



Vegetation Classification and Distribution Mapping Report

Petrified Forest National Park

Natural Resource Technical Report NPS/SCPN/NRTR—2009/273



ON THE COVER

Petrified Forest National Park
Courtesy of U.S. Geological Survey Southwest Biological Science Center

Errata

Page	Error	Correction
G13	Figure G19. Ground photo for map class B9, Greasewood / New Mexico Saltbush Shrubland	Figure G19. Ground photo for map class B10, Greasewood / Shrubby Seepweed Shrubland
G13	Figure 20. Photosignature for map class B9, Greasewood / New Mexico Saltbush Shrubland	Figure 20. Photosignature for map class B10, Greasewood / Shrubby Seepweed Shrubland
G32	Figure G57. Ground photo for map class B27, Russian Thistle Sand Dune Vegetation	Figure G57. Ground photo for map class B29, Arizona Siltbush Sparse Vegetation
G32	Figure G58. Photosignature for map class B27, Russian Thistle Sand Dune Vegetation	Photosignature for map class B29, Arizona Siltbush Sparse Vegetation

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

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Acronyms and Abbreviations

AA	Accuracy assessment
ac	acres
APFO	Aerial Photography Field Office
BLM	United States Bureau of Land Management
BOR	Bureau of Reclamation
CEGL	Community Element Code – Global
CIR	color infrared
cm	centimeter
DEM	Digital Elevation Model
DOQQ	Digital Orthophoto Quarter Quadrangle
DVD	Digital Video Disk
ECW	Enhanced Compressed Wavelet
ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
ft	foot/feet
GB	gigabytes
GCP	Ground Control Point
GIS	Geographic Information System
GISSAL	Geographic Information Systems Spatial Analysis Laboratory
GPS	Global Positioning System
ha	hectares
I&M	Inventory and Monitoring Program
in	inch
ISA	Indicator Species Analysis
ITIS	Integrated Taxonomic Information System
km	kilometer
KSU	Kansas State University
m	meters
mi	miles
.mdb	Microsoft Access file format
MMU	Minimum Mapping Unit
MRPP	Multiple Response Permutation Procedure
n.d.	no date
NA	not applicable
NAD83	North American Datum of 1983
NAU	Northern Arizona University

Acronyms and Abbreviations *continued*

NBII	National Biological Information Infrastructure
NED	National Elevation Dataset
NMS	Non-metric Multi-dimensional Scaling
NP	National Park
NPS	National Park Service
NS	not sampled
NVCS	National Vegetation Classification Standard
NVC	National Vegetation Classification
.pdf	Adobe Portable Document Format
PEFO	Petrified Forest National Park
RMGSC	Rocky Mountain Geographic Science Center
SCPN	Southern Colorado Park Network
SBSC	Southwest Biological Science Center
spp	Species (plural)
TIF	Tagged Image Format
TNC	The Nature Conservancy
TSN	Taxonomic Serial Number
UNESCO	United Nations Education, Science, and Cultural Organization
USDA	U.S. Department of Agriculture
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VMP	Vegetation Mapping Program
.xls	Microsoft Excel file format

Executive Summary

The classification and distribution mapping of the vegetation of Petrified Forest National Park (PEFO) and surrounding environment was completed through a multi-agency effort between 2003 and 2007. The National Park Service's Southern Colorado Plateau Network facilitated the team that conducted the work, which comprised the U.S. Geological Survey's Southwest Biological Science Center, Kansas State University, Northern Arizona University, and NatureServe.

The project team described 39 plant communities for PEFO; 38 of which were described from quantitative classification based on field-relevé data collected in 1996 and 2003. The team derived one additional plant community from field observations during the photointerpretation phase of the project and field documented it during accuracy assessment. The National Vegetation Classification Standard served as a conceptual framework for assigning these plant communities to the alliance and association level. Seven of the thirty-nine plant communities were designated "park specials"; that is, plant communities with insufficient data to describe them as new alliances or associations.

The project team also developed a spatial vegetation map database representing PEFO, with four different map-class schemas: base, group, macrogroup, and management map classes. The base map classes represented the finest level of spatial detail. Initial polygons were through manual interpretation of 2003/2004 1:6,000 true color aerial photography supplemented by occasional computer screen digitizing on a mosaic of digitized aerial photos. These polygons were labeled with base map classes during photointerpretation. Field visits verified interpretation concepts.

The vegetation map database includes

- 46 base map classes, which consist of associations and park specials classified

with the quantitative analysis

- one additional association noted during photointerpretation
- non-vegetated land cover, such as infrastructure, land use, and geological land cover.

The base map classes consist of 6,989 polygons in the project area. A field-based accuracy assessment of the base map classes showed the overall accuracy to be 40.6%.

The group map classes represent aggregations of the base map classes, approximating the group level of the National Vegetation Classification Standard (NVCS), version 2 (Federal Geographic Data Committee 2008). Terrestrial ecological systems, as described by NatureServe (Comer et al. 2003), were used as a first approximation of the group level. The project team identified 15 group map classes for this project. The overall accuracy of the group map classes was determined using the same accuracy assessment data as for the base map classes. The overall accuracy of the group representation of vegetation was 55.7%.

The next higher level of the NVCS, the macrogroup, was also used to develop a map class schema. The project team identified 13 macrogroup map classes. The overall accuracy of the macro group representation of vegetation was 73.5%.

In consultation with park staff, the team developed management map classes, consisting of park-defined groupings of base map classes intended to represent a balance between maintaining required accuracy and providing a focus on vegetation of particular interest or import to park managers. The 24 management map classes had an overall accuracy of 68.6%.

While the main products of this project are the vegetation classification and the vegetation map databases, a number of

ancillary digital geographic information system and database products were also produced and can be used independently, or to augment the main products. These products include shapefiles of the location of field-collected data and relational databases of field-collected data.

Acknowledgments

Behind the authors of this report are the U.S. Geological Survey (USGS), National Park Service (NPS), Northern Arizona University (NAU), and Kansas State University affiliates that were responsible for much of the project's execution. The project team thanks the NAU classification field crew—Josh Lambert and Steve Till—and accuracy assessment field crew Jessica Fisher, Kyle Christie, Scott Stollery, Kelsey Johnson, Christina Bille, Meredith Jabis, and Meghan Pope for their hard work in the field. Heather Folger, Stacy McKnight, and Lakhbir Kaur from NAU provided data entry and quality control. Jonathan Donaldson provided important background research for the plant community descriptions. Terry Arundel, Jered Hansen, and Mike Gishey provided technical support to the USGS Southwest Biological Science team. Jason Sweet, Clancy Jensen, Katie Franke, Joseph Grasela, and Tammy Johnson provided digital data layer development, image processing and cartographic support from the Geographic Information Systems Spatial Analysis Laboratory (GISSAL) in the Department of Geography at Kansas State University. Patty Guertin of the USGS provided invaluable support during the compilation and publishing of the final products.

Logistical and administrative support was provided by Mark Sogge, Linda Lasley, and John D. Kite, Sparrow Adson, and Wendy Parrish of the Southwest Biological Science Center; Marie Saul and Cindy Judge of NAU; and Leslie Holland-Bartels and Carl Markon of the USGS Alaska Science Center. The team particularly thanks the staff of the Alaska Science Center for housing and providing logistical support for M. McTeague during the last part of the project.

Karen Beppler-Dorn, Chuck Dorn, and Pat Thompson at Petrified Forest National Park provided housing, critical logistical support, water drops for backcountry support, vehicle use for the classification field teams, and guidance to the project. The NPS Southern Colorado Plateau Network, through coordinator Lisa Thomas, provided funding support and information technology specialist Nicole Tancreto helped with spatial data acquisition. Tom Forsyth and Lynelle Wright at the Intermountain Region assisted with contract development. The USGS-NPS Vegetation Mapping Program national office, through support from Karl Brown, Tammy Hamer, Chris Lea, and Mike Story, provided the project team with critical financial and programmatic support.

Cindy Sessions of the U.S. Department of Agriculture's Aerial Photography Field Office assisted with the acquisition of aerial photography for the project.

The project team was permitted access to some sites in the park and in the project boundaries by several landowners and agencies.

The project also benefited from the critical review of the report and digital products by Janet Coles of the Northern Colorado Plateau Network and Sam Drake of the University of Arizona.

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1 Introduction

1.1 Background

Vegetation is a primary resource of natural areas, and description of vegetation composition, structure, and distribution is fundamental to effective land management. The term “vegetation” encompasses plants at multiple scales, from the most refined floristic levels (referred to as “plant communities” in this report) to the broadest physiognomic or life-form levels. This report describes the methods used and results obtained from a four-year project (2003-2007) to classify, describe, and develop a vegetation map database for Petrified Forest National Park (PEFO).

The National Park Service’s (NPS) Southern Colorado Plateau Network (SCPN), part of the service-wide Inventory and Monitoring (I&M) Program, organized and coordinated vegetation classification, description, and mapping at PEFO. For PEFO as well as its other 18 network parks, the SCPN needed baseline vegetation data upon which to develop and implement specific monitoring programs. Park managers needed baseline data and information on park resources for management purposes.

In addition to the NPS, the project team included members from the U.S. Geological Survey (USGS) Southwest Biological Science Center (SBSC), Department of Geography at Kansas State University (KSU), Northern Arizona University (NAU), and NatureServe. The USGS-NPS Vegetation Mapping Program partially funded the project, and the project team used the Vegetation Mapping Program’s programmatic standards.

1.2 Scope and Products

The scope of this project was Petrified Forest National Park and its environs, consisting of an approximately 1-km buffer around the 2003 park boundary. The total project area was 53,201 ha (131,463 ac); lands within the park boundary comprised 38,057 ha (94,042 ac) or 71.5% of the project area.

A major goal of the project was to identify and classify plant communities at the park, based on field-collected vegetation data and, to a lesser extent, observations made during fieldwork conducted in association with photointerpretation. First, the project team identified and quantitatively described plant communities using the National Vegetation Classification System (NVCS) as a classification framework. The term “plant communities” refers to the finest floristic levels of the NVCS (associations and alliances) and to park specials (i.e. plant communities with insufficient data to describe them as new alliances or associations) for some stands (table 1).

Second, the team created a spatial database (the vegetation map database) documenting the park’s vegetation and land cover. The vegetation map database represents four map class schemas (table 1):

1. the “base” map class, the finest level of floristic detail that could be mapped
2. the “group” map class, a physiognomic-floristic view of the vegetation
3. the “management” map class, park-defined groupings of base map classes to represent a balance between required accuracy and maintaining map classes of management concern
4. the “macrogroup” map class, aggregation of group map classes to represent the next higher level of the NVCS hierarchy

Finally, we assessed each map-class schema for accuracy. The base, group, and macrogroup map classes were not changed, but the management map classes were refined following a meeting with park resource staff.

This report and its appendices document the methods, results, and findings for the PEFO vegetation characterization and mapping project. The project has

Table 1. Terminology used to describe vegetation and map classes at Petrified Forest National Park.

Terminology	Definition	Derivation
Plant communities	Associations, alliances, and park specials	Field relevés or observations
Base map class	Individual plant communities or groupings of plant communities	Photointerpretation
Group map class	Groupings of base map classes that reflect physiognomy and floristics	Based on ecological systems
Macrogroup map class	Groupings of base map classes that reflect physiognomy and floristics	Aggregations of group map classes
Management map class	Groupings of base map classes that reflect management interests	Park defined

also produced a number of interrelated products that are available on a DVD that accompanies the hard-copy report, or on the USGS-NPS Vegetation Mapping Program web site (<http://biology.usgs.gov/npsveg/>). A full listing of project deliverables, their availability, file name, and format appears in Appendix A.

1.3 The USGS-NPS Vegetation Mapping Program

The USGS-NPS Vegetation Mapping Program is a cooperative project between the USGS and the NPS whose purpose is to classify, describe, and map vegetation in more than 270 national park units in the United States¹. The USGS Center for Biological Informatics administers the program in cooperation with the NPS Inventory and Monitoring Program. Through implementation of the NPS Natural Resource Challenge (National Park Service 1999) significant funding became available for completing important natural resource baseline inventories in park units, including vegetation classification and mapping. This support made it possible for the NPS to move forward with dozens of new park unit vegetation classification and mapping projects.

¹Language for the sections on the USGS-NPS Vegetation Mapping Program, National Vegetation Classification Standard, and Federal Geographic Data Committee was modified from von Loh and others (2006).

The Vegetation Mapping Program (VMP) supports consistent vegetation classification, mapping, and accuracy assessment protocols and standards across all park-mapping projects. The program has established guidance for all vegetation mapping projects in four documents:

- Standardized National Vegetation System (The Nature Conservancy and Environmental Systems Research Institute 1994a)
- Methodology for Assessing the Utility of Existing Data for Vegetation Mapping (The Nature Conservancy and Environmental Systems Research Institute 1996)
- Field Methods for Vegetation Mapping (The Nature Conservancy and Environmental Systems Research Institute 1994b)
- Accuracy Assessment Procedures (Environmental Systems Research Institute et al.1994)

In addition, the program follows national standards for all park vegetation classification and mapping projects:

- Vegetation classification follows the Federal Geographic Data Committee (FGDC) standards for vegetation classification and the National Vegetation Classification Standard (NVCS).
- Spatial data formatting follows the FGDC standards for spatial data transfer.

- Metadata for each spatial dataset follows the FGDC metadata standard.
- Spatial data is provided with a horizontal positional accuracy that meets National Map Accuracy Standards at the 1:24,000 scale; each well-defined object within the spatial database is within 1/50 of an inch display scale or 12.2 meters (40 ft) of its actual location.
- All plant names used in the classification are consistent with the Integrated Taxonomic Information System (ITIS).
- Each vegetated map class will meet or exceed 80% accuracy at the 90% confidence level.
- The minimum mapping unit (MMU) is 0.5 ha (1.24 ac).

1.4 The National Vegetation Classification Standard

Patterns of vegetation vary continuously over landscapes. Classification systems attempt to categorize those patterns by identifying and describing assemblages of plants that repeat in similar habitats. The NVCS provides a classification framework that is the standard for all NPS vegetation mapping projects (Comer et al. 2003, The Nature Conservancy, and Environmental Systems Research Institute 1994a). In 1997, the FGDC formally adopted the NVCS Version 1 (Federal Geographic Data Committee 1997). During the course of the project, Version 2 of the NVCS (Federal Geographic Data Committee 2008) was approved, but it was not used in this project as the vegetation classification units were still under development.

Not to be confused with the National Vegetation Classification (NVC) described below, the NVCS refers to the framework and rules of classification and evolved from vegetation classification work conducted over more than two decades by The Nature Conservancy (TNC), NatureServe, and the Natural Heritage Program network (Grossman et al. 1998). It derives in part from earlier vegetation

classification schemes produced by the United Nations Educational, Cultural, and Scientific Organization (UNESCO) (UNESCO 1973, Driscoll et al. 1984). Use of this standardized classification system helps ensure data compatibility throughout the National Park Service and other agencies.

The NVCS is a hierarchical system that allows vegetation classification to occur at multiple scales. In Version 1, there are seven levels: the upper five are based on the physiognomic characteristics of vegetation, and the lower two are based on the floristic characteristics of the plant community. Version 2 (Federal Geographic Data Committee 2008) has eight levels (table 2). The upper three levels (which are a reorganization of the five upper physiognomic levels from Version 1) indicate physiognomic characteristics that reflect geographically widespread (global) topographic and edaphic factors. The middle three levels, which are new to the NVCS hierarchy, focus on largely biogeographic and habitat factors along very broad regional-to-continental topographic, edaphic, and disturbance gradients. The lower two levels—*alliance* and *association*—are used in the park mapping project and are the same in both Version 1 and Version 2, with some changes to Version 2 alliances expected. Because the *Group* level in NVCS, Version 2 was still under development, NatureServe Ecological Systems were used to approximate the group level for the PEFO group map classes.

The NVCS provides a framework for levels of classification, but it does not provide descriptions of the vegetation types at all levels. The classification maintained by NatureServe and used by many federal agencies (including the NPS) is the NVC. The NVC includes the plant communities (associations and alliances) identified and described in the United States. Work conducted primarily by TNC through 1999 provided initial definitions of plant communities at each level. NatureServe

Table 2. The National Vegetation Classification System, Version 2, with definitions and examples.¹

Level	Level name	Primary basis for classification	Example
Upper Level 1	Formation Class	Defined by broad combinations of dominant general growth forms adapted to basic moisture, temperature, and/or substrate or aquatic conditions.	Shrubland and grassland
Upper Level 2	Formation Subclass	Defined by combinations of general dominant and diagnostic growth forms that reflect global macroclimatic factors driven primarily by latitude and continental position, or that reflect overriding substrate or aquatic conditions.	Temperate and boreal shrubland and grassland
Upper Level 3	Formation	Defined by combinations of dominant and diagnostic growth forms that reflect global macroclimatic conditions as modified by altitude, seasonality of precipitation, substrates, and hydrologic conditions.	Temperate shrubland and grassland
Mid Level 4	Division	Defined by combinations of dominant and diagnostic growth forms and a broad set of diagnostic plant taxa that reflect biogeographic differences in composition and continental differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	North American great plains grassland and shrubland
Mid Level 5	Macrogroup	Defined by combinations of moderate sets of diagnostic plant species and diagnostic growth forms that reflect biogeographic differences in composition and sub-continental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	Great Plains tall grassland and shrubland
Mid Level 6	Group	Defined by combinations of relatively narrow sets of diagnostic plant species (including dominants and co-dominants), broadly similar composition, and diagnostic growth forms that reflect biogeographic differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	Great Plains mesic tallgrass prairie
Lower Level 7	Alliance	Defined by characteristic range of species composition, habitat conditions, physiognomy, and diagnostic species, typically at least one of which is found in the uppermost or dominant stratum of the vegetation. They reflect regional to subregional climate, substrates, hydrology, moisture/nutrient factors, and disturbance regimes.	Wet-mesic tallgrass prairie
Lower Level 8	Association	Defined on the basis of a characteristic range of species composition, diagnostic species occurrence, habitat conditions and physiognomy. They reflect topographic climate, substrates, hydrology, and disturbance regimes.	Central wet-mesic tallgrass prairie

¹Adopted from Federal Geographic Data Committee (2008)

inherited that documentation when it branched from TNC. NatureServe manages and continues to develop the database of NVC plant community entities. Their online database, NatureServe Explorer (<http://www.natureserve.org/explorer/>), provides public access to regularly updated versions of the NVC plant community listings and descriptions. NatureServe's documentation of alliances and associations is the most accessible listing currently available. However, the plant community listings within the NVC are not complete, and projects such as the one described in this report constantly add to the documentation and listing of NVC types.

1.4.1. Alliances and Associations

Alliances and associations are based on both the co-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 Explorer (2009) 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 indicates 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 class in which they are classified (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 PEFO:

Artemisia filifolia / *Bouteloua eriopoda* Shrubland
Purshia stansburiana – *Eriogonum corymbosum* Shrubland

Examples of alliance names from PEFO:

Artemisia filifolia Shrubland Alliance
Purshia (stansburiana, mexicana) Shrubland 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).

1.4.2. Ecological Systems Classification

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 NVCS, but are rather a vegetation-mapping concept. However, NVC associations occur with 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 found in a particular setting.

1.5 Park Environment

Petrified Forest National Park, part of the

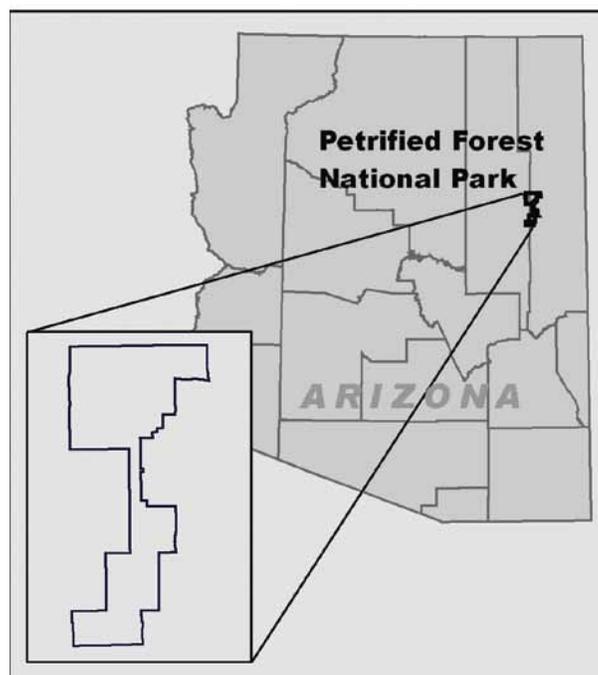


Figure 1. Location of Petrified Forest National Park in Arizona.

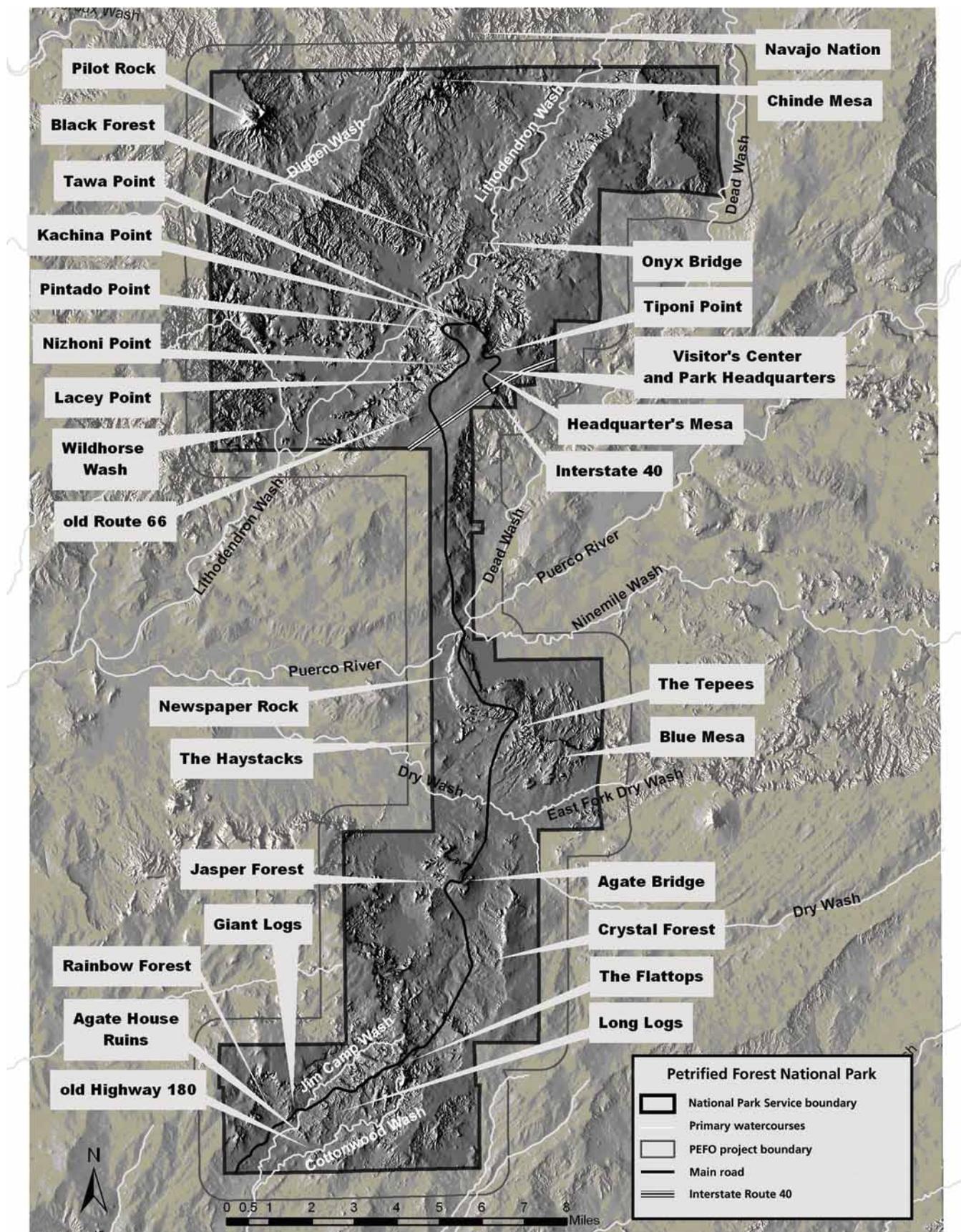


Figure 2. Petrified Forest National Park, project environs, and locations of places named in this report and its appendices.

plateau country of the ‘four-corners’ area of the Colorado Plateau, is located east of Holbrook in northeastern Arizona. The park is hourglass-shaped and approximately 40 km (24 mi) long (fig. 1). Topographic relief within the park is not extreme (1620 m to 1890 m, or around 5,273 ft to 6,152 ft), with the major elevation changes occurring where various mesas within the park drop to surrounding plateau lands. The Puerco River bisects the park at the midpoint (fig. 2). Interstate 40 intersects the park in the northern section. The Petrified Forest Road runs the length of the park and connects the northern park headquarters and the southern park museum. Two areas at PEFO, approximately 50% of the park, are designated wilderness: a northern wilderness unit located in the Painted Desert and a southern unit located in the Rainbow Forest area (Thomas et al. 2006).

The project area includes the entire park and a buffer (park environs) of 1 km (0.6 mi). These park environs include lands owned by private cattle ranchers, state lands with cattle allotments, and Navajo Nation tribal lands, and consist of approximately 15,144 ha (about 37,421 ac). The entire study area is 53,201 ha or around 131,463 ac.

1.5.1 Park Establishment

Theodore Roosevelt established Petrified Forest National Park as a national monument in 1906. His Presidential Proclamation (34 Stat. 3266) states:

“... whereas, the mineralized remains of Mesozoic forests, commonly known as the ‘Petrified Forest’ . . . are among the greatest of scientific interest and value and it appears that the public good would be promoted by preserving these deposits . . . with as much land as may be necessary for proper protection thereof.”

The park contains one of the largest concentrations of petrified wood in the world, as well as abundant plant and

animal fossils from the 225 million year-old Chinle Formation (NPS 2004, Thomas et al. 2006). Subsequent proclamations and acts of Congress expanded the park to include cultural as well as natural resources. PEFO gained national park status in 1962 (72 Stat. 69) and portions of the park (20,340 ha or 52,070 ac) were designated as wilderness in 1970 (84 Stat. 1105). The boundaries of the park now encompass a variety of significant natural and cultural resources, including some of the most valuable and accessible paleontological resources in the world (NPS 2004).

1.5.2 Pre-park History

According to the most reliable information, human occupation of the Southwest began after the end of the Pleistocene, about 10,000-15,000 years ago (Cordell 1997). The earliest inhabitants of the southwestern region, called Paleo-Indians, hunted large animals like mammoth and bison and left evidence of their presence in the form of hearths, tools, and sometimes bones at kill and butchering sites. Although no campsites or bone concentrations have been found, Folsom-style projectile points with their distinctive, fluted (grooved) form have been found in the park, suggesting that the areas that are now park lands were at least occasionally occupied during this period (Thomas et al. 2003).

During the decline and extinction of the Pleistocene megafauna after around 10,000 BC, people most likely relied increasingly on plant resources for survival. During the Archaic period, from about 6000 BC to around 300 AD, plant resources probably became an increasingly important part of the subsistence base in the Southwest. Sometime around 1000 BC, people in what is now the southwestern region of the United States became more sedentary and began to cultivate domesticated plant species (Cordell 1997). Crop plants like corn and squash developed in Mexico. During the time of the Archaic culture,

human occupants of the park area left basin metates (grinding stones) and tools typical of the period in campsites on mesatops throughout the park. The transitional nature of the late Archaic to more sedentary lifestyle and the use of domesticated plants are indicated by the presence of charred corn kernels associated with one site (Thomas et al. 2003).

The development of permanent settlements probably began around 200 AD (Cordell 1997). The first dwellings of the Basketmaker II/III Period (300 AD – 800 AD) were usually semi-subterranean pithouses in small clusters or villages. These types of structures, along with stone-lined storage cists, pottery, baskets, and the remains of cultivars, are found within the park boundaries (Thomas et al. 2003, NPS 2004, <http://www.nps.gov/pefo>).

Over time, permanent surface dwellings were constructed, populations of the Basketmaker III and Pueblo I Period, from around 800 AD to around 950 AD, became ever more substantial, and there was greater aggregation of human populations (Cordell 1997). At PEFO, most sites of this period occur on the bluff overlooking Dead Wash and Puerco River, and in the Dry Wash basin and near the southern boundaries of the park (Thomas et al. 2003).

Small pueblos, clustered near arable lands and major watercourses, mark the beginning of the Pueblo II/III Period around 800 AD, which lasted until around 1300 AD (Cordell 1997). Pueblo II/III sites, typically small pueblos with 10-20 rooms and a kiva, occur throughout the park (Thomas et al. 2003). The Puerco Ruins, one of the most visible archeological resources in the park, date from near the end of the Pueblo II period (around 1100 AD).

During the Pueblo IV Period (1300 AD – 1450 AD), large multi-room dwellings were

constructed along major river corridors or other reliable water sources. Two major pueblos have been found at Petrified Forest: Puerco Pueblo and Stone Axe Pueblo at Wallace Tank, a spring four miles southeast of Puerco Pueblo (Thomas et al. 2003). Drought and probably other factors contributed to the abandonment of the park area around the mid 1400s. People from the park area probably moved to areas with more permanent water supplies. The Hopi and Zuni people living in the surrounding areas today may be some of their descendants (Thomas et al. 2003).

1.5.3 Historic Period

Around 1500 AD, Athabascan-speaking people (Navajo and Apache tribes today) moved into the region, although these groups likely did not use lands that now make up the park until the 1700s (NPS 2004, Thomas et al. 2003). Early Athabascan-speakers settled in mountainous areas. After the arrival of Europeans and their livestock, subsistence included cattle and sheep, and access to grazing lands and adequate watering sites became important. Today, the Navajo Nation is adjacent to the north boundary of the park, and the San Carlos Apache Reservation is about 60 mi (96 km) to the south.

Spanish explorers were the first Europeans to reach the vicinity of present-day park lands. In 1540, some members of Coronado's expedition likely passed to the northeast of the park lands on their way to Hopi villages and to the Grand Canyon area (Bolton 1930). The Petrified Forest area itself was probably only peripheral to the interests and activities of the Spanish and Athabascan speakers, although introduced livestock may have grazed there in small numbers during the 1700s and early 1800s.

In the 1800s, various American expeditions passed through the park region. The Sitgreaves expedition in 1851 and the Whipple expedition in

1853 included several scientists who recorded information on the flora, fauna, and landscape (relevant comments are summarized in Thomas et al. 2003). Beale (1857) proceeded westward from Zuni, New Mexico, and crossed the Puerco River, traveling west until he reached the Little Colorado River near Holbrook; Beale noted cottonwood trees on the river bottoms, along with abundant grass.

These expeditions, as well as the movement of people and livestock to gold strikes in California, set the stage for new settlers in the area. Cattle and sheep were herded through northern Arizona, and ranchers moved sheep and cattle into Little Colorado drainage areas. The coming of the railroad in 1881 further encouraged ranching (Thomas et al. 2003).

1.5.4 Possible Human Impacts on the Landscape

Early humans may have burned the vegetation to attract or to drive big game (Pyne 1982), although the few artifacts from the Paleo period at PEFO suggest that there were very few people in the area during this time period. Archaic people may have also burned or manipulated vegetation. In Puebloan times, intensive farming, using floodwater agriculture and manipulation of intermittent streams, may also have affected certain areas of the park. Of all the human activities occurring in the Petrified Forest region, livestock grazing during the historic period probably had the most significant effect on the landscape.

Thomas et al. (2003) summarized the changes in livestock numbers in Northern Arizona during the 1700s and 1800s. On Navajo lands, there were around 64,000 sheep by 1742 and perhaps 500,000 by the 1850s (Young 1968). The Navajo people are said to have grazed sheep on lands between the Little Colorado River and the San Juan River, and from the San Francisco Peaks to the Rio Puerco, thus possibly covering lands that are now included

within the park. After the Navajo returned from their exile at Bosque Redondo in New Mexico in 1868, they rebuilt their herds up to around 1,100,000 sheep, 400,000 goats, and 60,000 horses (Young 1968). These herds were likely kept within reservation boundaries. However, grazing on higher elevations and upstream of drainages running into the park likely may have affected parklands through erosion and down cutting of stream channels.

The number of sheep held by ranchers outside Navajo lands in Arizona increased from about 800 in 1870 to 76,000 in 1880 (Sheridan 1995). This increased to 700,000 in the next decade. Most of Arizona's sheep were raised in the northern counties. Barnes (1913) estimated approximately 1,570,000 sheep in Arizona. Cattle were not as abundant as sheep, their numbers increased from around 50,000 in the late 1870s (Hamilton 1883) to 812,000 in 1913 (Barnes 1913). There were ranches in the Holbrook area in the late 1800s and early 1900s, so grazing no doubt had a direct effect on lands that are now part of the park. In addition, grazing in the Little Colorado and Puerco drainages may also have affected the park lands, through erosion and deposition, as well as downcutting of stream channels. A series of droughts in the late 1800s and early 1900s, in association with intense grazing, probably accelerated erosion, downcutting, and decline of groundwater levels (Thomas et al. 2003).

1.5.5 Climate

Petrified Forest National Park is within Bailey's (Bailey et al. 1994) Colorado Plateau Semidesert Province, a region of around 195,000 km² (75,300 mi²) including parts of Arizona, New Mexico, and Utah. In general, the climate has the cold winters typical of high elevations. Summer days are often hot, and nights are cool. Temperature at PEFO is highest in July and lowest in January [July mean high = 92.3° F with an extreme of 105° F in 1995; January mean high = 47.5° F with an extreme of

-27° F in 1971 (mean based on 1931-2009 data; Western Regional Climate Center, <http://www.wrcc.dri.edu>).

Most of the annual precipitation falls in the warm months of July and August (Western Regional Climate Center, <http://www.wrcc.dri.edu>), with more widespread rain falling in winter. However, in some years, unusual amounts of rainfall may fall during late-winter and spring. The mean annual precipitation from 1948 to 2007 was 9.48 in (24.2 cm), with torrential rains falling primarily in the summer months, but occasionally at other times of the year. June is the driest month during most years. Peaks in temperature and precipitation occur at approximately the same time during the year.

The Mogollon Rim, a massif that stretches across the central part of Arizona, primarily influences winter storms. PEFO is located on the rain shadow side of this mountain and canyon region. During the winter, precipitation originates in low-pressure systems that travel eastward from the eastern Pacific and deposits as snow or rain as the low encounters the Mogollon Rim. However, the Mogollon Rim acts as an orographic barrier, reducing the amount of snow and rain that reaches the park. When precipitation does occur from winter storms, it is characterized by gentle showers followed by strong winds (Thomas et al. 2003).

On the Colorado Plateau, this summer rainfall pattern is characteristic of areas of perennial woodland, shrubland, and grassland with a component of warm-season annuals that appear from year to year, depending on conditions. In some of these years, greater than usual precipitation, along with the right temperatures during late winter or spring, may result in the germination and establishment of annual plant species in great abundance (Cully and Cully 1989).

1.5.6 Geology, Hydrology, and Topography

The badlands exposed in the park belong to the Upper Triassic Chinle Formation and represent the deposits of a vast 225 million year old river system. Around 4-8 million years ago, during the Miocene and Pliocene, fluvial and lacustrine sediments were deposited over the Chinle Formation; volcanic ash and lava were also deposited during this time. More recent Quaternary deposits (1.8 million years ago to the present) of windblown sand and alluvial material cover much of the park (Thomas et al. 2006, <http://www.nps.gov/pefo>).

Numerous intermittent washes and drainages occur throughout the park. Perhaps the most reliable, although intermittent, water source is the Puerco River, a tributary of the Little Colorado that runs through the narrow mid-section (or “neck”) of the park. Only about 2.7 km of stream length is within park boundaries. Springs, seeps, tinajas, and tanks also occur within park boundaries (Thomas et al. 2006).

Water erosion has shaped much of the landscape at the park. Torrential summer rains cause rapid erosion from steep, bare slopes, and fine sediments are susceptible to “piping” or the creation of many small tunnels under the surface of slopes and hills. Over time, sheet erosion and gullying have given the badlands their distinctive dissected appearance (<http://www.nps.gov/pefo>).

Petrified Forest consists of three distinct geographic areas: the Painted Desert, the Puerco River Valley, and the Rainbow Forest. The Painted Desert in the northern third of the park is comprised of southwest to northeast trending clay hills, mesas, and buttes that reflect the influences of the Little Colorado River as it erodes the Chinle Formation. These “badland” desert systems are sparsely vegetated because plants have great difficulty becoming established in the shrinking and swelling

bentonite soils (Chronic 1986). High erosion rates in the Painted Desert also make it difficult for plants to become established. From the Painted Desert rim, the land slopes down to the southeast through a series of wide erosional basins to the Puerco River. The middle section of the park is a relatively narrow strip of land across this valley. In the southern third of the park, the land has eroded into small groups of buttes and mesas separated by the wide expanses of Dry Wash and its tributaries (Thomas et al. 2006).

1.5.7 Wildlife

Petrified Forest National Park provides habitat for a diverse assemblage of mammals, avifauna, and herpetofauna.

Mammals

The badlands and grasslands of the park support 59 species of mammals. Coyotes (*Canis latrans*) are found throughout the park. Pronghorn antelope (*Antilocapra americana*) occur in grasslands and also occasionally in the badlands of the park. Smaller mammals include Gunnison's prairie dog (*Cynomys gunnisoni*), white-tailed antelope squirrel (*Ammospermophilus leucurus*), Ord's kangaroo rat (*Dipodomys ordii*), and deer mice (*Peromyscus maniculatus*).

Avifauna

Birds are the most speciose group of the vertebrates, with 231 species known for the park. The common raven (*Corvus corax*) is one of the most conspicuous bird species, often seen at parking lots looking for handouts, as well as flying overhead throughout the park. Golden eagles (*Aquila chrysaetos*), various hawks, and turkey vultures (*Cathartes aura*) are also seen throughout the park. Mockingbirds (*Mimus polyglottos*) and thrashers are found in shrublands and grasslands. Horned larks (*Eremophila alpestris*) and meadow larks (*Sturnella neglecta*) are common in the grasslands. American robins (*Turdus migratorius*), western bluebirds (*Sialia mexicana*),

and Townsends's solitaires (*Myadestes townsendi*) are found in areas with trees (Thomas et al. 2006, <http://www.nps.gov/pefo>).

Reptiles and Amphibians

Current records indicate that PEFO supports seven species of amphibians, including tiger salamanders (*Ambystoma tigrinum*), Woodhouse's toads (*Bufo woodhousii*), red-spotted toads (*B. punctatus*), and other toad species. Amphibians hibernate in damp soils and reproduce when rains form standing water in pools and intermittent stream channels. The 16 species of reptiles known to occur in the park include the colorful collared lizard (*Crotaphytus collaris*), gopher snake (*Pituophis catenifer*), western rattlesnake (*Crotalus oreganus*), and western box turtle (*Terrapene ornata*).

No federally or state-listed threatened or endangered wildlife reside in the park (Thomas et al. 2006).

1.5.8 Vegetation

Biotic communities at PEFO belong to the Colorado Plateau Semi-Desert Province (Bailey et al. 1994) and include primarily arid grasslands, xeric shrublands, and sparsely vegetated badlands. Riparian species, such as cottonwoods and willows (*Populus* spp. and *Salix* spp.), grow along some of the permanent streams. Within the province as a whole, woodland is the most extensive vegetation formation, dominated by open stands of Colorado pinyon pine (*Pinus edulis*) and several species of juniper (*Juniperus* spp.), but the extent of woodland in the park is limited.

Two rare plants are found in the park:

- gladiator milkvetch (*Astragalus xiphoides*) occurs in several populations
- paper-spined cactus (*Pediocactus papyracanthus*) occurs in pinyon-juniper woodland.

One of the more important and least recognized biological communities in this

area is cryptobiotic soil. These living crusts are comprised of cyanobacteria, lichens, mosses, green algae, microfungi, and bacteria, and represent up to 70% of the living ground cover. (NPS 2004, Thomas et al. 2006, Belnap and Lange 2002).

Sheep and cattle grazed in the Petrified Forest area until 1936, when grazing was excluded from the southern part of the park. In 1981, a perimeter fence was erected to prevent trespass grazing on park lands.

Thomas et al. (2003) prepared a preliminary vegetation classification for PEFO based on field sampling of the vegetation, analysis, and classification under the National Vegetation Classification System. This classification identified 19 plant communities consisting of seven shrubland alliances, three dwarf-shrubland alliances, five herbaceous alliances, one dwarf shrubland-herbaceous alliance, two shrubland-herbaceous alliances, and one sparse vegetation alliance. Data from the 2003 effort are included as part of the vegetation classification results listed in this report.

2 Identification and Classification of Plant Communities

2.1 Methods

The classification team, consisting of ecologists M.L. McTeague and A. Cully, identified and classified plant communities of Petrified Forest National Park (PEFO) to the finest floristic level possible. They used three approaches:

1. reanalysis of relevé data collected in 1996
2. new field data collection, analysis, and quantitative classification
3. direct field observation during photo-interpretation for one-plant communities (see section 3 Base Map Class Development)

All plant communities, whether identified through quantitative classification or direct observation, were reconciled with the current NatureServe Explorer registry of NVC alliances and associations, and reviewed for compatibility by K. Schulz of NatureServe. New plant assemblages were classified as park specials if they were not supported by sufficient observation data to be identified to an existing alliance or association or to be identified as a new, or provisional, plant community.

2.1.1 Relevé Data

2.1.1.1 Existing Data

The team used relevés² from a 1996 vegetation sampling directed by Dr. Kathryn Thomas (Thomas et al. 2003). These relevés were collected throughout the park in an effort to classify the vegetation at PEFO. Previously, they had been quantitatively analyzed and assigned alliance-level classification. As the plant communities were not expected to change significantly in that time, the team was able to use 186 relevés from the 1996 effort. These data were compared qualitatively

² A relevé is a vegetation sample using a quadrant that can be square, rectangular, or circular. Size varies according to the type of vegetation being sampled. Relevés are usually placed non-randomly in a uniform and representative sample of the vegetation being sampled. They are distinguished from line-transects and completely random sampling (Kent and Coker 1992).

to the results of the quantitative analysis of newly collected data and were provisionally assigned plant communities at the same time (see “Quantitative data analysis” below).

2.1.1.2 Newly Collected Data

In 2003, a field team led by M. McTeague collected plant-community data in the form of cover/abundance values for individual plant species in 149 relevé plots (Mueller-Dombois and Ellenburg 2002) (see sample datasheet in the project DVD). The sampling design stratified the park landscape into unique biophysical types for relevé allocation. This approach assumed that environmental variables drive vegetation patterns at PEFO and that a stratification based on environmental variables would assure adequate sampling across the range of plant-community variability. The biophysical types were derived by layering spatial data for aspect, elevation, watercourse presence, and geology in a GIS environment (table 3) and identifying each unique combination as one type. The number of polygons targeted for sampling within each biophysical type was proportional to the

Table 3. Categories of environmental variables used to identify unique biophysical units to sample at Petrified Forest National Park.

Environmental variables	Categories
Aspect	North facing (116-269°) South facing (270-115°)
Elevation (Using 10 m DEM)	High elevation(1756-1890m) Low elevation (1620-1755m)
Stream (Including 5m Buffer)	Streams No Streams
Geology Map (Apache and Navajo County)	Qal=alluvial/alluvium deposits Qc=alluvium and sand sheets Qd=eolian deposits Ql=colluvial deposits TR=Triassic Tb=volcanic bft=Black Forest Tuff ss=sandstone

total area and frequency of occurrence of that type within the project area.

The team had planned to sample at the centroid of each selected polygon. If the sample site was determined to not be representative of a homogeneous vegetation community, the relevé was moved to the closest representative vegetation community within the biophysical unit. A 500-m² relevé was established (1000-m² in sparsely vegetated communities with less than 10% cover), and plant species cover/abundance data, as well as environmental data, were collected (table 4). The classification team examined the field data during the collection period to determine if adequate numbers of relevés were sampled for each expected and observed community type. Plant communities under-represented in the stratified sampling design were sampled opportunistically at the end of the 2003 field season.

Table 4. Summary of data collected within 2003 classification relevés at Petrified Forest National Park.

Type of information	Items noted
Plot documentation	Plot location and identification, geographic references, plot size, picture documentation
Environmental description	Elevation, slope, aspect, position, landform, geology, soil texture
Surface cover	Fine particles, gravel, cobble, stone, boulders, bedrock; litter, duff, moss, lichen, biotic crust; animal use; human/natural disturbance
Vegetation description	Leaf phenology, leaf type, physiognomic class
Vegetation strata	Height, cover class and dominant species each stratum
Plant species	Observed plant species on survey site
Other vegetation characteristics	Mortality, nurse plant function, etc.

2.1.1.3 Quantitative Data Analysis

Data from the 2003 classification relevés were entered into a Microsoft® Access 2000 database and quality checked. The cover values for species that occurred in multiple strata were combined into a single cover estimate for classification and for the

plant community descriptions. However, total cover estimates for tree, shrub, and herbaceous cover were calculated based on cover estimates for lifeform and not strata height. The classification team imported the data into an Excel spreadsheet and formatted it for use in PC-Ord, a multivariate statistical analysis program (McCune and Mefford 1999).

