lasiandra</i>	Pacific willow	Salicaceae	N
<i>Salsola tragus</i>	prickly Russian thistle	Chenopodiaceae	E
<i>Sarcobatus vermiculatus</i>	greasewood	Chenopodiaceae	N
<i>Scirpus pungens</i>	common threesquare	Cyperaceae	N
<i>Sclerocactus parviflorus</i>	smallflower fishhook cactus	Cactaceae	N
<i>Sclerocactus parviflorus</i> ssp. <i>terrae-canyonae</i>	longspine fishhook cactus	Cactaceae	N
<i>Sclerocactus whipplei</i>	Whipple's fishhook cactus	Cactaceae	N
<i>Sedum stenopetalum</i>	wormleaf stonecrop	Crassulaceae	N
<i>Selaginella mutica</i>	bluntleaf spikemoss	Selaginellaceae	N
<i>Senecio flaccidus</i> var. <i>flaccidus</i>	threadleaf groundsel	Asteraceae	N
<i>Senecio spartioides</i>	broomlike ragwort	Asteraceae	N
<i>Shepherdia rotundifolia</i>	roundleaf buffaloberry	Eleagnaceae	N
<i>Sidalcea neomexicana</i>	salt spring checkerbloom	Malvaceae	N
<i>Sisymbrium altissimum</i>	tall tumbled mustard	Brassicaceae	E
<i>Solanum jamesii</i>	wild potato	Solanaceae	N
<i>Solanum triflorum</i>	cutleaf nightshade	Solanaceae	N
<i>Solidago canadensis</i>	Canada goldenrod	Asteraceae	N
<i>Sonchus asper</i>	spiny sowthistle	Asteraceae	E
<i>Sparganium eurycarpum</i>	broadfruit bur-reed	Sparganiaceae	N
<i>Sphaeralcea coccinea</i>	scarlet globemallow	Malvaceae	N
<i>Sphaeralcea grossulariifolia</i>	gooseberryleaf globemallow	Malvaceae	N
<i>Sphaeralcea parvifolia</i>	smallflower globemallow	Malvaceae	N
<i>Sporobolus airoides</i>	alkali sacaton	Poaceae	N
<i>Sporobolus contractus</i>	spike dropseed	Poaceae	N
<i>Sporobolus cryptandrus</i>	sand dropseed	Poaceae	N
<i>Sporobolus flexuosus</i>	mesa dropseed	Poaceae	N
<i>Stephanomeria exigua</i>	small wirelettuce	Asteraceae	N
<i>Stephanomeria minor</i> var. <i>minor</i>	narrowleaf wirelettuce	Asteraceae	N
<i>Stephanomeria thurberi</i>	Thurber's wirelettuce	Asteraceae	N
<i>Streptanthella longirostris</i>	longbeak streptanthella	Brassicaceae	N
<i>Streptanthus cordatus</i>	heartleaf twistflower	Brassicaceae	N
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Caprifoliaceae	N

Appendix D. Plant species list, Navajo National Monument, cont.

Scientific name	Common name	Family	Nativity
<i>Symphoricarpos oreophilus</i> var. <i>utahensis</i>	Utah snowberry	Caprifoliaceae	N
<i>Talinum brevifolium</i>	pygmy fameflower	Portulacaceae	N
<i>Talinum confertiflorum</i>	New Mexico fameflower	Portulacaceae	N
<i>Tamarix ramosissima</i>	saltcedar	Tamaricaceae	E
<i>Taraxacum officinale</i>	common dandelion	Asteraceae	E
<i>Tetradymia canescens</i>	spineless horsebrush	Asteraceae	N
<i>Tetraneuris acaulis</i> var. <i>acaulis</i>	stemless four-nerve daisy	Asteraceae	N
<i>Tetraneuris ivesiana</i>	Ives' fournerved daisy	Asteraceae	N
<i>Thalictrum fendleri</i>	Fendler's meadow-rue	Ranunculaceae	N
<i>Thelypodium integrifolium</i>	entireleaved thelypody	Brassicaceae	N
<i>Thlaspi montanum</i> var. <i>fendleri</i>	Fendler's pennycress	Brassicaceae	N
<i>Townsendia incana</i>	hoary Townsend daisy	Asteraceae	N
<i>Toxicodendron radicans</i>	eastern poison ivy	Anacardiaceae	N
<i>Tradescantia occidentalis</i>	prairie spiderwort	Commelinaceae	N
<i>Tribulus terrestris</i>	puncturevine	Zygophyllaceae	E
<i>Triglochin maritima</i>	seaside arrowgrass	Juncaginaceae	N
<i>Tripterocalyx carnea</i> var. <i>wootonii</i>	Wooton's sandpuffs	Nyctaginaceae	N
<i>Valeriana acutiloba</i>	sharpleaf valerian	Valerianaceae	N
<i>Verbena bracteata</i>	bigbract verbena	Verbenaceae	N
<i>Verbesina encelioides</i>	golden crownbeard	Asteraceae	N
<i>Vulpia octoflora</i>	sixweeks fescue	Poaceae	N
<i>Xanthium strumarium</i>	rough cocklebur	Asteraceae	N
<i>Yucca angustissima</i>	narrowleaf yucca	Agavaceae	N
<i>Yucca angustissima</i> var. <i>toftiae</i>	Toft's narrowleaf yucca	Agavaceae	N
<i>Yucca baccata</i>	banana yucca	Agavaceae	N

N=native to North America

E=exotic or introduced from other continents.

Table compiled from NPSpecies, the National Park Service biodiversity database (secure online version, <https://science1.nature.nps.gov/npspecies/web/main/start>, accessed 11/3/2008) and from this project; plant species from this study may not be vouchered.

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