The classification team first identified descriptive statistics in the relevé dataset and examined whether statistical differences existed when comparing the compositional heterogeneity of the physiognomic groups represented in the relevé data. The team initially used non-metric multi-dimensional scaling (NMS) ordination (which provides a view of community organization in multi-dimensional space) to analyze the entire dataset of 149 relevé sites from the 2003 field efforts (fig. 3). The resulting descriptive statistics showed high beta-diversity ($\beta=7.46$), indicating a high degree of compositional heterogeneity. The team then attempted to minimize relevé heterogeneity by dividing the data into four groupings or classes, based on the apparent lifeform of the dominant species in each relevé: shrubland, grassland, steppe (a shrub-grassland mixture), and sparse. All analyses were then rerun on each class (fig. 4). Species occurring only once within a class were usually removed from the dataset in order to reduce noise. However, if a species occurred only once but was the dominant species in a relevé, it was retained because of its influence within the plant community.

The team also conducted an outlier analysis to identify any relevés that might skew the analysis. If it was determined that the outlier relevés were actually unique plant communities, we retained those relevés (despite their introducing noise to the dataset) due to their importance for the community analysis.

The team then conducted a cluster analysis—a hierarchical clustering

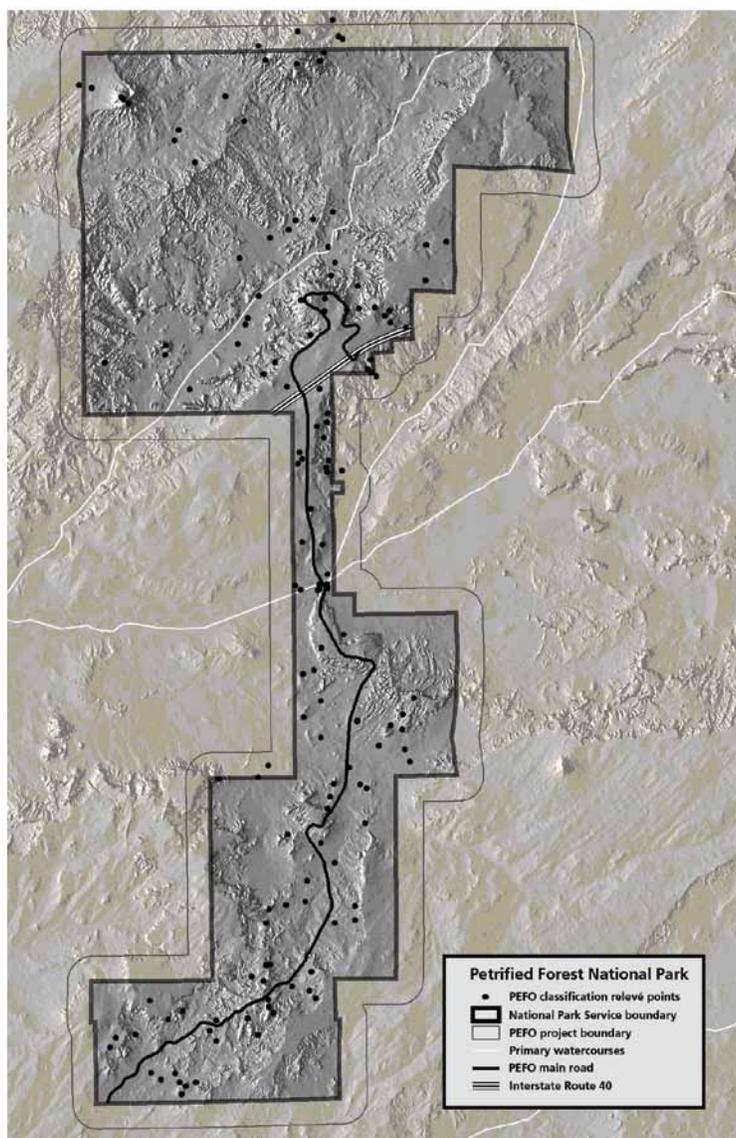


Figure 3. Location of 149 classification relevés at Petrified Forest National Park observed in 2003.

classification of objects—for each of the four groupings. Cluster analysis produces a dendrogram with relevés clustered at different levels. To choose “stopping points” in the cluster analysis dendrogram, the team used indicator species analysis (ISA) scores, which can identify species that characterize a group of relevés (Dufrêne and Legendre 1997; McCune and Grace 2002). The team used a method described by McCune and Grace (2002) to maximize the effectiveness of ISA scores as a means of identifying natural relevé clusters within the dendrogram. Based on the assumption that indicator scores peak at an intermediate level of clustering,

they used the change in the number of significant indicators as the criterion for identifying relevé clusters.

The team calculated ISA scores and p-values for each successive level of the cluster analysis, and plotted the number of significant indicators against the number of clusters at each level of the dendrogram (Decker and Coles 2003), as illustrated in Figure 5 for the shrubland class. This was done for each class to generate a graphic that the team could use to evaluate and choose the optimum levels indicating natural relevé clusters. The stopping point for each cluster was interpreted as the

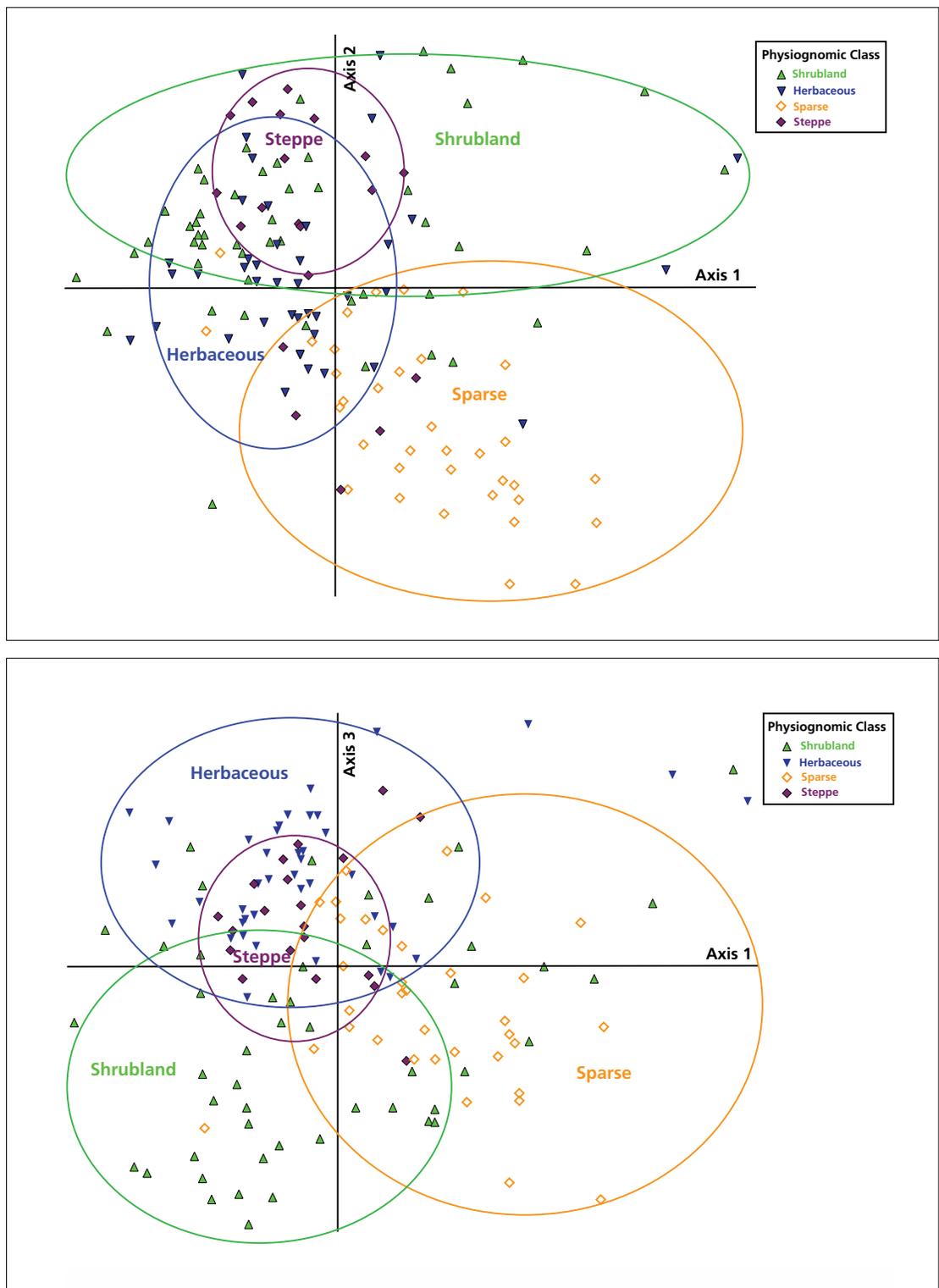


Figure 4. Non-metric Multi-dimensional Scaling (NMS) ordination of 149 classification relevés collected in 2003 shows the relevés highly clustered by their physiognomic class on both axes 1 and 3, and axes 1 and 2.

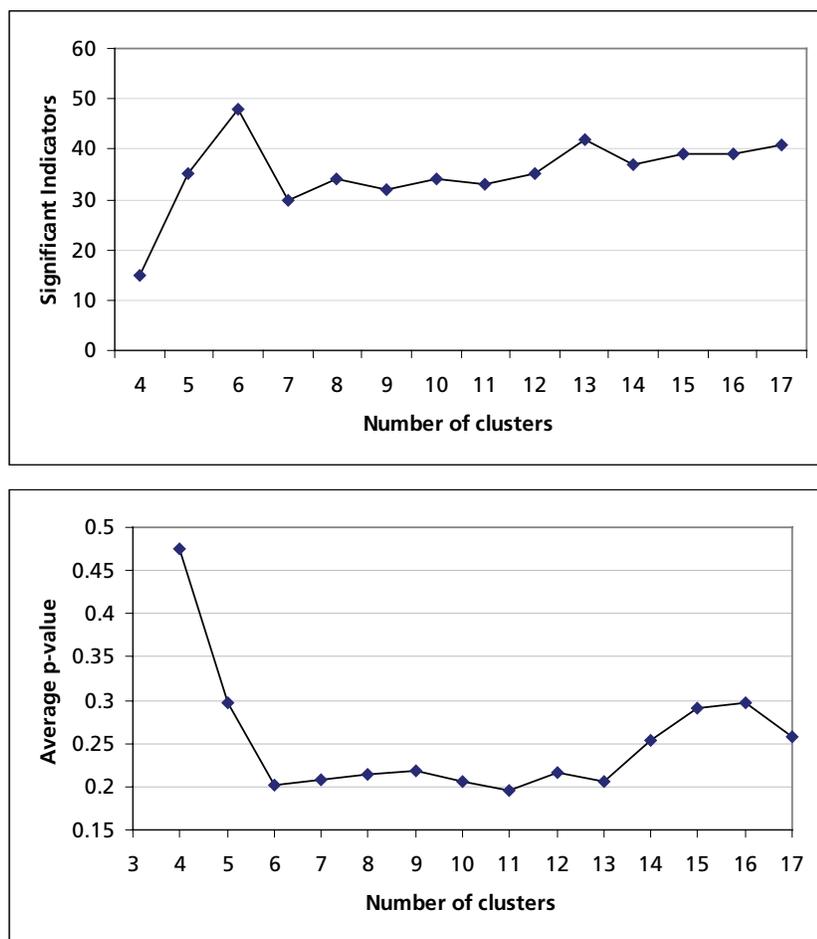


Figure 5. The number of significant indicators (top) and the p-value (bottom) for Indicator Species. Analysis scores are calculated for each level of the cluster dendrogram (not shown) and plotted against the number of clusters in the dendrogram for that level. The peak score for the number of significant indicators and the minimum score for the average p-value are used to determine the number of clusters that represent the best classification of the relevés. The scores for the shrubland class in Figure 4 are illustrated here.

finest level of ecological meaning for of the relevés within that cluster.

The team analyzed the optimal groupings by looking at the statistically significant indicator species, determined in the ISA, and identifying species with a p-value of <0.5 and indicator values of >30 . Only dominant and common native species were considered indicator species. If the species was an exotic species or an infrequent, ephemeral species that was not likely to be a long-term community indicator, it was eliminated from the analysis. The classification team interpreted these groupings to represent provisional NVC vegetation associations.

The classification team also cross-checked the clusters of relevés with established NVC associations. During this analysis, they assigned each relevé an initial association name using previously defined association nomenclature (when available)

listed in NatureServe's Explorer website (<http://www.natureserve.org/explorer/>). If needed, the team developed provisional association names. After each cluster was assigned a provisional association name, the team compared the results among the four classes and determined whether there was overlap in the provisional associations among them. If there was overlap, and the relevés represented an association with relevés in multiple lifeform classes, the relevés were reassigned to the lifeform class to which NatureServe had assigned the the association. For instance, if relevés representing an *Atriplex obovata* dominated plant community were provisionally identified as occurring in sparse, shrubland, and mixed grass-shrub communities, all relevés were re-assigned to the community representing the modal strata.

The team also applied a Multiple Response Permutation Procedure (MRPP) (McCune

and Grace 2002) to test if the allocated NVC associations were different enough between each other to be statistically significant. MRPP is a nonparametric test of the hypothesis that there is no difference between groups and provides a test statistic and a p-value.

2.1.2 Photo-Interpreter Observations

One plant community, *Sarcobatus vermiculatus* / *Atriplex obovata* Shrubland, was identified from fieldwork associated with photointerpretation. It was described without quantitative analysis.

2.1.3 NVC Nomenclature

NatureServe reviewed the first iteration of plant community names and reconciled them with the NVC alliances and associations in their Biotics (<http://www.natureserve.org/prodServices/biotics.jsp>) database. The SBSC and NatureServe teams consulted on the NVC nomenclature for each plant community before the naming was finalized.

2.2 Results

The team used the results of the reinterpretation of the 1996 classification relevés, quantitative classification of 2003 relevés, and the one photointerpretation observation to identify 39 plant communities at PEFO (table 5). Appendix B lists the strength of documentation for all plant communities. Full descriptions of these communities can be found in Appendix C. Ancillary products related to accuracy assessment include all species on the classification relevés (as well as the species found on accuracy assessment sites) and are listed in Appendix D.

2.2.1 Plant Community Characteristics

Thirty-two of the plant communities at PEFO were associations. All but these three had been described previously in the NatureServe database and/or at other

locations: *Calamovilfa gigantea* Desert Wash Shrub Herbaceous Vegetation, *Eriogonum leptophyllum* Sparse Vegetation, and *Purshia stansburiana* – *Eriogonum corymbosum* Shrubland. *Achnatherum hymenoides* Shrub Herbaceous Alliance, observed and classified in 1996, was not observed again in 2003. Since the 1996 data were insufficient to classify it to the association level, it was eliminated from the current listing of plant communities for the park. Persistent drought, especially in the sampling year 2003, caused many perennial grasses to remain dormant or to die. As a result, these grasses were not as abundant as they were during the 1996 sampling.

Seven plant communities were identified as park specials (table 5). These plant communities appear to be unique to the park. Their uniqueness does not imply rarity, but rather that they are assemblages of plant species for which not enough data exists to develop new NVC types.

The plant communities identified represented four major physiognomic types: woodland, shrubland, herbaceous, and sparse. There were three woodland associations within three alliances. These three associations were reassigned to the shrub grouping of relevés used in quantitative classification, based on the NatureServe description of the plant community. Shrublands were represented by 14 associations within 12 alliances, one undifferentiated alliance, and four park specials.

Relevés grouped as steppe in quantitative classification were reassigned to either shrubland or herbaceous based on NatureServe description of the plant community. Herbaceous plant communities were represented by ten associations within eight alliances and by three park specials. Lastly, sparse vegetation at the park was represented by four associations within three alliances. Some of the woodland, shrubland, and herbaceous associations at PEFO were

Table 5. Plant communities at Petrified Forest National Park and sources of supporting field documentation.

Plant community	NVCS Alliance	NatureServe database code	Type	Number of supporting field observations		
				2003 ¹	1996 ²	2006 ³
WOODLAND						
1	<i>Juniperus monosperma</i> / <i>Artemisia bigelovii</i> Woodland	<i>Juniperus monosperma</i> Woodland Alliance	CEGL000705	Association	2	12
2	<i>Pinus edulis</i> - (<i>Juniperus osteosperma</i>) / <i>Bouteloua gracilis</i> Woodland	<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance	CEGL000778	Association	1	
3	<i>Populus fremontii</i> / <i>Ericameria nauseosa</i> Woodland	<i>Populus fremontii</i> Temporarily Flooded Woodland Alliance	CEGL002465	Association	2	3
SHRUBLAND						
4	<i>Allenrolfea occidentalis</i> Shrubland	<i>Allenrolfea occidentalis</i> Shrubland Alliance	CEGL000988	Association	1	8
5	<i>Artemisia filifolia</i> / <i>Bouteloua eriopoda</i> Shrubland	<i>Artemisia filifolia</i> Shrubland Alliance	CEGL001077	Association	4	
6	<i>Artemisia filifolia</i> Colorado Plateau Shrubland		CEGL002697	Association	7	6 28
7	<i>Atriplex canescens</i> / <i>Pleuraphis jamesii</i> Shrubland	<i>Atriplex canescens</i> Shrubland Alliance	CEGL001288	Association	4	5 51
8	<i>Ericameria nauseosa</i> Desert Wash Shrubland	<i>Ericameria nauseosa</i> Shrubland Alliance	CEGL002261		8	10 17
9	<i>Forestiera pubescens</i> Shrubland	<i>Forestiera pubescens</i> Temporarily Flooded Shrubland Alliance	CEGL001168	Association		1
10	<i>Gutierrezia sarothrae</i> - (<i>Opuntia</i> spp.) / <i>Pleuraphis jamesii</i> Dwarf-shrubland	<i>Gutierrezia sarothrae</i> Dwarf-Shrubland Alliance	CEGL002690	Association	2	13
11	<i>Isocoma drummondii</i> - <i>Pleuraphis jamesii</i> Shrubland			Park Special	1	3 8
12	<i>Iva acerosa</i> - <i>Sporobolus airoides</i> Shrubland			Park Special	1	2
13	<i>Krascheninnikovia lanata</i> / <i>Bouteloua gracilis</i> Dwarf-shrub Herbaceous Vegetation	<i>Krascheninnikovia lanata</i> Dwarf-Shrubland Herbaceous Alliance	CEGL001321	Association	1	6
14	<i>Krascheninnikovia lanata</i> Dwarf-shrubland	<i>Krascheninnikovia lanata</i> Dwarf-Shrubland Alliance	CEGL001320	Association	1	1
15	<i>Purshia stansburiana</i> - <i>Eriogonum corymbosum</i> Shrubland	<i>Purshia (stansburiana, mexicana)</i> Shrubland Alliance	CEGL004011	Association	5	7
16	<i>Rhus trilobata</i> - <i>Ephedra (viridis, torreyana)</i> Talus Shrubland	<i>Rhus trilobata</i> Shrubland Alliance	CEGL003776	Association	3	5
17	<i>Salix exigua</i> / Barren Shrubland	<i>Salix (exigua, interior)</i> Temporarily Flooded Shrubland Alliance	CEGL001200	Association	2	1
18	<i>Salvia pachyphylla</i> Dwarf-shrubland			Park Special	2	6
19	<i>Sarcobatus vermiculatus</i> / <i>Atriplex obovata</i> Shrubland			Park Special		15
20	<i>Sarcobatus vermiculatus</i> / <i>Suaeda moquinii</i> Shrubland	<i>Sarcobatus vermiculatus</i> Intermittently Flooded Shrubland Alliance	CEGL001370	Association	1	5

Table 5. continued

Plant community	NVCS Alliance	NatureServe database code	Type	# of supporting field observations		
				2003 ¹	1996 ²	2006 ³
21 <i>Suaeda moquinii</i> Shrubland	<i>Suaeda moquinii</i> Shrubland Alliance	CEGL001991	Association	1		1
22 <i>Tamarix</i> spp. Temporarily Flooded Semi-natural Shrubland	<i>Tamarix</i> Spp. Semi-Natural Temporarily Flooded Shrubland Alliance	CEGL003114	Association	2	1	6
HERBACEOUS						
23 <i>Atriplex obovata</i> / <i>Sporobolus airoides</i> - <i>Pleuraphis jamesii</i> Shrub Herbaceous Vegetation	<i>Sporobolus airoides</i> - (<i>Pleuraphis jamesii</i>) Shrub Herbaceous Alliance	CEGL001775	Association	12	17	62
24 <i>Bouteloua eriopoda</i> - <i>Pleuraphis jamesii</i> Herbaceous Vegetation	<i>Bouteloua eriopoda</i> Herbaceous Alliance	CEGL001751	Association	4	1	1
25 <i>Bouteloua gracilis</i> - <i>Pleuraphis jamesii</i> Herbaceous Vegetation	<i>Bouteloua gracilis</i> Herbaceous Alliance	CEGL001759	Association	3	13	16
26 <i>Bouteloua gracilis</i> Herbaceous Vegetation	<i>Bouteloua gracilis</i> Herbaceous Alliance	CEGL001760	Association	9	21	2
27 <i>Calamovilfa gigantea</i> Desert Wash Shrub Herbaceous Vegetation	<i>Calamovilfa gigantea</i> Shrub Herbaceous Alliance	CEGL004012	Association	3		
28 <i>Ericameria nauseosa</i> / <i>Bouteloua gracilis</i> Shrub Herbaceous Vegetation	<i>Ericameria nauseosa</i> Shrub Short Herbaceous Alliance	CEGL003495	Association	2		6
29 <i>Opuntia whipplei</i> - <i>Sporobolus airoides</i> Shrub Herbaceous Vegetation			Park Special	1		
30 <i>Pleuraphis jamesii</i> - <i>Sporobolus airoides</i> Herbaceous Vegetation	<i>Pleuraphis jamesii</i> Herbaceous Alliance	CEGL001778	Association	4	29	45
31 <i>Salsola tragus</i> Sand Dune Vegetation			Park Special	2		13
32 <i>Sporobolus airoides</i> - <i>Bouteloua gracilis</i> Herbaceous Vegetation	<i>Sporobolus airoides</i> Sod Herbaceous Alliance	CEGL001686	Association	7	6	41
33 <i>Sporobolus airoides</i> Southern Plains Herbaceous Vegetation		CEGL001685	Association	2	3	36
34 <i>Sporobolus coromandelianus</i> Herbaceous Vegetation			Park Special	1		
35 <i>Sporobolus cryptandrus</i> Great Basin Herbaceous Vegetation	<i>Sporobolus cryptandrus</i> Herbaceous Alliance	CEGL002691	Association	1		
SPARSE						
36 <i>Atriplex obovata</i> Badland Sparse Vegetation	Painted Desert Sparsely Vegetated Alliance	CEGL002928	Association	12	15	33
37 <i>Ephedra torreyana</i> - <i>Artemisia bigelovii</i> Sparse Vegetation	<i>Ephedra Torreyana</i> Sparsely Vegetated Alliance	CEGL002350	Association	12	12	38
38 <i>Eriogonum leptophyllum</i> Sparse Vegetation		CEGL004013	Association	6	4	10
39 <i>Zuckia brandegeei</i> Sparse Vegetation	<i>Zuckia brandegeei</i> Sparsely Vegetated Alliance	CEGL002493	Association	17	12	12

¹2003 Classification Relevés²1996 Existing Relevés³2006 AA Relevés

sparse compared to descriptions of the plant community in the NatureServe database; however, they were not classified as sparse vegetation at PEFO and remained in the physiognomic level assigned by the NatureServe description of the plant community.

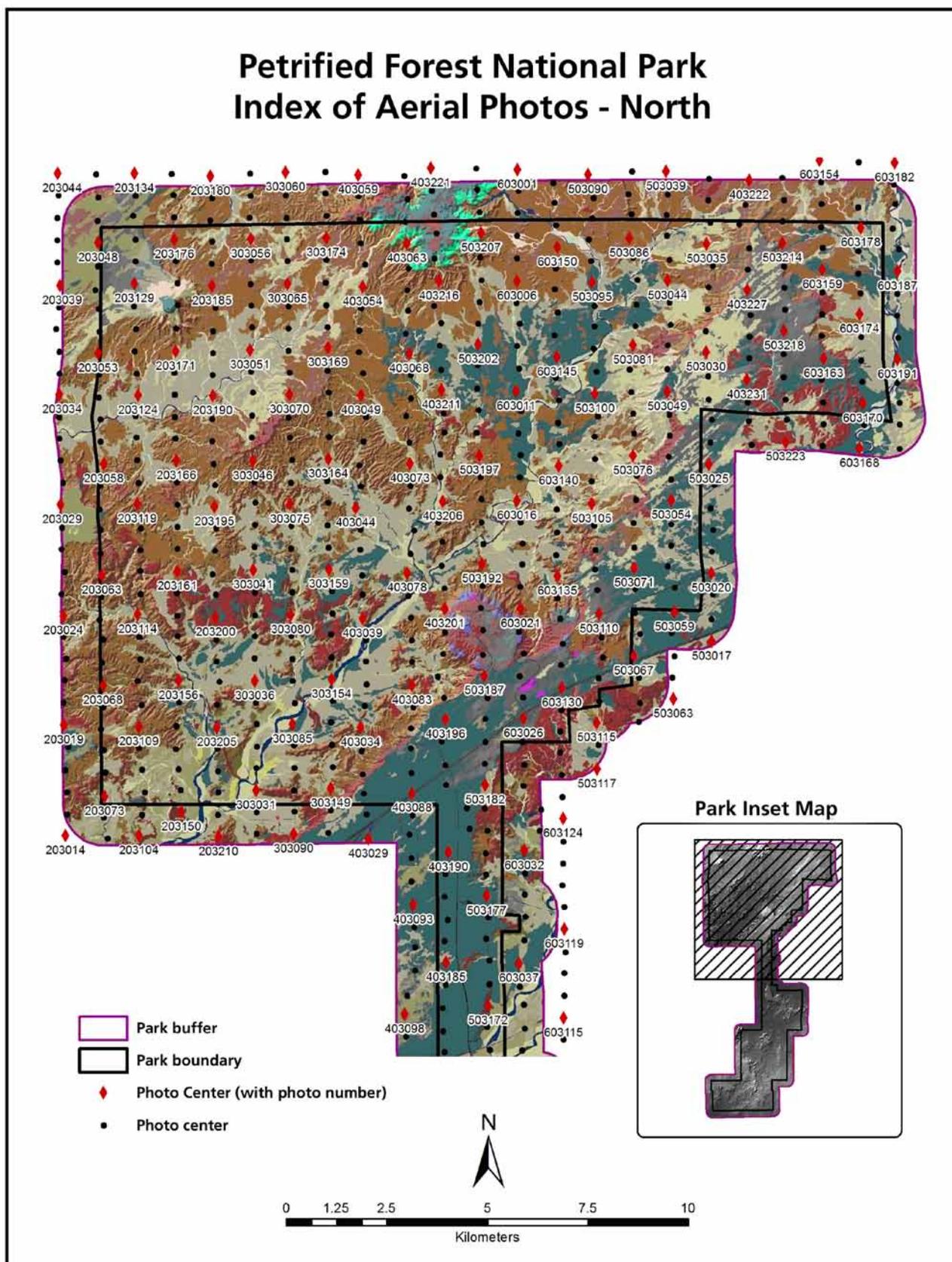


Figure 6. Index of aerial photographs for the northern half of Petrified Forest National Park. Background color scheme represents vegetation management classes for the park (see Figure 9. Base map classes at Petrified Forest National Park).

3 Base Map Class Development

3.1 Methods

3.1.1 Overview

To create the base map classes, the mapping team, consisting primarily of Monica McTeague (NAU) and Anne Cully (NPS), developed GIS polygons and labeled them to the finest floristic level possible using a traditional photointerpretation approach. The resulting base map polygons are the finest spatial data in the GIS database. Ideally, each polygon represents a map class that consists of one plant community that is an association, alliance, or park special; or one land-use class. However, one-to-one correspondence of map class to a single plant community is sometimes not possible because mixed or indistinguishable photosignatures on the aerial photography make it difficult for the photointerpreter to distinguish every plant community. In such cases, the map class assigned represents a group of associations, alliances, or park specials. The group, management, and macrogroup map classes described in Section 4 derive from the base map classes.

3.1.2 Imagery

The SCPN acquired new stereo aerial photography of PEFO through the U.S. Department of Agriculture's Aerial Photography Field Office (APFO). APFO subcontractor Photo Flight Geomatics, of Tucson, Arizona, acquired the imagery on September 13, 14, 17, and 19 of 2003; an additional flight was made on June 17, 2004 to cover areas that were missed in 2003. The imagery was taken in true color film at a scale of 1:6,000, with 20–40% sidelap and 50–60% overlap. The APFO provided two sets of 9 × 9-in contact prints to the SCPN. The NAU and NPS mapping team used the images for reference during polygon delineation and labeling. Upon project completion, one set of contact prints will reside at PEFO and one at the SCPN. Figures 6 and 7 show the flight lines and photo centers.

3.1.3 Field Reconnaissance

The photointerpreters, Cully and McTeague, conducted field reconnaissance of plant communities and their corresponding photosignatures during March and October 2004; May, July, August, October, and November 2005; and April 2006, prior to and simultaneous to delineating and labeling polygons. Cully and McTeague traveled together in the park for the first visits to ensure that they had a consistent understanding of the flora and plant communities. After the initial visits, they divided the park into northern and southern portions, and each took one portion for photointerpretation.

Cully and McTeague visited 113 sites in areas represented by photosignatures that were not easily identifiable on the aerial photography, and in areas that were representative of vegetation associations (fig. 8). At each site they recorded (1) the geographic coordinates of the site, (2) the vegetation structure and composition (including dominant species cover estimates), and (3) a brief description of the site's environmental characteristics. They took two or more digital photographs at each observation point. For many sites, they recorded additional field observations directly onto transparent polyester sheets overlain on the aerial photos (see section 3.1.4). These were used in the lab as a guide during photointerpretation. The data were entered into a Microsoft® Access database and each observation site was assigned a provisional plant community assignment.

3.1.4 Base Map Class Polygons and Labels

The NAU and NPS mapping team delineated map polygons on a transparent polyester sheet overlain on the true-color aerial photographs. Adjoining photos were used to determine the central area on a particular photo frame with the least distortion, known as the 'effective area'; this area was boxed in on the polyester

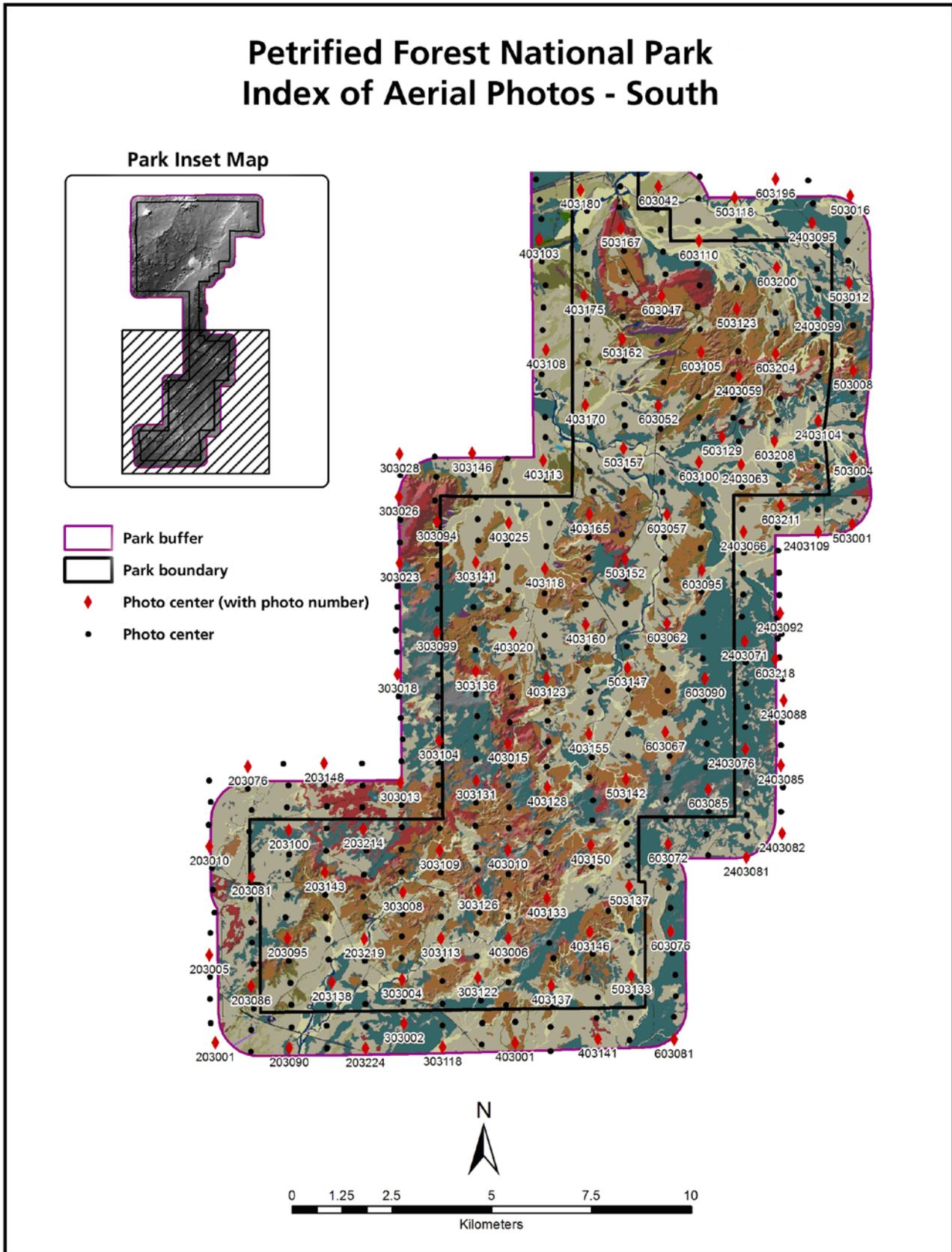


Figure 7. Index of aerial photographs for the southern half of Petrified Forest National Park. Background color scheme represents vegetation management classes for the park (see Figure 20. Management map classes at Petrified Forest National Park).

overlay as the work area for the photo. Fiducial marks (representing a fixed basis of reference) were transferred to each transparent polyester sheet, along with the park code and photo number. A stereoscope was used to help distinguish topographic features with elevational differences and details of photo signatures. Each photo of the northern section and every other photo of the southern section was interpreted, and every other photo of the southern section. This decision was based on the preferences of each photointerpreter after ensuring that joining the northern and southern sets of transparent polyester sheets would not create problems in the final map.

The ground reference data for photointerpretation was supplied by the field reconnaissance observations, classification relevés, and the 1996 sampling data. Cully and McTeague developed a list of provisional base map classes that represented the plant communities as seen in the aerial photography. They labeled the polygons using known and interpreted relationships among the photo signatures, the ground reference data, and the provisional base map classes. Adjustments were made to the provisional base map classes and to the plant community classification during this phase of the project. Adjustments consisted of

- adding map classes to the land use classification, based on observations during field reconnaissance
- including unique stands of plant communities into existing map classes
- expanding provisional map class concepts to include field observed plant communities

Cully and McTeague identified each delineated map class with a numeric code referencing its provisional map class assignment and any modifiers applicable to the polygon. The modifiers, developed in coordination with the Northern



Figure 8. Location of photointerpreters' observation points at Petrified Forest National Park.

Colorado Plateau Network (NCPN), indicated vegetation density (in percentage categories), pattern, and height (table 6) and were applied to the uppermost stratum of each plant community. The height modifier described the average height of the plant community represented by the polygon. A modifier was also used to describe the environmental condition surrounding the vegetation. Cully

Table 6. Modifiers applied to map classes to further characterize the vegetation of each map unit..

Modifier	Modifier code	Interpretation
Density	A	Open Vegetation/Discontinuous (25-60% cover)
	B	Dispersed Vegetation (10-25% cover)
	C	Sparse Vegetation (2-10% cover)
	D	Barren (<2% cover)
Pattern	0	No data
	1	Clumped/Bunched
	2	Linear
	3	Gradational/Transitional
	4	Regularly Alternating
Height (forest/woodland vegetation)	5	Homogenous (default)
	H	5-15 meters
	I	1-5 meters
	J	< 1 meter
	Height (Shrubland/Herbaceous /sparse vegetation)	K
L		0.5-1 meters
M		0-0.5 meters
Environmental condition (surrounding vegetation)	a	Altered, applies when some alteration is evident, but the type is indistinguishable
	c	Vegetated sand dunes
	d	Chained
	e	Other Vegetation Treatments, altered by natural or human features
	f	Spring
	g	An upland vegetation map class occurring in wash
	p	Prairie dog town
	t	Paved road
	u	Gravel/dirt road
	w	Pipeline corridor
z	Vegetation at the time of the photo appears dead, probably due to drought impacts.	

and McTeague labeled non-vegetated map classes using the Anderson et al. (1976) Level II land cover and land use classification as a guide.

The photointerpreters exchanged completed transparent polyester sheet overlays and reviewed each with its associated photo for consistency of interpretation, accuracy in labeling, and adequacy of edge matching with

adjacent photos. Photointerpretation was supplemented by the occasional use of “heads up” on-screen digitizing, using individual registered contact prints (see 3.1.5.1 below) or DOQQ’s.

The base map class concepts and their provisional names were presented to the park staff at a map class label meeting held on April 13, 2006. Base map class names were discussed and finalized with some

names being adjusted based on the input of park staff during that meeting.

3.1.5. Base Map Automation

The Geographic Information Systems Spatial Analysis Laboratory (GISSAL) in the Department of Geography at Kansas State University provided the technical expertise to automate the polygons and associated map class and modifier assignments, creating a spatial vegetation map database.

3.1.5.1 Aerial Photograph Mosaic

SCPN provided GISSAL with one complete set of the 1:6,000 true color aerial photographs. Each of the 9 in x 9 in contact prints was scanned at a resolution of 500 dpi and full color depth, then saved in TIF image format, resulting in an uncompressed file size of 74.5 MB per photo. Digital versions of the aerial photographs were cropped in Adobe Photoshop 6.0 (Adobe Systems Inc., San Jose, CA) to remove the black borders present on the original hardcopy photos.

Orthorectification was performed with ER Mapper 7.0 (Leica Geosystems, San Diego, CA) using National Elevation Dataset (NED) digital elevation models (DEMs) as the height reference. Northing and easting for ground control points (GCPs) were determined from an existing low-resolution digital orthophotograph. Between four and six GCPs common to each scanned aerial photograph and corresponding digital orthophotograph were defined within ER Mapper until a root mean square error (RMS_{error}) of ≤ 1 pixel (equivalent to an error of less than 0.3048 meters or 12 inches) was achieved. When necessary, additional GCPs were identified to meet this threshold. The output projection and datum for the final product were UTM Zone 12N and NAD 83.

Individual orthorectified photographs were compressed at a ratio of 1:35 and saved in ECW format. Each of the individual orthorectified digital photos

was combined in a mosaic operation and color-balanced in ER Mapper to produce the final seamless 1:6,000 scale digital photomosaic, at 0.3048 meter or 12 inch pixel resolution, for the park and its environs.

3.1.5.2 Vegetation Map Database Development

The photointerpretation team provided more than 1000 transparent polyester sheet overlays with map polygon delineation to GISSAL. Each overlay included boundary information for delineated map polygons, along with codes representing the numeric reference for the base map class, including any applicable modifiers. Overlays were scanned and converted into black and white digital raster files (TIF format) for processing and archiving.

Digital versions of the scanned overlays were orthorectified in ER Mapper 7.0 using 1/3 arc second (10 meter) digital elevation models (DEMs) from the National Elevation Dataset (NED) as the height reference, and the previously created digital orthophotomosaic as the base map. As was performed previously with orthorectification, 4-6 GCPs common between the scanned overlays and the high-resolution orthophotomosaic were defined within ER Mapper until a horizontal root mean square error (RMS_{error}) of ≤ 1 pixel (equivalent to 0.3048 meters or 12 inches) was achieved. If necessary, additional GCPs were identified to meet this threshold.

After orthorectification was completed, each overlay was subjected to a raster-to-vector conversion using the ArcScan extension available with the ArcGIS 9.2 (ESRI, Redlands, CA) software. Vector line features generated from the scanned vegetation boundaries were "edge-matched" with boundary lines generated from adjacent overlays and then converted into polygon features. Map unit attribute information, read directly from photointerpreter markings on the

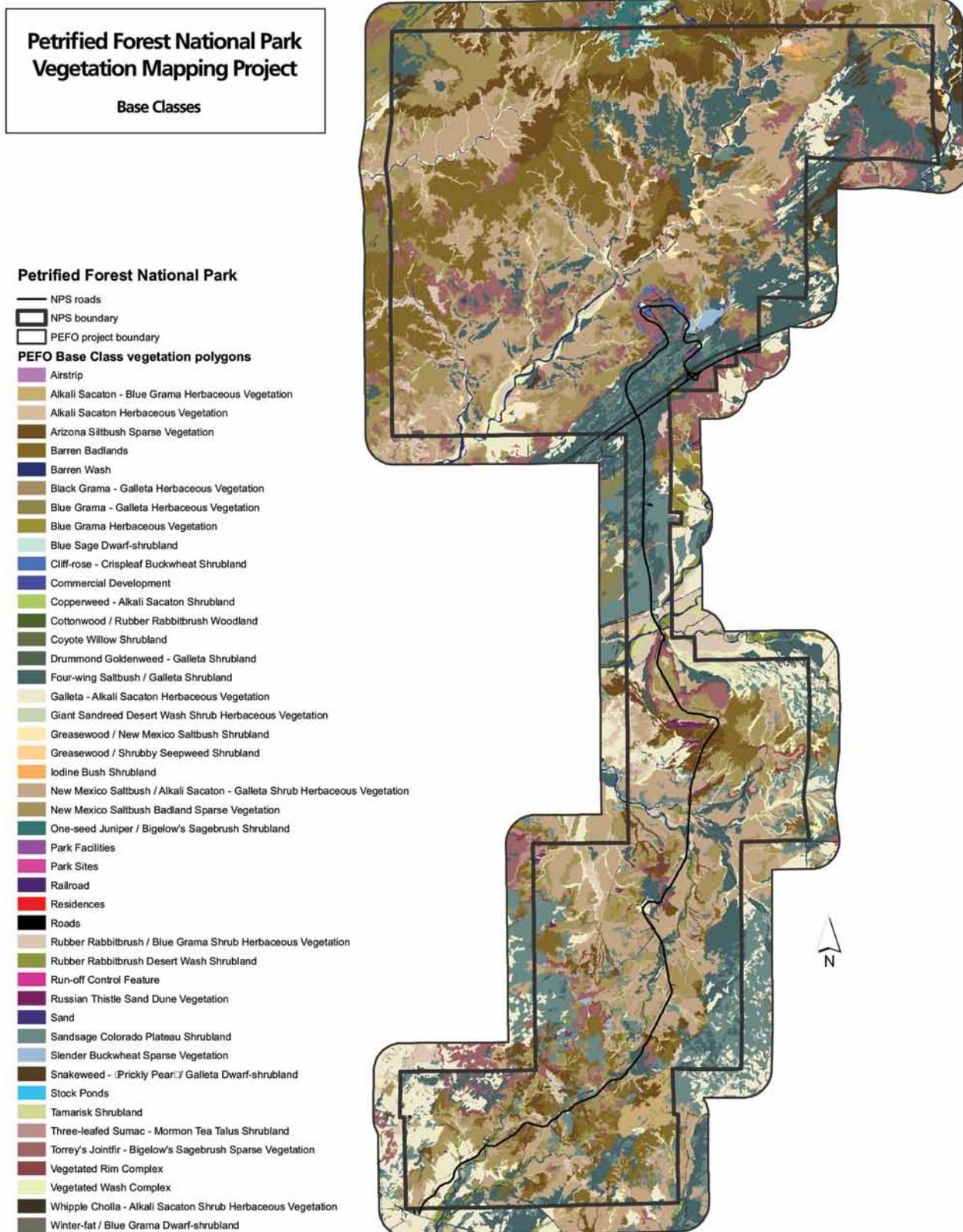


Figure 9. Base map classes at Petrified Forest National Park.

overlays, was then added to the attribute table of each base map polygon. Additional attributes, including vegetation associations and communities, were then incorporated using a tabular join in ArcGIS 9.2. The resulting vegetation map, in shapefile format, was then reviewed independently for attribute accuracy through a “heads-up” comparison of the vegetation map with the original orthorectified overlays in the ArcMap application of ArcGIS 9.2.

3.2 Results

The vegetation map database for PEFO (fig. 9, table 7) encompasses 46 base map classes:

- 8 classes describing infrastructure
- 5 describing land cover and geology types
- 4 describing sparse vegetation
- 15 describing grasslands
- 15 describing shrublands
- 2 describing woodlands and forests.

The vegetation map database is georeferenced to Universal Transverse Mercator (UTM) projection North American Datum of 1983 (NAD 83) zone 12.

The vegetation map database contains 6,989 polygons, of which 1,956 (28%) are smaller than 0.5 ha (table 8). The majority of the vegetated polygons smaller than 0.5 ha in size occur in nine base map classes. Map classes that occurred in the barren badlands were relatively easy to distinguish from unvegetated areas on the aerial photography and were often mapped even when the patches were less than 0.5 ha in size.

All base map classes have a one-to-one representation with a plant community. Six plant communities were not specifically mapped, as they could not be distinguished on the aerial photography,

but were included within the surrounding mapped vegetation: 1) *Artemisia filifolia* / *Bouteloua eriopoda* Shrubland, 2) *Forestiera pubescens* Temporarily Flooded Shrubland Alliance, 3) *Krascheninnikovia lanata* Dwarf-shrubland, 4) *Suaeda moquinii* Shrubland, 5) *Sporobolus coromandelianus* Herbaceous Vegetation, and 6) *Sporobolus cryptandrus* Great Basin Herbaceous Vegetation. These plant communities frequently occurred in patches smaller than the minimum map unit and are not characteristic of any of the base map units. *Pinus edulis* – (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland was also not mapped as a unique map unit but was incorporated with One-seed Juniper / Bigelow’s Sagebrush Shrubland as a base map class.

A summary of the base-map class distribution, as well as the distribution of the management, group, and macrogroup map classes, is presented in section 4. A key to the base map classes, crosswalked to plant community, as well as the group, macrogroup, and management map classes, is presented in Appendix E. Appendix F lists the relationship of plant communities defined in section 2 to base map classes and to the other three map schemas. Photosignatures and summaries of the characteristics of each base map class are presented in Appendix G.

Table 7. Base map classes at Petrified Forest National Park and the plant communities or land cover/land use types they represent.

Base Map Class			Plant Community	Level
Woodland				
B1	Cottonwood / Rubber Rabbitbrush Woodland	3	<i>Populus fremontii</i> / <i>Ericameria nauseosa</i> Woodland	Association
B2	One-seed Juniper / Bigelow's Sagebrush Shrubland	1	<i>Juniperus monosperma</i> / <i>Artemisia bigelovii</i> Woodland, <i>Pinus edulis</i> - (<i>Juniperus osteosperma</i>) / <i>Bouteloua gracilis</i> Woodland	Association
Shrubland				
B3	Blue Sage Dwarf-Shrubland	18	<i>Salvia pachyphylla</i> Dwarf-Shrubland	Park Special
B4	Cliff-rose - Crispleaf Buckwheat Shrubland	15	<i>Purshia stansburiana</i> - <i>Eriogonum corymbosum</i> Shrubland	Association
B5	Copperweed - Alkali Sacaton Shrubland	12	<i>Iva acerosa</i> - <i>Sporobolus airoides</i> Shrubland	Park Special
B6	Coyote Willow Shrubland	17	<i>Salix exigua</i> / Barren Shrubland	Association
B7	Drummond Goldenweed - Galleta Shrubland	11	<i>Isocoma drummondii</i> - <i>Pleuraphis jamesii</i> Shrubland	Park Special
B8	Four-wing Saltbush / Galleta Shrubland	7	<i>Atriplex canescens</i> / <i>Pleuraphis jamesii</i> Shrubland	Association
B9	Greasewood / New Mexico Saltbush Shrubland	19	<i>Sarcobatus vermiculatus</i> / <i>Atriplex obovata</i> Shrubland	Park Special
B10	Greasewood / Shrubby Seepweed Shrubland	20	<i>Sarcobatus vermiculatus</i> / <i>Suaeda moquinii</i> Shrubland	Association
B11	Iodine Bush Shrubland	4	<i>Allenrolfea occidentalis</i> Shrubland	Association
B12	Rubber Rabbitbrush Desert Wash Shrubland	8	<i>Ericameria nauseosa</i> Desert Wash Shrubland	Association
B13	Sandsage Colorado Plateau Shrubland	6	<i>Artemisia filifolia</i> Colorado Plateau Shrubland	Association
B14	Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland	10	<i>Gutierrezia sarothrae</i> - (<i>Opuntia</i> spp.) / <i>Pleuraphis jamesii</i> Dwarf-shrubland	Association
B15	Tamarisk Shrubland	22	<i>Tamarix</i> spp. Semi-Natural Temporarily Flooded Shrubland	Association
B16	Three-leafed Sumac - Mormon Tea Talus Shrubland	16	<i>Rhus trilobata</i> - Ephedra (<i>viridis</i> , <i>torreyana</i>) Talus Shrubland	Association
B17	Winter-fat / Blue Grama Dwarf-shrub	13	<i>Krascheninnikovia lanata</i> / <i>Bouteloua gracilis</i> Dwarf-shrub Herbaceous Vegetation	Association
Herbaceous				
B18	Alkali Sacaton Herbaceous Vegetation	33	<i>Sporobolus airoides</i> Southern Plains Herbaceous Vegetation	Association
B19	Alkali Sacaton - Blue Grama Herbaceous Vegetation	32	<i>Sporobolus airoides</i> - <i>Bouteloua gracilis</i> Herbaceous Vegetation	Association
B20	Black Grama - Galleta Herbaceous Vegetation	25	<i>Bouteloua eriopoda</i> - <i>Pleuraphis jamesii</i> Herbaceous Vegetation	Association
B21	Blue Grama Herbaceous Vegetation	26	<i>Bouteloua gracilis</i> Herbaceous Vegetation	Association
B22	Blue Grama - Galleta Herbaceous Vegetation	24	<i>Bouteloua gracilis</i> - <i>Pleuraphis jamesii</i> Herbaceous Vegetation	Association
B23	Galleta - Alkali Sacaton Herbaceous Vegetation	30	<i>Pleuraphis jamesii</i> - <i>Sporobolus airoides</i> Herbaceous Vegetation	Association
B24	Giant Sandreed Desert Wash Shrub Herbaceous Vegetation	27	<i>Calamovilfa gigantea</i> Desert Wash Shrub Herbaceous Vegetation	Association
B25	New Mexico Saltbush / Alkali Sacaton - Galleta Shrub Herbaceous Vegetation	23	<i>Atriplex obovata</i> / <i>Sporobolus airoides</i> - <i>Pleuraphis jamesii</i> Shrub Herbaceous Vegetation	Association
B26	Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation	28	<i>Ericameria nauseosa</i> / <i>Bouteloua gracilis</i> Shrub Herbaceous Vegetation	Association
B27	Russian Thistle Sand Dune Vegetation	31	<i>Salsola tragus</i> Sand Dune Vegetation	Park Special
B28	Whipple Cholla - Alkali Sacaton Shrub Herbaceous Vegetation	29	<i>Opuntia whipplei</i> - <i>Sporobolus airoides</i> Shrub Herbaceous Vegetation	Park Special
Sparse				
B29	Arizona Siltbush Sparse Vegetation	39	<i>Zuckia brandegeei</i> Sparse Vegetation	Association
B30	New Mexico Saltbush Badland Sparse Vegetation	36	<i>Atriplex obovata</i> Badland Sparse Vegetation	Association
B31	Slender Buckwheat Sparse Vegetation	38	<i>Eriogonum leptophyllum</i> Sparse Vegetation	Association

Table 7. *continued*

Base Map Class		Plant Community	Level
B32	Torrey's Jointfir - Bigelow's Sagebrush Sparse Vegetation	37 Ephedra torreyana - Artemisia bigelovii Sparse Vegetation	Association
Land Use/Landforms			
B33	Airstrip	Not applicable	
B34	Barren Badlands	Not applicable	
B35	Barren Wash	Not applicable	
B36	Park Facilities	Not applicable	
B37	Park Sites	Not applicable	
B38	Railroad	Not applicable	
B39	Residences	Not applicable	
B40	Roads	Not applicable	
B41	Run-off Control Feature	Not applicable	
B42	Sand	Not applicable	
B43	Stock Ponds	Not applicable	
B44	Vegetated Rim Complex	Not applicable	
B45	Vegetated Wash Complex	Not applicable	
B46	Commercial Development	Not applicable	

Table 8. Base map classes at Petrified Forest National Park occurring in polygons smaller than the MMU size.

Base Map Class		# map units less than MMU ¹	# all map units	% Area <MMU	Total area (ha)
B1	Cottonwood / Rubber Rabbitbrush Woodland	5	11	5.50%	1
B11	Iodine Bush Shrubland	9	27	4.60%	3
B12	Rubber Rabbitbrush Desert Wash Shrubland	55	224	2.70%	14
B13	Sandsage Colorado Plateau Shrubland	413	1032	2.30%	105
B14	Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland	4	48	0.20%	1
B15	Tamarisk Shrubland	19	59	3.00%	5
B16	Three-leafed Sumac - Mormon Tea Talus Shrubland	6	24	1.30%	1
B18	Alkali Sacaton Herbaceous Vegetation	24	59	4.60%	6
B19	Alkali Sacaton - Blue Grama Herbaceous Vegetation	12	42	0.90%	3
B2	One-seed Juniper / Bigelow's Sagebrush Shrubland	16	27	1.60%	3
B20	Black Grama - Galleta Herbaceous Vegetation	1	5	0.80%	0
B21	Blue Grama Herbaceous Vegetation	8	28	0.70%	2
B22	Blue Grama - Galleta Herbaceous Vegetation	4	31	0.10%	0
B23	Galleta - Alkali Sacaton Herbaceous Vegetation	97	535	0.70%	28
B24	Giant Sandreed Desert Wash Shrub Herbaceous Vegetation	15	32	13.60%	4
B25	New Mexico Saltbush / Alkali Sacaton - Galleta Shrub Herbaceous Vegetation	117	712	0.30%	30
B26	Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation	105	338	1.60%	25
B27	Russian Thistle Sand Dune Vegetation	7	39	1.90%	2
B29	Arizona Siltbush Sparse Vegetation	37	213	0.30%	9
B3	Blue Sage Dwarf-shrubland	4	12	0.80%	1

Table 8 *continued*

Base Map Class		# map units less than MMU¹	# all map units	% Area <MMU	Total area (ha)
B30	New Mexico Saltbush Badland Sparse Vegetation	162	770	0.70%	46
B31	Slender Buckwheat Sparse Dwarf-shrubland Vegetation	4	21	0.70%	1
B32	Torrey's Jointfir - Bigelow's Sagebrush Sparse Vegetation	236	668	1.80%	57
B34	Barren Badlands	133	440	0.60%	34
B35	Barren Wash	5	47	0.30%	1
B36	Park Facilities	15	21	10.50%	2
B37	Park Sites	1	2	5.40%	0
B39	Residences	22	23	76.80%	2
B40	Roads	17	52	1.60%	4
B41	Run-off Control Feature	2	2	100.00%	1
B42	Sand	1	2	9.30%	0
B43	Stock Ponds	19	25	42.90%	4
B44	Vegetated Rim Complex	8	55	0.90%	2
B45	Vegetated Wash Complex	140	478	1.80%	34
B46	Commercial Development	5	6	64.30%	1
B5	Copperweed / Alkali Sacaton Shrubland	1	2	12.10%	0
B6	Coyote Willow Shrubland	4	6	7.70%	1
B8	Four-wing Saltbush / Galleta Shrubland	217	803	0.80%	56
B9	Greasewood / New Mexico Saltbush Shrubland	6	48	0.80%	2

¹MMU = minimum mapping unit of .5 ha

4 Accuracy Assessment and Additional Map Classes

The Southwest Biological Science Center (SBSC) team completed the vegetation map database by coordinating field collection of accuracy assessment observations; developing the accuracy statistics for the base map classes; developing the group, macrogroup, and management map classes; and developing accuracy assessment statistics for those map schemas. In this step, the team used the accuracy assessment guidelines and protocols developed by the USGS-NPS Vegetation Mapping Program (Environmental Systems Research Institute et al. 1994). They developed the accuracy assessment by comparing the performance of base map class polygons, as mapped, with field-collected data at the location of those polygons.

4.1 Methods

To conduct the accuracy assessment, the team: (1) developed a sampling design, (2) collected field data with on-the-ground field sampling (reference data), and (3) developed map performance statistics. As is common practice when measuring uncertainty in mapped classes, a sample of polygon locations representing each map class (the sample data) was compared to the reference data. The higher-level group, macrogroup, and management map classes consisted of aggregations of base map classes. They were assessed using the same reference data as for the base map. Finally, the team developed summary statistics describing the characteristics of the base, group, macrogroup, and management map classes.

4.1.1 Field Sampling Design

The map database, with base map classes, was made available to the SBSC team for accuracy assessment in two separate shapefiles. The initial shapefile represented the northern half of the park, and the final shapefile consisted of the entire park, including the southern half.

Although it is ideal to develop a sampling design using a complete map database, the full map database was not available until the late summer months. Prior to developing the sample design, the SBSC team checked the topology and data structure of each map section for node and label errors.

The team generally limited accuracy assessment sampling to within the park boundaries. With the approval of park managers, the team did not field assess land use and non-vegetated map classes. These map classes are well known and often easier to identify on the aerial photography than the vegetated classes, and the field team had limited field-season time to sample the vegetated map classes. All vegetated map classes, including park specials and those based on photointerpretation alone, were included in the accuracy assessment sampling design.

The SBSC team used the “scenario” table recommended by the Vegetation Mapping Program (ESRI et al. 1994) to estimate the number of sample sites needed for each map class in order to achieve a statistical measure of class accuracy with a confidence level of 90% and an acceptable sample error of 10%. Each scenario was based on the number of polygons and total area of a map class. The team assigned each map class to one of five different scenarios to determine the target number of sampling sites needed (table 9). Depending upon its scenario assignment, a map class could include between 1 and 30 sampling sites.

The team developed the sampling design for the park in two stages. To compensate for the northern half containing only a portion of all park polygons, the team reduced the initial number of sample sites for that section by multiplying the portion of the total map that the section represented by the target number of sample sites determined through the scenario table. This allowed

Table 9. Sampling design scenarios used to determine the target number of field accuracy assessment observation sites.

Scenario	Class	Area	Number of Polygons	Sample Size
A	Abundant	> 50 ha	>= 30	30
B	Relatively Abundant	> 50 ha	< 30	20
C	Relatively Rare	< 50 ha	> 30	20
D	Rare	< 50 ha	> 5 but < 30	5
E	Very Rare	< 50 ha	<= 5	visit every polygon

From ESRI et al. 1994

the team to make the best estimate for the appropriate number of sampling points in that section. The team retained sample sites for map classes that the team thought would be less abundant in the southern half of the map.

When the SBSC team received the composite map database, they used the composite map database to re-estimate the number of target sample sites. Based on the complete map, the team found some map classes were under- or over-sampled based on the new estimate. The team sampled additional under-represented map classes in the southern part of the park and did not continue sampling oversampled map classes.

The location of each accuracy assessment site was determined randomly using Hawth's Analysis Tools v3.26 (<http://www.spatial ecology.com/htools/tool desc.php>). In addition to the targeted number of polygons sampled for each class, there were 5-20 extra polygons per map class included in the random sample in case the field team could not access the originally targeted polygons. Polygons larger than 0.5 ha (the MMU) had priority as field sampling sites. Accuracy assessment sites were 15 meters or more from the edge of the polygon.

4.1.2 Field Data Collection

A dichotomous key to plant communities and map classes was developed to assist with accuracy assessment in the field (see Appendix E). Ecologist and photointerpreter Monica McTeague

visited the park prior to the accuracy assessment to review the plant community/map class key and the accuracy assessment field sampling methodologies. During this trip, she revised the plant community/map class key to provide better descriptions of the field relationships of associations and map classes.

The SBSC accuracy-assessment field crew began their work in June 2006 and completed sampling by November that year. McTeague trained the field crew in order to familiarize them with the park, logistical concerns, and field methodologies. Targeted accuracy assessment sites were identified as either primary or secondary. The crew attempted to access all primary sites. If they were not accessible, the crew sampled secondary sites.

Each field team of two members carried a GPS unit (Garmin 5, Garmin 3+, or Garmin GPSMAP 76 (WAAS enabled)) pre-loaded with the geographic coordinates for the designated sampling site. In addition, each team had a hard-copy list of the geographic coordinates for each target site, area, and perimeter length of the polygon containing the target site, and distance to the nearest edge of an adjacent polygon, as well as two sets of maps to help orient them to the site. The first map was a large area map with all of the sampling sites drawn on a 1:24,000 scale topographic base. The second set of maps showed each site within its associated polygon outline on a DOQQ

base. These fine-scale maps allowed each field team to locate specific polygons on the ground and to visualize the size and shape of the polygon they were assessing.

The field team navigated to each site and then examined the polygon, using the field maps as a guide to the polygon's shape. They recorded site data (table 10) and generally took at least one photo from the site waypoint. They determined the plant community found on the ground and the corresponding base map class using the plant community/map class key in an area of at least 0.5 ha in size (e.g. a circle within a 40-m radius) from the geographic coordinates of the designated sampling site. The evaluator assigned confidence in the base map classes using a categorical scale: exact, good (some problems), poor, or none that fit; and documented the reasons for a confidence level that was less than exact. If additional map classes or plant communities were present in the polygon, the evaluator listed alternate map classes. During the accuracy assessment fieldwork, the field crew and the SBSC project leaders refined the plant community/map class key and some of the plant community descriptions.

4.1.3 Field data processing and accuracy assessment statistics

Data from 662 sampling locations were entered into a Microsoft Access database. The SBSC team rigorously quality checked the data including comparing the entered data with the original data sheet.

The SBSC team developed accuracy

assessment statistics by comparing the reference map class (the map class determined in the field during accuracy assessment) to the map class in the vegetation map database (the map class assigned by the photointerpreter) at the sampled waypoint (table 11). In some cases, if the field crew could not access a sample location, they made observations from a removed location. When this occurred, the geographic coordinates of the target sample site, as determined during development of the sampling design, were the geographic location for the reference data. The team listed all sites where there was a difference in the sample and reference comparison (an apparent error). The field data sheet for each apparent error was re-examined and the alternate map class accepted if it matched the reference data.

The team developed a contingency table (also known as an error matrix) to summarize the reference and sample data comparisons for each map class. The SBSC team used methods described in the Vegetation Mapping Program guidelines (Environmental Systems Research Institute et al. 1994) to calculate user and producer accuracy (see Glossary) for individual map classes, as well as overall accuracy, and a kappa index, which accounts for correct classifications due to chance (Foody 1992; The Nature Conservancy and Environmental Systems Research Institute 1994a). The kappa index was calculated for map classes that were assigned target sites; map classes that were observed in the field, but were not

Table 10. Summary of data collected within 2006 accuracy assessment observation sites.

Type of information	Items noted
Site documentation	Site identification, georeferencing, photo, elevation
Map class	Base map class of the site
Confidence in map class	The evaluators confidence in base map class assignment
Plant community	Association, alliance, or park special at site
Confidence in plant community	The evaluators confidence in plant community assignment
Vegetation description	Cover class, dominant species by strata

Table 11. Terminology used for accuracy assessment data collection and analysis at Petrified Forest National Park.

Terminology	Definition
Reference map class	Map class observed in the field during accuracy assessment, considered to be the true map class.
Sample map class	Map class assigned in the vegetation map database.
Contingency table or error matrix	A matrix where rows indicate the sample map classes and columns represent the reference map classes. At each row and column intersection, the number of observations for each sample/reference combination is noted. The vegetation map database is considered correct for all the cases where the sample map class and the reference map class are the same. These observations usually occur on the diagonal on the matrix.
Users accuracy	The number of correct reference observations divided by the total number of reference observations for a map class.
Producers accuracy	The number of sample map classes correctly mapped divided by the total number of reference observations made for that map class.
Overall accuracy	The total number of correctly classified reference observations divided by the total number of reference observations regardless of map class.
Kappa Index	An alternate expression of overall accuracy with correction for chance correct classifications.

targeted for accuracy assessment, such as a land-cover class observed as a reference observation but not targeted as a sample, were not included in the calculation of the kappa index. Statistics were derived using the JMP v5.1 statistical application. The two-tailed, 90% confidence intervals for users, producers and overall accuracy were calculated using Score Confidence Interval Tables, which have better coverage probabilities with smaller sample sizes (Agresti and Coull 1998).

4.1.4 Group, Macrogroup, and Management Map Classes

After assessment statistics were calculated for the base map classes, the SBSC team developed three aggregated map-class schemas: the group, macrogroup, and management map schemas. The group map-class schema is an aggregation of base map classes based on the concept of the group level of the NVCS Version 2 (Federal Geographic Data Committee 2008) (see table 2). The SBSC team used the ecological-system assignments for associations developed by NatureServe as a substitute for assignment of group map class, which were not available in final form at the time this project was completed. The macrogroup is an additional midlevel grouping in the NVCS Version 2, one level of aggregation above the group.

Management map classes reflect base map-class performance and resource management needs. User and producer accuracy statistics for each map class, as well as confusion among map classes as shown on the base map contingency table (see Appendix H1), were used to develop recommendations for aggregations of commonly confused and floristically or ecologically similar map classes. PEFO resource management staff reviewed these map-class recommendations at a meeting held at the park on May 17, 2007. They made recommendations for management class aggregations using management goals for particular plant communities of particular interest, regardless of their assessed accuracy performance.

The SBSC team created a cross-walk between the base map classes and each aggregated map class (see Appendix F). The crosswalks were used to add the group, macrogroup, and management map classes to the map database. The team also created a crosswalk between the reference data for the accuracy assessment and the group, macrogroup, and management map classes to conduct an accuracy assessment of each aggregated map class. The number of polygons and the area of each map class within the base, group, macrogroup, and management map-class schemas were calculated within a GIS.

4.2 Results

4.2.1 Accuracy Assessment Samples

In 2006, 662 accuracy assessment locations were sampled (fig. 10). Data from 630 of these locations were used in the accuracy assessment analysis. The team eliminated 32 accuracy assessment points from the accuracy assessment analysis in cases where the team did not fully understand the source of the error. This occurred in areas where the sampled point was closer to the polygon boundary than the error recorded by the GPS unit. The team was not sure if the thematic error was due to error in georeferencing or to error in the vegetation map database. Also, points were eliminated when the vegetation type recorded did not match the species information recorded.

4.2.2 Base Map Class Accuracy and Summary Statistics

4.2.2.1 Accuracy

The overall accuracy of the 46 base map classes was 40.6%; kappa index was 42.2% +/- 0.22. As the kappa index and its standard error use only map classes with both sample and corresponding reference data, it is slightly greater than the overall accuracy. The contingency table for base map class accuracy is presented in Appendix H1.

The nine land-use map classes were not assessed (table 12) but the five landform defined map classes were. Two of the vegetated map classes were not assessed for accuracy; each consisted of only one polygon outside the park boundaries.

Three base map classes, Sand, Coyote Willow Shrubland and Blue Sage Dwarf-shrubland, had both 100% user and producer accuracy. Another six map classes (table 12) met the 80% accuracy standard for either the user or producer accuracy but not both. Except for producer accuracy for Barren Badlands (87.5%), accuracy for the seven most abundant map classes was less than 80%.



Figure 10. Location of 662 accuracy assessment points at Petrified Forest National Park observed in 2006.

4.2.2.2 Summary Statistics

Seven base map classes individually contributed 5% or more to the land cover of the park (excluding environs); together they constitute just over 77% of the total park land cover (table 13). The most abundant map classes were:

- New Mexico Saltbush / Galleta – Alkali Sacaton Shrub Herbaceous Vegetation (24.2%, fig. 11)

Table 12. Accuracy statistics for the base map classes.

Base Map Class		User accuracy	90% CI (range)	Producer accuracy	90% CI (range)
Woodland					
B1	Cottonwood / Rubber Rabbitbrush Woodland	100.0	42.5 - 100.0	66.7	25.4 - 92.2
B2	One-seed Juniper / Bigelow's Sagebrush Shrubland	81.8	57.3 - 93.8	100.0	NA ²
Shrubland					
B3	Blue Sage Dwarf-shrubland	100.0	68.9 - 100.0	100.0	68.9 - 100.0
B4	Cliff-rose - Crispleaf Buckwheat Shrubland	66.7	43.1 - 84.1	88.9	62.3 - 97.5
B5	Copperweed / Alkali Sacaton Shrubland	0.0	NA	0.0	NA
B6	Coyote Willow Shrubland	100.0	27.0 - 100.0	100.0	27.0 - 100.0
B7	Drummond Goldenweed / Galleta Shrubland	NS		NS	
B8	Four-wing Saltbush / Galleta Shrubland	40.0	26.7 - 54.9	26.7	17.4 - 38.9
B9	Greasewood / New Mexico Saltbush Shrubland	41.9	28.6 - 56.6	81.3	61.2 - 92.2
B10	Greasewood / Shrubby Seepweed Shrubland	100.0	27.0 - 100.0	20.0	4.6 - 56.5
B11	Iodine Bush Shrubland	21.1	9.8 - 39.5	66.7	34.7 - 88.3
B12	Rubber Rabbitbrush Desert Wash Shrubland	35.5	23.0 - 50.3	64.7	44.9 - 80.5
B13	Sandsage Colorado Plateau Shrubland	58.6	43.5 - 72.3	63.0	47.2 - 76.4
B14	Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland	0.0	NA	NS ³	NS
B15	Tamarisk Shrubland	31.6	17.3 - 50.4	85.7	54.8 - 96.7
B16	Three-leafed Sumac - Mormon Tea Talus Shrubland	9.1	2.1 - 32.3	20.0	4.6 - 56.5
B17	Winter-fat / Blue Grama Dwarf-shrub	0.0	NA	0.0	NA
Herbaceous					
B19	Alkali Sacaton - Blue Grama Herbaceous Vegetation	37.5	20.8 - 57.8	15.0	8.0 - 26.5
B18	Alkali Sacaton Herbaceous Vegetation	20.0	10.1 - 35.8	13.5	6.7 - 25.3
B20	Black Grama - Galleta Herbaceous Vegetation	0.0	NA	NS	NS
B22	Blue Grama - Galleta Herbaceous Vegetation	33.3	14.2 - 30.2	18.8	7.8 - 38.8
B21	Blue Grama Herbaceous Vegetation	0.0	NA	0.0	NA
B23	Galleta - Alkali Sacaton Herbaceous Vegetation	55.2	40.2 - 69.3	37.2	26.2 - 49.8
B24	Giant Sandreed Desert Wash Shrub Herbaceous Vegetation	0.0	NA	NS	NS
B25	New Mexico Saltbush / Galleta - Alkali Sacaton Shrub Herbaceous Vegetation	40.0	27.7 - 54.9	19.4	12.5 - 28.8
B26	Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation	6.9	2.3 - 18.8	40.0	14.3 - 72.8
B27	Russian Thistle Sand Dune Vegetation	50.0	32.7 - 67.3	55.6	36.9 - 72.8
B28	Whipple Cholla / Alkali Sacaton Shrub Herbaceous Vegetation	NS		NS	
Sparse					
B29	Arizona Siltbush Sparse Vegetation	13.3	6.1 - 26.6	33.3	15.9 - 56.9
B30	New Mexico Saltbush Badland Sparse Vegetation	16.1	8.1 - 29.6	17.9	9.0 - 32.4
B31	Slender Buckwheat Sparse Dwarf-shrubland Vegetation	38.9	22.7 - 58.0	50.0	30.0 - 70.1
B32	Torrey's Jointfir – Bigelow's Sagebrush Sparse Vegetation	56.7	41.9 - 70.4	44.7	32.3 - 57.9

Table 12 *continued*

Base map class		User accuracy	90% CI (range)	Producer accuracy	90% CI (range)
B33	Airstrip	Not sampled			
B34	Barren Badlands	87.5	74.9 - 94.3	53.8	42.6 - 64.7
B35	Barren Wash	70.8	54.1 - 83.3	85.0	67.8 - 93.8
B36	Park Facilities	NS		NS	
B37	Park Sites	NS		NS	
B38	Railroad	NS		NS	
B39	Residences	NS		NS	
B40	Roads	NS		NS	
B41	Run-off Control Feature	NS		NS	
B42	Sand	100.0	42.5 - 100.0	100.0	42.5 - 100.0
B43	Stock Ponds	NS		NS	
B44	Vegetated Rim Complex	42.9	28.8 - 58.2	52.2	35.7 - 68.2
B45	Vegetated Wash Complex	67.9	52.3 - 80.2	50.0	37.1 - 62.9
B46	Commercial Development	NS		NS	

³ NA = not applicable, statistic could not be calculated.

² NS =map class not sampled during accuracy assessment.

- Four-wing Saltbush / Galleta Shrubland (14.4%, fig. 12)
- New Mexico Saltbush Badland Sparse Vegetation (14.4%, fig. 13)
- Barren Badlands (12.3%, fig. 14)
- Sandsage Colorado Plateau Shrubland (6.8%, fig. 15)
- Arizona Siltbush Sparse Vegetation (5.7%, fig.16)
- Torrey's Jointfir Shrubland – Bigelow's Sagebrush Sparse Vegetation (5.6%, fig. 17).

Thirty-one classes contributed less than 1% cover each. Five map classes occurred only in the project environs. Nine of the small classes also had more than half of their distribution in the park environs. Additional information on the distribution of each map class occurs in Appendix G.

4.2.3 Group map class accuracy and summary statistics

4.2.3.1 Accuracy

Fifteen group map classes (fig. 18,

Appendix F) were created by aggregating the base map classes (table 14). The overall accuracy of the group map classes was 55.7%; Kappa index was 49.9%±0.02 (table 15, Appendix H2). Colorado Plateau Pinyon-Juniper Woodland met the 80% standard for both user and producer accuracy. Inter-Mountain Basins Greasewood Flat and Inter-Mountain Basins Riparian Woodland and Shrubland meet the 80% standard for producer accuracy. The other map classes were below 80% accuracy for both the user and producer accuracy.

4.2.3.2 Summary Statistics

The group map classes consist of five non-vegetated types and ten vegetated map classes (table 16). Within the park the three most abundant map classes are: 1) Inter-Mountain Basins Semi-Desert Shrub-Steppe (44.7%), 2) Southern Colorado Plateau Sand Shrubland (21.2%), and 3) Inter-Mountain Basins Shale Badland. Together they constitute 84.3% of the park's vegetated cover.

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Table 13. Base map class summary statistics.

Base Map Class	Project area				Park area			Occurrence outside park boundaries
	# Poly-gons	ha	ac	% Project land cover	ha	ac	%Park land cover	
Woodland								
B1 Cottonwood / Rubber Rabbitbrush Woodland	11	15.2	37.6	0.0%	1.7	4.3	0.0%	88.5%
B2 One-seed Juniper / Bigelow's Sagebrush Shrubland	27	211.4	522.3	0.4%	70.8	174.9	0.2%	66.5%
Shrubland								
B3 Blue Sage Dwarf-shrubland	12	122.8	303.5	0.2%	69.2	171.0	0.2%	43.7%
B4 Cliff-rose - Crispleaf Buckwheat Shrubland	11	57.1	141.1	0.1%	57.1	141.1	0.2%	0.0%
B5 Copperweed / Alkali Sacaton Shrubland	2	2.0	4.9	0.0%	2.0	4.9	0.0%	0.0%
B6 Coyote Willow Shrubland	6	13.2	32.5	0.0%	2.2	5.4	0.0%	83.4%
B7 Drummond Goldenweed / Galleta Shrubland	1	0.8	1.9	0.0%			0.0%	100.0%
B8 Four-wing Saltbush / Galleta Shrubland	803	7339.8	18137.0	13.8%	5473.8	13526.2	14.4%	25.4%
B9 Greasewood / New Mexico Saltbush Shrubland	48	212.3	524.6	0.4%	186.5	460.8	0.5%	12.2%
B10 Greasewood / Shrubby Seepweed Shrubland	3	7.4	18.3	0.0%	6.3	15.6	0.0%	14.9%
B11 Iodine Bush Shrubland	27	56.1	138.7	0.1%	49.6	122.6	0.1%	11.6%
B12 Rubber Rabbitbrush Desert Wash Shrubland	224	508.4	1256.4	1.0%	343.5	848.9	0.9%	32.4%
B13 Sandsage Colorado Plateau Shrubland	1032	4492.3	11100.8	8.4%	2577.8	6369.8	6.8%	42.6%
B14 Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland	48	438.7	1084.1	0.8%	169.7	419.4	0.4%	61.3%
B15 Tamarisk Shrubland	59	154.6	382.1	0.3%	62.0	153.3	0.2%	59.9%
B16 Three-leafed Sumac - Mormon Tea Talus Shrubland	24	98.3	242.8	0.2%	36.2	89.5	0.1%	63.2%
B17 Winter-fat / Blue Grama Dwarf-shrub	1	3.0	7.4	0.0%	3.0	7.4	0.0%	0.0%
Herbaceous								
B18 Alkali Sacaton Herbaceous Vegetation	59	125.3	309.6	0.2%	92.3	228.0	0.2%	26.3%
B19 Alkali Sacaton - Blue Grama Herbaceous Vegetation	42	377.1	931.8	0.7%	284.2	702.3	0.7%	24.6%
B20 Black Grama - Galleta Herbaceous Vegetation	5	23.6	58.3	0.0%	23.6	58.3	0.1%	0.0%
B21 Blue Grama Herbaceous Vegetation	28	261.1	645.1	0.5%	33.6	83.0	0.1%	87.1%
B22 Blue Grama - Galleta Herbaceous Vegetation	31	544.1	1344.5	1.0%	145.0	358.3	0.4%	73.4%
B23 Galleta - Alkali Sacaton Herbaceous Vegetation	535	4143.3	10238.3	7.8%	1586.0	3919.2	4.2%	61.7%
B24 Giant Sandreed Desert Wash Shrub Herbaceous Vegetation	32	33.0	81.5	0.1%	17.7	43.7	0.0%	46.4%
B25 New Mexico Saltbush / Alkali Sacaton – Galleta Shrub Herbaceous Vegetation	712	11046.0	27295.3	20.8%	9218.0	22778.2	24.2%	16.5%

Table 13. *continued*

Base Map Class	Project area				Park area			
	# Poly-gons	ha	ac	% Project land cover	ha	ac	% Park land cover	Occurrence outside park boundaries
B27 Russian Thistle Sand Dune Vegetation	39	100.7	248.9	0.2%	95.9	236.9	0.3%	4.8%
B28 Whipple Cholla / Alkali Sacaton Shrub Herbaceous Vegetation	1	0.6	1.6	0.0%			0.0%	100.0%
Sparse								
B29 Arizona Siltbush Sparse Vegetation	213	2685.0	6634.9	5.0%	2165.3	5350.7	5.7%	19.4%
B30 New Mexico Saltbush Badland Sparse Vegetation	770	6815.6	16841.7	12.8%	5497.4	13584.5	14.4%	19.3%
B31 Slender Buckwheat Sparse Dwarf-shrubland Vegetation	21	114.0	281.8	0.2%	113.3	280.0	0.3%	0.6%
B32 Torrey's Jointfir – Bigelow's Sagebrush Sparse Vegetation	668	3227.3	7974.9	6.1%	2119.2	5236.8	5.6%	34.3%
Land use/landforms								
B33 Airstrip	1	2.6	6.5	0.0%			0.0%	100.0%
B34 Barren Badlands	440	5587.5	13807.1	10.5%	4664.9	11527.3	12.3%	16.5%
B35 Barren Wash	47	498.7	1232.4	0.9%	319.4	789.1	0.8%	36.0%
B36 Park Facilities	21	16.0	39.5	0.0%	16.0	39.5	0.0%	0.0%
B37 Park Sites	2	0.8	1.9	0.0%	0.8	1.9	0.0%	0.0%
B38 Railroad	2	5.2	12.9	0.0%	2.3	5.7	0.0%	56.0%
B39 Residences	23	2.4	6.0	0.0%	0.1	0.2	0.0%	96.9%
B40 Roads	52	217.6	537.6	0.4%	143.6	354.9	0.4%	34.0%
B41 Run-off Control Feature	2	0.5	1.3	0.0%	0.5	1.3	0.0%	0.0%
B42 Sand	2	2.8	6.9	0.0%	2.8	6.9	0.0%	0.0%
B43 Stock Ponds	25	8.8	21.8	0.0%			0.0%	100.0%
B44 Vegetated Rim Complex	55	223.2	551.5	0.4%	167.4	413.6	0.4%	25.0%
B45 Vegetated Wash Complex	478	1873.2	4628.7	3.5%	1385.8	3424.5	3.6%	26.0%
B46 Commercial Development	6	1.4	3.5	0.0%	0.0	0.0	0.0%	100.0%
Total¹	6989	53,201.1	131,463.3		38,057.2	94,042.1		

¹Area totals may vary by 0.1 to 0.2 units due to rounding.

Table 14. Cross-walk of group map classes and base map classes

Group Map Class		Base Map Class
G1	Agriculture	Run-off Control Feature Stock Ponds
G2	Colorado Plateau Mixed Bedrock and Tableland	Cliff-rose - Crispleaf Buckwheat Shrubland Three-leafed Sumac - Mormon Tea Talus shrubland Vegetated Rim Complex
G3	Colorado Plateau Pinyon-Juniper Woodland	One-seed Juniper / Bigelow's Sagebrush Shrubland
G4	Development	Commercial Development
G5	Inter-Mountain Basins Active and Stabilized Dune	Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation Russian Thistle Sand Dune Vegetation
G6	Inter-Mountain Basins Greasewood Flat	Greasewood / New Mexico Saltbush Shrubland Greasewood / Shrubby Seepweed Shrubland Iodine Bush Shrubland
G7	Inter-Mountain Basins Riparian Woodland and Shrubland	Cottonwood / Rubber Rabbitbrush Woodland Coyote Willow Shrubland Tamarisk Shrubland
G8	Inter-Mountain Basins Wash	Barren Wash Copperweed / Alkali Sacaton Shrubland Drummond Goldenweed / Galleta Shrubland Giant Sandreed Desert Wash Shrub Herbaceous Vegetation Rubber Rabbitbrush Desert Wash Shrubland Vegetated Wash Complex
G9	Inter-Mountain Basins Semi-Desert Grassland	Alkali Sacaton - Blue Grama Herbaceous Vegetation Alkali Sacaton Herbaceous Vegetation Black Grama - Galleta Herbaceous Vegetation Blue Grama - Galleta Herbaceous Vegetation Blue Grama Herbaceous Vegetation Galleta - Alkali Sacaton Herbaceous Vegetation Whipple Cholla / Alkali Sacaton Shrub Herbaceous Vegetation
G10	Inter-Mountain Basins Semi-Desert Shrub-Steppe	Torrey's Jointfir – Bigelow's Sagebrush Sparse Vegetation New Mexico Saltbush / Galleta - Alkali Sacaton Shrub Herbaceous Vegetation New Mexico Saltbush Badland Sparse Vegetation Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland Winter-fat / Blue Grama Dwarf-shrub
G11	Inter-Mountain Basins Shale Badland	Arizona Siltbush Sparse Vegetation Barren Badlands Blue Sage Dwarf-shrubland Sand Slender Buckwheat Sparse Dwarf-shrubland Vegetation
G12	Park Facilities	Park Facilities Park Sites
G13	Residential	Residences

Table 14 *continued*

Group Map Class	Base Map Class
G14 Southern Colorado Plateau Sand Shrubland	Four-wing Saltbush / Galleta Shrubland Sandsage Colorado Plateau Shrubland
G15 Transportation	Airstrip Railroads Roads



Figure 11. An example of New Mexico Saltbush / Galleta – Alkali Sacaton Shrub Herbaceous Vegetation at Petrified Forest National Park.



Figure 12. An example of Four-wing Saltbush / Galleta Shrubland at Petrified Forest National Park.



Figure 13. An example of New Mexico Saltbush Badland Sparse Vegetation at Petrified Forest National Park.

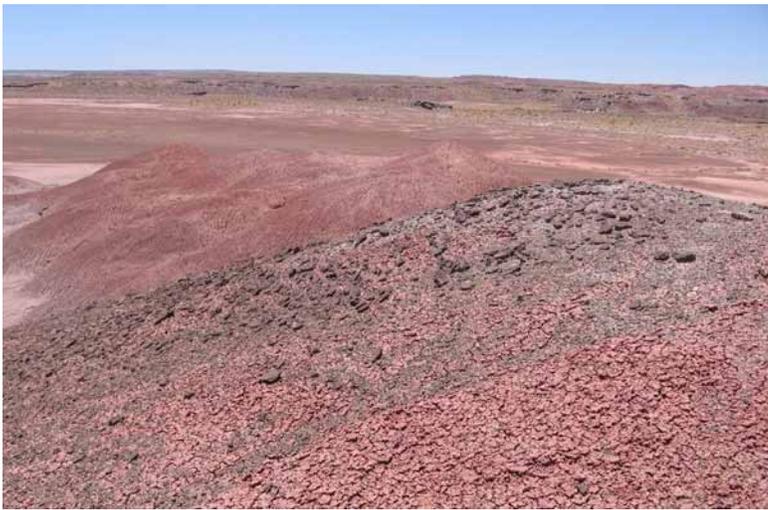


Figure 14. An example of Barren Badlands at Petrified Forest National Park.



Figure 15. An example of Sandsage Colorado Plateau Shrubland at Petrified Forest National Park.



Figure 16. An example of Arizona Silt-bush Sparse Dwarf-Shrubland Vegetation at Petrified Forest National Park.



Figure 17. An example of the base map class Torrey's Jointfir Shrubland – Bigelow's Sagebrush Sparse Vegetation at Petrified Forest National Park.

Table 15. Accuracy statistics for the group map classes.

Group Map Class		User accuracy	90% CI ¹ (range)	Producer accuracy	90% CI (range)
G1	Agriculture	Not sampled		Not sampled	
G2	Colorado Plateau Mixed Bedrock and Tableland	52.9	41.6 - 64.0	73.0	59.7 - 83.1
G3	Colorado Plateau Pinyon-Juniper Woodland	81.8	57.3 - 93.8	100.0	76.9 - 100.0
G4	Development	Not sampled		Not sampled	
G5	Inter-Mountain Basins Active and Stabilized Dune	36.7	26.4 - 48.5	78.3	61.6 - 89.0
G6	Inter-Mountain Basins Greasewood Flat	47.1	36.0 - 58.4	85.7	71.7 - 93.4
G7	Inter-Mountain Basins Riparian Woodland and Shrubland	40.9	25.6 - 58.2	81.8	57.3 - 93.8
G8	Inter-Mountain Basins Wash	66.3	57.7 - 73.9	69.4	60.7 - 76.9
G9	Inter-Mountain Basins Semi-Desert Grassland	69.3	60.8 - 76.7	44.9	38.0 - 51.9
G10	Inter-Mountain Basins Semi-Desert Shrub-Steppe	41.8	34.7 - 49.2	38.1	31.5 - 45.1
G11	Inter-Mountain Basins Shale Badland	60.2	51.5 - 68.4	62.4	53.5 - 70.5
G12	Park Facilities	Not sampled		Not sampled	
G13	Residential	Not sampled		Not sampled	
G14	Southern Colorado Plateau Sand Shrubland	67.8	57.2 - 76.8	55.6	45.9 - 64.8
G15	Transportation	Not sampled		NS	

¹CI = confidence interval

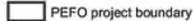
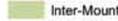
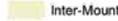
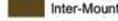
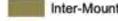
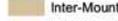
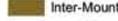
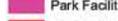
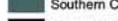
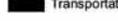
Table 16. Summary statistics for group map classes.

Group Map Class	Project area				Park area			Occurrence outside park boundaries
	# Polygons	ha	ac	% Project land cover	ha	ac	% Park land cover	
G1 Agriculture	27	9.3	23.1	0.0%	0.5	1.3	0.0%	94.3%
G2 Colorado Plateau Mixed Bedrock and Tableland	90	378.5	935.4	0.7%	260.7	644.1	0.7%	31.1%
G3 Colorado Plateau Pinyon-Juniper Woodland	27	211.4	522.3	0.4%	70.8	174.9	0.2%	66.5%
G4 Development	6	1.4	3.5	0.0%	0.0	0.0	0.0%	100.0%
G5 Inter-Mountain Basins Active and Stabilized Dune	377	1631.0	4030.4	3.1%	946.6	2339.1	2.5%	42.0%
G6 Inter-Mountain Basins Greasewood Flat	78	275.8	681.6	0.5%	242.4	599.0	0.6%	12.1%
G7 Inter-Mountain Basins Riparian Woodland and Shrubland	76	183.0	452.2	0.3%	66.0	163.0	0.2%	63.9%
G8 Inter-Mountain Basins Wash	784	2916.1	7205.9	5.5%	2068.4	5111.1	5.4%	29.1%
G9 Inter-Mountain Basins Semi-Desert Grassland	701	5475.0	13529.1	10.3%	2164.7	5349.0	5.7%	60.5%
G10 Inter-Mountain Basins Semi-Desert Shrub-Steppe	2199	21530.6	53203.3	40.5%	17007.4	42026.2	44.7%	21.0%
G11 Inter-Mountain Basins Shale Badland	688	8512.2	21034.2	16.0%	7015.6	17335.9	18.4%	17.6%
G12 Park Facilities	23	16.8	41.4	0.0%	16.8	41.4	0.0%	0.0%
G13 Residential	23	2.4	6.0	0.0%	0.1	0.2	0.0%	96.9%
G14 Southern Colorado Plateau Sand Shrubland	1835	11832.1	29237.7	22.2%	8051.6	19895.9	21.2%	32.0%
G15 Transportation	55	225.4	557.0	0.4%	145.9	360.5	0.4%	35.3%
Total¹	6989	53,201.1	131,463.3		38,057.2	94,041.1		

¹Area totals may vary by 0.1 to 0.2 units due to rounding.

**Petrified Forest National Park
Vegetation Mapping Project
Group Classes**

Petrified Forest National Park

-  NPS roads
-  NPS boundary
-  PEFO project boundary
- PEFO Group Class vegetation polygons**
-  Agriculture
-  Colorado Plateau Mixed Bedrock and Tableland
-  Colorado Plateau Pinyon-Juniper Woodland
-  Development
-  Inter-Mountain Basins Active and Stabilized Dune
-  Inter-Mountain Basins Greasewood Flat
-  Inter-Mountain Basins Riparian Woodland and Shrubland
-  Inter-Mountain Basins Semi-Desert Grassland
-  Inter-Mountain Basins Semi-Desert Shrub-Steppe
-  Inter-Mountain Basins Shale Badland
-  Inter-Mountain Basins Wash
-  Park Facilities
-  Residential
-  Southern Colorado Plateau Sand Shrubland
-  Transportation

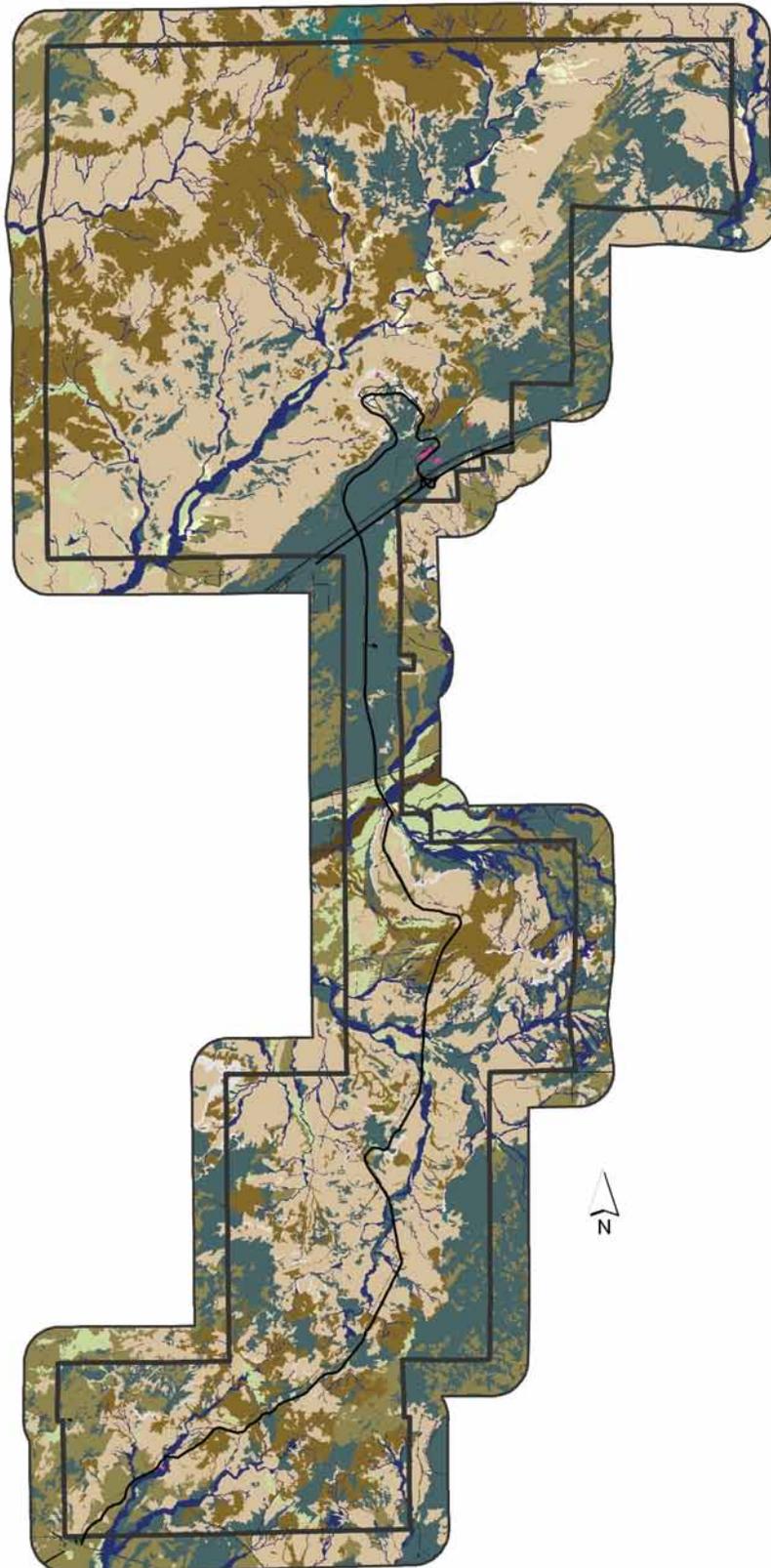


Figure 18. Group map classes for Petrified Forest National Park.

Continued from page 39

4.2.4 Macrogroup Map Class Accuracy and Summary Statistics

4.2.4.1 Accuracy

Thirteen macrogroup map classes (fig. 19; table 17, Appendix F) were created by aggregating the base map classes. The overall accuracy of the group map classes was 73.5%; the kappa index was $62.9\% \pm 0.02$ (table 18, Appendix H3). Colorado Plateau Pinyon-Juniper Woodland met the 80% standard for both user and producer accuracy. Inter-Mountain Basins Greasewood Flat, Inter-Mountain Basins Riparian Woodland and Shrubland, and Inter-Mountain Basins Semi-Desert Grassland and Steppe met the 80% standard for producer accuracy. Inter-Mountain Basins Semi-Desert Grassland and Steppe met the standard for user accuracy. Colorado Plateau Mixed Bedrock and Tableland, Inter-Mountain Basins Wash, and Southern Colorado Plateau Sand Shrubland were below 80% accuracy for both the user and producer accuracy.

4.2.4.2 Summary Statistics

The macrogroup map classes consist of five non-vegetated types and eight vegetative map classes (table 19). Two map classes dominate macrogroup view of park vegetation: 1) Inter-Mountain Basins Semi-Desert Grassland and Steppe (68.8%) and 2) Southern Colorado Plateau Sand Shrubland (21.2%).

4.2.5 Management Map Class Accuracy and Summary Statistics

4.2.5.1 Accuracy

Twenty-four management map classes were created by aggregating the base map classes (fig. 20; table 20, Appendix F). The overall accuracy of the management map classes (table 21, Appendix H4) was 68.6%, with a kappa index of 64.1% and standard error of 0.02. Nine non-vegetated map classes were not assessed. Four of the management map classes met the 80% standard for both user and producer

accuracy, and four met the standard for producer accuracy.

4.2.5.2 Summary Statistics

The 24 management map classes consist of nine non-vegetated classes and 15 vegetated classes (table 22). The three most abundant classes within the park constitute nearly 86% of the park vegetation:

- Badland Sparse Vegetation (32.4%),
- Alkali Sacaton Steppe and Mixed Grasslands (32.1%)
- Sandsage – Fourwing Saltbush Colorado Plateau Shrubland (21.2%)

4.3 Discussion

4.3.1 Challenges

Map class accuracy for PEFO was adversely influenced by several factors including extensive invasive species, vegetation cover and pattern, and the quality of the aerial photography.

Russian thistle (*Salsola tragus*) is an invasive non-native annual forb, which responds rapidly to rain during the growing season forming ephemeral cover. The photointerpreters identified polygons dominated by Russian thistle as the Russian Thistle Sand Dune Vegetation. However, the invasive and annual characteristics of this species caused problems in consistent identification. For example, photointerpretation was often based on identification of the landform type on which infestations of Russian thistle were most evident: sand dunes. These dunes may have a predominance of native vegetation or some infestation of Russian thistle, or may have complete type conversion to Russian thistle. Since Russian thistle is an annual, degraded dunes may appear as bare or with low cover of native vegetation during many months of the year.

The Russian thistle dries into a brittle skeleton that may blow away or may remain for many seasons. The accuracy

Table 17. Cross-walk of macrogroup map classes to base map classes.

Macrogroup Map Class		Base Map Class
MG1	Agriculture	Run-off Control Feature Stock Ponds
MG2	Colorado Plateau Mixed Bedrock and Tableland	Cliff-rose - Crispleaf Buckwheat Shrubland Three-leafed Sumac - Mormon Tea Talus shrubland Vegetated Rim Complex
MG3	Colorado Plateau Pinyon-Juniper Woodland	One-seed Juniper / Bigelow's Sagebrush Shrubland
MG4	Development	Commercial Development
MG5	Inter-Mountain Basins Active and Stabilized Dune	Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation Russian Thistle Sand Dune Vegetation
MG6	Inter-Mountain Basins Greasewood Flat	Greasewood / New Mexico Saltbush Shrubland Greasewood / Shrubby Seepweed Shrubland Iodine Bush Shrubland
MG7	Inter-Mountain Basins Riparian Woodland and Shrubland	Cottonwood / Rubber Rabbitbrush Woodland Coyote Willow Shrubland Tamarisk Shrubland
MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	Alkali Sacaton - Blue Grama Herbaceous Vegetation Alkali Sacaton Herbaceous Vegetation Arizona Siltbush Sparse Vegetation Barren Badlands Torrey's Jointfir – Bigelow's Sagebrush Sparse Vegetation Black Grama - Galleta Herbaceous Vegetation Blue Grama - Galleta Herbaceous Vegetation Blue Grama Herbaceous Vegetation Blue Sage Dwarf-shrubland Galleta - Alkali Sacaton Herbaceous Vegetation New Mexico Saltbush / Galleta - Alkali Sacaton Shrub Herbaceous Vegetation New Mexico Saltbush Badland Sparse Vegetation Sand Slender Buckwheat Sparse Dwarf-shrubland Vegetation Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland Whipple Cholla / Alkali Sacaton Shrub Herbaceous Vegetation Winter-fat / Blue Grama Dwarf-shrub
MG9	Inter-Mountain Basins Wash	Barren Wash Copperweed / Alkali Sacaton Shrubland Drummond Goldenweed / Galleta Shrubland Giant Sandreed Desert Wash Shrub Herbaceous Vegetation Rubber Rabbitbrush Desert Wash Shrubland Vegetated Wash Complex
MG10	Park Facilities	Park Facilities Park Sites
MG11	Residential	Residences
MG12	Southern Colorado Plateau Sand Shrubland	Four-wing Saltbush / Galleta Shrubland Sandsage Colorado Plateau Shrubland

Table 17 *continued*

Macrogroup Map Class		Base Map Class
MG13	Transportation	Airstrip Railroad Roads

Table 18. Accuracy statistics for macrogroup map class.

Macrogroup Map Class		User accuracy	90% CI ¹ (range)	Producer accuracy	90% CI (range)
MG1	Agriculture	Not sampled		Not sampled	
MG2	Colorado Plateau Mixed Bedrock and Tableland	52.9	41.6 - 64.0	77.1	63.8 - 86.6
MG3	Colorado Plateau Pinyon-Juniper Woodland	81.8	57.3 - 93.8	100.0	76.9 - 100.0
MG4	Development	Not sampled	Not sampled	Not sampled	Not sampled
MG5	Inter-Mountain Basins Active and Stabilized Dune	36.7	26.4 - 48.5	81.8	65.1 - 92.6
MG6	Inter-Mountain Basins Greasewood Flat	47.1	36.0 - 58.4	85.7	71.7 - 93.4
MG7	Inter-Mountain Basins Riparian Woodland and Shrubland	40.9	25.6 - 58.2	81.8	57.3 - 93.8
MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	93.0	90.1 - 95.0	77.2	73.3 - 80.6
MG9	Inter-Mountain Basins Wash	66.3	57.5 - 73.9	69.4	60.7 - 76.9
MG10	Park Facilities	Not sampled		Not sampled	
MG11	Residential	Not sampled		Not sampled	
MG12	Southern Colorado Plateau Sand Shrubland	67.8	57.2 - 76.8	56.3	46.6 - 65.6
MG13	Transportation	Not sampled		Not sampled	

¹CI = confidence interval

Table 19. Summary statistics for macrogroup map classes.

Macrogroup map class		Project area				Park area			Occurrence outside park boundaries
		# Poly-gons	Ha	Ac	% Project land cover	Ha	Ac	% Park land cover	
MG1	Agriculture	27	9.3	23.1	0.0%	0.5	1.3	0.0%	94.3%
MG2	Colorado Plateau Mixed Bedrock and Tableland	90	378.5	935.4	0.7%	260.7	644.1	0.7%	31.1%
MG3	Colorado Plateau Pinyon-Juniper Woodland	27	211.4	522.3	0.4%	70.8	174.9	0.2%	66.5%
MG4	Development	6	1.4	3.5	0.0%	0.0	0.0	0.0%	100.0%
MG5	Inter-Mountain Basins Active and Stabilized Dune	377	1631.0	4030.4	3.1%	946.6	2339.1	2.5%	42.0%
MG6	Inter-Mountain Basins Greasewood Flat	78	275.8	681.6	0.5%	242.4	599.0	0.6%	12.1%
MG7	Inter-Mountain Basins Riparian Woodland and Shrubland	76	183.0	452.2	0.3%	66.0	163.0	0.2%	63.9%
MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	3588	35517.9	87766.6	66.8%	26187.7	64711.1	68.8%	26.3%
MG9	Inter-Mountain Basins Wash	784	2916.1	7205.9	5.5%	2068.4	5111.1	5.4%	29.1%
MG10	Park Facilities	23	16.8	41.4	0.0%	16.8	41.4	0.0%	0.0%
MG11	Residential	23	2.4	6.0	0.0%	0.1	0.2	0.0%	96.9%
MG12	Southern Colorado Plateau Sand Shrubland	1835	11832.1	29237.7	22.2%	8051.6	19895.9	21.2%	32.0%
MG13	Transportation	55	225.4	557.0	0.4%	145.9	360.5	0.4%	35.3%
Total¹		6989	53,201.2	131,463.1		38,057.5	94,041.9		

¹Area totals may vary by 0.1 to 0.2 units due to rounding.

**Petrified Forest National Park
Vegetation Mapping Project
Macrogroup Classes**

Petrified Forest National Park

- NPS roads
- ▭ NPS boundary
- ▭ PEFO project boundary
- PEFO Macrogroup Class vegetation polygons**
- Agriculture
- Colorado Plateau Mixed Bedrock and Tableland
- Colorado Plateau Pinyon-Juniper Woodland
- Development
- Inter-Mountain Basins Active and Stabilized Dune
- Inter-Mountain Basins Greasewood Flat
- Inter-Mountain Basins Riparian Woodland and Shrubland
- Inter-Mountain Basins Semi-Desert Grassland and Steppe
- Inter-Mountain Basins Wash
- Park Facilities
- Residential
- Southern Colorado Plateau Sand Shrubland
- Transportation

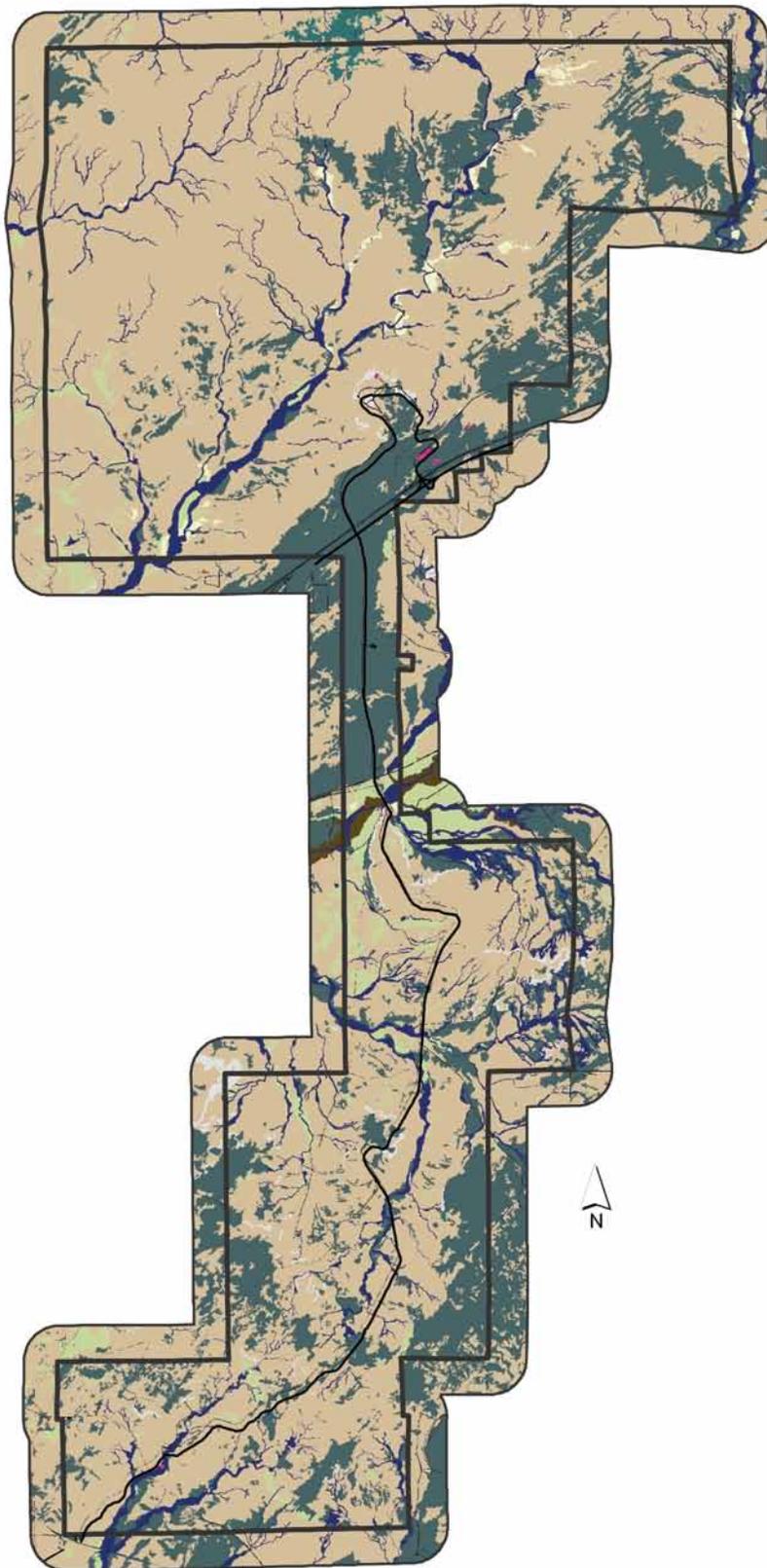


Figure 19. Macrogroup map classes for Petrified Forest National Park.

Table 20. Cross-walk of management to base map classes.

Management Map class		Base Map class
MN1	Airstrip	Airstrip
MN2	Alkali Sacaton Steppe and Mixed Grasslands	Alkali Sacaton - Blue Grama Herbaceous Vegetation Alkali Sacaton Herbaceous Vegetation Black Grama - Galleta Herbaceous Vegetation Galleta - Alkali Sacaton Herbaceous Vegetation New Mexico Saltbush / Galleta - Alkali Sacaton Shrub Herbaceous Vegetation Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland Whipple Cholla / Alkali Sacaton Shrub Herbaceous Vegetation
MN3	Badland Sparse Vegetation	Arizona Siltbush Sparse Vegetation Barren Badlands New Mexico Saltbush Badland Sparse Vegetation
MN4	Barren Wash	Barren Wash
MN5	Blue Grama Steppe and Mixed Grasslands	Blue Grama - Galleta Herbaceous Vegetation Blue Grama Herbaceous Vegetation Winter-fat / Blue Grama Dwarf-shrub
MN6	Blue Sage Dwarf-shrubland	Blue Sage Dwarf-shrubland
MN7	Cliff-rose - Crispleaf Buckwheat Shrubland	Cliff-rose - Crispleaf Buckwheat Shrubland
MN8	Commercial Development	Commercial Development
MN9	Cottonwood / Rubber Rabbitbrush Woodland	Cottonwood / Rubber Rabbitbrush Woodland
MN10	Coyote Willow Shrubland	Coyote Willow Shrubland
MN11	Greasewood Flats	Greasewood / New Mexico Saltbush Shrubland Greasewood / Shrubby Seepweed Shrubland Iodine Bush Shrubland
MN12	One-seed Juniper / Bigelow's Sagebrush Shrubland	One-seed Juniper / Bigelow's Sagebrush Shrubland
MN13	Park Facilities	Park Facilities
MN14	Park Sites	Park Sites
MN15	Railroad	Railroad
MN16	Residences	Residences
MN17	Roads	Roads
MN18	Run-off Control Feature	Run-off Control Feature
MN19	Russian Thistle Sand Dune Vegetation	Russian Thistle Sand Dune Vegetation
MN20	Sand / Mudflat	Sand
MN21	Sandsage - Fourwing Saltbush Colorado Plateau Shrubland	Four-wing Saltbush / Galleta Shrubland Sandsage Colorado Plateau Shrubland
MN22	Stock Ponds	Stock Ponds
MN23	Vegetated Rim Complex	Torrey's Jointfir – Bigelow's Sagebrush Sparse Vegetation Slender Buckwheat Sparse Dwarf-shrubland Vegetation Three-leafed Sumac - Mormon Tea Talus shrubland Vegetated Rim Complex

Table 20 *continued*

Management Map Class	Base Map Class
MN24 Vegetated Wash Complex	Copperweed / Alkali Sacaton Shrubland Drummond Goldenweed / Galleta Shrubland Giant Sandreed Desert Wash Shrub Herbaceous Vegetation Rubber Rabbitbrush Desert Wash Shrubland Tamarisk Shrubland Vegetated Wash Complex

Table 21. Accuracy assessment statistics for management map classes.

Management Map Class		User accuracy	90% CI¹ (range)	Producer accuracy	90% CI (range)
MN1	Airstrip	Not sampled		Not sampled	
MN2	Alkali Sacaton Steppe and Mixed Grasslands	73.0	66.9 - 78.3	64.0	58.0 - 69.5
MN3	Badland Sparse Vegetation	71.0	62.7 - 78.0	72.5	64.6 - 79.5
MN4	Barren Wash	70.8	54.1 - 83.3	85.0	67.8 - 93.8
MN5	Blue Grama Steppe and Mixed Grasslands	40.0	22.3 - 60.7	27.3	14.8 - 44.7
MN6	Blue Sage Dwarf-shrubland	100.0	68.9 - 100.0	100.0	68.9 - 100.0
MN7	Cliff-rose - Crispleaf Buckwheat Shrubland	66.7	43.1 - 84.1	88.9	62.3 - 97.5
MN8	Commercial Development	Not sampled		Not sampled	
MN9	Cottonwood / Rubber Rabbitbrush Woodland	100.0	42.5 - 100.0	66.7	25.4 - 92.2
MN10	Coyote Willow Shrubland	100.0	27.0 - 100.0	100.0	27.0 - 100.0
MN11	Greasewood Flats	47.1	36.0 - 58.4	85.7	71.7 - 93.4
MN12	One-seed Juniper / Bigelow's Sagebrush Shrubland	81.8	57.3 - 93.8	100.0	76.9 - 100.0
MN13	Park Facilities	Not sampled		Not sampled	
MN14	Park Sites	Not sampled		Not sampled	
MN15	Railroad	Not sampled		Not sampled	
MN16	Residences	Not sampled		Not sampled	
MN17	Roads	Not sampled		Not sampled	
MN18	Run-off Control Feature	Not sampled		Not sampled	
MN19	Russian Thistle Sand Dune Vegetation	50.0	32.7 - 67.3	55.6	36.9 - 72.8
MN20	Sand / Mudflat	100.0	42.5 - 100.0	100.0	42.5 - 100.0
MN21	Sandsage - Fourwing Saltbush Colorado Plateau Shrubland	67.8	57.3 - 76.8	55.6	45.9 - 64.8
MN22	Stock Ponds				
MN23	Vegetated Rim Complex	72.4	63.9 - 79.5	77.8	69.0 - 84.2
MN24	Vegetation Wash Complex	70.2	61.5 - 77.7	80.8	72.2 - 87.2

¹CI = confidence interval

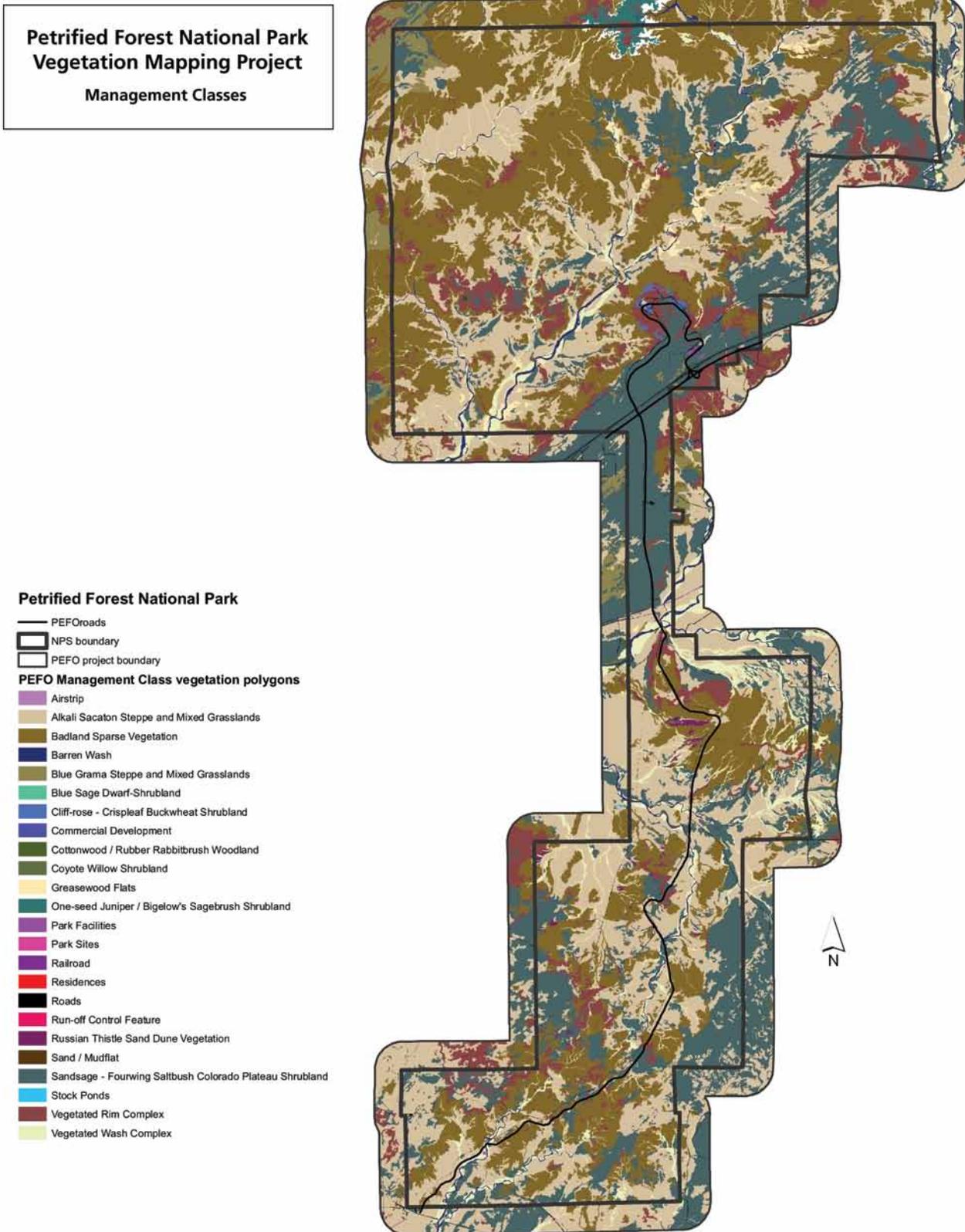


Figure 20. Management map classes for Petrified Forest National Park.

Table 22. Summary statistics for management map classes.

Management Map Class		Project area				Park area			Outside park boundaries
		# Polygons	Ha	Ac	% Project land cover	Ha	Ac	% park land cover	
MN1	Airstrip	1	2.6	6.5	0.0%			0.0%	100.0%
MN2	Alkali Sacaton Steppe and Mixed Grasslands	1740	17684.9	43700.3	33.2%	12224.6	30207.6	32.1%	30.9%
MN3	Badland Sparse Vegetation	1423	15088.2	37283.7	28.4%	12327.7	30462.5	32.4%	18.3%
MN4	Barren Wash	47	498.7	1232.4	0.9%	319.4	789.1	0.8%	36.0%
MN5	Blue Grama Steppe and Mixed Grasslands	60	808.2	1997.0	1.5%	181.5	448.6	0.5%	77.5%
MN6	Blue Sage Dwarf-shrubland	12	122.8	303.5	0.2%	69.2	171.0	0.2%	43.7%
MN7	Cliff-rose - Crispleaf Buckwheat Shrubland	11	57.1	141.1	0.1%	57.1	141.1	0.2%	0.0%
MN8	Commercial Development	6	1.4	3.5	0.0%	0.0	0.0	0.0%	100.0%
MN9	Cottonwood / Rubber Rabbitbrush Woodland	11	15.2	37.6	0.0%	1.7	4.3	0.0%	88.5%
MN10	Coyote Willow Shrubland	6	13.2	32.5	0.0%	2.2	5.4	0.0%	83.4%
MN11	Greasewood Flats	78	275.8	681.6	0.5%	242.4	599.0	0.6%	12.1%
MN12	One-seed Juniper / Bigelow's Sagebrush Shrubland	27	211.4	522.3	0.4%	70.8	174.9	0.2%	66.5%
MN13	Park Facilities	21	16.0	39.5	0.0%	16.0	39.5	0.0%	0.0%
MN14	Park Sites	2	0.8	1.9	0.0%	0.8	1.9	0.0%	0.0%
MN15	Railroad	2	5.2	12.9	0.0%	2.3	5.7	0.0%	56.0%
MN16	Residences	23	2.4	6.0	0.0%	0.1	0.2	0.0%	96.9%
MN17	Roads	52	217.6	537.6	0.4%	143.6	354.9	0.4%	34.0%
MN18	Run-off Control Feature	2	0.5	1.3	0.0%	0.5	1.3	0.0%	0.0%
MN19	Russian Thistle Sand Dune Vegetation	39	100.7	248.9	0.2%	95.9	236.9	0.3%	4.8%
MN20	Sand / Mudflat	2	2.8	6.9	0.0%	2.8	6.9	0.0%	0.0%
MN21	Sandsage - Fourwing Saltbush Colorado Plateau Shrubland	1835	11832.1	29237.7	22.2%	8051.6	19895.9	21.2%	32.0%
MN22	Stock Ponds	25	8.8	21.8	0.0%			0.0%	100.0%
MN23	Vegetated Rim Complex	768	3662.8	9051.0	6.9%	2436.1	6019.8	6.4%	33.5%
MN24	Vegetated Wash Complex	796	2572.0	6355.6	4.8%	1811.1	4475.3	4.8%	29.6%
Total¹		6989	53,201.2	131,463.1		38,057.4	94,041.8		

¹Area totals may vary by 0.1 to 0.2 units due to rounding.

assessment crew, who sampled in the fall following a drier summer monsoon season, often found these skeletons on sand dunes and were instructed to assess the underlying vegetation. Summer monsoon rainfall in 2005, the year before accuracy assessment, had resulted in prolific growth of Russian thistle where it occurred in the seed bank. The skeletons that the accuracy assessment crew viewed probably remained from that infestation event. Half of the polygons mapped as Russian Thistle Sand Dune Vegetation were assessed in the field as another map class; however, Russian thistle was commonly found at these sites. Conversely, polygons in the field identified as Russian Thistle Sand Dune Vegetation in the photointerpretation frequently supported native vegetation and were field identified as Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation or Four-wing Saltbush / Galleta Shrubland.

The vegetation at PEFO has few distinct boundaries between types, particularly those types that are composed of grasses with shrubs. There is a gradient in grass cover as well as shrub cover. The grass species and the shrub species are not readily distinguishable using aerial photography; in fact, some species are not even readily distinguishable even when you are beside the species in the field. Compounding this is the mosaic pattern that often occurs with shrub distribution.

The cover of shrubs can vary at a grain finer than the minimum-mapping unit (.5 ha). These mosaics of varying shrub density make the assignment of map classes difficult between the field and a photo-interpretation assessment. This results in field assessments that may be based on dominant species cover whereas the photo-interpretation assessments might be based on diagnostic or indicator species as the only distinguishable community characteristic on the aerial photo.

Sparse vegetation at PEFO is often so

sparse that indicator species used to distinguish the community may not be apparent during accuracy assessment but may still be present in the map polygon. Frequently vegetation at PEFO, even in the more densely vegetated areas, has less than 25% cover. This makes it difficult to determine on the ground as well as from the aerial photo when a species is co-dominant or dominant since the determination relies on assessing relative differences of less than 5% cover. Patchiness in vegetation cover, as discussed above, further confounds the determination. The accuracy-assessment field team assessed a minimum mapping unit within the polygon whereas the photointerpreter delineated the entire polygon.

The vegetation at PEFO displays a surprising amount of variability in appearance, considering that it is largely composed of perennial shrubs and grasses. When dormant, grasses are brown and diminished in volume compared to their non-dormant aspect. Shrubs also can lose leaves and fade in color during drought. Variation in annual rainfall and variation in the seasonal timing and amounts of winter, spring and summer monsoonal rains greatly influence the visual aspect of the PEFO vegetation. These climatic factors influenced the ground appearance of the plant communities during the fieldwork of 1996 and 2003, the photointerpretation data collection in 2004-2006, and the accuracy-assessment data collection in 2006. Additionally, the photointerpretation team was mapping conditions present on aerial photography acquired earlier than the field observations, which introduces some potential of a mismatch between ground conditions and the imagery. These changes are difficult to account for in the development of the map and in assessing the map accuracy.

The photosignatures of some map classes, such as in the badlands, were masked by the strong spectral signature of bare soil. Where this happened, the

photointerpreters often used landform signatures to map the vegetation rather than vegetation signatures. Grasslands with mixed grass species were also difficult to interpret due to the similarity in the tone and texture of the different grass species. The communities with similar grass compositions were difficult to pick out on the photography as unique vegetation communities.

distribution, and mapping projects to conduct activities related to resource management, environmental compliance, planning (locating new features), fire management planning, habitat modeling, education and interpretation, inventory and monitoring (placement of sample sites), research, and cooperative work with adjacent land owners.

However, the accuracy assessment metrics presented here allow a user of the vegetation map database to evaluate the performance of each map-class schema. Additional information can be gained on the sources of confusion between the map classes using the contingency tables in Appendix H.

Ancillary products related to accuracy assessment include Appendix D (all field species including those identified within accuracy-assessment observation sites) and Appendix E (field sheets used for observations).

4.3.2 Uses and Limitations of the Vegetation Map Database and Affiliated Products

The vegetation map database provides four representations of the PEFO vegetation. The finest thematic resolution, represented by the base map classes, offers the best spatial detail with the lowest accuracy. The group, macrogroup, and management map classes represent the vegetation at coarser thematic resolution but with greater accuracy. Each representation provides information, and the representation chosen for any particular objective should be evaluated using the accuracy assessment and summary statistics tables provided in this report.

The vegetation map database and ancillary products produced during the project can provide both background and direct input to a number of park and SCPN activities. Other national park units have used products from vegetation classification,

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Glossary

Glossary modified from USGS-NPS Vegetation Mapping Program: <http://biology.usgs.gov/npsveg/glossary.html>.

Accuracy: The closeness of results of observations, computations, or estimates to the true values or to values that are accepted as being true (Rabchevsky 1984). In the USGS-NPS Vegetation Mapping Program there are two aspects of accuracy: thematic and positional accuracy.

Accuracy assessment: The process of determining the positional and thematic accuracy of the spatial vegetation community data. This is an independent process performed after the vegetation mapping and classification is complete.

Accuracy assessment point: A location where accuracy assessment data are collected.

Aerial photography: Analog imagery taken from an airplane. The optical axis is oriented perpendicular to the earth's surface so that the film is parallel to the surface being photographed. (also Vertical Aerial Photography). A sequence of aerial photographs will overlap so the photos can be used in stereoscopic analysis (stereo pairs). The overlap is referred to as "endlap" (top-to-bottom area in common, same flightline) and "sidelap" (side-to-side area in common, different flightlines) (portions from Rabchevsky 1984). Aerial photography used in the program is 9 × 9-inch vertical, stereoscopic, color or color infrared photography.

Alliance: A physiognomically uniform group of associations sharing one or more diagnostic (dominant, differential, indicator, or character) species that, as a rule, are found in the uppermost stratum of the vegetation (FGDC 1997). This is the second-finest level in the National Vegetation Classification Standard hierarchy. See the table under USNVC.

Anderson Classification System: A land cover/land use classification system

developed for use with remote sensing systems in the 1970s adopted for the USGS-NPS Vegetation Mapping Program to map cultural land cover (Anderson et al. 1976); see below.

Anderson Classification System.

Level I	Level II
Urban or Built-up Land	Residential Commercial and Services Industrial Transportation, Communications, and Utilities Industrial and Commercial Complexes Mixed Urban or Built-up Land Other Urban or Built-up Land
Agricultural Land	Cropland and Pasture Orchard, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas Confined Feeding Operations Other Agricultural Lands
Water (non-vegetated portion)	Streams and Canals Lakes Reservoirs Bays and Estuaries
Barren Land	Dry Salt Flats Beaches Sandy Areas other than Beaches Strip Mines, Quarries, and Gravel Pits Transitional Areas Mixed Barren Lands
Perennial Snow or Ice	Perennial Snowfields Glaciers

Note: This is not the complete Anderson Level II Classification. Areas of natural vegetation are classified under the NVCS.

Association: The finest level of the National Vegetation Classification Standard. The association is a physiognomically uniform group of vegetation stands that share one or more diagnostic (dominant, differential,

indicator, or character) overstory and understory species. These elements occur as repeatable patterns of assemblages across the landscape, and are generally found under similar habitat conditions (FGDC 1997). See table under USNVC an example. Within the program association is the preferred term, but it is also synonymous with community, community type, plant community, type, vegetation community, and vegetation type.

Attribute: (digital data) A numeric, text, or image data field in a relational database table (such as a GIS) that describes a spatial feature (point, line, polygon, cell) (ESRI 1994).

Automate: The process of entering data into a computer. Synonymous with digitize.

Base map: The source or control from which all spatial data are developed and geo-referenced to. Photo interpreted data are transferred to a base to rectify and register the data. For this program, base maps consist of USGS DOQQs or specially made orthophotos.

Class: The level in the National Vegetation Classification Standard hierarchy based on the structure of the vegetation and determined by the relative percentage of cover and the height of the dominant, uppermost life forms (Grossman et al. 1998). See the table under USNVC.

Classification accuracy: How closely the map classes match the vegetation communities found on the landscape. This is determined by accuracy assessment protocols. See “Producing rigorous and consistent accuracy assessment procedures” at <http://biology.usgs.gov/npsveg/aa/index.html> for more information. Also see producer and user accuracy.

Community: An assemblage of species that co-occur in defined areas at certain times and have the potential to interact with one another (Grossman et al. 1998). May also refer to an association in the

USNVC, but this is not preferred.

Contingency table: A table that compares mapped data with ground data to determine accuracy. The “known” classes derived from accuracy assessment plots are compared to the classes derived from photo interpretation. The results are then tabulated in the form of a contingency table to determine the degree of misclassification that has occurred between classes. Also referred to as error matrix, confusion matrix, or misclassification matrix. For an example of a contingency table see http://biology.usgs.gov/npsveg/scbl/aa_matrix.html.

Cover: The area of ground covered by the vertical projection of the aerial parts of plants of one or more species. (FGDC 1997).

Cover type: A designation based upon the plant species forming a plurality of composition within a given area (e.g., Oak–Hickory) (FGDC 1977). Also refers to an alliance or group of alliances in the USNVC.

Coverage: A file format used by Arc/Info software for vector spatial data.

Crosswalk: Relationship between the elements of two classification systems. For example, there is a crosswalk between map classes and units of the NVCS. This relationship is often shown in a look up table.

Datum: A mathematical model that describes the size and shape of the ellipsoid. The earth is not a sphere, but an ellipsoid distorted by rotation about its axis, with the globe bulging at the equator and flattened at the poles. The flattening is not uniform around the Earth due to the influence of the continents location (Snyder 1982). Using the wrong datum in relation to geographic coordinates can result in errors of hundreds of meters in position. This Program uses the North American Datum (NAD) of 1983 or NAD83.

Density: The relationship between the area covered by the overstory of a vegetation community and the total area of a polygon in which the community is found. One of the physiognomic modifiers classified in the USGS-NPS Vegetation Mapping Program. Density in map units is classified as Closed/Continuous >60 %, Discontinuous 40–60%, Dispersed 25–40%, Sparse 10–25%, Rare 2–10%. Compare with pattern and height.

Dichotomous field key: A document that identifies vegetation communities on the basis of exclusive characteristics. An example of exclusive characteristics is forested versus non-forested. Also known as vegetation field key and vegetation key. This key is an important product of each vegetation-mapping project. For an example of a dichotomous field key visit <http://biology.usgs.gov/npsveg/agfo/report.pdf#vegkey>.

Digital Orthophoto Quarter Quadrangle (DOQQ): USGS digital product derived from high altitude aerial photography. These digital images are rectified and registered to locations on the earth and cover approximately one quarter of a 7.5-minute quadrangle. Also called 3.75-minute DOQ. DOQs are often used as base maps to register the photo interpreted data in this program.

Digitize: The process of entering data into a computer. There are several methods of entering spatial data into a computer including manual digitizing, scan digitizing, and soft copy photogrammetric methods. Synonymous with automate.

Division: The highest level in the NVCS separating Earth cover into either vegetated or non-vegetated categories (FGDC 1997). See table under USNVC.

Dominance: The extent to which a given species or life form predominates in a community because of its size, abundance or cover, and affects the fitness of associated species (FGDC 1997).

Error: The distance of results of

observations, computations, or estimates from the true values or to values that are accepted as being true. Also refers to the misclassification of thematic data. Contrast with accuracy.

Error matrix: See contingency table.

Federal Geographic Data Committee (FGDC): Coordinates the development of the National Spatial Data Infrastructure (NSDI). The NSDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data. The 17 federal agencies that make up the FGDC are developing the NSDI in cooperation with organizations from state, local and tribal governments, the academic community, and the private sector. The program complies with FGDC standards for vegetation classification, metadata, spatial data transfer, and positional accuracy.

Field reconnaissance: Preliminary field visits by photo interpreters and vegetation classification experts to gain an overview of the vegetation of the project area and how it relates to the NVCS. Communication between photo interpreters and vegetation classification experts during this fieldwork is key to developing an accurate classification system. Observation point data are collected during this reconnaissance.

Field verification: Field visits by photo interpreters after photo interpretation is complete to check for correctness of photo interpretation. At this point changes may be made to the photo interpretation. This occurs prior to accuracy assessment.

Flight line: Refers to a line or strip of aerial photography. Usually designated on the film as “flightline number – photo number”. Technical: A line connecting the principal points of sequential vertical aerial photographs (portions from Rabchevsky 1984)

Floristics: The kinds and number of plant species in particular areas and their distribution.

Formation: A level in the National Vegetation Classification Standard hierarchy below subgroup which represents vegetation types that share a definite physiognomy or structure within broadly defined environmental factors, relative landscape positions, or hydrologic regimes (Grossman et al. 1998). See table under USNVC.

Geographic Information System (GIS): An organized collection of geographically (spatially) referenced information (portions from ESRI 1994).

Georeference: The process of converting a map or image into real-world coordinates. A non-georeferenced map or image is said to be in “digitizer-inches” or “scanner-inches,” that is, it has no real-world coordinates.

Global Positioning System (GPS): A system of satellites, ground receiving stations and handheld receivers that allow accurate measurement of feature coordinates on the face of the earth. GPS receivers are used to measure the location of field plots, reconnaissance points, and accuracy assessment points.

Ground truth: The process of taking aerial photographs into the field to verify the ground condition compared to how that condition appears in the photograph.

Group: The level in the National Vegetation Classification Standard hierarchy below subclass based on leaf characteristics and identified and named in conjunction with broadly defined macroclimatic types to provide a structural-geographic orientation (Grossman et al. 1998). See table under USNVC.

Habitat: The combination of environmental or site conditions and ecological processes influencing a plant community.

Habitat type: (1) a collective term for all parts of the land surface supporting, or capable of supporting, the same kind of

climax plant association (Daubenmire 1978); (2) an aggregation of land areas having a narrow range of environmental variation and capable of supporting a given plant association (Gabriel and Talbot 1984).

Hectare: A metric unit of measure equal to 10,000 m², or approximately 2.471 acres.

Height: Height of the overstory of a vegetation community. One of the physiognomic modifiers classified in the USGS-NPS Vegetation Mapping Program. Height in map units is classified as <0.5 meters, 0.5–2 meters, 2–5 meters, 5–15 meters, 15–35 meters, 35–50 meters, or >50 meters. Compare with density and pattern.

Integrated Taxonomic Information System (ITIS): A comprehensive, standardized reference for the scientific names, and synonyms and common names, for all the plants and animals and other biological organisms of North America and the surrounding oceans developed and maintained by an international partnership among agencies, organizations, and taxonomic specialists. This database is accessible over the Internet and is used by scientists, resource managers, educators and students, museum curators, conservationists, and the interested public. The USDA PLANTS database (<http://plants.usda.gov/>) is an important ITIS partner providing plant taxonomic information to ITIS (<http://www.itis.gov/>).

Land cover classification: A classification of the cultural, physical, and vegetation features that cover the earth, commonly used with remote sensing technology. Vegetation classification is a subset of land cover classification.

Land use classification: A classification of the earth’s surface that defines the use that people are making of the land, commonly used with remote sensing technology, and commonly combined with land cover classification. Natural vegetation areas may be classified as “vacant” or “forest,” or “grazing”.

Land use/Land cover classification: A combination of a land use classification and land cover classification where the land use classification is used to classify areas that are under a definite land use, such as agriculture, residential, or mining. The land cover classification is used to classify lands that do not have definite land use, such as areas of bare rock, snow and ice, or open water. The Anderson Classification System is a land cover and land use classification.

Look-up table: A computer file that relates the elements of one classification to another in a crosswalk. The values of a map classification are related to the associations of the NVCS in a park project.

Map accuracy: A measure of the maximum errors permitted in horizontal positions and elevations shown on maps. The National Map Accuracy Standard of the USGS at 1:24,000 scale is the map accuracy standard for the program. This standard is that 90% of well-defined objects should appear within 40 feet (12.2 meters) of their true location. See United States National Map Accuracy Standards.

Map attribute: Collectively the map class (or map unit) code, the physiognomic modifier codes, and special modifiers if they are used: map unit code is that portion of the map attribute code defining the map unit (e.g., AB) the physiognomic modifier code portion of map attribute code defining the vegetation community's structure (e.g. -1A3). The map attribute code is thus AB-1A3.

Map class: The vegetation units that can be discerned on an aerial photograph. Often associations in an alliance cannot be distinguished on an aerial photograph because the differences are found in the understory, so map classes must be developed. For example, at Devils Tower National Monument, there were five associations in the Ponderosa Pine Woodland Alliance, but it was necessary to create two ponderosa pine map classes because the associations could not be

distinguished on the photography. Map classes may be complexes or mosaics of associations or map classes may also be the same as an association if that can be discerned on the photograph. Also known as map unit.

Map unit: See map class.

Map validation: The process of field checking and updating photo interpretation. This step is completed prior to accuracy assessment.

Metadata: Data about data. Metadata describes the content, quality, condition, and other characteristics of data. Its purpose is to help organize and maintain a organization's internal investment in spatial data, provide information about an organization's data holdings to data catalogues, clearinghouses, and brokerages, and provide information to process and interpret data received through a transfer from an external source (FGDC 1997). The FGDC sets standards for metadata content and structure.

Minimum Mapping Unit (MMU): The smallest area that will be consistently delineated during photo interpretation. The MMU for the USGS-NPS Vegetation Mapping Program is 0.5 hectares.

National Vegetation Classification Standard (NVCS): The Federal Geographic Data Committee's vegetation classification standard. It has been adopted to the formation level (as of June 2001); adoption of the floristic levels is pending. It is based on the Association for Biodiversity Information's United States National Vegetation Classification (USNVC) system. See table under USNVC for comparison and crosswalk.

NatureServe Explorer: A website managed by NatureServe that provides authoritative conservation information in a searchable database for more than 50,000 plants, animals, and ecological communities in the U.S. and Canada. Vegetation community data developed by the USGS-NPS Program is available

on NatureServe (URL is <http://www.natureserveexplorer.org/>).

North American Datum (NAD):

The datum for map projections and coordinates throughout North America (see also datum). Usually associated with a version, such as 1927 or 1983. This program uses the 1983 datum (NAD83), which is consistent with satellite location systems. The 1983 datum uses the GRS 80 spheroid whereas the 1927 datum uses the Clarke 1866 spheroid (portions from ESRI 1994).

Observation point: A field location point used to support map unit and vegetation classification development. These points are collected during reconnaissance and the mappers' subsequent fieldwork.

Order: The second-highest level in the NVCS hierarchy under Division. The orders within the Vegetated Division are generally defined by dominant life form (tree, shrub, dwarf shrub, herbaceous, or non-vascular). (FGDC 1997). See table under USNVC.

Ortho image: An aerial photograph that has had the distortions due to camera lens, topographic relief, tilt of the aircraft, and other factors common to aerial photography removed and has been registered to locations on the earth. A digital ortho image can be placed in a GIS and have other layers, such as vegetation, overlain on it. Aerial photo interpretation can also be registered to an ortho image in the process of registering and automating the data into a GIS. A DOQ is a digital ortho image covering 3.75 minutes by 3.75 minutes of the earth's surface.

Pattern: Configuration of vegetation features or across a landscape. One of the physiognomic modifiers classified in the USGS-NPS Vegetation Mapping Program. Pattern in map units is classified as Evenly Dispersed, Clumped/Bunched, Gradational/Transitional, Alternating. Compare with density and height.

Photo interpretation: The art and science

of identifying and delineating objects on an aerial photograph. Photo interpreters in the USGS-NPS Vegetation Mapping Program are knowledgeable about the vegetation in their project area and highly skilled in identifying vegetation map units accurately and consistently.

Photo interpretation key: A description of the distinguishing features that make up the signature of each map class. This description may include written clues, as well as graphic examples of the signatures.

Photosignature: Characteristics of an item on a photograph by which the item may be identified.

Physiognomy: The structure and life form of a plant community (FGDC 1997).

Plant community: A generic term that references any vegetation found in the mapping study and can be any level in the USNVC, association or alliance, or a unique community to the park, a park special.

Positional accuracy: The nearness of a point in a spatial database to its actual location on the earth's surface. The program standard for horizontal positional accuracy meets National Map Accuracy Standards at the 1:24,000 scale. This means that each well-defined object in the spatial database will be within 1/50 of an inch of its actual location or 40 feet (12.2 meters).

Producer accuracy: The probability that a reference sample (the ground data) has been classified correctly, also known as error of omission. This quantity is computed by dividing the number of samples that have been classified correctly by the total number of reference samples in that class (Story and Congalton 1986). Compare with user accuracy.

Projection: A map or a geospatial database is a flat representation of data located on a curved surface. A projection is a device for producing all or part of a round body on a flat sheet. This projection cannot be done without distortion, so the cartographer

must choose which characteristic (distance, direction, scale, area, or shape) that is to be emphasized at the expense of the other characteristics (Snyder, 1982). All spatial data in the program are represented in the Universal Transverse Mercator (UTM) coordinate system that is based on the transverse mercator projection applied between 84 degrees north and 80 degrees south latitude.

Quadrangle: A USGS paper map. Typically, a 7.5-minute USGS map. Informally known as quad.

Quarter quadrangle: A map or image that includes $\frac{1}{4}$ the area of a 7.5-minute quadrangle and is organized in quadrants of the original quadrangle as follows: Northeast, Northwest, Southeast, and Southwest. USGS DOQQs cover $\frac{1}{4}$ of a 7.5-minute quadrangle. Informally known as quarter quad.

Rectify: Remove distortions common to aerial photographs in the process of automating the photo-interpreted information into a digital database. Distortions on aerial photographs are due to topographic relief on the ground, radial distortion in the geometry of the aerial photography, tip and tilt of the plane, and differences in elevation of the airplane from its nominal scale. This process may be separate or included in the registration process depending on the technology used. See transfer.

Register: The process of correlating objects on an aerial photograph with locations on the surface of the Earth using a defined coordinate system. This is necessary to be able to place the vegetation community data in a GIS with other appropriate data such as transportation, topography, soils, etc. This process may be separate or included in the rectification process depending on the technology used. See transfer.

Scale: The relationship between a distance portrayed on a map and the same distance on the Earth (Dana 1999). A map scale can be defined by a representative fraction

(e.g., 1 unit on map / 12,000 units on ground) or by a graphic scale bar.

Spatial Data Transfer Standard (SDTS): A comprehensive transfer standard for Earth-referenced data endorsed by the Federal Geographic Data Committee. Spatial data in SDTS format consists of a group of files each with specific content and format.

Signature: The unique combination of color, texture, pattern, height, physiognomy, and position in the landscape used by an photo interpreters to identify map classes on an aerial photograph.

Stratum: A horizontal layer of vegetation. A stratum may be defined by the life form of the vegetation (tree, shrub, herbaceous), or its actual height.

Structure (Vegetation): The spatial distribution pattern of life forms in a plant community, especially with regard to their height, abundance, or coverage within the individual layers. Synonymous with physiognomy.

Subclass: The level in the National Vegetation Classification Standard hierarchy under class based on growth form characteristics (Grossman et al. 1998). See hierarchy under USNVS.

Subgroup: The level in the National Vegetation Classification Standard hierarchy below group which divides each group into either a “natural/semi-natural” or “cultural” (planted/cultivated) subgroup (Grossman et al. 1998). See hierarchy under USNVS.

Transfer: The process of moving photo interpreted data from an aerial photo overlay to an ortho image to register and rectify the data. This process varies depending on the type of technology used.

Transform(ation): The process of converting coordinates (map or image) from one coordinate system to another. This involves scaling, rotation, translation, and warping (images) (ESRI 1994).

Transition zone: An area where the vegetation composition and structure is intermediate between two associations. The transition zone may be small as the associations abruptly change due to a large shift in the landscape, such as a cliff, or it may be large as the physical environment changes gradually. Transition zones often are challenges to properly classify and/or map vegetation.

United States National Map Accuracy Standards (NMAS): USGS accuracy standards for published maps, including horizontal and vertical accuracy, accuracy testing method, accuracy labeling on published maps, labeling when a map is an enlargement of another map, and basic information for map construction as to latitude and longitude boundaries. The table below shows the standard for some common map scales. To meet NMAS maps must have less than 10 percent of the points tested (well-defined points) exceed the standard. Note that the conversion of paper maps into digital data usually creates additional error.

Horizontal accuracy examples.

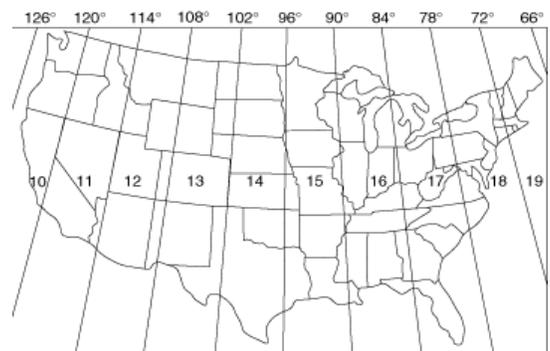
Scale	Engineering Scale	National Map Accuracy Standard
1:1,200	1" = 100'	+/- 3.33 feet
1:2,400	1" = 200'	+/- 6.67 feet
1:4,800	1" = 400'	+/- 13.33 feet
1:9,600	1" = 800'	+/- 26.67 feet
1:10,000		+/- 27.78 feet
1:12,000	1" = 1000'	+/- 33.33 feet
1:24,000	1" = 2000'	+/- 40.00 feet
1:63,360	1" = one mile	+/- 105.60 feet
1:100,000		+/- 166.67 feet

United States National Vegetation Classification (USNVC): The Association for Biodiversity's vegetation classification system. It is the basis for the FGDC National Vegetation Classification Standard.

User accuracy: The probability that a

sample from the mapped data actually represents that category on the ground, also known as error of commission. This quantity is computed by dividing the number of correctly classified samples by the total number of samples that were classified as belonging to that category (Story and Congalton 1986). Compare with producer accuracy.

Universal Transverse Mercator (UTM): Map coordinate system (not a map projection) that is defined by the Transverse Mercator projection, which has a set of zones defined by a central meridian as shown in the figure below for the United States (Portions from ESRI 1994). All spatial data products developed by the program (vegetation spatial data, plot and accuracy assessment plot data locations are in this coordinate system.



Universal Transverse Mercator projections for the U.S.

Vegetation: The collective plant cover over an area (FGDC 1997).

Vegetation characterization: The detailed portrayal of a vegetation association using diagnostic and dominant species, structure, and ecological processes. The program has a formal structure for association description based on the ABI model. Also known as vegetation description. An example of an association characterization can be found at <http://biology.usgs.gov/npsveg/agfo/mapclass/scbc.pdf>.

Vegetation classification: The process of categorizing vegetation into repeatable

and consistent elements. Also a document the lists and organizes the vegetation communities in an area. An example of a vegetation classification can be found at <http://biology.usgs.gov/npsveg/agfo/report.pdf#classification>.

Vegetation community: See plant community.

Vegetation description: See vegetation characterization.

Vegetation field key: See dichotomous field key

Vegetation key: See dichotomous field key

Vegetation mapping: The process of identifying, labeling, and placing in real world coordinates vegetation communities.

Vegetation structure: See structure (vegetation).

Vertical aerial photography: See Aerial Photography.

Wetland: A location on the landscape that is characterized by either hydric soils or hydrophytic plants or both. A wetland may be vegetated or non-vegetated. The vegetation description for each association includes its wetland status.

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Appendix A

List of Petrified Forest National Park vegetation mapping project products

This appendix lists the products developed for the Petrified Forest National Park vegetation mapping project. The report and appendices are available in hard copy and on the project DVD. The vegetation map database, field data locations and plant data, graphics, images, and metadata are also available on the DVD. This appendix lists each product, its file name on the DVD, and the format in which the product is available. The DVD is available with the hard copy report and through the Southern Colorado Plateau Network. These products are also available on the USGS-NPS Vegetation Mapping Program product pages (<http://biology.usgs.gov/npsveg/products/pefo.html>).

Product/File Names	Description
Report	
peforpt.pdf	Full report
pefoquantclass.doc	Graphics of quantitative classification
pefoveg.pdf	Low resolution map graphic
pefoveg_large.pdf	High resolution map graphic
pefoplotsclass.pdf	
pefoplotsaa.pdf	
pefoplotspi.pdf	Map graphics of classification, accuracy assessment, and photo-interpretation plots
Aerial photography	
pefocirmosaic.exe	Aerial photo mosaic
metapefocirmosaic.txt	Metadata for aerial photo mosaic in text format
pefodoqq.exe	All Digital Ortho Quarter Quads
metapefophotosdoqq.txt	Metadata for DOQQs in text format
Field data	
pefodata.mdb	Access database that includes all classification and accuracy assessment field data
metapefodata.txt	Metadata for classification and accuracy assessment field data in text format
pefofieldphotos.exe	Field photos: classification and accuracy assessment
pefoplotfieldform.pdf	Classification plots field form
pefoaafldform.pdf	Accuracy assessment plots field form
Classification spatial data	
pefoplot.exe	Classification plots shapefile and metadata
metapefofield.txt	Metadata for classification plots
Thematic AA points spatial data	
pefoaa.exe	Accuracy assessment plots shapefile and metadata

Appendix A *continued*

Product/File Names	Description
metapefoaa.txt	Metadata for accuracy assessment shapefile in text format
Park boundary spatial data	
pefobdy.exe	Park boundary shapefile and metadata
metapefobdy.txt	Metadata for park boundary in text format
Project boundary spatial data	
pefoprjbdy.exe	Project boundary shapefile and metadata
metapefoprjbdy.txt	Metadata for project boundary in text format
Vegetation map spatial data	
pefo.exe	Vegetation map shapefile and metadata
metapefospatial.txt	Metadata for vegetation maps in text format
Photointerpretation sites spatial data	
pefophotoplots.exe	Photointerpretation observation locations shapefile and metadata
metapefophotoplots.txt	Photointerpretation sites shapefile metadata in text format

Appendix B

Relevé numbers

This appendix lists the relevé numbers of ground-based observations for each plant community in this project. Although the 1993 database is not available through this project, data for the 2003 classification relevés and 2006 accuracy assessment observations are available as an Access database and mapped as a GIS shapefile. Images of the 2004 classification relevés and 2006 accuracy assessment observations are also available. The 2004 classification relevé number refers to the field PlotCode, found in the table, tblPlotDetails, in pefodata.exe. It is cross-walked to the field PlotCode, which is used to reference the relevé in all other classification tables in the database. The 2006 accuracy-assessment observation numbers refers to the field, PlotAACode, found in all four accuracy assessment tables in pefodata.exe. The photointerpreter's observation locations are also mapped as a shapefile. Locations on the DVD for these products, and their corresponding metadata, can be found in Appendix A. The number for the photointerpreter's observation locations refers to the field, PlotCode, in the pefophotoplots shapefile.

Appendix B

Plant Community	2003	1993	AA
Woodland			
1 <i>Juniperus monosperma</i> / <i>Artemisia bigelovii</i> Woodland	PE-110, PE-145		A1, A11, A1-A, A2, A2-A, A3, A4, A8, A9, A5, F10, F9
2 <i>Pinus edulis</i> - (<i>Juniperus osteosperma</i>) / <i>Bouteloua gracilis</i> Woodland	PE-114		
3 <i>Populus fremontii</i> / <i>Ericameria nauseosa</i> Woodland	PE-124, PE-139		A1-S, A2-S, I17-S
Shrubland			
4 <i>Allenrolfea occidentalis</i> Shrubland	PE-080		B14, B15, B21, B22, B3, BB3, FF7, FF8
5 <i>Artemisia filifolia</i> / <i>Bouteloua eriopoda</i> Shrubland	PE-010, PE-035, PE-036, PE-128		
6 <i>Artemisia filifolia</i> Colorado Plateau Shrubland	PE-026, PE-056, PE-060, PE-092, PE-093, PE-120, PE-143, PE-146	6008, 6033, 6049, 6061, 6083, 7301	B12-S, B13-S, B15-S, B1-S, B3-S, B5-S, B8-S, B9-S, C10, C11, C19, C22, C24, C25, C5-S, C6-S, E1, H12, I1-S, J1, K4, N14, N16, N18, N30, N5, T2, U1
7 <i>Atriplex canescens</i> / <i>Pleuraphis jamesii</i> Shrubland	PE-002, PE-012, PE-013, PE-047	6053, 6055, 6063, 6074, 6076	A6, B11, B12, B17, B2-S, B4-S, B7, B8, B9, C12, C12-S, C13-S, C14, C17-S, C18-S, C19-S, C20, C22-S, C28, C6, C8, C8-S, C9-S, F12, F2-S, F3-S, F7, G21-S, G7-S, H10, I11-S, J1-S, J2-S, L1-S, L5-S, L9-S, N21, N22, N24, N25, N26, N29, N3, N4, N6, O4-S, R12-S, R13-S, R5-S, R8-S, V3
8 <i>Ericameria nauseosa</i> Desert Wash Shrubland	PE-008, PE-024, PE-109, PE-111, PE-126, PE-129, PE-037, PE-140	6037, 6040, 6043, 6058, 6078, 7148, 7170; 6080, 6082, 7159	B25, BB2, BB24, C1-S, C20-S, C21-S, C23-S, C24-S, C27-S, C2-S, C3-S, C4-S, C7-S, F12-S, G4, J5-S, W9-S
9 <i>Forestiera pubescens</i> Shrubland		6011	
10 <i>Gutierrezia sarothrae</i> - (<i>Opuntia</i> spp.) / <i>Pleuraphis jamesii</i> Dwarf-shrubland	PE-038, PE-107	6001, 6018, 6020, 6023, 6025, 6028, 6035, 6045, 6048, 6073, 7083, 7014, 7252	
11 <i>Isocoma drummondii</i> - <i>Pleuraphis jamesii</i> Shrubland	PE-112	7054, 7175, 7154	BB4, D1, D3, E4, FF5, K21, X9-S, K3
12 <i>Iva acerosa</i> - <i>Sporobolus airoides</i> Shrubland	PE-116		G5, G6
13 <i>Krascheninnikovia lanata</i> / <i>Bouteloua gracilis</i> Dwarf-shrub Herbaceous Vegetation	PE-086		B31-S, C2, E2, P5, P6, P7
14 <i>Krascheninnikovia lanata</i> Dwarf-shrubland	PE-137		C3

Appendix B continued

Plant Community	2003	1993	AA
15 <i>Purshia stansburiana</i> - <i>Eriogonum corymbosum</i> Shrubland	PE-123, PE-133, PE-138, PE-141, PE-144		A13, F11, F2, F3, F4, F5, F6
16 <i>Rhus trilobata</i> - <i>Ephedra (viridis, torreyana)</i> Talus Shrubland	PE-105, PE-134, PE-148		H6-S, Y1, Y4-S, Y7-S, Y8-S
17 <i>Salix exigua</i> / Barren Shrubland	PE-006, PE-127		D1-S
18 <i>Salvia pachyphylla</i> Dwarf-shrubland	PE-108, PE-115		J2, J3, J4, J5, J6, J7
19 <i>Sarcobatus vermiculatus</i> / <i>Atriplex obovata</i> Shrubland			B24, FF1, FF10, FF11, FF14, FF19, FF20, FF26, FF28, FF3, FF30, FF6, FF9, G12, L8-S
20 <i>Sarcobatus vermiculatus</i> / <i>Suaeda moquinii</i> Shrubland	PE-066		BB1-S, BB2-S, E2-S, P19-S, P20-S
21 <i>Suaeda moquinii</i> Shrubland	PE-106		E1-S
22 <i>Tamarix</i> spp. Temporarily Flooded Semi-natural Shrubland	PE-005, PE-125	7128	BB25, BB26, F6-S, F9-S, G14, F10-S
Herbaceous			
23 <i>Atriplex obovata</i> / <i>Sporobolus airoides</i> - <i>Pleuraphis jamesii</i> Shrub Herbaceous Vegetation	PE-014, PE-022, PE-033, PE-040, PE-048, PE-050, PE-070, PE-081, PE-094, PE-117, PE-131, PE-149	6012, 6047, 6057, 6060, 6070, 6072, 7007, 7009, 7017, 7021, 7023, 7076, 7111, 7115, 7138, 7173, 7281	B1, B2, B6, C14-S, C16-S, C17, E5, FF15, FF16, FF17, FF18, FF21, FF23, G1-S, G2-S, G8-S, HH1, I16-S, K1, K11-S, K15, L1, L11, L15, L17, L26, L30, L5, M3-S, M4-S, N2-S, N3-S, N6-S, N7-S, N8-S, P11-S, P12-S, P13-S, P14-S, P15-S, P16-S, P17-S, P18-S, R14-S, R6, S10-S, T10-S, T15-S, T17-S, T18-S, T19-S, T21-S, T2-S, U12-S, U13-S, U15-S, U4-S, W8, X19, X21, X4-S, Y2-S
24 <i>Bouteloua eriopoda</i> - <i>Pleuraphis jamesii</i> Herbaceous Vegetation	PE-023, PE-041, PE-042, PE-087	7124	K6-S
25 <i>Bouteloua gracilis</i> - <i>Pleuraphis jamesii</i> Herbaceous Vegetation	PE-004, PE-068, PE-099	6013, 6016, 6017, 6052, 7307, 7029, 7032, 7090, 7096, 7098, 7119, 7123, 7314	C15-S, C27, E13, G3-S, I6-S, N10-S, N11-S, N4-S, P1, P2, P4, P4-S, R1-S, R6-S, T4-S, T9-S
26 <i>Bouteloua gracilis</i> Herbaceous Vegetation	PE-046, PE-057, PE-058, PE-059, PE-061, PE-071, PE-088, PE-096, PE-136	6002, 6007, 6010, 6021, 6024, 6027, 6029, 6030, 6032, 6034, 7024, 7028, 7030, 7062, 7089, 7100, 7102, 7113, 7243, 7261, 7280	B7-S, P3
27 <i>Calamovilfa gigantea</i> Desert Wash Shrub Herbaceous Vegetation	PE-104, PE-121, PE-135		
29 <i>Opuntia whipplei</i> - <i>Sporobolus airoides</i> Shrub Herbaceous Vegetation	PE-097		

Appendix B *continued*

Plant Community	2003	1993	AA
30 <i>Pleuraphis jamesii</i> - <i>Sporobolus airoides</i> Herbaceous Vegetation	PE-015, PE-043, PE-085, PE-103	6003, 6019, 6038, 6039, 6041, 6044, 6045, 6054, 6068, 6079, 7004, 7008, 7015, 7033, 7037, 7050, 7053, 7058, 7091, 7099, 7101, 7105, 7108, 7116, 7120, 7130, 7145, 7153, 7155	E10, E15, E16, E17, E21, E22, E24, E28, E6, E7, E9, FF22, K3-S, L21, O10-S, O2, O3, O8-S, P10, P7-S, P9, Q1, R11, R12, R13, R14, R16-S, R17, R18, R19, R20, R28, R3, R30, R34, R35, R36, R37, R8, S1, S3, S5, S6, T9, X22
31 <i>Salsola tragus</i> Sand Dune Vegetation	PE-016, PE-130		T10, K12, K17, K18, K20, K26, K30, N1, N11, N12, R2-S, R3-S, R9-S
32 <i>Sporobolus airoides</i> - <i>Bouteloua gracilis</i> Herbaceous Vegetation	PE-018, PE-019, PE-020, PE-025, PE-034, PE-073, PE-150	6015, 7002, 7039, 7087, 7131, 7293	B4, B6-S, C11-S, CC1-A, E12, E25, E3, E8, G10-S, I14-S, I15-S, I3-S, I4-S, I8-S, K12-S, K13-S, K14-S, K16-S, K1-S, K4-S, K9, L10-S, L2-S, O2-S, O3-S, P21-S, P2-S, P8, P8-S, Q2-S, R11-S, R7-S, S10, S2, S4, T11, T16-S, T4, U14-S, U5-S, U6-S
33 <i>Sporobolus airoides</i> Southern Plains Herbaceous Vegetation	PE-053, PE-076	6022, 6046, 7003,	C18, D2, E11, E14, E18, E19, E20, E23, E31, E32, E33, E34, E35, FF12, FF27, FF36, FF4, L20, L4-S, L7-S, M1-S, M2-S, O1-S, O4, O5, O5-S, O6-S, O7-S, O9-S, P10-S, P1-S, P9-S, R18-S, R9, T1, T3
34 <i>Sporobolus coromandelianus</i> Herbaceous Vegetation	PE-067		
35 <i>Sporobolus cryptandrus</i> Great Basin Herbaceous Vegetation	PE-065		
Sparse			
36 <i>Atriplex obovata</i> Badland Sparse Vegetation	PE-021, PE-028, PE-039, PE-051, PE-064, PE-069, PE-075, PE-082, PE-089, PE-095, PE-119	6036, 6059, 6067, 6071, 6077, 7010, 7012, 7036, 7042, 7047, 7084, 7132, 7137, 7147, 7156	AA6, BB12, K2-S, L10, L13, L14, L6, N5-S, R25, T11-S, T12-S, T13-S, T14-S, T20-S, T22-S, T7-S, T8-S, U3-S, U7-S, U9-S, V11-S, V12-S, V2-S, W1, W10, W10-S, W12, W12-S, W15, W19, X11, X17, X6-S
37 <i>Ephedra torreyana</i> - <i>Artemisia bigelovii</i> Sparse Vegetation	PE-009, PE-011, PE-030, PE-031, PE-052, PE-062, PE-077, PE-083, PE-090, PE-122, PE-132, PE-142	6004, 6005, 6031, 6042, 6050, 6051, 6056, 6062, 6064, 6065, 6075, 7178	C15, F1, F8, G5-S, G6-S, H18, H19, H23, H25, H27, H28, H3, H4, H5, H6, H8, H9, I2-S, I5-S, I7-S, K16, L16, M1, N2, N8, Q1-S, S11-S, S12-S, S1-S, S3-S, S6-S, S8-S, Y11-S, Y12-S, Y15-S, Y29-S, Y3-S, Y6-S
38 <i>Eriogonum leptophyllum</i> Sparse Vegetation	PE-001, PE-003, PE-007, PE-045, PE-084, PE-100	7056, 7060, 7164, 7066	V4, H1-S, H2-S, S2-S, S5-S, T5-S, W4, W6, Y13-S, Y9-S
39 <i>Zuckia brandegeei</i> Sparse Vegetation	PE-017, PE-027, PE-029, PE-032, PE-044, PE-049, PE-054, PE-055, PE-063, PE-078, PE-079, PE-091, PE-098, PE-101, PE-113, PE-118, PE-147	7038, 7044, 7057, 7059, 7065, 7078, 7082, 7086, 7125, 7162, 7294, 7313	H11, H7, L19, L3, S4-S, T6-S, U1-S, V9-S, W17, W7-S, I1, T1-S

Appendix C

Global and local plant community descriptions

C.1 Introduction

The plant community descriptions present information on each association, alliance, and park special as it occurs in Petrified Forest NP (local) and as it has been found elsewhere (global) (NatureServe 2007). The plant communities are organized by life form—woodland, shrubland, herbaceous, and finally sparse.

Following is a summary of the information provided by each description, in the order in which it occurs within each description:

1. Scientific name for plant community
 - Translated name for plant community assigned by NatureServe
 - NatureServe Code: Community Element Global code (CEGL) assigned by NatureServe
2. Summary: Global concept of plant community
3. Classification
 - Classification Confidence: The level of confidence in the classification, based on the quality and type of data used in the analysis, as well as the extent to which the entire (or potential) range of the element was considered. Values include: 1 = Strong, 2 = Moderate, and 3 = Weak.
 - Classification Comments: Globally and locally
 - Vegetation Hierarchy
 - Physiognomic Class: NVCS version 1 class
 - Physiognomic Subclass: NVCS version 1 subclass
 - Physiognomic Group: NVSC version 1 group
 - Physiognomic Subgroup: NVCS version 1 subgroup
 - Formation Name: NVCS version 1 formation name
 - Alliance Name: NVCS version 1 alliance name
4. Ecological Systems Placement: Nature Serve-assigned ecological system
5. NatureServe Conservation Status: NatureServe-assigned conservation status rank (G5 Secure/G4 Apparently secure/G3 Vulnerable/G2 Imperiled/GNR Not yet ranked)
6. Distribution: Global and local distribution
7. Environmental Setting
 - USFWS Wetland System (Cowardin et al. 1979)
 - Global and local environments of occurrence
8. Vegetation
 - Global and local descriptions
 - Most Abundant Species: Global and local
 - Other Noteworthy Species: Global and local
9. Element Sources
 - Authors of global and local descriptions
 - References

Appendix C. Global and local plant community descriptions

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C.2 Woodland

C.2.1. *Juniperus monosperma* / *Artemisia bigelovii* Woodland

Base map class	One-seed Juniper / Bigelow's Sagebrush Shrubland
NatureServe common name	One-seed Juniper / Bigelow's Sagebrush Woodland
NatureServe code	CEGL000705

Summary:

This woodland association ranges from southern Colorado to northern New Mexico and Arizona, and possibly extreme southern Utah. Stands occur in the mesas and hillslopes, piedmonts, canyons, escarpments, and other geographic breaks in the southern Colorado Plateau to foothills of the southern Rocky Mountains and breaks in the southwestern Great Plains. Elevation ranges from 1520-2130 m (5000-7000 ft). Sites are on nearly level surfaces to steep, rocky slopes in canyons and on hillsides. Stands occur on all aspects except in elevational extremes where low-elevation stands are restricted to the more mesic north slopes; whereas high-elevation stands occur on southern aspects. Sites are typically dry with shallow, rocky, calcareous, alkaline soils. Soil textures range from sandy loam to clay soils typically derived from limestone, sandstone, or shale. The vegetation is characterized by a typically open (5-15% cover) to occasionally moderately dense evergreen, scale-leaved tree canopy 2-7 m tall composed of *Juniperus monosperma*. Sparse canopy stands have trees distributed in patches, resembling a savanna; whereas, in the moderately dense stands, the tree crowns touch. Occasional *Pinus edulis* trees may also be present. At higher elevations, *Juniperus scopulorum* may be present, and in the southern extent, Madrean evergreen woodland elements such as *Juniperus deppeana* and *Juniperus coahuilensis* (= *Juniperus erythrocarpa*) may be present but not codominant. The understory is typically a sparse and patchy dwarf-shrub layer dominated by *Artemisia bigelovii*. Other shrubs and dwarf-shrubs may be present, such as *Atriplex canescens*, *Ephedra* spp., *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Opuntia* spp., *Parryella filifolia*, *Purshia stansburiana*, *Yucca* spp., and *Mahonia fremontii*, depending on geography. A sparse to moderately dense herbaceous layer dominated by perennial grasses may be present. The most abundant species are *Bouteloua eriopoda*, *Bouteloua gracilis*, *Aristida* spp., *Pleuraphis jamesii* (= *Hilaria jamesii*), *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Piptatherum micranthum* (= *Oryzopsis micrantha*), *Sporobolus* spp., *Hesperostipa comata*, *Hesperostipa neomexicana*, and introduced annual grass *Bromus tectorum*. Many forb species can occur, but few have much cover.

Classification confidence: 2-Moderate

Classification comments:

Globally. Stuever and Hayden (1997a) suggest that this association may occur in southern Utah; however, Welsh et al. (1993) states that all identifications of *Juniperus monosperma* in Utah are tentative.

Petrified Forest National Park. The sparse total vegetation cover of these two relevés and the existence of a tree layer makes it difficult to classify this association as a woodland community. However, the dominant species in both relevés was *Juniperus monosperma*, which had a distinct structural component not present in the adjacent vegetation communities.

Vegetation hierarchy:

Physiognomic class	I	Woodland
Physiognomic subclass	I.A	Evergreen woodland
Physiognomic group	I.A.8	Temperate or subpolar needle-leaved evergreen woodland
Physiognomic subgroup	I.A.8.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	I.A.8.N.c	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name		<i>Juniperus monosperma</i> Woodland Alliance (A.504), One-seed Juniper Woodland Alliance

Ecological systems placement:

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

NatureServe conservation status:

Global rank. G5 (23-Feb-1994).

Distribution:

Globally. This juniper woodland association occurs in the southern Colorado Plateau, foothills of the southern Rocky Mountains, and it extends out on limestone and sandstone breaks in the southwestern Great Plains ranging from northeastern Arizona and northern New Mexico into southeastern Colorado and possibly extreme southern Utah.

Petrified Forest National Park. *Juniperus monosperma* - *Artemisia bigelovii* Woodland was identified from two relevés on terrace landforms at Petrified Forest National Park. This association was sampled on top of Chinde Mesa and west of Dry Wash and southwest of Crystal Forest.

Environmental summary:

Globally. Stands occur in the mesas and hillslopes, piedmonts, canyons, escarpments, and other geographic breaks in the southern Colorado Plateau to the foothills of the southern Rocky Mountains and breaks in the southwestern Great Plains. Elevation ranges from 1520-2130 m (5000-7000 ft). Sites are on nearly level surfaces to steep, rocky slopes in canyons and on hillsides. Stands occur on all aspects except in elevational extremes where low-elevation stands are restricted to the more mesic north slopes; whereas high-elevation stands occur on southern aspects. Sites are typically dry with shallow, rocky, calcareous, alkaline soils. Soil textures range from sandy loam to clay soils typically derived from limestone, sandstone, or shale.

Petrified Forest National Park. This association was sampled at 1732 and 1838 m (5680-6030 ft) elevation. Slope is none to minimal (0-3%). Sandstone surface rocks were identified at one of the relevés.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. The vegetation is characterized by a typically open (5-15% cover) to occasionally moderately dense evergreen, scale-leaved tree canopy 2-7 m tall composed of *Juniperus monosperma*. Sparse canopy stands have trees distributed in patches, resembling a savanna; whereas, in the moderately dense stands, the tree crowns touch. Occasional *Pinus edulis* trees may also be present. At higher elevations, *Juniperus scopulorum* may be present, and in the southern extent, Madrean evergreen woodland elements such as *Juniperus deppeana* and *Juniperus coahuilensis* (= *Juniperus erythrocarpa*) may be present but not codominant.

The understory is typically a sparse and patchy dwarf-shrub layer dominated by *Artemisia bigelovii*. Other shrubs and dwarf-shrubs may be present, such as *Atriplex canescens*, *Ephedra* spp., *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Opuntia* spp., *Parryella filifolia*, *Purshia stansburiana*, *Yucca* spp., and *Mahonia fremontii*, depending on geography. A sparse to moderately dense herbaceous layer dominated by perennial grasses may be present. The most abundant species are *Bouteloua eriopoda*, *Bouteloua gracilis*, *Aristida* spp., *Dasyochloa pulchella*, *Pleuraphis jamesii* (= *Hilaria jamesii*), *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Piptatherum micranthum* (= *Oryzopsis micrantha*), *Sporobolus* spp., *Hesperostipa comata*, *Hesperostipa neomexicana*, and introduced annual grass *Bromus tectorum*. Many forb species can occur, but few have much cover. Common forbs include *Chaetopappa ericoides*, *Chamaesyce fendleri*, *Cryptantha* sp., *Chaetopappa ericoides*, *Eriogonum corymbosum*, *Eriogonum jamesii*, *Lesquerella fendleri*, and *Zinnia grandiflora*.

Petrified Forest National Park. Two relevés were classified as *Juniperus monosperma* - *Artemisia bigelovii* Woodland with a total vegetation cover of 15 and 18%. The vegetation cover consisted of a tree stratum with 4 and 5% cover, a shrub stratum with 10 and 12% cover, and an herbaceous stratum with 0.5 and 2% cover. The species diversity for the relevés was 22 and 24 species. The vegetation was dominated by *Juniperus monosperma* in the tree layer with 4 and 5% cover. *Artemisia bigelovii* has significant cover in the shrub layer with each relevé having 2% cover.

Most abundant species:

Stratum	Global species	PEFO species
Tree canopy	<i>Juniperus monosperma</i>	<i>Juniperus monosperma</i>
Tall/short shrub/ sapling	<i>Artemisia bigelovii</i> , <i>Gutierrezia sarothrae</i>	<i>Artemisia bigelovii</i>
Herb (field)	<i>Achnatherum hymenoides</i> , <i>Aristida purpurea</i> , <i>Bouteloua eriopoda</i> , <i>Bouteloua gracilis</i> , <i>Bromus tectorum</i> , <i>Hesperostipa comata</i> , <i>Hesperostipa neomexicana</i>	N/A

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Bourgeron and Engelking 1994; Dick-Peddie 1993; Driscoll et al. 1984; Larson and Moir 1987; Shaw et al. 1989; Stuever and Hayden 1997a; Welsh et al. 1993; Western Ecology Working Group n.d.

C.2 Woodland

C.2.2. *Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland

Base map class	<i>Pinus edulis</i> - (<i>Juniperus osteosperma</i>) / <i>Bouteloua gracilis</i> Woodland was only located at one small area. This association was mapped with the One-seed Juniper / Bigelow's Sagebrush Shrubland base map class.
NatureServe common name	Two-needle Pinyon - (Utah Juniper) / Blue Grama Woodland
NatureServe code	CEGL000778

Summary:

This woodland association is known from mountains and mesas in the southern Colorado Plateau, from the Mogollon Rim, extending north into southern Utah and probably western Colorado. Elevations normally range from 1700-2400 m (5575-7875 ft). Sites are variable but generally are relatively dry and rocky. Stands occur on flat to moderate slopes along drainages and on mesatops, on gentle to moderate (10-40%) rocky slopes of foothills, and at the bases of cinder cones. The substrates are variable and range from deep, coarse-textured soils derived from cinder to finer-textured soils derived from sandstone, shale and limestone. The vegetation is characterized by an open to moderately dense tree canopy (10-65% cover) codominated by *Pinus edulis* and *Juniperus osteosperma* trees that are between 1 and 5 m tall. *Pinus edulis* may be present with relatively small cover in some stands. *Juniperus deppeana* may replace *Juniperus osteosperma* in southern stands. Other species of *Juniperus*, such as *Juniperus scopulorum*, may be present in higher elevation stands. Shrub cover is sparse (<10% cover). If *Quercus gambelii* is present, it has less than 5% cover. Other associated shrubs may be present in low cover, such as *Cercocarpus montanus*, *Chrysothamnus viscidiflorus*, *Ephedra viridis*, *Ericameria nauseosa*, *Eriogonum microthecum*, *Rhus trilobata*, or *Yucca* spp. The herbaceous layer is typically moderately dense and is dominated by the warm-season, perennial short grass *Bouteloua gracilis*. Associated graminoids include *Aristida* spp., *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Bouteloua curtipendula*, *Elymus elymoides*, *Koeleria macrantha*, *Hesperostipa comata* (= *Stipa comata*), *Hesperostipa neomexicana* (= *Stipa neomexicana*), and *Pleuraphis jamesii* (= *Hilaria jamesii*). *Muhlenbergia montana* is absent or scarce (<1% cover). Forb cover is typically low but may be moderately diverse.

Classification confidence: 2-Moderate.

Classification comments:

Globally. The two *Pinus edulis* / *Bouteloua gracilis* plant associations are treated as phases in Stuever and Hayden (1997a). In the USNVC we are including stands with southern Great Plains, Chihuahuan Desert floristic affinities in *Pinus edulis* - (*Juniperus monosperma*) / *Bouteloua gracilis* Woodland (CEGL002151), and stands with the Colorado Plateau and Great Basin floristic affinities in *Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland. Both of these associations may include stands codominated by *Juniperus deppeana* in their southern extent. Stuever and Hayden (1997a) also described a *Juniperus deppeana* phase (recognized by its dominance in the stand) and hillslope phase, which occurs on slopes >15% and may have low cover of grasses (<5% cover). More survey work is needed to fully understand the distribution and ecological relationships between these three species of *Juniperus* and *Pinus edulis*.

Petrified Forest National Park. The one relevé classified as *Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland may need to be reassessed with additional data collected at Petrified Forest National Park and the Navajo Nation. This relevé was separated from *Juniperus monosperma* / *Artemisia bigelovii* Woodland (CEGL000705) based on co-dominance of *Pinus edulis* in the tree layer. However, the *Juniperus monosperma* / *Artemisia bigelovii* Woodland association does have similar characteristics to the relevé described here: it lacks cover of *Bouteloua gracilis* in the herbaceous layer and has a dominance of *Artemisia bigelovii* in the shrub layer.

Vegetation hierarchy:

Physiognomic class	I	Woodland
Physiognomic subclass	I.A	Evergreen woodland
Physiognomic group	I.A.4	Temperate or subpolar needle-leaved evergreen woodland
Physiognomic subgroup	I.A.8.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	I.A.4.N.a	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Alliance name		<i>Pinus edulis</i> - (<i>Juniperus</i> spp.) Woodland Alliance (A.516), Two-needle Pinyon - (<i>Juniper</i> species) Woodland Alliance

Ecological systems placement:

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

NatureServe conservation status:

Global rank. G5 (23-Feb-1994).

Distribution:

Globally. This woodland association is known from mountains and mesas in the southern Colorado Plateau and Mogollon Rim of northern Arizona and extends into southern Utah and probably into western Colorado and possibly into western New Mexico.

Petrified Forest National Park. *Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland occurred on one relevé. It was located on a terrace north of Petrified National Forest on the Navajo Nation.

Environmental summary:

Globally. This woodland association is known from mountains and mesas in the southern Colorado Plateau, from the Mogollon Rim, extending north into southern Utah and probably western Colorado. Elevations normally range from 1700-2400 m (5575-7875 ft). Sites are variable but generally are relatively dry and rocky. Stands occur on flat to moderate slopes along drainages and on mesotops, on gentle to moderate (10-40%) rocky slopes of foothills, and at the bases of cinder cones. The substrates are variable and range from to deep, coarse-textured soils derived from cinder, to sandy loams derived from sandstone or fine-textured soils derived from limestone or shale.

Petrified Forest National Park. This association occurs at an elevation of 1840 m (6030 ft) with a moderate slope of 7%. The relevé has mudstone surface rocks.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This plant association is characterized by an open to moderately dense tree canopy (10-65% cover) codominated by *Pinus edulis* and *Juniperus osteosperma* trees that are between 1 and 5 m tall. *Pinus edulis* may be present with relatively small cover in some stands. *Juniperus deppeana* may replace *Juniperus osteosperma* in southern stands. Other species of *Juniperus*, such as *Juniperus scopulorum*, may be present in higher elevation stands. Shrub cover is sparse (<10% cover). If *Quercus gambelii* is present, it has less than 5% cover. Other associated shrubs may be present, such as scattered *Artemisia tridentata*, *Brickellia californica*, *Cercocarpus montanus*, *Chrysothamnus viscidiflorus*, *Ephedra viridis*, *Ericameria nauseosa*, *Eriogonum corymbosum*, *Eriogonum microthecum*, *Fallugia paradoxa*, *Gutierrezia sarothrae*, *Opuntia* spp., *Purshia stansburiana*, *Rhus trilobata*, *Ribes cereum*, or *Yucca* spp. The herbaceous layer is typically moderately dense and is dominated by the warm-season, perennial short grass *Bouteloua gracilis*. Associated graminoids include *Aristida* spp., *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Bouteloua curtipendula*, *Elymus elymoides*, *Koeleria macrantha*, *Hesperostipa comata* (= *Stipa comata*), *Hesperostipa neomexicana* (= *Stipa neomexicana*), and *Pleuraphis jamesii* (= *Hilaria jamesii*). *Muhlenbergia montana* is absent or scarce (<1% cover). Forb cover is typically low but may be moderately diverse. Species such as *Artemisia dracuncululus*, *Eriogonum* spp., *Hymenoxys richardsonii*, and *Oxytropis lambertii* are common.

Petrified Forest National Park. One relevé was classified as *Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland with total vegetation cover of 12%, consisting of 3% within the tree stratum, 8% within the shrub stratum, and 1% within the herbaceous stratum. This relevé had a species diversity of 24 species. The total vegetation cover was very low for this association. The tree layer was dominated by *Pinus edulis* with 5% cover and *Juniperus monosperma* with 1% cover. The shrub layer was dominated by *Artemisia bigelovii* with 2% cover and *Ephedra torreyana* with 1% cover. The herbaceous layer was very sparse.

Most abundant species:

Stratum	Global species	PEFO species
Tree canopy	<i>Juniperus deppeana</i> , <i>Juniperus osteosperma</i> , <i>Juniperus scopulorum</i> , <i>Pinus edulis</i>	<i>Juniperus osteosperma</i> , <i>Pinus edulis</i>
Herb (field)	<i>Bouteloua gracilis</i>	N/A

Other noteworthy species:

Global species	PEFO species
<i>Bromus tectorum</i>	Data are not available.

References:

Bourgeron and Engelking 1994, Dick-Peddie 1986, Driscoll et al. 1984, Dwyer and Pieper 1967, Hansen et al. 2004c, Jameson 1962, Kennedy 1983a, Ladyman and Muldavin 1996, Larson and Moir 1987, Little 1987, Moir and Carleton 1987, Muldavin et al. 1998a, Powell 1988a, Stuever and Hayden 1997a, USFS 1982, Western Ecology Working Group n.d., Wright et al. 1973, Wright et al. 1979.

C.2 Woodland

C.2.3. *Populus fremontii* / *Ericameria nauseosa* Woodland

Base Map Class	Cottonwood / Rubber Rabbitbrush Woodland
NatureServe Common Name	Fremont Cottonwood / Rubber Rabbitbrush Woodland
NatureServe Code	CEGL002465

Summary:

This common woodland association occurs on the high terraces of perennial streams and on the banks of intermittent washes throughout the Colorado Plateau on sites that are rarely subject to flooding. Sites are level to gently sloping and are located between 1165 and 2165 m (3825-7100 ft) elevation. Soils are poorly developed, well-drained sands and loamy sands derived from alluvium. Total vegetation cover ranges from 34 to 170%. The 10- to 15-m tall canopy is dominated by mature *Populus fremontii* trees that range in cover from 5 to 50%. Other trees, both riparian and upland, may be present with low cover in the canopy and subcanopy, including *Populus angustifolia*, *Salix gooddingii*, and *Juniperus osteosperma*. Young *Populus* and *Salix* are rare, because these stands are often at least 2 m above the water table. The shrub layer is low to moderate in terms of species composition and cover. *Ericameria nauseosa* dominates or codominates the stratum, often with *Artemisia tridentata* ssp. *tridentata*. Other shrubs may be scattered through the stand, including *Rhus trilobata*, *Sarcobatus vermiculatus*, *Opuntia* spp., *Forestiera pubescens*, *Atriplex canescens*, and *Fraxinus anomala*. The exotic *Tamarix chinensis* may also be present. The herbaceous layer is diverse in terms of species composition, although many species are exotic and most reflect upland conditions. Common graminoids include *Achnatherum hymenoides*, *Agrostis stolonifera*, *Bromus tectorum*, *Bromus japonicus*, *Elymus canadensis*, *Sporobolus* spp., and *Juncus balticus*. Forbs commonly present include *Ambrosia acanthi-carpa*, *Artemisia campestris*, *Castilleja linariifolia*, *Equisetum hyemale*, *Lepidium montanum*, *Sphaeralcea* spp., and *Heterotheca villosa*.

Classification confidence: 2-Moderate

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. This plant community was restricted to a few small areas in the park and the park environs. In the riparian corridor, scattered cottonwood trees did occur, but these patches were not large enough and did not contain a high enough abundance of cottonwoods to be mapped as this association. The few cottonwoods remaining in the riparian corridor appeared to mostly be larger, older trees with little regeneration of seedlings.

Vegetation hierarchy:

Physiognomic class	I	Woodland
Physiognomic subclass	I.B	Deciduous woodland
Physiognomic group	I.B.2	Cold-deciduous woodland
Physiognomic subgroup	I.B.2.N	Natural/Semi-natural cold-deciduous woodland
Formation name	I.B.2.N.b	Temporarily flooded cold-deciduous woodland
Alliance name		<i>Populus fremontii</i> Temporarily Flooded Woodland Alliance (A.644), Fremont Cottonwood Temporarily Flooded Woodland Alliance

Ecological systems placement:

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

NatureServe conservation status:

Global rank. GNR (24-Mar-2005).

Distribution:

Globally. This association has been described from southeastern Utah. It is likely to be widespread throughout the Colorado Plateau.

Petrified Forest National Park. *Populus fremontii* / *Ericameria nauseosa* Woodland was identified on two relevés in Petrified Forest National Park. This association occurred on a bajada, a drainage channel, a playa, and a talus slope. Relevés were sampled about 0.5 km west of the park road and north of the Puerco River, as well as in the northwestern corner of the park along the banks of Digger Wash.

Environmental summary:

Globally. This common woodland association occurs on the high terraces of perennial streams and on the banks of intermittent washes throughout the Colorado Plateau. These habitats are rarely subject to flooding. Sites are level to gently sloping and are located between 1165 and 2165 m (3825-7100 ft) elevation. Aspect is not important in determining the distribution of this association. Bare soil and litter cover most of the unvegetated surface. Soils are poorly developed, well-drained sands and loamy sands derived from alluvium.

Petrified Forest National Park. This association occurred at elevations of 1630 and 1720 m (5340-5640 ft). The slope was low (1-4%). Substrates found within this association included various types of gravel. This association was restricted to wetland areas with intermittent or seasonal flooding.

USFWS wetland system: Palustrine.

Vegetation description:

Globally. This woodland association is common throughout the Colorado Plateau, where it occupies dry terraces along intermittent and perennial stream courses. Total vegetation cover ranges from 27 to 170%. The 10- to 15-m tall canopy is dominated by mature *Populus fremontii* trees that range in cover from 5 to 50%. Other trees, both riparian and upland, may be present with low cover in the canopy and subcanopy, including *Populus angustifolia*, *Salix gooddingii*, and *Juniperus osteosperma*. Young *Populus* and *Salix* are rare, because these stands are often at least 2 m above the water table. The shrub layer is low to moderate in terms of species composition and cover. *Ericameria nauseosa* dominates or codominates the stratum, often with *Artemisia tridentata* ssp. *tridentata*. Other shrubs may be scattered through the stand, including *Rhus trilobata*, *Sarcobatus vermiculatus*, *Opuntia* spp., *Forestiera pubescens*, *Atriplex canescens*, *Fraxinus anomala*, and in the southern extent *Parryella filifolia* and *Isocoma drummondii*. The exotic *Tamarix chinensis* may also be present. The herbaceous layer is diverse in terms of species composition, although many species are exotic, and most reflect upland conditions. Common graminoids include *Achnatherum hymenoides*, *Agrostis stolonifera*, *Bromus tectorum*, *Bromus japonicus*, *Elymus canadensis*, *Sporobolus airoides*, and *Juncus balticus*. Forbs commonly present include *Ambrosia acanthicarpa*, *Artemisia campestris*, *Castilleja linariifolia*, *Equisetum hyemale*, *Lepidium montanum*, *Sphaeralcea* spp., and *Heterotheca villosa*.

Petrified Forest National Park. Two relevés were classified as *Populus fremontii* / *Ericameria nauseosa* Woodland with total vegetation cover of 27 and 61%. The vegetation cover consisted of a tree stratum with 10 and 50% cover, a shrub stratum with 3 and 10% cover, and an herbaceous stratum with 7 and 8% cover. The species diversity for this association was 13 and 34 species. The vegetation was dominated by *Populus fremontii* in the tree layer with 10 and 50% cover. *Ericameria nauseosa* dominated the shrub layer with 0.5 and 2% cover. One relevé had a high cover of the non-native grass *Bromus tectorum* with 3% cover.

Most abundant species:

Stratum	Global species	PEFO species
Tree canopy	<i>Populus fremontii</i>	<i>Populus fremontii</i>
Tall/short shrub/ sapling	<i>Atriplex canescens</i> , <i>Ericameria nauseosa</i> , <i>Artemisia tridentata</i> ssp. <i>tridentata</i>	<i>Ericameria nauseosa</i>
Herb (field)	<i>Artemisia campestris</i> , <i>Achnatherum hymenoides</i>	N/A

Other noteworthy species:

Global species	PEFO species
<i>Bromus tectorum</i> , <i>Tamarix chinensis</i>	Data are not available.

References:

Western Ecology Working Group n.d.

C.3 Shrubland

C.3.1. *Allenrolfea occidentalis* Shrubland

Base map class	Iodine Bush Shrubland
NatureServe common name	Iodinebush Shrubland
NatureServe code	CEGL000988

Summary:

This is a sparsely vegetated shrubland found on seasonally wet, alkaline playas, intermittent floodplains, or along washes in saline overflow areas below 1680 m (5500 ft) elevation. The dominant species, and playa communities in general, are widely distributed throughout the Intermountain West, ranging from southeastern Oregon south to Texas. These shrublands or barrens are flat to extremely low-gradient, almost always in desert ecosystems with less than 18 cm (7 inches) of rain per year, and usually in areas with very poor drainage that flood during rare rainstorms. Playas and washes dominated by *Allenrolfea occidentalis* generally appear to be small, rare, and poorly understood throughout their range. *Allenrolfea occidentalis* dominates the shrub layer, but cover is often quite low, ranging from 20% to less than 1%. Most stands have barren playa forb understories, but grasses, including *Leymus cinereus*, *Distichlis spicata* (= ssp. *stricta*), *Sporobolus airoides*, and *Sporobolus wrightii*, and succulent forbs, such as *Suaeda suffrutescens* var. *detonsa*, *Salicornia* spp., and *Nitrophila* spp., are occasionally found. Most stands occur in a matrix of *Sarcobatus vermiculatus*- or *Atriplex canescens*-dominated shrublands, and in small stands, either *Sarcobatus vermiculatus* or *Atriplex canescens* can occur throughout the community.

Classification confidence: 2-Moderate

Classification comments:

Globally. This appears to be a distinct, widespread type. With additional studies throughout the range of this habitat, it is possible that the type may be split into a number of geographic communities based on associated forbs. However, current data indicate the type is very similar throughout at least the northern half of its range, where it occurs in a matrix composed largely of *Sarcobatus vermiculatus* salt desert scrub. In the southern part of its range, where it is slightly more common, it occurs in a matrix of *Larrea tridentata* or *Ambrosia dumosa*. This is a broadly defined type that may need to be subdivided by characteristics of the understory. Muldavin et al. (2000b) classified five different plant associations in the Tulerosa Basin in southern New Mexico.

Petrified Forest National Park. This association had higher herbaceous cover than shrub cover. However, since only one relevé of this vegetation community was sampled, and the existing *Allenrolfea occidentalis* Shrubland already occurred in the NatureServe database, the relevé was retained under this association classification. If additional data are collected and the continual high herbaceous cover is sampled, than this association may need to be reclassified as a shrub herbaceous vegetation community.

Vegetation hierarchy:

Physiognomic class	III.	Shrubland
Physiognomic subclass	III.A	Evergreen shrubland
Physiognomic group	III.A.5	Extremely xeromorphic evergreen shrubland
Physiognomic 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>Allenrolfea occidentalis</i> Shrubland Alliance (A.866), Iodinebush Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.781	Inter-Mountain Basins Wash
CES304.786	Inter-Mountain Basins Playa

NatureServe conservation status:

Global rank. G3 (23-Oct-2002). This is a very widespread, but limited and somewhat rare, alkaline playa vegetation type. It is not well studied, and it is poorly protected, but generally most stands are not very threatened. Where water is available from adjacent mountains, these areas are often converted to agriculture. However, their limited threats require a G3 rank. If many additional sites are discovered in Nevada, it could become a G4, and if the types associated with *Sarcobatus* turn out to be distinct from those with *Atriplex canescens*, it could be ranked higher. Protection of some sites in Nevada is important to assure that it remains secure throughout its range.

Distribution:

Globally. This playa community is widely distributed throughout the Intermountain West, ranging from southeastern Oregon south to Texas.

Petrified Forest National Park. *Allenrolfea occidentalis* Shrubland was identified from one relevé on the upper slope of a bajada in the northern wilderness, west of Black Forest, and also on an observation point on a saline overflow area along an intermittent wash flowing into Lithodendron Wash. Substrates were marine shales such as Chinle.

Environmental summary:

Globally. This shrubland association occurs across arid and semi-arid portions of the western U.S. at elevations ranging from near sea level to 1680 m. Stands occur on the outer margins of broad intermittent floodplains and playas, or can form landscape mosaics with other saline communities in saline marshes or gypsum-influenced habitats. Bare soil covers most of the unvegetated surface, and there is very little litter. Soils are fine-textured and derived from alluvium.

Petrified Forest National Park. This association occurred at 1680 m (5500 ft) elevation. The slope was minimal (1%).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. *Allenrolfea occidentalis* dominates the shrub layer, but the cover is often quite low, ranging from 20% to less than 1%. Most stands have barren playa forb understories, but grasses, including *Leymus cinereus*, *Distichlis spicata* (= ssp. *stricta*), *Sporobolus airoides*, and *Sporobolus wrightii*, and succulent forbs, such as *Suaeda suffrutescens* var. *detonsa*, *Salicornia* spp., and *Nitrophila* spp., are occasionally found. Most stands occur either in a shrubland matrix dominated by *Sarcobatus vermiculatus* or *Atriplex canescens*, or in small stands; either *Sarcobatus vermiculatus* or *Atriplex canescens* can occur throughout these small stand communities. In the southern extent of its range, scattered *Isocoma drummondii*, *Iva acerosa*, or *Prosopis glandulosa* may be present. Exotic species, such as occasional *Tamarix* spp., *Bromus tectorum*, or *Salsola tragus*, may occur in this community.

Petrified Forest National Park. Only one relevé was classified as *Allenrolfea occidentalis* Shrubland, with total vegetation cover of 19%. The vegetation cover consisted of a shrub stratum with 14% cover and an herbaceous stratum with 5% cover. This relevé had a species diversity of 16 species. The vegetation in the shrub layer was dominated by *Allenrolfea occidentalis*, with 6% cover, and the herbaceous layer was dominated by *Sporobolus airoides*, with 5% cover.

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Allenrolfea occidentalis</i>	<i>Allenrolfea occidentalis</i>
Herb (field)	N/A	<i>Sporobolus airoides</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Bourgeron and Engelking 1994, Driscoll et al. 1984, Griffiths 1902, Kagan et al. 2000, Muldavin et al. 2000b, NVNHP 2003, ORNHP unpubl. data, Western Ecology Working Group n.d.

C.3 Shrubland

C.3.2. *Artemisia filifolia* / *Bouteloua eriopoda* Shrubland

Base map class	This association was not mapped as a separate unit. The photointerpreters were not able to distinguish the understory grasses, and these representative relevés were combined into Sandsage Colorado Plateau Shrubland and Torrey's Jointfir – Bigelow's Sagebrush Shrubland map classes.
NatureServe common name	Sandsagebrush / Black Grama Shrubland
NatureServe code	CEGL001077

Summary:

This sand sagebrush shrubland association occurs in the northern Jornada del Muerto and Tulerosa basins in south-central New Mexico and at Petrified Forest National Park in the southern Colorado Plateau at 1416-1748 m (4646-5735 ft) elevation. Stands frequently occur on flat to rolling sandsheets or sandy plains, mesatops, lower hillslopes and dunes. Slopes range from 0-27%. Soils are often sandy, but range from fine sandy loams to silty-clay loams with an abrupt clay or caliche layer within 100 cm of the surface. The vegetation is characterized by an open to moderately dense (10-30 % cover) short-shrub layer (<1.5 m tall) dominated by *Artemisia filifolia*, with an open to moderately dense (5-60% cover) grassy understory dominated by *Bouteloua eriopoda* or sometimes codominated with *Bouteloua gracilis*. Other common species include *Aristida* spp., *Gutierrezia sarothrae*, *Opuntia* spp., and *Sporobolus flexuosus*. In the southern portion of its range, Chihuahuan Desert species are usually present, such as *Yucca elata* and *Dasyochloa pulchella*.

Classification confidence: 2-Moderate

Classification comments:

Globally. Stands from the Tulerosa and Jornada basins have a strong Madrean floristic element that may justify classifying them as distinct from the Colorado Plateau stands. More classification work is needed to clarify this. Many stands have an open shrub layer and significant graminoid layer that may be better classified as a shrub-steppe or shrub-herbaceous vegetation association.

Petrified Forest National Park. This association was named for the dominance of *Artemisia filifolia* in the shrub layer and the presence of *Bouteloua eriopoda* in the herbaceous layer. *Bouteloua gracilis* occurred with equal abundance to *Bouteloua eriopoda* in almost all the relevés; however, the existing NVCS characterizes the uniqueness of this association based on the presence of *Bouteloua eriopoda*, not *Bouteloua gracilis*. At Petrified Forest National Park, we tended to see equal cover of the two *Bouteloua* species. Both species were always present in this association with either species dominating or codominating the herbaceous layer.

This association is separated from the other Sandsage association, *Artemisia filifolia* Colorado Plateau Shrubland, by the presence of a significant grass understory and low shrub cover. Therefore, the *Artemisia filifolia* / *Bouteloua eriopoda* Shrubland association may be better classified as shrub herbaceous vegetation rather than the current shrubland designation.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A.	Evergreen shrubland
Physiognomic group	III.A.4.	Microphyllous evergreen shrubland
Physiognomic 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 filifolia</i> Shrubland Alliance (A.816), Sandsagebrush Shrubland Alliance

Ecological systems placement:

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

NatureServe conservation status:

Global rank. G4 (17-Jul-2000).

Distribution:

Globally. This association is described from the south-central New Mexico and northeastern Arizona.

Petrified Forest National Park. *Artemisia filifolia* / *Bouteloua eriopoda* Shrubland was sampled from four relevés located mostly on low slopes and sideslopes and on sand dunes and sandsheets within Petrified Forest National Park. These relevés were all located in the central neck area of Petrified Forest National Park—specifically, west of the park road, south of Interstate 40 and south of the northern headquarters, and southeast of the northern headquarters and west of the NPS boundary.

Environmental summary:

Globally. This sand sagebrush shrubland association occurs in the northern Jornada and Tulerosa basins in south-central New Mexico and at Petrified Forest National Park in the southern Colorado Plateau at 1416-1748 m (4646-5735 ft) elevation. Stands frequently occur on flat to rolling sandsheets or sandy plains, mesatops, lower hillslopes, and dunes. Northern Chihuahuan Desert stands are often found near the periphery of sandsheets or on deflated plains where sand deposits are thinner and soils more developed (Muldavin et al. 2000b). Slopes range from 2-11% in New Mexico and 0-27% in Arizona. Soils are often sandy, but range from fine sandy loams to silty-clay loams with an abrupt clay or caliche layer within 100 cm of the surface (Muldavin et al. 2000b).

Petrified Forest National Park. This association occurred between the elevations of 1709 and 1743 m (5615-5720 ft). Slopes ranged from none to moderate (0-27%, average 11%).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. The vegetation is characterized by an open to moderately dense short-shrub layer (<1.5 m tall) dominated by *Artemisia filifolia*, with an open to moderately dense grassy understory dominated by *Bouteloua eriopoda* or sometimes codominated with *Bouteloua gracilis*. Other common species include *Aristida* spp., *Gutierrezia sarothrae*, and *Sporobolus flexuosus*. In the southern portion of its range, Chihuahuan Desert species are usually present, such as *Yucca elata* and *Dasyochloa pulchella*. *Opuntia phaeacantha* is also characteristic of northern Chihuahuan Desert stands. In northeastern Arizona, other characteristic species include

Achnatherum hymenoides, *Chamaesyce fendleri*, *Cryptantha crassisepala*, *Ephedra torreyana*, *Eriogonum leptocladon*, *Ipomopsis longiflora*, *Machaeranthera canescens*, *Phacelia crenulata*, *Plantago patagonica*, *Senecio spartioides*, *Stephanomeria exigua*, and *Yucca angustissima*. The introduced annual grass *Bromus tectorum* is common in some stands.

Petrified Forest National Park. Four relevés were classified as *Artemisia filifolia* / *Bouteloua eriopoda* Shrubland, with total vegetation cover ranging from 28-37% (average 34%). The vegetation cover consisted of a shrub stratum with 9-18% cover (average 13%) and an herbaceous stratum with 16-28% cover (average 22%). The species diversity ranged from 26 and 45 species (average 34 species). The shrub layer was dominated by *Artemisia filifolia* and ranged from 2 and 6% cover (average 4%). The herbaceous layer was dominated by *Bouteloua eriopoda*, ranging between 0.5 and 5% cover (average 4%) and *Bouteloua gracilis*, ranging between 2 and 5% cover (average 4%).

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Artemisia filifolia</i>	<i>Artemisia filifolia</i>
Herb (field)	<i>Bouteloua eriopoda</i> , <i>Bouteloua gracilis</i>	<i>Bouteloua eriopoda</i> , <i>Bouteloua gracilis</i>

Other noteworthy species:

Global species	PEFO species
<i>Bromus tectorum</i>	Data are not available.

References:

Bourgeron and Engelking 1994, Dick-Peddie 1993, Driscoll et al. 1984, Muldavin and Mehlhop 1992, Muldavin et al. 2000b, Sims et al. 1976, Western Ecology Working Group n.d.

C.3 Shrubland

C.3.3. *Artemisia filifolia* Colorado Plateau Shrubland

Base map class	Sandsage Colorado Plateau Shrubland
NatureServe common name	Sand Sagebrush Colorado Plateau Shrubland
NatureServe code	CEGL002697

Summary:

This sand sagebrush shrubland association is widespread in the Colorado Plateau of Utah, Arizona, and probably New Mexico. It occurs on sandy, often somewhat disturbed sites on valley floors, stream terraces, stabilized dunes and sandsheets, benches, floodplains, and alluvial fans. Most sites are level to gently sloping, with a few on moderate slopes (up to 21%), and may be oriented to any aspect, although there is a slight tendency toward warmer southerly aspects. Elevations range from 1122 to 1769 m (3680-5803 ft). Sand or bare soil cover most of the unvegetated ground surface, although biological soil crusts may have up to 40% cover. Soils are sandy and derived from local sandstones, alluvium, or eolian deposits. Total vegetation cover ranges broadly, from sparsely vegetated disturbed sites with less than 5% total cover to stable, well-developed communities with more than 50% cover. Regardless of cover, the vegetation is characterized by an open shrub canopy dominated by *Artemisia filifolia* that is usually mixed with other shrubs, especially *Atriplex canescens*, *Ericameria nauseosa*, and *Opuntia* spp. Less commonly, the shrub layer will include *Vanclevea stylosa*, *Eriogonum leptocladon*, or *Sarcobatus vermiculatus*. *Coleogyne ramosissima*, *Ephedra viridis*, and *Ephedra torreyana* are generally absent or have only trace cover. The herbaceous layer is moderate in terms of species composition and provides sparse to moderate cover. Graminoids that are consistently present include *Achnatherum hymenoides* and *Bromus tectorum*; some sites may also have *Hesperostipa comata*, *Pleuraphis jamesii*, *Sporobolus cryptandrus*, and *Vulpia octoflora*. Forbs vary among sites but are typical of sandy habitats, including *Abronia fragrans*, *Lepidium montanum*, *Oenothera pallida*, *Salsola tragus*, and *Sphaeralcea parvifolia*. Cryptogams may be absent or may provide up to 40% cover.

Classification confidence: 1 - Strong.

Classification comments:

Globally. This association is distinguished from other *Artemisia filifolia* shrubland associations by its restriction to the Colorado Plateau, the somewhat mixed shrub canopy that usually includes *Atriplex canescens*, a poorly-developed herbaceous layer and often a number of species that indicate disturbance or somewhat alkaline conditions. This association also occurs in a broader range of habitats than other *Artemisia filifolia* types. However, *Artemisia filifolia* - *Ephedra* (*torreyana*, *viridis*) Shrubland is poorly defined, and many stands of *Artemisia filifolia* Colorado Plateau Shrubland contain one or the other species of *Ephedra*; it is possible that these two associations should be combined.

Petrified Forest National Park. *Artemisia filifolia* Colorado Plateau Shrubland was distinguished from *Artemisia filifolia* / *Bouteloua eriopoda* Shrubland by a higher shrub cover and a diverse herbaceous layer that is not dominated by either *Bouteloua eriopoda* or *Bouteloua gracilis*.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A.	Evergreen shrubland
Physiognomic group	III.A.4.	Microphyllous evergreen shrubland
Physiognomic 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 filifolia</i> Shrubland Alliance (A.816), Sandsagebrush 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

NatureServe conservation status:

Global rank. GNR (14-Aug-2001).

Distribution:

Globally. This sand sagebrush shrubland association is widespread on sandy sites in the Colorado Plateau of Utah, Colorado, Arizona and New Mexico.

Petrified Forest National Park. *Artemisia filifolia* Colorado Plateau Shrubland was identified from seven relevés within Petrified Forest National Park. All of these relevés occurred on sandy surfaces or sand dunes. They were sampled throughout the monument and included the northern wilderness area southeast of Pintado Point and west of Lithodendron Wash, west of Dry Wash and west of Crystal Forest, near The Flattops extending to the southern wilderness area, and south of Jim Camp Wash.

Environmental summary:

Globally. This sand sagebrush shrubland association is widespread on sandy sites in the Colorado Plateau of Utah, Colorado, Arizona, and New Mexico. This common shrubland association occurs on sandy sites on valley floors, valley sides, stream terraces, stabilized dunes and sandsheets, benches, floodplains, and alluvial fans. Most sites are level to gently sloping, with a few on moderate slopes (up to 21%), and may be oriented to any aspect, although there is a slight tendency to occur on warmer southerly aspects. Elevations range from 1122 to 1769 m (3680-5803 ft). Sand or bare soil covers most of the unvegetated ground surface, although cryptobiological soil crusts may have up to 40% cover. Soils are sandy and derived from local sandstones, alluvium, or eolian deposits.

Petrified Forest National Park. This association occurred between 1622 and 1730 m (5525-5700 ft) elevation. Slope ranged from none to moderate (0-18%, average 7%). Only one relevé had any surface rocks—a mixture of basalt and sandstone.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. Total vegetation cover ranges broadly, from sparsely vegetated disturbed and alluvial terrace sites with less than 5% total cover to stable, well-developed communities with more than 50% cover. Regardless of cover, the vegetation is characterized by an open shrub canopy of *Artemisia filifolia*, usually mixed with other shrubs, especially *Atriplex canescens*, *Ericameria nauseosa*, and *Opuntia* spp. Less commonly, the shrub layer will include *Vanclvea stylosa*, *Eriogonum leptocladon*, or *Sarcobatus vermiculatus*. *Coleogyne ramosissima*, *Ephedra viridis*,

and *Ephedra torreyana* are generally absent or have relatively low cover (usually <1%). The herbaceous layer is moderate in terms of species composition and provides sparse to moderate cover. Graminoids that are consistently present include *Achnatherum hymenoides* and *Bromus tectorum*; some sites may also have *Hesperostipa comata*, *Pleuraphis jamesii*, *Sporobolus cryptandrus*, and *Vulpia octoflora*. Forbs vary among sites but are typical of sandy habitats, including *Abronia fragrans*, *Lepidium montanum*, *Oenothera pallida*, *Salsola tragus*, and *Sphaeralcea parvifolia*. Cryptogams may be absent or may provide up to 40% cover.

Petrified Forest National Park. Seven relevés were classified as *Artemisia filifolia* Colorado Plateau Shrubland with total vegetation cover ranging from 21 to 31% (average 26%). The vegetation consisted of a shrub stratum with 9-18% cover (average 11%) and an herbaceous stratum with 4-21% cover (average 15%). Each relevé had a species diversity ranging between 24 and 38 species (average 34 species). The shrub layer always had a presence of *Artemisia filifolia*, and in most cases, it was the dominant shrub, ranging between 1 and 4% cover (average 3%). In some cases, *Artemisia filifolia* acted as an indicator species for this vegetation association and had less cover than other shrubs. This association tended to have a diverse understory of herbaceous species.

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Artemisia filifolia</i>	<i>Artemisia filifolia</i>

Other noteworthy species:

Global species	PEFO species
<i>Bromus rubens</i> , <i>Bromus tectorum</i> , <i>Halogeton glomeratus</i> , <i>Malcolmia africana</i> , <i>Salsola kali</i> ssp. <i>tragus</i>	Data are not available.

References:

Cogan et al. 2004, Western Ecology Working Group n.d.

C.3 Shrubland

C.3.4. *Atriplex canescens* / *Pleuraphis jamesii* Shrubland

Base map class	Four-wing Saltbush / Galleta Shrubland
NatureServe common name	Fourwing Saltbush / James' Galleta Shrubland
NatureServe code	CEGL001288

Summary:

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

Classification confidence: 2 - Moderate.

Classification comments:

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

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

Petrified Forest National Park. Since *Atriplex canescens* / *Pleuraphis jamesii* Shrubland can be a degraded vegetation community with many dead annuals and a low cover of shrubs, this map class served as a catch-all in some cases to map many of the flat areas with a mixed herbaceous community and low shrub cover that includes a low cover of *Atriplex canescens*.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A.	Evergreen shrubland
Physiognomic group	III.A.5.	Extremely xeromorphic evergreen shrubland
Physiognomic 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 (A.869), Fourwing Saltbush Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.793	Southern Colorado Plateau Sand Shrubland
CES304.775	Inter-Mountain Basins Active and Stabilized Dune
CES304.784	Inter-Mountain Basins Mixed Salt Desert Scrub

NatureServe conservation status:

Global rank. G3G4 (1-Feb-1996).

Distribution:

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

Petrified Forest National Park. *Atriplex canescens* / *Pleuraphis jamesii* Shrubland was identified from four relevés at Petrified Forest National Park. Two relevés occurred on rolling plains; the others on a sand dune and a low slope. The relevés were mainly located in the northern section of the park on Headquarters Mesa near Kachina Point, near the northern Visitor Center, and north of Interstate 40 west of the park road. The association was also located in the central neck section of the park north of the Puerco River.

Environmental summary:

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

Petrified Forest National Park. This association occurred between the elevations of 1663 and 1785 m (5456-5856 ft). Slope was minimal and ranged from none to 3% (average 1%).

USFWS wetland system: Not applicable.

Vegetation description:

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

Petrified Forest National Park. Four relevés were classified as *Atriplex canescens* / *Pleuraphis jamesii* Shrubland. The total vegetation cover of these relevés varied between 25 and 30% (average 28%) with a shrub stratum of 4-8% cover (average 6%) and an herbaceous stratum of 18-26% cover (average 22%). Each relevé varied in species diversity between 21 and 30 species (average 26 species). The shrub layer was relatively patchy, was dominated or codominated by *Atriplex canescens*, and varied between 1 and 6% cover (average 3%). In some of the relevés, other shrubs may codominate the association. *Pleuraphis jamesii* either dominated the herbaceous layer or occurred as an indicator species for this association, ranging from 1 to 12% cover (average 6%). Two of these relevés had a high cover of annuals and notable drought impacts. *Phacelia crenulata* covered 9% of one relevé, and *Phacelia* sp. had a high cover in two of the relevés (6 and 10%).

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/sapling	<i>Chrysothamnus viscidiflorus</i> , <i>Ericameria nauseosa</i> , <i>Atriplex canescens</i> , <i>Gutierrezia sarothrae</i> , <i>Krascheninnikovia lanata</i>	<i>Atriplex canescens</i>
Herb (field)	<i>Achnatherum hymenoides</i> , <i>Bouteloua gracilis</i> , <i>Pleuraphis jamesii</i> , <i>Sporobolus airoides</i> , <i>Sporobolus cryptandrus</i>	<i>Pleuraphis jamesii</i>

Other noteworthy species:

Global species	PEFO species
<i>Bromus tectorum</i> , <i>Salsola kali</i>	Data are not available.

References:

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

C.3 Shrubland

C.3.5. *Ericameria nauseosa* Desert Wash Shrubland

Base map class	Rubber Rabbitbrush Desert Wash Shrubland
NatureServe common name	Rubber Rabbitbrush Desert Wash Shrubland
NatureServe code	CEGL002261

Summary:

This association is found in or near temporary watercourses on point bars, basin floors, and low stream terraces in western Colorado and eastern Utah. Stands have been found between 1189 and 2104 m (3900-6900 ft) elevation. Sites are flat to gently sloping (<3 degrees) and of any aspect. The unvegetated surface is mostly bare soil, sand, and/or loose rocks. There is usually little litter, but sometimes woody debris can be deposited by floods. Parent materials are variable, but sandstone, shale, and gneiss are most common on sampled stands. Soils are rapidly drained to well-drained sands or sandy loams. This shrubland association has sparse to moderate total vegetation cover (1-65%). This association is characterized by an open short-shrub layer distributed in linear rows along the intermittent drainages. *Ericameria nauseosa* is the dominant shrub with 1-15% cover. Other shrubs are typically present but contribute little cover. These include *Artemisia tridentata*, *Atriplex canescens*, *Atriplex confertifolia*, *Ephedra viridis*, *Fraxinus anomala*, *Gutierrezia sarothrae*, *Purshia stansburiana*, *Quercus havardii*, and *Sarcobatus vermiculatus*. The herbaceous stratum has sparse to moderate cover. The exotic *Bromus tectorum* is often abundant. Other herbaceous species commonly found are *Achnatherum hymenoides*, *Descurainia pinnata*, *Elymus elymoides*, *Glycyrrhiza lepidota*, *Hesperostipa comata*, *Hordeum jubatum*, and *Pleuraphis jamesii*.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. In sparse or patchy stands, *Ericameria nauseosa* acts as an indicator species.

Petrified Forest National Park. This map class was distinguished from *Ericameria nauseosa* / *Bouteloua gracilis* Shrub Herbaceous Vegetation by its location in or near a wash system. This association also had higher shrub cover and lower herbaceous cover.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A.	Evergreen shrubland
Physiognomic group	III.A.4.	Microphyllous evergreen shrubland
Physiognomic 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 (A.835), Rubber Rabbitbrush Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.781	Inter-Mountain Basins Wash

NatureServe conservation status:

Global rank. GNR (10-Jan-2005).

Distribution:

Globally. This association has been found in western Colorado and eastern Utah. It is likely found in other places of the arid western U.S.

Petrified Forest National Park. *Ericameria nauseosa* Desert Wash Shrubland was identified from eight relevés in Petrified Forest National Park. All of these relevés were associated with washes and occurred on bajadas, playas, and talus landforms. They were mostly located in the northern half of the project area, including east of Chinde Point in the northern wilderness area, southwest of Pintado Point near the Lithodendron Wash, the northwestern corner of the park near Digger Wash, and on the northern and eastern slopes of Chinde Mesa. The association also occurred in the central neck area of the park north of the Puerco River and south of Interstate 40 near the northern headquarters office.

Environmental summary:

Globally. This association is found in or adjacent to temporary watercourses on point bars, basin floors, and low stream terraces. Stands have been found between 1189 and 2104 m (3900-6900 ft) elevation. Sites are flat to gently sloping (<3 degrees) and of any aspect. The unvegetated surface is mostly bare soil, sand, and/or loose rocks. There is usually little litter, but sometimes woody debris can be deposited by floods. Parent materials are variable, but sandstone, shale, and gneiss are most common on sampled stands. Soils are rapidly drained to well-drained sands, sandy loams or silt loams derived from alluvium. Biological soil crusts may be present but do not provide much cover.

Petrified Forest National Park. This association varied between 1660 and 1780 m (5340-5840 ft) elevation. The slope was minimal, ranging from 0 to 4% (average 2%). All of these relevés were associated with washes or areas that seasonally flood. Several of them had surface rock cover, including sandstone, mudstone, assorted gravel, and cobbles.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This shrubland association has sparse to moderate total vegetation cover (1-65%). This association is characterized by an open to moderately dense short-shrub layer distributed in linear rows along the intermittent drainages. *Ericameria nauseosa* is the dominant shrub with 1-15% cover. In sparse or patchy stands, *Ericameria nauseosa* acts as an indicator species. Other shrubs are typically present, but contribute little cover. These include *Artemisia tridentata*, *Atriplex canescens*, *Atriplex confertifolia*, *Ephedra viridis*, *Fraxinus anomala*, *Gutierrezia sarothrae*, *Purshia stansburiana*, *Quercus havardii*, and *Sarcobatus vermiculatus*. The herbaceous stratum has sparse to moderate cover. The exotic *Bromus tectorum* is often abundant. Other herbaceous species commonly found are *Achnatherum hymenoides*, *Descurainia pinnata*, *Elymus elymoides*, *Glycyrrhiza lepidota*, *Hesperostipa comata*, *Hordeum jubatum*, and *Pleuraphis jamesii*.

Petrified Forest National Park. Eight relevés were classified as *Ericameria nauseosa* Desert Wash Shrubland, with total vegetation cover varying between 9 and 29% (average 18%). The vegetation cover consisted of a shrub stratum which ranged from 7 to 15% cover (average 12%) and an herbaceous stratum with 2-11% cover (average 5%). The species diversity ranged from 17 to 38 species (average 27 species). *Ericameria nauseosa* always had significant cover in the shrub layer and ranged from 0.5 to 6% cover (average 2%); however, it did not have to dominate the shrub layer to be classified as this association. Due to the patchiness of the riparian system in some areas, *Ericameria nauseosa* acted an indicator species.

Most abundant species:

Stratum	Global species	PEFO species
Tall/short shrub/ sapling	<i>Ericameria nauseosa</i>	<i>Ericameria nauseosa</i>
Herb (field)	<i>Achnatherum hymenoides</i> , <i>Bouteloua gracilis</i> , <i>Pleuraphis jamesii</i> , <i>Sporobolus airoides</i> , <i>Sporobolus</i> <i>cryptandrus</i>	<i>Pleuraphis jamesii</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Western Ecology Working Group n.d.

C.3 Shrubland

C.3.6. *Forestiera pubescens* Shrubland

Base map class	Not mapped
NatureServe common name	Wild Privet Shrubland
NatureServe code	CEGL001168

Summary:

This shrubland association is reported from canyon bottoms, floodplains, sandy terraces along major rivers, and washes in southwestern Colorado, northeastern Arizona, and southeastern Utah. Elevation ranges from 1340 to 1680 m (4400-5500 ft). Stands typically form a narrow, but continuous, band about 3 m above the channel on streambanks and natural levees at the interface between the riparian zone and drier uplands. They occur on the outer edge of the active floodplain. Soils range from silty clays over clay loam to sandy loam derived from alluvium. This shrubland consists of a dense to open canopy of *Forestiera pubescens*, often with *Atriplex canescens*, *Ericameria nauseosa*, or *Rhus trilobata*, on the flat benches and floodplains adjacent to and above the river channel. There is often a mix of riparian and upland vegetation in these areas, with *Salix exigua* forming a dense band along the stream edge. This dense riparian shrubland can form a narrow, unfragmented, continuous cover that may alternate creekside to creekside, as part of the natural mosaic of the floodplain for one-tenth of a mile to several miles. *Phragmites australis*, a tall erect grass, or *Sporobolus airoides* often occur among the shrubs, with *Artemisia tridentata*, *Ericameria nauseosa* (= *Chrysothamnus nauseosus*), or pinyon-juniper dominating the adjacent upland vegetation. The dominance or codominance *Forestiera pubescens* in the shrub layer characterizes this association.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. More survey and classification work is needed to clarify the concept of this association throughout its range. It may be possible to split into more associations based on understory dominants.

Petrified Forest National Park. Data are not available.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.B.	Deciduous shrubland
Physiognomic group	III.B.2.	Cold-deciduous shrubland
Physiognomic subgroup	III.B.2.N.	Natural/Semi-natural cold-deciduous shrubland
Formation name	III.B.2.N.d.	Temporarily flooded cold-deciduous shrubland
Alliance name		<i>Forestiera pubescens</i> Temporarily Flooded Shrubland Alliance (A.969), Wild Privet Temporarily Flooded Shrubland Alliance

Ecological systems placement:

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

NatureServe conservation status:

Global rank. G1G2 (30-Nov-1998). The *Forestiera pubescens* riparian shrubland has not been documented outside of a few locations in Colorado. It probably occurs in Utah, Arizona, and New Mexico, although not in any great abundance. Indications of its possible presence are inferred from (1) the Flora of Utah, which lists fourteen collections of *Forestiera pubescens* from sandy terraces along the Colorado and San Juan rivers, and smaller tributaries in Emery, Garfield, Grand, Kane, San Juan, and Wayne counties (Welsh et al. 1987), and (2) Arizona floras that list *Forestiera pubescens* as *Forestiera neomexicana* (a synonym), but do not record the number or location of the collections. Livestock grazing is limited in this plant association due to the dense shrub cover, and *Forestiera pubescens* is not very palatable to livestock.

Distribution:

Globally. This association is known from Colorado in the San Miguel/Dolores River Basin.

Petrified Forest National Park. This association occurred adjacent to the Puerco River west of U.S. Highway 191.

Environmental summary:

Globally. This shrubland association is reported from canyon bottoms, floodplains, sandy terraces along major rivers, and washes in southwestern Colorado, northeastern Arizona, and southeastern Utah. Elevation ranges from 1340 to 1680 m (4400-5500 ft). Stands typically form a narrow, but continuous, band about 3 m above the channel on streambanks and natural levees at the interface between the riparian zone and drier uplands. They occur on the outer edge of the active floodplain. Soils range from silty clays over clay loam to sandy loam derived from alluvium..

Petrified Forest National Park. This association occurred in a valley bottom at 1503 m (4930 ft) elevation. The site was a level, intermittently flooded area adjacent to the Puerco River. The substrate was a sandy loam soil.

USFWS wetland system: Palustrine.

Vegetation description:

Globally. This shrubland consists of a dense to open canopy of *Forestiera pubescens*, often with *Atriplex canescens*, *Ericameria nauseosa*, or *Rhus trilobata*, on the flat benches and floodplains adjacent to and above the river channel. There is often a mix of riparian and upland vegetation in these areas, with *Salix exigua* mixing or forming a dense band along the stream edge. This dense riparian shrubland can form a narrow, unfragmented, continuous cover that may alternate creekside to creekside, as part of the natural mosaic of the floodplain for one-tenth of a mile to several miles. *Phragmites australis*, a tall erect grass, or *Sporobolus airoides* often occur among the shrubs. Common forbs include *Descurainia pinnata*, *Chenopodium album*, and *Stanleya pinnata*. The invasive, exotic shrub *Tamarix chinensis* may be present to codominant in some stands. *Artemisia tridentata*, *Ericameria nauseosa*, or pinyon-juniper often dominate the adjacent upland vegetation. This appears to be a flood-tolerant association which may be excluded from grazing due to the density of shrub cover.

Petrified Forest National Park. Only one relevé was classified as *Forestiera pubescens* Shrubland, with total vegetation cover of 56%. The vegetation cover consisted of 37% cover in the shrub stratum and 19% cover in the herbaceous stratum. The species diversity was low, with only six species. The shrub layer was characterized by *Forestiera pubescens* with 12% cover and with common associates *Atriplex canescens* (7% cover) and *Ericameria nauseosa* (14% cover). The herbaceous layer was dominated by *Sporobolus airoides* with 18% cover.

Most abundant species:

Stratum	Global species	PEFO species
Tall shrub/sapling	<i>Forestiera pubescens</i>	<i>Forestiera pubescens</i>
Short shrub/ sapling	<i>N/A</i>	<i>Ericameria nauseosa</i>
Herb (field)	<i>N/A</i>	<i>Sporobolus airoides</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Carsey et al. 2003a, Driscoll et al. 1984, Kittel and Lederer 1993, Kittel et al. 1999b, Welsh et al. 1987, Western Ecology Working Group n.d.

C.3 Shrubland

C.3.7. *Gutierrezia sarothrae* - (*Opuntia* spp.) / *Pleuraphis jamesii* Dwarf-shrubland

Base map class	Snakeweed – (Prickly Pear) / Galleta Dwarf-shrubland
NatureServe common name	Snakeweed - (Prickly-pear species) / James' Galleta Dwarf-shrubland
NatureServe code	CEGL002690

Summary:

This dwarf-shrubland was described from Utah and northern Arizona where it occurs on level to gently sloping hillslopes, plateaus and bluffs. Aspects are reported from the southeast, south, and southwest. Soils are variable, but tend to be fine-textured and may occur over gravel and cobbles. Disturbance may be important in maintaining the vegetation community as some stands have been created by chaining of trees and improper grazing by livestock. This broadly defined association is characterized by an open dwarf-shrub canopy (10-30% cover) that is dominated by *Gutierrezia sarothrae*, frequently with *Opuntia* spp. and an herbaceous layer with *Pleuraphis jamesii* present to abundant (1-30% cover). Some stands have a diverse woody layer that includes low cover of several shrub species and occasional *Pinus edulis* or *Juniperus osteosperma* trees. The herbaceous layer is typically dominated by graminoids with several species present including *Pleuraphis jamesii*, *Achnatherum hymenoides*, *Aristida purpurea*, *Bouteloua gracilis*, *Elymus elymoides*, *Hesperostipa comata*, or *Pascopyrum smithii*. There is usually only sparse cover of native forbs like *Chamaesyce* spp. or *Sphaeralcea coccinea*. Introduced species such as *Bromus tectorum* or *Salsola kali* may dominate the herbaceous layer of some disturbed stands.

Classification confidence: 3 - Weak.

Classification comments:

Globally. This broadly defined dwarf-shrubland includes stands that could also be classified as a dwarf-shrub herbaceous association.

Petrified Forest National Park. *Gutierrezia sarothrae* tended to be a rather ubiquitous species that occurred with notable cover in many associations. These two relevés were classified as this specific association due to their high cover of *Gutierrezia sarothrae* without any other dominant or diagnostic shrubs in the shrub layer.

Vegetation hierarchy:

Physiognomic class	IV	Dwarf-shrubland
Physiognomic subclass	IV.B.	Deciduous dwarf-shrubland
Physiognomic group	IV.B.2.	Cold-deciduous dwarf-shrubland
Physiognomic subgroup	IV.B.2.N.	Natural/Semi-natural cold-deciduous dwarf-shrubland
Formation name	IV.B.2.N.a.	Cespitose cold-deciduous dwarf-shrubland
Alliance name		<i>Gutierrezia sarothrae</i> Dwarf-Shrubland Alliance (A.2528), Snakeweed Dwarf-shrubland Alliance

Ecological systems placement:

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

NatureServe conservation status:

Global rank. GNR (26-Jul-2001).

Distribution:

Globally. This association is described from Utah and northern Arizona, but is likely more widespread throughout the semi-arid western U.S.

Petrified Forest National Park. *Gutierrezia sarothrae* - (*Opuntia* spp.) / *Pleuraphis jamesii* Dwarf-shrubland was identified from two relevés in Petrified Forest National Park. One relevé was sampled on a sand dune/sandsheet and the other on a midslope with talus. One of the relevés was sampled south of Interstate 40 and south of the northern headquarters office and the other was sampled in the southwestern corner of the northern wilderness area, west of Wildhorse Wash.

Environmental summary:

Globally. This association is described from Utah and northern Arizona where it occurs on level to gently sloping hillslopes, plateaus, and bluffs. Elevations range from 1350 to 2000 m. Aspects are reported from the southeast, south, and southwest. Soils are variable, but tend to be fine-textured and may occur over gravel and cobbles. Disturbance may be important in maintaining this vegetation community as some stands may have been created by chaining of trees and improper grazing by livestock.

Petrified Forest National Park. This association occurred at elevations of 1700 and 1720 m (5650 and 5590 ft). The slopes of these relevés were moderate at 3 and 13%.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This broadly defined association is characterized by an open dwarf-shrub canopy (10-30% cover) dominated by *Gutierrezia sarothrae*, frequently with *Opuntia* spp. and an herbaceous layer with *Pleuraphis jamesii* present to abundant (0-30% cover). Some stands have a diverse woody layer that includes low cover of *Artemisia nova*, *Atriplex canescens*, *Atriplex confertifolia*, *Chrysothamnus viscidiflorus*, *Coleogyne ramosissima*, *Ephedra* spp., *Eriogonum* spp., *Grayia spinosa*, *Lycium pallidum*, *Purshia tridentata*, or occasional *Pinus edulis* or *Juniperus osteosperma* trees. The herbaceous layer is typically dominated by graminoids with several species present including *Pleuraphis jamesii*, *Achnatherum hymenoides*, *Aristida purpurea*, *Bouteloua gracilis*, *Elymus elymoides*, *Hesperostipa comata*, or *Pascopyrum smithii*. There is usually only sparse cover of native forbs like *Chamaesyce* spp. or *Sphaeralcea coccinea*; however, introduced species such as *Bromus tectorum*, *Erodium cicutarium*, *Sisymbrium altissimum*, or *Salsola kali* may dominate the herbaceous layer of some disturbed stands.

Petrified Forest National Park. Two relevés were classified *Gutierrezia sarothrae* - (*Opuntia* spp.) / *Pleuraphis jamesii* Dwarf-shrubland with total vegetation cover of 16 and 28%. The vegetation cover consisted of the shrub stratum with 11 and 16% cover and the herbaceous stratum with 5 and 12% cover. Species diversity was 26 and 34 species. The vegetation in the shrub layer was dominated by *Gutierrezia sarothrae* with 3 and 14% cover. The *Opuntia* sp. shrubs covered just 0.5% in both relevés. *Pleuraphis jamesii* was a significant species in the herbaceous layer with 3% cover in both relevés.

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Gutierrezia sarothrae</i>	<i>Gutierrezia sarothrae</i>
Herb (field)	<i>Pleuraphis jamesii</i>	<i>Pleuraphis jamesii</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Cogan et al. 2004, Stubbendieck et al. 1992, USFS 1937, Von Loh et al. 2002, Western Ecology Working Group n.d.

C.3 Shrubland

C.3.8. *Isocoma drummondii* - *Pleuraphis jamesii* Shrubland [Park Special]

Base map class	Drummond Goldenweed - Galleta Shrubland
NatureServe common name	Drummond's Jimmyweed - James' Galleta Shrubland [Park Special]
NatureServe code	Park Special

Summary:

This *Isocoma drummondii* dominated sand deposit association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. This community type was newly described during the community classification process of this project. One relevé was sampled; however, the unique species composition did not allow this relevé to be placed into any of the existing NVCS communities. Since we only had one relevé of this unique community type and three relevés in a similar community type during an earlier classification effort (Thomas et al. 2003), we did not have enough data to develop a new NVCS association. Therefore, this community type was described as a unique local community type or a park special until further data are collected.

Vegetation hierarchy:

Physiognomic class	N/A	N/A
Physiognomic subclass	N/A	N/A
Physiognomic group	N/A	N/A
Physiognomic subgroup	N/A	N/A
Formation name	N/A	N/A
Alliance name		N/A

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.775	Inter-Mountain Basins Active and Stabilized Dune

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. Only one relevé was sampled of *Isocoma drummondii* - *Pleuraphis jamesii* Shrubland (Park Special). It was located on a sand dune/sandsheet north of Petrified Forest National Park on the eastern slopes of Chinde Mesa.

Environmental summary:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. This community type occurred at 1761 m (5776 ft) elevation. There was not a significant slope (1%). Surface rocks consisted of mudstone.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. One relevé was classified as *Isocoma drummondii* - *Pleuraphis jamesii* Shrubland (Park Special), with total vegetation cover of 13%. The vegetation cover consisted of 8% cover in the shrub stratum and 5% cover in the herbaceous stratum. The species diversity was 15 species for this relevé. The vegetation in the shrub layer was dominated by *Isocoma drummondii* with 3% cover, and the vegetation in the herbaceous layer was dominated by *Pleuraphis jamesii* with 1% cover.

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	N/A	<i>Isocoma drummondii</i>
Herb (field)	N/A	<i>Pleuraphis jamesii</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Atriplex confertifolia</i> , <i>Sporobolus cryptandrus</i>

References:

Thomas et al. 2003.

C.3 Shrubland

C.3.9. *Iva acerosa* - *Sporobolus airoides* Shrubland [Park Special]

Base map class	Copperweed - Alkali Sacaton Shrubland
NatureServe common name	Copperweed - Alkali Sacaton Shrubland [Park Special]
NatureServe code	Park Special

Summary:

This *Iva acerosa* dominated wash association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. This community type was newly described during the community classification process of this project. Only one relevé was sampled; however, the unique species composition did not allow this relevé to be placed into any of the existing NVCS communities. Since we only had one relevé of this unique community type and three relevés in a similar community type during an earlier classification effort (Thomas et al. 2003), we did not have enough data to develop a new NVCS association. Therefore, this community type was described as a unique local community type or a park special until further data are collected.

Vegetation hierarchy:

Physiognomic class	N/A	N/A
Physiognomic subclass	N/A	N/A
Physiognomic group	N/A	N/A
Physiognomic subgroup	N/A	N/A
Formation name	N/A	N/A
Alliance name		N/A

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.781	Inter-Mountain Basins Wash

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. *Iva acerosa* - *Sporobolus airoides* Shrubland (Park Special) was sampled at one relevé within Petrified Forest National Park. This relevé was located in a wash that has periodic streamflow on a bajada-like landform on the southwestern slopes of Chinde Mesa.

Environmental summary:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. This association occurred at 1790 m (5860 ft) elevation with little slope (5%). This relevé had a presence of mudstone surface rocks.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. Only one relevé was classified as *Iva acerosa* - *Sporobolus airoides* Shrubland (Park Special), with total vegetation cover of 30%. This vegetation cover consisted of 20% cover in the shrub stratum and 10% cover in the herbaceous stratum. The species diversity for this relevé was 26 species. The vegetation in the shrub layer was dominated by *Iva acerosa* with 8% cover. *Parryella filifolia* also had a fairly high cover in the shrub layer with 4% cover. *Sporobolus airoides* dominated the herbaceous cover (7% cover).

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	N/A	<i>Iva acerosa</i> , <i>Parryella filifolia</i>
Herb (field)	N/A	<i>Sporobolus airoides</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Atriplex confertifolia</i> , <i>Hymenoxys richardsonii</i>

References:

Data are not available.

C.3 Shrubland

C.3.10. *Krascheninnikovia lanata* / *Bouteloua gracilis* Dwarf-shrub Herbaceous Vegetation

Base map class	Winter-fat / Blue Grama Dwarf-shrubland
NatureServe common name	Winter-fat / Blue Grama Dwarf-shrub Herbaceous Vegetation
NatureServe code	CEGL001321

Summary:

This widespread, open dwarf-shrub type is found in the western Great Plains from eastern Wyoming, western Kansas, Colorado, and New Mexico to the Colorado Plateau and semi-desert mountains in the northern Chihuahuan Desert. This shrub herbaceous association occurs on alluvial flats, plains, mesas, and desert mountains. Stands occupy flat to gentle slopes between 1630 and 2080 m (5360-6820 ft) elevation. Ground cover is largely bare soil. In Colorado Plateau stands, there is often significant cover of biotic crusts (to 30% cover). The sometimes rocky soils are typically shallow, alkaline, calcareous and loamy or clayey in soil texture and are derived from shale or alluvium. The vegetation is characterized by an open dwarf-shrub canopy of *Krascheninnikovia lanata* and an understory dominated by *Bouteloua gracilis*. Other shrubs may be present with very low cover, including *Artemisia nova*, *Atriplex* spp., *Ephedra viridis*, *Gutierrezia sarothrae*, *Opuntia imbricata*, and *Opuntia polyacantha*. Associated graminoids present may include *Achnatherum hymenoides*, *Aristida purpurea*, *Elymus elymoides*, *Hesperostipa comata*, *Muhlenbergia torreyi*, *Pascopyrum smithii*, *Pleuraphis jamesii*, *Sporobolus airoides*, and *Sporobolus cryptandrus*. Forb cover is typically low but may be diverse.

Classification confidence: 1 - Strong.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. Although *Gutierrezia sarothrae* had higher cover than *Krascheninnikovia lanata*, it was not chosen as the species determined to drive the community description since it tends to be a ubiquitous species throughout the park.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.8.	Temperate or subpolar grassland with a sparse dwarf-shrub layer
Physiognomic subgroup	V.A.8.N.	Natural/Semi-natural temperate or subpolar grassland with a sparse dwarf-shrub layer
Formation name	V.A.8.N.a.	Short temperate or subpolar lowland grassland with a sparse needle-leaved or microphyllous dwarf-shrub layer
Alliance name		<i>Krascheninnikovia lanata</i> Dwarf-Shrub Herbaceous Alliance (A.1565), Winter-fat Dwarf-shrub Herbaceous Alliance

Ecological systems placement:

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

NatureServe conservation status:

Global rank. G4 (1-Feb-1996).

Distribution:

Globally. This widespread, open dwarf-shrub type is found in the western Great Plains from western Kansas and eastern Colorado, to semi-desert mountains (Oscura and San Andres mountains) in south-central New Mexico and Colorado Plateau (northern Arizona and southern Utah). This association is likely more widespread since its dominant/diagnostic species are common in the western U.S.

Petrified Forest National Park. *Krascheninnikovia lanata* - *Bouteloua gracilis* Dwarf-shrub was identified from one relevé at Petrified Forest National Park. This one relevé occurred on a sand dune/sandsheet and was located in the central neck of the park in the open plains.

Environmental summary:

Globally. This widespread, open dwarf-shrub type is found in the western Great Plains from eastern Wyoming, western Kansas, Colorado, and New Mexico semi-desert mountains (Oscura and San Andres mountains in south-central New Mexico) and Colorado Plateau. This shrub herbaceous association occurs on alluvial flats, plains, mesas, and desert mountains. Stands occupy flat to gentle slopes between 1630 and 2080 m (5360-6820 ft) elevation. Ground cover is largely bare soil. In Colorado Plateau stands, there is often significant cover of biotic crusts (to 30% cover). The sometimes rocky soils are typically shallow, alkaline, calcareous and loamy or clayey in soil texture and are derived from shale or alluvium (Francis 1986, Lauer et al. 1999, Muldavin et al. 2000b). In Kansas, stands occur in areas with sparse vegetation on uplands and flats. Soils are shallow, rocky, and alkaline (Lauer et al. 1999).

Petrified Forest National Park. This association occurred at an elevation of 1717 m (5633 ft). The slope was minimal (2%).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. The vegetation contains an open shrub and graminoid layer. The dwarf-shrub layer is about 0.5 m tall, containing annual stems from a woody rootstock, and microphyllous leaves. The dominant dwarf-shrub is *Krascheninnikovia lanata*. The sparse to dense herbaceous layer is dominated by *Bouteloua gracilis*. Other shrubs may be present with very low cover, including *Artemisia nova*, *Atriplex* spp., *Ephedra viridis*, *Gutierrezia sarothrae*, *Opuntia imbricata*, and *Opuntia polyacantha*. Associated graminoids present may include *Achnatherum hymenoides*, *Aristida purpurea*, *Elymus elymoides*, *Hesperostipa comata*, *Muhlenbergia torreyi*, *Pascopyrum smithii*, *Pleuraphis jamesii*, *Sporobolus airoides*, and *Sporobolus cryptandrus* (Francis 1986, Muldavin et al. 2000b). Forb cover is typically low but may be diverse. Common species in the Colorado Plateau are *Chaetopappa ericoides*, *Cryptantha crassise-pala*, *Gilia leptomeria*, *Helianthus petiolaris*, *Machaeranthera canescens*, *Mentzelia albicaulis*, *Plantago patagonica*, *Senecio spartioides*, and *Sphaeralcea coccinea*; *Glandularia bipinnatifida* is the most constant in mountains of south-central New Mexico. In Kansas, *Stanleya pinnata*, a subshrubby perennial from a woody base, can be over 1 m tall and is often present; *Echinacea angustifolia* and *Liatris punctata* often codominate with *Bouteloua gracilis* in the herbaceous layer. Exotic annual grass *Bromus tectorum* is frequently present in disturbed stands.

Petrified Forest National Park. Only one relevé was classified as *Krascheninnikovia lanata* - *Bouteloua gracilis* Dwarf-shrub, with total vegetation cover of 26%. This vegetation cover consisted of 13% cover in the shrub stratum and 13% cover in the herbaceous stratum. The species diversity was 23 species. The vegetation in the shrub layer was dominated by *Krascheninnikovia lanata* with 5% cover and *Gutierrezia sarothrae* with 6% cover. The herbaceous layer was dominated by *Bouteloua gracilis* with 5% cover.

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Krascheninnikovia lanata</i>	<i>Krascheninnikovia lanata</i>
Herb (field)	<i>Bouteloua gracilis</i>	<i>Bouteloua gracilis</i>

Other noteworthy species:

Global species	PEFO species
<i>Bromus tectorum</i>	<i>Data are not available.</i>

References:

BIA 1979, Bourgeron and Engelking 1994, Driscoll et al. 1984, Francis 1986, Johnston 1987, Lauver et al. 1999, Muldavin and Mehlhop 1992, Muldavin et al. 1998d, Muldavin et al. 2000b, Soil Conservation Service 1978, Western Ecology Working Group n.d.

C.3 Shrubland

C.3.11. *Krascheninnikovia lanata* Dwarf-shrubland

Base map class	<i>Krascheninnikovia lanata</i> Dwarf-shrubland was not mapped as a separate map class because it lacked a definable photosignature and had only one representative relevé. This one location was incorporated within the map class Four-wing Saltbush / Galleta Shrubland.
NatureServe common name	Winter-fat Dwarf-shrubland
NatureServe code	CEGL001320

Summary:

This association is known from Colorado Plateau west into the Great Basin and northern Mojave Desert and east into the northern panhandle of Texas and is likely to be more widespread in similar habitats in the southwestern Great Plains. It is an alkaline dwarf-shrub association that occurs primarily on sandsheets, slopes, and plains often on eolian deposits near canyon walls and in alkaline flats in and around playas and along washes. Sites are flat to steep (up to 40% slope) and occur between 800 and 1770 m (2620-5800 ft) elevation. Soils are rapidly drained loamy sands or sandy loams derived from alluvium from a variety of parent materials and sandstones that have eroded and been redeposited by wind and water. It occurs on low to high levels of soil salinity and alkalinity. Total vegetation cover ranges from 5 to 45% and is characterized by the dwarf-shrub *Krascheninnikovia lanata* with cover between 5 and 30%. In southern Nevada, scattered *Ambrosia dumosa*, *Atriplex polycarpa*, *Larrea tridentata*, *Lycium andersonii*, *Sphaeralcea ambigua*, and *Suaeda moquinii* (= *Suaeda fruticosa*) may be present. The herbaceous layer is poorly developed but may contain tufts of the grass *Achnatherum hymenoides*. Forbs commonly present include *Eriogonum* spp., *Opuntia polyacantha*, *Oenothera pallida*, *Plantago patagonica*, and *Sphaeralcea parvifolia*. Biological soil crusts may provide up to 45% cover. Introduced annuals *Bromus tectorum*, *Bromus rubens*, and *Salsola tragus* may be abundant on some sites.

Classification confidence: 3 - Weak.

Classification comments:

Globally. This is a broadly defined association that includes stands from the Colorado Plateau, Great Basin, and northern Mojave Desert characterized by the dominance of *Krascheninnikovia lanata* without a notable herbaceous layer. The herbaceous layer is typically absent or sparse or dominated by introduced species such as *Bromus tectorum* or *Salsola tragus*. This is a very-small-patch association as presently defined from Lake Meredith National Recreation Area, Texas. The concept will need further review to determine if it is a viable association or should be considered as patches within a broader association.

Petrified Forest National Park. Only one relevé was sampled of this association. More samples are needed to fully characterize this association at the park.

Vegetation hierarchy:

Physiognomic class	IV	Dwarf-shrubland
Physiognomic subclass	IV.A.	Evergreen dwarf-shrubland
Physiognomic group	IV.A.2.	Extremely xeromorphic evergreen dwarf-shrubland
Physiognomic subgroup	IV.A.2.N.	Natural/Semi-natural extremely xeromorphic evergreen dwarf-shrubland
Formation name	IV.A.2.N.a.	Extremely xeromorphic evergreen subdesert dwarf-shrubland
Alliance name	<i>Krascheninnikovia lanata</i> Dwarf-Shrubland Alliance (A.1104), Winter-fat Dwarf-shrubland Alliance	

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.775	Inter-Mountain Basins Active and Stabilized Dune

NatureServe conservation status:

Global rank. G5? (23-Feb-1994).

Distribution:

Globally. This association is known from the Colorado Plateau west into the Great Basin and northern Mojave Desert.

Petrified Forest National Park. *Krascheninnikovia lanata* Dwarf-shrubland was identified from one relevé. It was located on a sand dune/sandsheet at Petrified Forest National Park northwest of Pilot Rock.

Environmental summary:

Globally. This association is known from the Colorado Plateau west into the Great Basin and northern Mojave Desert and in the panhandle of Texas. It is an alkaline dwarf-shrub association that occurs primarily on sandsheets, slopes, and plains often on eolian deposits near canyon walls and in alkaline flats in and around playas and along washes. Sites are gentle to steep (up to 40% slope) and occur between 800 and 1770 m (2620-5800 ft) elevation. Soils are rapidly drained loamy sands from alluvium derived from a mixture of rocks such as granodiorite, quartzite, latite, limestone, and basalt in southern Nevada (Faden 1977) and sandy loams derived from Navajo and Entrada sandstones in southeastern Utah that have eroded and been redeposited by wind and water. It occurs on low to high levels of soil salinity and alkalinity.

In Texas, this community occurs on shallow soils on ridges and on footslopes along the Canadian River. In general, the soils are redbed-derived and shallow in nature. It would seem that this shrub is able to grow on a variety of soils but prefers the shallower, rocky areas. It is often found growing in association with other shrubs but may grow alone in small colonies. When this community is found, it is never extensive and rarely occupies more than a third of an acre. There is usually some evidence of deer browsing on this species, and in areas where it is accessible, domestic livestock will browse it as well.

Petrified Forest National Park. This association occurred at 1770 m (5800 ft) elevation.

USFWS wetland system: Palustrine.

Vegetation description:

Globally. On the Colorado Plateau, total vegetation cover ranges from 5 to 45% and is characterized by the dwarf-shrub *Krascheninnikovia lanata* with cover between 5 and 30%. In southern Nevada, scattered *Ambrosia dumosa*, *Atriplex polycarpa*, *Larrea tridentata*, *Lycium andersonii*, *Sphaeralcea ambigua*, and *Suaeda moquinii* (= *Suaeda fruticosa*) may be present (Faden 1977). The herbaceous layer is poorly developed but may contain tufts of the grass *Achnatherum hymenoides*. Forbs commonly present include *Eriogonum* spp., *Opuntia polyacantha*, *Oenothera pallida*, *Plantago patagonica*, and *Sphaeralcea parvifolia*. Biological soil crusts provide up to 45% cover. Introduced annuals *Bromus tectorum*, *Bromus rubens*, and *Salsola tragus* may be abundant on some sites.

In Texas, this small community is dominated by *Krascheninnikovia lanata*, with some other short shrubs also being present in lesser amounts. Associated shrubs present in the community include *Dalea formosa*, *Mimosa borealis*, *Atriplex canescens*, and occasionally small *Prosopis glandulosa*. The community gives the appearance of being droughty and forbs are few. *Tetaneuris scaposa*, *Gutierrezia sarothrae*, *Chaetopappa ericoides* (= *Leucelene ericoides*), *Paronychia jamesii*, and *Eriogonum longifolium* are the most common. The most common grasses

are *Aristida purpurea*, *Hesperostipa neomexicana* (= *Stipa neomexicana*), *Bouteloua gracilis*, and *Bouteloua curtipendula*.

Petrified Forest National Park. Only one relevé was classified as *Krascheninnikovia lanata* Dwarf-shrubland, with total vegetation cover of 34%. This vegetation cover consisted of 31% cover in the shrub stratum and 3% cover in the herbaceous stratum. The species diversity was 15 species. The vegetation in the shrub layer was dominated by *Krascheninnikovia lanata*, with 30% cover.

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Krascheninnikovia lanata</i>	<i>Krascheninnikovia lanata</i>

Other noteworthy species:

Global species	PEFO species
<i>Bromus tectorum</i>	Data are not available.

References:

Bourgeron and Engelking 1994, Driscoll et al. 1984, Faden 1977, Mitchell et al. 1966, NVNHP 2003, Western Ecology Working Group n.d.

C.3 Shrubland

C.3.12. *Purshia stansburiana* - *Eriogonum corymbosum* Shrubland

Base map class	Cliff-rose – Crispleaf Buckwheat Shrubland
NatureServe common name	Stansbury's Cliffrose - Crispleaf Wild Buckwheat Shrubland
NatureServe code	CEGL004011

Summary:

This shrubland association is only known from Petrified Forest National Park. The summary that follows is derived from data from five relevés. This association occurs on lower slopes, midslopes, terraces, and mesas between 1740 and 1920 m (5700–6290 ft) elevation. Slope ranges from none to steep (0–22%) (average 9%). Most of the stands have basalt surface rocks, and one has sandstone surface rocks. Total vegetation cover ranges from 15 to 24% cover (average 18%). The vegetation is characterized by an open shrub layer codominated by *Purshia stansburiana* and *Eriogonum corymbosum*, with an open to sparse herbaceous stratum (0.5–6% cover). Species diversity ranges from 20 to 24 species. Other shrubs are often present with low cover, such as *Artemisia bigelovii*, *Atriplex canescens*, *Ephedra torreyana*, *Ephedra viridis*, *Brickellia oblongifolia*, and *Gutierrezia sarothrae*. Common grasses and forbs present include *Chamaesyce fendleri*, *Chamaesyce parryi*, *Cryptantha crassisejala*, *Phacelia crenulata*, *Elymus elymoides*, and exotic annual grass *Bromus rubens*.

Classification confidence: 3 - Weak.

Classification comments:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. One relevé lacked coverage of *Eriogonum corymbosum*; however, it had similar composition and structure to the other relevés in this association and had a significant cover of *Purshia stansburiana*. This relevé was included in this association for this classification effort; however, with additional classification efforts, it may be reclassified.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A.	Evergreen shrubland
Physiognomic group	III.A.4.	Microphyllous evergreen shrubland
Physiognomic 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>Purshia (stansburiana, mexicana)</i> Shrubland Alliance (A.833), (Stansbury's Cliffrose, Mexican Cliffrose) Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.765	Colorado Plateau Mixed Bedrock Canyon and Tableland
CES304.789	Inter-Mountain Basins Shale Badland

NatureServe conservation status:

Global rank. GNR (14-Feb-2007).

Distribution:

Globally. This association is known only from Petrified Forest National Park in northeastern Arizona. It likely occurs elsewhere on the Colorado Plateau.

Petrified Forest National Park. *Purshia stansburiana* - *Eriogonum corymbosum* Shrubland was identified from five relevés within Petrified Forest National Park. This association occurred on various landforms, including lower slopes, midslopes, terraces, and mesas. It was located north of Pintado Point on the slopes of Headquarters Mesa, south of Tawa Point near the park road, on the northwest slopes of Pilot Rock, on top of Pilot Rock, west of Dry Wash, and west of Crystal Forest.

Environmental summary:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. This association occurred between the elevations of 1740 and 1920 m (5700-6290 ft). Slope ranges from none to steep (0-22%, average 9%). Most of the relevés had basalt surface rocks and one had sandstone surface rocks.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. Five relevés were classified as *Purshia stansburiana* - *Eriogonum corymbosum* Shrubland, with total vegetation cover varying between 15 and 24% cover (average 18%). This vegetation cover consisted of a shrub stratum with 10-18% cover and an herbaceous stratum with 0.5-6% cover (average 3%). The species diversity ranged from 20 to 24 species (average 22 species). The vegetation was dominated in the shrub layer by *Purshia stansburiana* with 0.5-5% cover (average 3%) and *Eriogonum corymbosum* with 0-3% cover (average 1%).

Petrified Forest National Park. Only one relevé was classified as *Krascheninnikovia lanata* Dwarf-shrubland, with total vegetation cover of 34%. This vegetation cover consisted of 31% cover in the shrub stratum and 3% cover in the herbaceous stratum. The species diversity was 15 species. The vegetation in the shrub layer was dominated by *Krascheninnikovia lanata*, with 30% cover.

Most abundant species:

Stratum	Global species	PEFO species
Tall shrub/sapling	<i>Purshia stansburiana</i>	<i>Purshia stansburiana</i>
Short shrub/sapling	N/A	<i>Eriogonum corymbosum</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Western Ecology Working Group n.d.

C.3 Shrubland

C.3.13. *Rhus trilobata* - *Ephedra* (*viridis*, *torreyana*) Talus Shrubland

Base map class	Three-leafed Sumac - Mormon Tea Talus Shrubland
NatureServe common name	Skunkbush - (Mormon-tea, Torrey's Joint-fir) Talus Shrubland
NatureServe code	CEGL003776

Summary:

This Colorado Plateau mixed shrub assemblage occurs on steep, rocky colluvial slopes and bedrock canyon rims associated with mesas, canyons, benches, ravines, hills, hogbacks, escarpments, and valley sides. Slopes are typically moderate and range from level to steep (0-70%), occur between 1238 and 1700 m (4000-5580 ft) elevation, and tend to occur on southerly to westerly aspects (less often east-facing slopes). Soils are shallow and rocky and range from rapidly drained clay loams to sandy loams derived from shales and sandstones. It tends to be slightly more mesic than most other talus type vegetation. Total vegetation cover is sparse, not exceeding 25%. It is characterized by a scattered mixture of shrubs, among which *Rhus trilobata* var. *trilobata* and *Ephedra torreyana* or *Ephedra viridis* are conspicuous and either dominant or codominant. As many as ten other species of shrubs may also be present, including *Amelanchier utahensis*, *Artemisia bigelovii*, *Atriplex confertifolia*, *Brickellia microphylla*, *Chrysothamnus viscidiflorus*, *Coleogyne ramosissima*, *Ericameria nauseosa*, *Eriogonum corymbosum*, and *Philadelphus microphyllus*. *Fraxinus anomala* is absent, and if *Pinus edulis* or *Juniperus osteosperma* are present, cover is less than 1%. Herbaceous cover is sparse and variable. Biological soil crust formation is rare on these active slopes.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. This map class was photointerpreted based on the environmental characteristics of the talus slopes, assuming that the three shrub species uniquely characterized this habitat type.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.B.	Deciduous shrubland
Physiognomic group	III.B.2.	Cold-deciduous shrubland
Physiognomic 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>Rhus trilobata</i> Shrubland Alliance (A.3569), Skunkbush Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.765	Colorado Plateau Mixed Bedrock Canyon and Tableland

NatureServe conservation status:

Global rank. GNR (20-Mar-2006).

Distribution:

Globally. This association is known from Arches National Park but likely is widespread in the canyonlands of the Colorado Plateau in eastern Utah.

Petrified Forest National Park. *Rhus trilobata* - *Ephedra (viridis, torreyana)* Talus Shrubland was identified at three relevés on talus slopes within Petrified Forest National Park. The relevés were located on talus slopes. This association was recorded from two main locations: one location south of Blue Mesa near the Blue Mesa Road and the other north of Jasper Forest in the southwestern corner of the park.

Environmental summary:

Globally. This Colorado Plateau mixed shrub assemblage occurs on steep, rocky colluvial slopes and bedrock canyon rims associated with mesas, canyons, benches, ravines, hills, hogbacks, escarpments, and valley sides. Slopes are typically moderate and range from level to steep (0-70%), occur between 1238 and 1700 m (4000-5580 ft) elevation, and tend to occur on southerly to westerly aspects (less often east-facing slopes). Soils are shallow and range from rapidly drained clay loams to sandy loams. Parent materials include shales (Moenkopi and Chinle) and sandstones (Cedar Mountain, Navajo, and Wingate). Most of the unvegetated surface is covered by gravel, talus, bedrock and large rocks, and occasionally petrified wood. There is little dead wood, biological soil crust, or litter. It tends to be slightly more mesic than most other talus type vegetation.

Petrified Forest National Park. Elevation ranged from 1680 to 1700 m (5500-5580 ft). All of the relevés were sampled on steep slopes that varied between 45 and 50% (average 47%), with variable aspects ranging from an easterly to a southwestern direction. The talus in all of the relevés was composed of sandstone. One relevé also had a low cover of surface rocks consisting of petrified wood.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This shrubland association has sparse to low cover of vegetation, not exceeding 25% total cover. It is characterized by a scattered mixture of shrubs, among which *Rhus trilobata* var. *trilobata* and *Ephedra torreyana* or *Ephedra viridis* are conspicuous and either dominant or codominant. As many as ten other species of shrubs may also be present, including *Amelanchier utahensis*, *Artemisia bigelovii*, *Atriplex confertifolia*, *Brickellia microphylla*, *Chrysothamnus viscidiflorus*, *Coleogyne ramosissima*, *Ericameria nauseosa*, *Eriogonum corymbosum*, and *Philadelphus microphyllus*. *Fraxinus anomala* is absent or has trace cover, and if *Pinus edulis* or *Juniperus osteosperma* are present, cover is less than 1%. The herbaceous layer may include many species but never provides more than a few percent cover. *Achnatherum hymenoides*, *Aristida purpurea*, *Elymus elymoides*, *Pleuraphis jamesii*, *Leymus salinus*, and exotic annual grasses *Bromus rubens* or *Bromus tectorum* are common grasses. Forb compositions are variable with frequent species including *Artemisia ludoviciana*, *Chaetopappa ericoides*, *Cryptantha crassisepala*, *Stanleya pinnata*, and *Plantago patagonica*. Biological soil crust formation is rare on these active slopes.

Petrified Forest National Park. Three relevés were classified as *Rhus trilobata* - *Ephedra (viridis, torreyana)* Talus Shrubland, with total vegetation cover ranging from 8 to 21% (average 15%). This vegetation cover consisted of a shrub layer with 6-12% cover (average 9%) and an herbaceous layer with 2-9% cover (average 6%). The species diversity ranged from 19 to 31 species (average 26 species). The vegetation was composed of three indicator shrub species: *Rhus trilobata*, *Ephedra viridis*, and *Ephedra torreyana*. Each of these shrub species may or may not be present, and their relative proportions to one another varied depending on the environmental conditions. In these three relevés, *Rhus trilobata* ranged from 0 to 2% cover (average 1%), *Ephedra viridis* ranged from 1 to 4% cover (average 3%), and *Ephedra torreyana* ranged from 0 to 0.5% cover (average <0.5%).

Most abundant species:

Stratum	Global species	PEFO species
Tall shrub/sapling	<i>Amelanchier utahensis</i> , <i>Rhus trilobata</i> var. <i>trilobata</i>	N/A
Short shrub/sapling	N/A	<i>Rhus trilobata</i> , <i>Ephedra torreyana</i> , <i>Ephedra viridis</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Western Ecology Working Group n.d.

C.3 Shrubland

C.3.14. *Salix exigua* / Barren Shrubland

Base map class	Coyote Willow Shrubland
NatureServe common name	Coyote Willow / Barren Shrubland
NatureServe code	CEGL001200

Summary:

This riparian shrubland is common in the Rocky Mountains, Colorado Plateau, and Great Basin. It is composed of nearly pure stands of *Salix exigua*, with few other species. Exposed gravel, cobbles, or sand characterize the ground cover, but an undergrowth of a few, scattered forbs and grasses is usually present. This association occurs within the annual flood zone of rivers on point bars, islands, sand or cobble bars, and streambanks.

Classification confidence: 1 - Strong.

Classification comments:

Globally. In the western Great Plains this association includes stands composed of intermediates between *Salix interior* (= *Salix exigua* ssp. *interior*) and *Salix exigua* (= *Salix exigua* ssp. *exigua*) (Dorn 1997, G. Kittel pers. comm. 2001). Until recently these taxa were combined at the species level (Kartesz 1999). More information on the distribution of introgression between *Salix interior* (= *Salix exigua* ssp. *interior*) and *Salix exigua* (= *Salix exigua* ssp. *exigua*) is needed to fully understand the ranges of these two species.

Petrified Forest National Park. The understory of this association was sparse but not totally barren. This association may be better classified under a different association classification. Currently, the classification is based on pre-existing NVCS association nomenclature and might be better classified with additional sampling of *Salix exigua* communities at Petrified Forest National Park.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.B.	Deciduous shrubland
Physiognomic group	III.B.2.	Cold-deciduous shrubland
Physiognomic subgroup	III.B.2.N.	Natural/Semi-natural cold-deciduous shrubland
Formation name	III.B.2.N.d.	Temporarily flooded cold-deciduous shrubland
Alliance name		<i>Salix (exigua, interior)</i> Temporarily Flooded Shrubland Alliance (A.947), (Coyote Willow, Sandbar Willow) Temporarily Flooded Shrubland Alliance

Ecological systems placement:

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

NatureServe conservation status:

Global rank. G5 (15-Jun-2001).

Distribution:

Globally. This riparian shrubland association is common along waterways of all sizes at lower to middle elevations in the Great Basin, Colorado Plateau and Rocky Mountains extending out into the western Great Plains along major rivers.

Petrified Forest National Park. *Salix exigua* / Barren Shrubland occurred at two relevés within Petrified Forest National Park on bajada, playa, and talus landforms. Both these relevés were sampled from the same area in the central neck area of the park. The relevés were located south of the railroad tracks on the northern edge of the Puerco River, east of the park road, and along the corridor of Dead Wash.

Environmental summary:

Globally. This riparian shrubland is common in the Rocky Mountains, Colorado Plateau, and Great Basin. Elevation ranges from 780-2600 m. This association occurs within the annual flood zone of rivers on point bars, islands, sand or cobble bars, and on streambanks occurring along a wide variety of stream reaches, from moderately sinuous and moderate-gradient reaches. It can form large, wide stands on mid-channel islands in larger rivers or narrow stringer bands on small, rocky tributaries. Substrates are typically coarse alluvial deposits of sand, silt and, cobbles that are highly vertically stratified from flooding scour and deposition, often consisting of alternating layers of finer textured soil with organic material over coarser alluvium. Occasionally, this association occurs on deep pockets of sand. The lack of soil development and high ground cover of coarse alluvial material are key indicators for this association.

Petrified Forest National Park. This association occurred at 1630 and 1640 m (5330-5370 ft) elevation. Slope was none to slight (0-1%).

USFWS wetland system: Palustrine.

Vegetation description:

Globally. This riparian association is characterized by a sparse to dense, tall-shrub (1.5-3 m) canopy composed of *Salix exigua*, with ground cover of exposed gravel, cobbles, or sand. *Salix exigua* may be the only shrub in the community, or other shrubs and trees may be present with relatively low cover, including *Alnus incana*, *Ericameria nauseosa*, *Rhus trilobata*, *Salix monticola*, *Salix ligulifolia* (= *Salix eriocephala* var. *ligulifolia*), *Salix irrorata*, *Salix lucida*, *Abies lasiocarpa*, *Acer negundo*, *Populus angustifolia*, *Populus deltoides*, *Populus fremontii*, and *Salix gooddingii*. A sparse herbaceous layer may be present among the bare soil, gravel, cobbles, or boulders, consisting of a wide variety of forbs and graminoids. *Mentha arvensis* and species of *Carex*, *Eleocharis*, *Juncus*, *Schoenoplectus*, and *Equisetum* are often present. Introduced species, such as *Elaeagnus angustifolia*, *Tamarix* spp., *Bromus tectorum*, *Bromus inermis*, *Elymus repens* (= *Elytrigia repens*), *Poa pratensis*, *Agrostis stolonifera* (and other exotic forage species), *Taraxacum officinale*, *Coryza canadensis*, and *Lepidium latifolium* have been reported from some stands.

Petrified Forest National Park. Two relevés were classified as *Salix exigua* / Barren Shrubland, with total vegetation cover of 25 and 32%. This vegetation cover consisted of low tree cover (0.5%) in one relevé and none in the other, a dominant shrub cover with 20 and 30% cover, and a low herbaceous cover of 2 and 5% within the herbaceous stratum. The species diversity for the association was 20 and 24 species. The vegetation in the shrub layer was dominated by *Salix exigua*, which had 18 and 22% cover. *Ericameria nauseosa* had some cover in both relevés with 3 and 4% cover.

Most abundant species:

Stratum	Global species	PEFO species
Tall shrub/sapling	<i>Salix exigua</i>	<i>Salix exigua</i>

Other noteworthy species:

Global species	PEFO species
<i>Bromus tectorum</i> , <i>Melilotus officinalis</i> , <i>Tamarix chinensis</i> , <i>Xanthium strumarium</i>	<i>Data are not available.</i>

References:

Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Carsey et al. 2003a, Christy 1973, Cogan et al. 2004, Cowardin et al. 1979, Culver et al. 1996, Dorn 1997, Driscoll et al. 1984, Durkin et al. 1995b, Hall and Hansen 1997, Hansen et al. 1995, Hansen et al. 2004b, IDCDC 2005, Johnston 1987, Jones and Walford 1995, Kagan et al. 2004, Kittel and Lederer 1993, Kittel et al. 1994, Kittel et al. 1995, Kittel et al. 1996, Kittel et al. 1999a, Kovalchik 1987, Manning and Padgett 1995, Muldavin et al. 2000a, Padgett 1981, Padgett et al. 1988b, Padgett et al. 1989, Richard et al. 1996, Tuhy and Jensen 1982, Von Loh et al. 2002, Western Ecology Working Group n.d.

C.3 Shrubland

C.3.15. *Salvia pachyphylla* Dwarf-shrubland [Park Special]

Base map class	Blue Sage Dwarf-shrubland
NatureServe common name	Rose Sage Dwarf-shrubland [Park Special]
NatureServe code	Park Special

Summary:

This *Salvia pachyphylla* dominated badland association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. With only two relevés of *Salvia pachyphylla* Dwarf-shrubland (Park Special) sampled, there was not enough data to develop a new NVCS association for this community type. Until additional data are collected, this type will be retained as a Petrified Forest National Park Special. However, it is not likely that this community will be sampled in areas outside of the NPS boundary since *Salvia pachyphylla* has a restricted range and is isolated to a few small locations in northern Arizona.

Vegetation hierarchy:

Physiognomic class	N/A	N/A
Physiognomic subclass	N/A	N/A
Physiognomic group	N/A	N/A
Physiognomic subgroup	N/A	N/A
Formation name	N/A	N/A
Alliance name		N/A

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.789	Inter-Mountain Basins Shale Badland

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. *Salvia pachyphylla* Dwarf-shrubland (Park Special) occurred on two relevés within Petrified Forest National Park. They were located on mid- and lower slopes of Chinde Mesa.

Environmental summary:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. This association occurred at 1820 and 1830 m (5980-6000 ft) elevation. The slopes were steep (29-38%) with northeastern and northwestern orientations. Both relevés had mudstone surface rocks.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. Two relevés were classified as *Salvia pachyphylla* Dwarf-shrubland (Park Special), with total vegetation cover of 11 and 19%. This vegetation cover consisted of a tree stratum of 2% cover in both relevés, a shrub stratum with 9 and 14% cover, and an herbaceous stratum with 0.5 and 3% cover. The species diversity was 20 and 23 species. The vegetation in the shrub layer was dominated by *Salvia pachyphylla*, with 3 and 4% cover.

Most abundant species:

Stratum	Global species	PEFO species
Tall shrub/sapling	<i>Data are not available.</i>	<i>Salvia pachyphylla</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Achnatherum hymenoides, Artemisia bigelovii, Bromus tectorum, Chaetopappa ericoides, Chamaesyce fendleri, Cordylanthus wrightii, Cryptantha sp., Ephedra torreyana, Eriogonum corymbosum, Gutierrezia sarothrae, Hesperostipa neomexicana, Juniperus monosperma, Parryella filifolia, Pleuraphis jamesii, Rhus trilobata, Yucca angustissima</i>

References:

Data are not available.

C.3 Shrubland

C.3.16. *Sarcobatus vermiculatus* / *Atriplex obovata* Shrubland [Park Special]

Base map class	Greasewood / New Mexico Saltbush Shrubland
NatureServe common name	None assigned yet
NatureServe code	Not applicable

Summary:

Data are not available.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. Data are not available.

Vegetation hierarchy:

Physiognomic class	N/A	N/A
Physiognomic subclass	N/A	N/A
Physiognomic group	N/A	N/A
Physiognomic subgroup	N/A	N/A
Formation name	N/A	N/A
Alliance name		N/A

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.789	Inter-Mountain Basins Shale Badland

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. *Sarcobatus vermiculatus* / *Atriplex obovata* Shrubland (Park Special) was identified in the field during the photointerpretors' reconnaissance. Subsequently it was documented on 15 accuracy assessment observation sites. However, it was mapped on only three map units, two of which are in the park.

Environmental summary:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. This vegetation community occurred at elevations from 1639 m (5377 ft) to 1682 m (5518 ft).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. Fifteen accuracy assessment relevés were identified as *Sarcobatus vermiculatus* / *Atriplex obovata* Shrubland. Cover of *Sarcobatus vermiculatus* ranged from 5 to 25%. Co-dominant plants were the dwarf native shrub *Atriplex obovata* (cover 1 to 25%) and the native grass *Sporobolus airoides* (cover 1 to 75%). Species diversity among the relevés ranged from 3 to 9 species. *Sarcobatus vermiculatus* was co-dominant with the native dwarf-shrub *Atriplex obovata*. The association was found generally on saline and alkaline soils and in areas with periodic sheet flow, often near a wash system.

Most abundant species:

Stratum	Global species	PEFO species
Shrub (field)	<i>Data are not available.</i>	<i>Sarcobatus vermiculatus</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Atriplex obovata, Sporobolus airoides, Suaeda moquinii</i>

References:

Data are not available.

C.3 Shrubland

C.3.17. *Sarcobatus vermiculatus* / *Suaeda moquinii* Shrubland

Base map class	Greasewood / Shrubby Seepweed Shrubland
NatureServe common name	Black Greasewood / Shrubby Seepweed Shrubland
NatureServe code	CEGL001370

Summary:

This shrubland association is reported from the Colorado Plateau and Columbia Basin. Sites are generally flat to gently sloping saline valley bottoms and toeslopes, river floodplains, and playas at elevations ranging from 1620 to 1680 m (5315-5500 ft). Soils are deep, saline, alkaline clay loams. The vegetation has a generally sparse shrub layer (<20% cover) that is less than 1.5 m tall and is codominated by *Sarcobatus vermiculatus* and *Suaeda moquinii*. The herbaceous layer is sparse.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Compare this association with *Sarcobatus vermiculatus* / *Distichlis spicata* - (*Puccinellia nuttalliana*) Shrub Herbaceous Vegetation (CEGL002146).

Petrified Forest National Park. Although only one relevé of this association was sampled in this project, this association is already included in the NVCS and no further data collection was needed to include it. It would be useful to sample additional *Sarcobatus vermiculatus* communities in Petrified Forest National Park to determine the rarity of this association.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.B.	Deciduous shrubland
Physiognomic group	III.B.3.	Extremely xeromorphic deciduous shrubland
Physiognomic subgroup	III.B.3.N.	Natural/Semi-natural extremely xeromorphic deciduous shrubland
Formation name	III.B.3.N.b.	Intermittently flooded extremely xeromorphic deciduous subdesert shrubland
Alliance name		<i>Sarcobatus vermiculatus</i> Intermittently Flooded Shrubland Alliance (A.1046), Black Greasewood Intermittently Flooded Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.780	Inter-Mountain Basins Greasewood Flat
CES304.781	Inter-Mountain Basins Wash

NatureServe conservation status:

Global rank. GUQ (23-Feb-1994).

Distribution:

Globally. This association is reported from the Colorado Plateau into western Colorado and northern Arizona, and the Columbia Basin in eastern Oregon.

Petrified Forest National Park. *Sarcobatus vermiculatus* / *Suaeda moquinii* Shrubland was identified from only one relevé in Petrified Forest National Park. The one relevé of this community type occurred in a valley bottom and drainage channel located in the central neck area of the park, between the railroad tracks and the Puerco River.

Environmental summary:

Globally. This shrubland association is reported from the Colorado Plateau and Columbia Basin. Sites are generally flat to gently sloping saline valley bottoms and toeslopes, along intermittent washes, floodplains, and playas at elevations ranging from 1620 to 1680 m (5315-5500 ft). Soils are deep, saline, alkaline clay loams.

Petrified Forest National Park. The elevation and slope of this association are not available or recorded. This association occurred in a wetland environment with seasonal or intermittent flooding.

USFWS wetland system: Palustrine.

Vegetation description:

Globally. The vegetation has a generally sparse shrub layer (<20% cover) that is less than 1.5 m tall and is codominated by *Sarcobatus vermiculatus* and *Suaeda moquinii*. The herbaceous layer is sparse. Common species include *Distichlis spicata* and *Sporobolus cryptandrus*.

Petrified Forest National Park. One relevé was classified as *Sarcobatus vermiculatus* / *Suaeda moquinii* Shrubland, with total vegetation cover of 26%. This vegetation cover consisted of a shrub stratum with 15% cover and an herbaceous stratum with 11% cover. The species diversity was low, with only five species recorded. The vegetation was dominated in the shrub layer by *Sarcobatus vermiculatus*, with 6% cover. The herbaceous stratum was codominated by *Sporobolus cryptandrus* with 11% cover and *Suaeda moquinii* with 9% cover.

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Data are not available.</i>	<i>Sarcobatus vermiculatus</i>
Herb (field)	<i>Sarcobatus vermiculatus</i>	<i>Suaeda moquini</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Bourgeron and Engelking 1994, Branson and Owen 1970, CONHP unpubl. data 2003, Driscoll et al. 1984, Kagan et al. 2004, Kuchler 1964, Shiflet 1994, Western Ecology Working Group n.d.

C.3 Shrubland

C.3.18. *Suaeda moquinii* Shrubland

Base map class	<i>Suaeda moquinii</i> Shrubland was not mapped as a unique association. The photointerpreters were not able to distinguish this association on the aerial photography and had only one ground-sampled relevé as reference. This association was mapped as an inclusion with the surrounding vegetation; the single relevé was included with the Greasewood / Shrubby Seepweed Shrubland.
NatureServe common name	Shrubby Seepweed Shrubland
NatureServe code	CEGL001991

Summary:

These shrublands occur in desert basins or playas in Nevada, Arizona, and southern and eastern California. Sites are generally flat to gently sloping saline valley bottoms, floodplains and playas, saline seeps, and along intermittent washes at elevations ranging from sea level to 1640 m (5381 ft). Soils are deep, saline, alkaline clay loams. The vegetation has a generally sparse shrub layer that is less than 1.5 m tall and strongly dominated by *Suaeda moquinii* with scattered *Atriplex polycarpa*, *Atriplex canescens*, *Allenrolfea occidentalis*, or *Sarcobatus vermiculatus* in some stands. The sparse herbaceous layer may include the forbs *Bassia hyssopifolia* and *Salicornia maritima* (= *Salicornia europaea*). Graminoids are not abundant except for *Distichlis spicata* and occasional *Sporobolus airoides* or *Sporobolus cryptandrus*. The adjacent shrublands are dominated by *Sarcobatus vermiculatus* or *Atriplex* spp.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. Although *Distichlis spicata* has higher cover than *Suaeda moquinii*, *Suaeda moquinii* was determined to be more diagnostic of this community than *Distichlis spicata*, and a new association based on this one relevé that would include both *Suaeda moquinii* and *Distichlis spicata* was not developed due to the paucity of data.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.B.	Deciduous shrubland
Physiognomic group	III.B.2.	Cold-deciduous shrubland
Physiognomic subgroup	III.B.2.N.	Natural/Semi-natural cold-deciduous shrubland
Formation name	III.B.2.N.c.	Intermittently flooded cold-deciduous shrubland
Alliance name	<i>Suaeda moquinii</i> Intermittently Flooded Shrubland Alliance (A.941), Shrubby Seepweed Intermittently Flooded Shrubland Alliance	

Ecological systems placement:

Ecological system unique ID	Ecological system name
CE5304.786	Inter-Mountain Basins Playa
CE5304.780	Inter-Mountain Basins Greasewood Flat

NatureServe conservation status:

Global rank. G5 (23-Feb-1994).

Distribution:

Globally. This broadly defined shrubland association occurs in saline overflow areas in bottomlands in the Great Basin, Mojave, Colorado, and Sonoran deserts, and in the southern part of the Great Central Valley of California. The species occurs throughout the western U.S., so this type may be more widespread.

Petrified Forest National Park. *Suaeda moquinii* Shrubland was identified from one relevé along the flats adjacent to the Puerco River in Petrified Forest National Park.

Environmental summary:

Globally. These shrublands occur in desert basins or playas in Nevada, Arizona, and southern and eastern California. Sites are generally flat to gently sloping saline valley bottoms, floodplains and playas, saline seeps, and along intermittent washes at elevations ranging from sea level to 1640 m (5381 ft). Soils are deep, saline, alkaline clay loams derived from alluvium.

Petrified Forest National Park. This association occurred at an elevation of 1640 m (5381 ft). The site was a flat, intermittently flooded area adjacent to the Puerco River.

USFWS wetland system: Lacustrine.

Vegetation description:

Globally. This association is characterized by a sparse to open shrub layer less than 1.5 m tall that is strongly dominated by *Suaeda moquinii* sometimes with scattered *Atriplex polycarpa*, *Atriplex canescens*, *Allenrolfea occidentalis*, or *Sarcobatus vermiculatus*. The sparse herbaceous layer may include the forbs *Bassia hyssopifolia* and *Salicornia maritima* (= *Salicornia europaea*). Graminoids are not abundant except for *Distichlis spicata* and occasional *Sporobolus airoides* or *Sporobolus cryptandrus*.

Petrified Forest National Park. Only one relevé was classified as *Suaeda moquinii* Shrubland, with total vegetation cover of 17%. This vegetation cover consisted of 2% cover in the shrub stratum and 15% cover in the herbaceous stratum. The species diversity was low with only four species. The shrub layer was dominated by *Suaeda moquinii* with 6% cover, and the herbaceous layer was dominated by *Distichlis spicata* with 8% cover.

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Suaeda moquinii</i>	<i>Suaeda moquinii</i>
Herb (field)	<i>Distichlis spicata</i>	<i>Distichlis spicata</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Bourgeron and Engelking 1994, Donnelly et al. 2006, Driscoll et al. 1984, Faden 1977, NVNHP 2003, Western Ecology Working Group n.d.

C.3 Shrubland

C.3.19. *Tamarix* spp. Temporarily Flooded Semi-natural Shrubland

Base map class	Tamarisk Shrubland
NatureServe common name	Salt-cedar species Temporarily Flooded Semi-natural Shrubland
NatureServe code	CEGL003114

Summary:

This broadly defined association is composed of shrublands which form moderately dense to dense thickets on banks of larger streams across the western Great Plains, interior and southwestern U.S., and northern Mexico. Stands are dominated by introduced species of *Tamarix*, including *Tamarix ramosissima*, *Tamarix chinensis*, *Tamarix gallica*, and *Tamarix parviflora*. *Tamarix* spp. were introduced from the Mediterranean and have become naturalized in various sites, including salt flats and other saline habitats, springs, and especially along streams and regulated rivers, where it replaces the native vegetation, such as shrublands dominated by species of *Salix* or *Prosopis* or woodlands of *Populus* spp. A remnant herbaceous layer may be present, depending on the age and density of the shrub layer, although in many cases this layer also consists of aggressive exotic species such as *Lepidium latifolium*. *Tamarix* species have become a critical nuisance along most large rivers in the semi-arid West and, because of permanent changes in flood regimes and the difficulty of removing trees, reflect irreversibly changed vegetation on many sites.

Classification confidence: 1 - Strong.

Classification comments:

Globally. This is a broadly defined plant association that is composed of many diverse *Tamarix* spp.-dominated vegetation communities from a wide variety of environments. Muldavin et al. (2000a) described 8 community types that will be reviewed as possible USNVC associations.

Petrified Forest National Park. This association was dominated by the non-native invasive species *Tamarix* spp. These species are currently invading southwestern riparian systems. This map class should be re-evaluated regularly to assess changes in the distribution of this community type. Although this map class only occurred in a few polygons, this does not mean that *Tamarix* spp. do not occur in other locations in the project area. The association was only mapped in areas larger than the minimum mapping unit and in areas where *Tamarix* spp. dominated the species cover. During the classification field work, this species was identified as *Tamarix chinensis*; however, since the taxonomy of this species is not well-known and appropriate keys have not been developed to identify it, we used only the genus level to classify these relevés into an association.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A.	Evergreen shrubland
Physiognomic group	III.A.4.	Microphyllous evergreen shrubland
Physiognomic subgroup	III.A.4.N.	Natural/Semi-natural microphyllous evergreen shrubland
Formation name	III.A.4.N.c.	Temporarily flooded microphyllous shrubland
Alliance name		<i>Tamarix</i> spp. Semi-Natural Temporarily Flooded Shrubland Alliance (A.842), Salt-cedar species Semi-natural Temporarily Flooded Shrubland Alliance

Ecological systems placement:

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

NatureServe conservation status:

Global rank. GNA (invasive) (24-Jul-2001).

Distribution:

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

Petrified Forest National Park. *Tamarix* spp. Semi-natural Temporarily Flooded Shrubland was identified from two relevés in Petrified Forest National Park. These relevés occurred on bajada and talus landforms in the central neck area of the park along the northern edges of the Puerco River, both east and west of the park road.

Environmental summary:

Globally. These widespread shrublands are common along larger streams, rivers, and around playas in the western U.S. and Mexico. Elevation ranges from 75 m below sea level to 1860 m. *Tamarix* spp. have become naturalized in various sites including riverbanks, floodplains, basins, sandbars, side channels, springs, salt flats, and other saline habitats. Stands grow especially well along regulated rivers where flood-regenerated native species such as *Populus* are declining and the absence of regular scouring floods allows *Tamarix* seedlings to become established. Substrates are commonly thin sandy loam soil over alluvial deposits of sand, gravel, or cobbles.

Petrified Forest National Park. This association occurred at 1625 and 1639 m (5330-5377 ft) elevation. Slope ranged from none to low (0-4%). Both of these relevés occurred in areas with intermittent or seasonal flooding.

USFWS wetland system: Palustrine.

Vegetation description:

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

Petrified Forest National Park. Two relevés were classified as *Tamarix* spp. Semi-natural Temporarily Flooded Shrubland, with total vegetation cover of 35 and 39%. This vegetation cover consisted of a tree stratum with 0 and 13% cover, a shrub stratum with 19 and 30% cover, and an herbaceous stratum of 5 and 7% cover. The species diversity for these two relevés was 12 and 23 species. The vegetation was dominated in the shrub and tree layer by the non-native invasive shrubs *Tamarix* spp., with a combined cover of 31 and 30%.

Most abundant species:

Stratum	Global species	PEFO species
Tall shrub/sapling	<i>Tamarix chinensis</i> , <i>Tamarix gallica</i> , <i>Tamarix parviflora</i> , <i>Tamarix ramosissima</i>	<i>Tamarix chinensis</i>

Other noteworthy species:

Global species	PEFO species
<i>Bromus tectorum</i> , <i>Lepidium latifolium</i> , <i>Poa pratensis</i>	<i>Data are not available.</i>

References:

Baalman 1965, Carsey et al. 2003a, Cogan et al. 2004, Cowardin et al. 1979, Hansen et al. 1995, Hansen et al. 2004b, Hoagland 2000, Holland 1986b, MTNHP 2002b, Muldavin et al. 2000a, NVNHP 2003, Nachlinger and Reese 1996, Ortenberger and Bird 1933, Paysen et al. 1980, Sawyer and Keeler-Wolf 1995, Smith 1989, Stevens and Shannon 1917, Szaro 1989, Ungar 1968, Von Loh et al. 2002, Ware and Penfound 1949, Western Ecology Working Group n.d.

C.4 Herbaceous

C.4.1. *Atriplex obovata* / *Sporobolus airoides* - *Pleuraphis jamesii* Shrub Herbaceous Vegetation

Base map class	New Mexico Saltbush / Alkali Sacaton - Galleta Shrub Herbaceous Vegetation
NatureServe common name	New Mexico Saltbush / Alkali Sacaton - James' Galleta Shrub Herbaceous Vegetation
NatureServe code	CEGL001775

Summary:

This association occurs on alluvial flats in the southern Colorado Plateau in northwestern New Mexico and adjacent Arizona at 1680-1811 m (5570-5940 ft) elevation. Slopes are minimal and range from 0 to 6%. Soils are typically shallow, alkaline, and calcareous and are derived from alluvium. Soil texture ranges from fine sandy loam to silty clay loam. Ground cover is largely bare soil, sometimes with high cover of surface rock, including basalt, gravel, and petrified wood. The vegetation is characterized by an open dwarf-shrub canopy of *Atriplex obovata* with a grassy understory dominated by *Pleuraphis jamesii* and *Sporobolus airoides*. Other shrubs may be present with very low cover, including *Atriplex confertifolia*, *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Opuntia imbricata*, *Opuntia polyacantha*, and *Sarcobatus vermiculatus*. Associated graminoids may include *Elymus elymoides*, *Muhlenbergia torreyi*, *Schedonnardus paniculatus*, and *Sporobolus cryptandrus*. Forb cover is typically low but may be diverse.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. Data are not available.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.7.	Temperate or subpolar grassland with a sparse shrub layer
Physiognomic subgroup	V.A.7.N.	Natural/Semi-natural temperate or subpolar grassland with a sparse shrub layer
Formation name	V.A.7.N.e	Medium-tall temperate or subpolar grassland with a sparse needle-leaved or microphyllous evergreen shrub layer
Alliance name		<i>Sporobolus airoides</i> - (<i>Pleuraphis jamesii</i>) Shrub Herbaceous Alliance (A.1532), Alkali Sacaton - (James' Galleta) Shrub Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.788	Inter-Mountain Basins Semi-Desert Shrub-Steppe
CES304.784	Inter-Mountain Basins Mixed Salt Desert Scrub

NatureServe conservation status:

Global rank. GU (23-Feb-1994).

Distribution:

Globally. Data are not available.

Petrified Forest National Park. *Atriplex obovata* / *Sporobolus airoides* - *Pleuraphis jamesii* Shrub Herbaceous Vegetation occurred on twelve relevés. They were located mostly on or near sandsheets/sand dunes or near areas with sheetflow drainage or drainage channels. This association was sampled throughout the entire extent of the park, including the northern wilderness area west of the Black Forest, southwest of Chinde Mesa, and near Lithodendron Wash. It was also sampled from the Blue Mesa area, south of Newspaper Rock, southwest of Agate Bridge, and west of Crystal Forest and Dry Wash.

Environmental summary:

Globally. This association occurred between the elevations of 1640 and 1750 m (5370-5790 ft). Slopes of the relevés were minimal and ranged from 0 to 6% (average 2%). Rock substrates found within this association included basalt, gravel, and petrified wood. At one relevé, the presence of desert pavement on the surface was recorded.

Petrified Forest National Park. This association occurred at 1625 and 1639 m (5330-5377 ft) elevation. Slope ranged from none to low (0-4%). Both of these relevés occurred in areas with intermittent or seasonal flooding.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. The vegetation is characterized by an open dwarf-shrub canopy (<15% cover) of *Atriplex obovata* with a grassy understory dominated by *Pleuraphis jamesii* and *Sporobolus airoides*. Other shrubs may be present with very low cover, including *Atriplex confertifolia*, *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Opuntia imbricata*, *Opuntia polyacantha*, and *Sarcobatus vermiculatus* (Francis 1986). Associated graminoids present may include *Bouteloua gracilis*, *Elymus elymoides*, *Muhlenbergia torreyi*, *Schedonnardus paniculatus*, *Sporobolus cryptandrus*, and the annual *Vulpia octoflora*. Forb cover is typically low but may be diverse. Species include *Calochortus aureus*, *Chamaesyce fendleri*, *Plantago patagonica*, *Sphaeralcea incana*, and *Townsendia annua*.

Petrified Forest National Park. Twelve relevés were classified as *Atriplex obovata* / *Sporobolus airoides* - *Pleuraphis jamesii* Shrub Herbaceous Vegetation. The total vegetation cover of these relevés ranged from 10 to 26% (average 16%), with 1-12% within the shrub stratum (average 6%) and 3-22% within the herbaceous stratum (average 11%). The association's species diversity ranged from 13 to 34 species (average 24 species). The shrub layer was dominated or codominated by *Atriplex obovata* with 1 to 6% cover (average 3%). *Sarcobatus vermiculatus* also covered 5 and 6% of the shrub layer in two different relevés. The herbaceous layer was dominated by the combination of the two grasses: *Sporobolus airoides* ranged from 3 to 9% cover (average 5%) and *Pleuraphis jamesii* ranged from 0.5 to 5% cover (average 1%). *Townsendia annua*, an annual forb, had high cover in one relevé (5%).

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Atriplex obovata</i>	<i>Atriplex obovata</i>
Herb (field)	<i>Pleuraphis jamesii</i>	<i>Pleuraphis jamesii</i> , <i>Sporobolus airoides</i>

Other noteworthy species:

Global species	PEFO species
<i>Bromus tectorum</i>	<i>Data are not available.</i>

References:

Bourgeron and Engelking 1994, Driscoll et al. 1984, Francis 1986, Western Ecology Working Group n.d.

C.4 Herbaceous

C.4.2. *Bouteloua eriopoda* - *Pleuraphis jamesii* Herbaceous Vegetation

Base map class	Black Grama – Galleta Herbaceous Vegetation
NatureServe common name	Black Grama - James' Galleta Herbaceous Vegetation
NatureServe code	CEGL001751

Summary:

This Colorado Plateau desert grassland has been documented from the upper Rio Puerco watershed in northwestern New Mexico, in north-central Arizona and southeastern Utah, and extends south to central New Mexico at Sevilleta National Wildlife Refuge. Stands occur on flat to gently sloping plains, basin floors, mesatops, and less often on steeply sloping mesa sides. Substrates are variable and include loam to clay-loam soils derived from basalt outcrop, shale, clay and sandstone, and coarser textured soils derived from black cinders and sandstone. *Bouteloua eriopoda* and *Pleuraphis jamesii* (= *Hilaria jamesii*) dominate the low to moderate herbaceous cover. Associates include low cover of *Aristida purpurea*, *Bouteloua gracilis*, *Hesperostipa neomexicana* (= *Stipa neomexicana*), *Muhlenbergia porteri*, *Sporobolus airoides*, and *Sporobolus cryptandrus*. Shrubs are few and scattered and may include *Atriplex canescens*, *Ephedra torreyana*, *Ephedra viridis*, *Ericameria nauseosa*, and *Gutierrezia sarothrae*.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. Limited quantitative documentation exists for this type, outside of plots taken at Capitol Reef National Park, near the northern end of the association's range.

Petrified Forest National Park. The four relevés grouped into this association were characterized by *Bouteloua eriopoda* in the herbaceous stratum. In relevés with low total vegetation cover, the cover of *Bouteloua eriopoda* was also proportionally low. *Pleuraphis jamesii* was entirely absent in one relevé; therefore the classification of this relevé may need to be reconsidered.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.5.	Temperate or subpolar grassland
Physiognomic subgroup	V.A.5.N.	Natural/Semi-natural temperate or subpolar grassland
Formation name	V.A.5.N.e.	Short sod temperate or subpolar grassland
Alliance name		<i>Bouteloua eriopoda</i> Herbaceous Alliance (A.1284), Black Grama Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CE5304.787	Inter-Mountain Basins Semi-Desert Grassland

NatureServe conservation status:

Global rank. G3 (14-Nov-2005). This transitional Colorado Plateau-Chihuahuan Desert grassland has had its range significantly reduced by the impacts of livestock grazing over the last 150 years, particularly during years of extreme drought. Few examples remain that have not been significantly impacted by grazing and altered fire regimes. Overall, high-quality occurrences are not likely to exceed 50 in number. Inventory of potential occurrences in both the

Chihuahuan Desert and Colorado Plateau ecoregions is needed. The range of this association is not likely to extend much further north than southern Utah, as *Bouteloua eriopoda* is known only from the Colorado River drainage (including the Virgin River) south of Moab.

Distribution:

Globally. This Colorado Plateau association is known from the upper Rio Puerco watershed in northwestern New Mexico, Wupatki National Monument and Petrified Forest National Park in north-central Arizona, and scattered small sites at Capitol Reef National Park in southeastern Utah. It extends south to the Sevilleta National Wildlife Refuge in central New Mexico in the transition zone with the northern Chihuahuan Desert.

Petrified Forest National Park. *Bouteloua eriopoda* - *Pleuraphis jamesii* Herbaceous Vegetation was identified from four relevés in Petrified Forest National Park. These relevés occurred on the lower and midslopes of hills and on sandsheets and sand dunes. This association was identified in the central neck section of the park, specifically located east of the park road and north of the unpaved maintenance road, and east of the park road north of the Puerco River and south of the Borrow Pit road.

Environmental summary:

Globally. This Colorado Plateau desert grassland has been documented from the upper Rio Puerco watershed in northwestern New Mexico, in north-central Arizona, and from a single station in southeastern Utah. Elevations range from 1455-1830 m (4770-6000 ft) at the southern end of the range and at 1275 m on a south-facing slope in Utah. Stands occur on flat to gently sloping plains, basin floors, or steeply sloping mesa sides. Substrates are variable and include weakly developed Entisols and Entisol-Mollisol complexes often with loam to clay-loam soils derived from basalt outcrop, shale, clay and sandstone, and coarser textured soils derived from black cinders and sandstone.

Petrified Forest National Park. This association's elevation ranged from 1660 to 1690 m (5540-5550 ft). It occurred on low slopes ranging from 3 to 4% (average 4%). One of the relevés was surrounded by small washes.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association is characterized by *Bouteloua eriopoda* and *Pleuraphis jamesii* (= *Hilaria jamesii*) codominating an open to moderately dense perennial graminoid layer. Associates include low cover of *Aristida purpurea*, *Bouteloua gracilis*, *Hesperostipa neomexicana* (= *Stipa neomexicana*), *Muhlenbergia porteri*, *Sporobolus airoides*, *Sporobolus cryptandrus*, and *Sporobolus flexuosus*. Forb cover and diversity are low. Scattered shrubs and dwarf-shrub may be present, including *Atriplex canescens*, *Ephedra torreyana*, *Ephedra viridis*, *Ericameria nauseosa*, and *Gutierrezia sarothrae* (Francis 1986). The presence of *Bouteloua eriopoda* and *Muhlenbergia porteri*, and its occurrence at Sevilleta National Wildlife Refuge, suggests that this grassland is transitional to Chihuahuan Desert grasslands that begin over 100 miles to the south.

Petrified Forest National Park. The relevés classified as *Bouteloua eriopoda* - *Pleuraphis jamesii* Herbaceous Vegetation had total vegetation covers ranging from 15 to 30%. This vegetation cover consisted of a moderate shrub layer ranging from 5 to 22% cover (average 12%) and a significant herbaceous stratum ranging from 8 to 17% cover (average 13%). The species diversity for this association varied between 32 and 38 species (average 35 species). The vegetation was mainly dominated by herbaceous species and was typically characterized by the dominance or codominance of *Bouteloua eriopoda* and *Pleuraphis jamesii*. *Bouteloua eriopoda*'s cover ranged from 1 to 10% (average 6%) and *Pleuraphis jamesii* had a 0 to 4% cover (average 1%). The shrub layer had a low cover of *Gutierrezia sarothrae* in all relevés, ranging from 0.5 to 2% (average 1%).

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Atriplex obovata</i>	<i>Atriplex obovata</i>
Herb (field)	<i>Pleuraphis jamesii</i>	<i>Bouteloua eriopoda, Pleuraphis jamesii</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Driscoll et al. 1984, Francis 1986, Hansen et al. 2004b, Muldavin et al. 1998d, Western Ecology Working Group n.d.

C.4 Herbaceous

C.4.3. *Bouteloua gracilis* - *Pleuraphis jamesii* Herbaceous Vegetation

Base map class	Blue Grama - Galleta Herbaceous Vegetation
NatureServe common name	Blue Grama - James' Galleta Herbaceous Vegetation
NatureServe code	CEGL001759

Summary:

These grasslands occur on alluvial flats, mesas, and plains in the semi-arid southwestern Great Plains and the Colorado Plateau in southeastern Colorado, New Mexico, northern Arizona and southern Utah. Elevation ranges from 1625-1890 m (5330-5654 ft) on the Colorado Plateau and extends below 1525 m (5000 ft) in the southwestern Great Plains. Sites are flat to undulating, with shallow to moderately deep, loam to silty clay loam-textured soil. Stands are codominated by the graminoids *Bouteloua gracilis* and *Pleuraphis jamesii* (= *Hilaria jamesii*). These short and medium-tall perennial bunch grasses may form a sod-like ground cover with patches of bare ground, especially where grazing by livestock encourages a prostrate growth form. Canopy cover is relatively sparse to moderately dense (20-80% cover). Other grasses include *Buchloe dactyloides*, *Muhlenbergia torreyi*, *Sporobolus cryptandrus*, *Aristida* spp., *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Pascopyrum smithii*, *Hesperostipa comata* (= *Stipa comata*), or *Hesperostipa neomexicana* (= *Stipa neomexicana*). Forb cover is generally sparse but may be diverse. Characteristic species include *Sphaeralcea coccinea*, *Grindelia squarrosa*, *Cryptantha* spp., *Machaeranthera pinnatifida*, *Ratibida* spp., and *Zinnia grandiflora*. Scattered dwarf-shrubs, shrubs, and cacti, such as *Gutierrezia sarothrae*, *Artemisia bigelovii*, *Artemisia frigida*, *Krascheninnikovia lanata*, *Prosopis glandulosa*, *Yucca glauca*, *Opuntia imbricata*, and *Opuntia polyacantha*, are not uncommon. Codominance of *Bouteloua gracilis* and *Pleuraphis jamesii* distinguishes this vegetation from several closely related grasslands.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. More classification and survey work are needed to distinguish this type from closely related grasslands over its relatively broad geographic range, and to inventory its extent and condition.

Petrified Forest National Park. This association tends to have low total vegetation cover and correspondingly low total herbaceous cover. *Bouteloua gracilis* consistently occurred in every relevé but with low cover (<5%). *Pleuraphis jamesii* tended to have higher cover values, although with cover as low as 2% in one relevé.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.5.	Temperate or subpolar grassland
Physiognomic subgroup	V.A.5.N.	Natural/Semi-natural temperate or subpolar grassland
Formation name	V.A.5.N.e.	Short sod temperate or subpolar grassland
Alliance name		<i>Bouteloua gracilis</i> Herbaceous Alliance (A.1282), Blue Grama Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CE5304.787	Inter-Mountain Basins Semi-Desert Grassland

NatureServe conservation status:

Global rank. G3 (14-Nov-2005). G2G4 (15-Oct-1999). Historically, most sites supporting this association have been converted to dryland or to irrigated cropland in the plains. Overgrazing by livestock has changed some of these grasslands to sparse desert grasslands or desert scrubland. In addition, the reduction of fire frequency, either by livestock grazing the fine fuels that carry fires or by active suppression, has allowed the invasion of trees and shrubs. Loss to urban development has been significant in recent decades. Urban development and transformation to pinyon/juniper woodlands or desert grassland/scrubland are continuing the negative trend. More classification and survey work are needed to distinguish this type from closely related grasslands over its relatively broad geographic range and to inventory its extent and condition.

Distribution:

Globally. These grasslands are found in the southern shortgrass steppe of southeastern Colorado and eastern New Mexico, and alluvial flats and mesas of the Colorado Plateau in New Mexico and Utah, south to Sevilleta National Wildlife Refuge in central New Mexico.

Petrified Forest National Park. *Bouteloua gracilis* - *Pleuraphis jamesii* Herbaceous Vegetation was identified from three relevés within Petrified Forest National Park. Sites occurred on a plateau and on sand dunes/sandsheets in the central neck section of the park, south of Blue Mesa along the main park road and Dry Wash, and northwest of Jim Camp Wash and the Giant Logs.

Environmental summary:

Globally. These grasslands occur on alluvial flats, mesas, and plains in the semi-arid southwestern Great Plains and the Colorado Plateau in southeastern Colorado, New Mexico, northern Arizona and southern Utah. Elevation ranges from 1625-1890 m (5330-5654 ft) on the Colorado Plateau and extends below 1525 m (5000 ft) in the southwestern Great Plains. Sites are flat to undulating, with shallow to moderately deep, loam to silty clay loam-textured soil.

Petrified Forest National Park. The association occurred between the elevations of 1664 and 1725 m (5459-5654 ft), with zero to moderate slope (0-16%, average 6%). Only one stand had any surface rocks, including desert pavement and petrified wood.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association is characterized by an open to moderately dense (20-80% cover) herbaceous layer that is codominated by the graminoids *Bouteloua gracilis* and *Pleuraphis jamesii* (= *Hilaria jamesii*). These short and medium-tall perennial bunch grasses may form a sod-like ground cover with patches of bare ground, especially where grazing by livestock encourages a prostrate growth form. Other grasses include *Buchloe dactyloides*, *Muhlenbergia torreyi*, *Sporobolus cryptandrus*, *Aristida* spp., *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Pascopyrum smithii*, *Hesperostipa comata* (= *Stipa comata*), or *Hesperostipa neomexicana* (= *Stipa neomexicana*). Forb cover is generally sparse but may be diverse. Characteristic species include *Sphaeralcea coccinea*, *Grindelia squarrosa*, *Cryptantha* spp., *Machaeranthera pinatifida*, *Ratibida* spp., and *Zinnia grandiflora*. Scattered dwarf-shrubs, shrubs, and cacti, such as *Gutierrezia sarothrae*, *Artemisia bigelovii*, *Artemisia frigida*, *Krascheninnikovia lanata*, *Prosopis glandulosa* (southern stands), *Yucca glauca*, *Opuntia imbricata*, and *Opuntia polyacantha*, are not uncommon. Codominance of *Bouteloua gracilis* and *Pleuraphis jamesii* distinguishes this vegetation from several closely related grasslands.

Petrified Forest National Park. Three relevés were classified as *Bouteloua gracilis* - *Pleuraphis jamesii* Herbaceous Vegetation, with total vegetation cover varying between 10 and 24% (average 16%). The vegetation cover consisted of low cover in the shrub stratum of 2-3% (average 3%) and a moderate herbaceous stratum of 8-21% cover (average 14%). The species diversity for this association ranged from 18 to 27 species (average 23 species). The vegetation was codominated by *Bouteloua gracilis*, ranging from 1 to 3% cover (average 2%), and *Pleuraphis jamesii*, ranging from 2 to 15% cover (average 8%). In one stand, the annual forb *Plantago patagonica* had 5% cover.

Most abundant species:

Stratum	Global species	PEFO species
Herb (field)	<i>Bouteloua gracilis</i> , <i>Pleuraphis jamesii</i>	<i>Bouteloua gracilis</i> , <i>Pleuraphis jamesii</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Beavis et al. 1982, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Dick-Peddie 1993, Driscoll et al. 1984, Francis 1986, Johnston 1987, Muldavin et al. 1998d, Rogers 1953, Shaw et al. 1989, Soil Conservation Service 1978, Terwilliger et al. 1979a, Van Pelt 1978, Western Ecology Working Group n.d.

C.4 Herbaceous

C.4.4. *Bouteloua gracilis* Herbaceous Vegetation

Base map class	Blue Grama Herbaceous Vegetation
NatureServe common name	Blue Grama Herbaceous Vegetation, Blue Grama Shortgrass Prairie
NatureServe code	CEGL001760

Summary:

This minor plant association is reported from Arizona, Colorado, New Mexico, Utah, and Wyoming. Sites are flat to gently sloping and include plains, plateaus, and montane meadows. Substrates are variable and range from coarse-textured soils derived from sand, gravel, granite or cinder to silty clay loam prairie soils. The vegetation is characterized by a moderate to dense (25-80% cover) herbaceous layer that is strongly dominated by the warm-season, perennial shortgrass *Bouteloua gracilis*. Associated grasses are *Bouteloua curtipendula*, *Elymus elymoides*, *Muhlenbergia* spp., *Pascopyrum smithii*, *Pleuraphis jamesii* (= *Hilaria jamesii*), *Sporobolus cryptandrus*, and the introduced annual grass *Bromus tectorum*. Forb cover is sparse. Scattered *Ericameria nauseosa* shrubs and an occasional *Pinus edulis*, *Juniperus* spp., or *Pinus ponderosa* tree (in montane stands) may be present.

Classification confidence: 3 - Weak.

Classification comments:

Globally. This is a low-confidence association. There are many other associations in the *Bouteloua gracilis* Herbaceous Alliance (A.1282). This association often represents degraded montane grasslands and *Bouteloua gracilis*-dominated grasslands that lack other diagnostic species. *Bouteloua gracilis* is often able to persist after other species are eliminated because it is an extremely drought- and grazing-tolerant species.

Petrified Forest National Park. *Bouteloua gracilis*, the defining nominal species, has a wide cover range and does not have to dominate the herbaceous cover for relevés to be classified as this association. However, *Bouteloua gracilis* is considered the most diagnostic species in the herbaceous layer and was used to aggregate these relevés into one association classification.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.5.	Temperate or subpolar grassland
Physiognomic subgroup	V.A.5.N.	Natural/Semi-natural temperate or subpolar grassland
Formation name	V.A.5.N.e.	Short sod temperate or subpolar grassland
Alliance name		<i>Bouteloua gracilis</i> Herbaceous Alliance (A.1282), Blue Grama Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CE5304.787	Inter-Mountain Basins Semi-Desert Grassland

NatureServe conservation status:

Global rank. G4Q (23-Feb-1994).

Distribution:

Globally. This minor plant association occurs in Arizona, Colorado, New Mexico, Utah, and Wyoming.

Petrified Forest National Park. *Bouteloua gracilis* Herbaceous Vegetation was identified from nine relevés located in Petrified Forest National Park and its environs on upper, mid, and lower slopes, as well as on sand dunes/sandsheets and talus slopes. The association was located outside the park on private land northwest of Pilot Rock, north of Old Route 66 in the northern wilderness area and southwest of Alley Way Tank, north of Interstate 40 and east of the northern headquarters offices, near and southwest of Agate House Ruins, on the stream-bank of Cottonwood Wash, south of Cottonwood Wash and south of old Highway 180, east of the park road in the East Fork Wash, and west of Rainbow Forest.

Environmental summary:

Globally. This minor plant association is reported from Arizona, Colorado, New Mexico, Utah and Wyoming. Elevation ranges from 1660-2705 m (5420-8875 ft). Sites are flat to moderately sloping and include plains, plateaus, and montane meadows and parks. Substrates are variable and range from coarse-textured soils derived from sand, gravel, granite or cinder to silty clay loam prairie soils. Montane *Bouteloua gracilis*-dominated grasslands included in this association are typically the result of heavy grazing by wildlife and/or livestock that select out less grazing-tolerant mid grasses.

Petrified Forest National Park. This association occurred between 1660 and 1760 m (5420-57670 ft) elevation. Slopes ranged from low to steep (1 to 38%, average 10%). Over a third of the relevés had some surface rocks of rounded gravel and petrified wood.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association is characterized by a moderate to dense (10-80% cover) herbaceous layer that is strongly dominated by the warm-season, perennial shortgrass *Bouteloua gracilis*. Associated grasses are *Achnatherum hymenoides*, *Bouteloua curtipendula*, *Elymus elymoides*, *Koeleria macrantha*, *Muhlenbergia montana*, *Muhlenbergia richardsonis*, *Muhlenbergia torreyi*, *Pascopyrum smithii*, *Pleuraphis jamesii* (= *Hilaria jamesii*), *Sporobolus cryptandrus*, and the introduced annual grass *Bromus tectorum*. Forb cover is sparse. Associated forbs include *Artemisia carruthii*, *Artemisia dracuncululus*, *Eriogonum* spp., and *Sphaeralcea coccinea*. Scattered *Ericameria nauseosa* shrubs and an occasional *Juniperus* spp., *Pinus edulis*, or *Pinus ponderosa* tree (in montane stands) may be present.

Petrified Forest National Park. Nine relevés were classified as *Bouteloua gracilis* Herbaceous Vegetation, with total vegetation cover ranging from 12 to 29% (average 20%). The vegetation cover consisted of a shrub stratum with 1-11% cover (average 4%) and an herbaceous stratum with 9-22% cover (average 16%). The species diversity for this association ranged from 13 to 39 species (average 26 species). The herbaceous layer was either dominated by or had a significant proportion of cover from *Bouteloua gracilis*, ranging from 2 to 13% cover (average 8%). *Phacelia crenulata*, an annual species, had significant cover (5%) in two relevés. The shrub *Chrysothamnus greenei* had fairly significant cover of 4 and 5% in two relevés.

Most abundant species:

Stratum	Global species	PEFO species
Herb (field)	<i>Bouteloua gracilis</i>	<i>Bouteloua gracilis</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Bourgeron and Engelking 1994, Bradley et al. 1992, CONHP unpubl. data 2003, Driscoll et al. 1984, Dwyer and Pieper 1967, Fisser 1970, Fisser et al. 1965, Hansen et al. 2004a, Hansen et al. 2004c, Muldavin et al. 2000b, Pieper 1968, Western Ecology Working Group n.d., Williams 1961, Zimmerman 1967

C.4 Herbaceous

C.4.5. *Calamovilfa gigantea* Desert Wash Shrub Herbaceous Vegetation

Base map class	Giant Sandreed Desert Wash Shrub Herbaceous Vegetation
NatureServe common name	Big Sandreed Desert Wash Shrub Herbaceous Vegetation
NatureServe code	CEGL004012

Summary:

This vegetated wash association occurs at Petrified Forest National Park in northern Arizona and likely occurs elsewhere in the southern Colorado Plateau. Elevations at the national park range from 1650 to 1680 m (5400-5500 ft). Stands occur in or near gently sloping washes that experience periodic streamflow. The substrate is mixed alluvium, sometimes with a surface layer of rocks derived from sandstone, petrified wood, and mixed gravel. The vegetation cover is characterized by a relatively diverse (21 to 42 species) and open canopy that ranges from 17 to 23% total cover. The vegetation cover is composed of an open herbaceous layer (9-14% cover) dominated by the tall graminoid, *Calamovilfa gigantea* (5-9% cover). Scattered shrubs such as *Ericameria nauseosa* (2-3% cover) are present, with total shrub cover of 6-9%.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. This association had a similar composition and environment as *Ericameria nauseosa* Desert Wash Shrubland (CEGL002261), except that it had a higher cover of the grass *Calamovilfa gigantea*.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.5.	Temperate or subpolar grassland
Physiognomic subgroup	V.A.5.N.	Natural/Semi-natural temperate or subpolar grassland
Formation name	V.A.5.N.a.	Tall sod temperate or subpolar grassland
Alliance name		<i>Calamovilfa gigantea</i> Herbaceous Alliance (A.2680), Big Sandreed Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.781	Inter-Mountain Basins Wash

NatureServe conservation status:

Global rank. GNR (14-Feb-2007)

Distribution:

Globally. This association has only been described from Petrified Forest National Park in northeastern Arizona and likely occurs elsewhere in the Painted Desert of the southern Colorado Plateau. Until further inventory is completed, there is no global information.

Petrified Forest National Park. *Calamovilfa gigantea* Desert Wash Shrub Herbaceous Vegetation was identified from three relevés in Petrified Forest National Park. All of these relevés occurred in or near washes that experience periodic streamflow. Stands were sampled west of Dry Wash and north of Jasper Forest, north of Cottonwood Wash and south of Agate House Ruins, and south of Agate Bridge and west of the main park road.

Environmental summary:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. This association occurred between the elevations of 1650 and 1680 m (5400-5500 ft). The slope of every relevé was minimal (1%). In two relevés, surface rocks were present and consisted of sandstone, petrified wood, and mixed gravel.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. Three relevés were classified as *Calamovilfa gigantea* Desert Wash Shrub Herbaceous Vegetation, with total vegetation cover between 17 and 23% (average 20%). This vegetation cover consisted of a shrub stratum varying between 6 and 9% (average 8%) and an herbaceous stratum varying between 9 and 14% (average 12%). The species diversity for this association varied between 21 and 42 species (average 32 species). The herbaceous layer was dominated by *Calamovilfa gigantea* with 5-9% cover (average 7%) and the shrub layer was dominated by *Ericameria nauseosa* with 2-3% cover (average 3%).

Most abundant species:

Stratum	Global species	PEFO species
Herb (field)	N/A	<i>Calamovilfa gigantea</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Western Ecology Working Group n.d.

C.4 Herbaceous

C.4.6. *Ericameria nauseosa* / *Bouteloua gracilis* Shrub Herbaceous Vegetation

Base map class	Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation
NatureServe common name	Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation
NatureServe code	CEGL003495

Summary:

This shrub herbaceous association occurs on valley floors, swales, and alluvial flats in the southern and central part of the Colorado Plateau. Its presence generally indicates disturbance, and it may represent degraded forms of other grassland, shrubland, or woodland communities. Stands occupy gentle to moderate slopes (2-13%) between 1635 and 2010 m (5360-6600 ft) elevation. Aspect does not affect the distribution of this association. Litter and bare soil cover most of the unvegetated surface. Parent materials are variable and include sandstones and shale that have eroded and been re-deposited as alluvium or windblown sediments (loess). Soils are well-drained and fine-sandy or silty in texture. Total vegetation cover ranges from 10 to 65%, roughly equally divided between the shrub and herbaceous layers. The vegetation is characterized by an open short-shrub canopy of *Ericameria nauseosa* that ranges in cover from 5 to 25% and an understory dominated by *Bouteloua gracilis* that ranges in cover from 5 to 35%. Other shrubs may be present with very low cover, including *Tetradymia canescens*, *Atriplex* spp., *Gutierrezia sarothrae*, and *Opuntia polyacantha*. Associated graminoids present include the bunch grasses *Achnatherum hymenoides*, *Aristida purpurea*, *Pascopyrum smithii*, *Pleuraphis jamesii*, *Sporobolus airoides*, *Sporobolus cryptandrus*, and *Muhlenbergia pungens*. Only scattered forbs are present.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. Former CEGL001738 and CEGL001739 were lumped into this new association; separation of these two types by subspecies of *Ericameria nauseosa* was not supported by the data in Francis (1986).

Petrified Forest National Park. This map class was distinguished from *Ericameria nauseosa* Desert Wash Shrubland (CEGL002261) by its restriction to upland areas. This association also tended to have a proportionally higher herbaceous cover, as well as no codominance by other shrub species.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.7.	Temperate or subpolar grassland with a sparse shrub layer
Physiognomic subgroup	V.A.7.N.	Natural/Semi-natural temperate or subpolar grassland with a sparse shrub layer
Formation name	V.A.7.N.j.	Short temperate or subpolar grassland with a sparse microphyllous evergreen shrub layer
Alliance name		<i>Ericameria nauseosa</i> Shrub Short Herbaceous Alliance (A.1546), Rubber Rabbitbrush Shrub Short Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.775	Inter-Mountain Basins Active and Stabilized Dune
CES304.765	Colorado Plateau Mixed Bedrock Canyon and Tableland
CES304.788	Inter-Mountain Basins Semi-Desert Shrub-Steppe

NatureServe conservation status:

Global rank. GNR (14-Apr-2003).

Distribution:

Globally. This association has been documented from widely scattered sites in southern Utah, northern Arizona, from the upper Rio Puerco watershed in northern New Mexico (Francis 1986), Petrified Forest National Park in northeastern Arizona, and is likely to occur across the central part of the Colorado Plateau.

Petrified Forest National Park. *Ericameria nauseosa* / *Bouteloua gracilis* Shrub Herbaceous Vegetation was identified from two relevés on sand dunes/sandsheets and on a talus surface within Petrified Forest National Park. They were located south of Newspaper Rock and south of The Haystacks.

Environmental summary:

Globally. This shrub herbaceous association occurs on valley floors, swales and alluvial flats in the central part of the Colorado Plateau. Stands occupy gentle to moderate slopes (2-13%) between 1635 and 2010 m (5360-6600 ft) elevation. Aspect does not control the distribution of this association. Litter and bare soil cover most of the unvegetated surface. Parent materials are variable and include sandstones and shale that have eroded and been re-deposited as alluvium or windblown sediments. Soils are well-drained and fine-sandy or silty in texture.

Petrified Forest National Park. This association occurred at 1635 and 1640 m (5360-5380 ft) elevation. Slopes were minimal (2-4%).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. The total vegetation cover ranges from 10 to 65%, roughly equally divided between the shrub and herbaceous layers. The vegetation is characterized by a short-shrub canopy of *Ericameria nauseosa* that ranges in cover from 5 to 25% and an understory dominated by *Bouteloua gracilis* that ranges in cover from 5 to 35%. Other shrubs may be present with very low cover, including *Tetradymia canescens*, *Atriplex canescens*, *Atriplex confertifolia*, *Gutierrezia sarothrae*, and *Opuntia polyacantha*. Associated graminoids present include the bunch grasses *Achnatherum hymenoides*, *Aristida purpurea*, *Pascopyrum smithii*, *Sporobolus airoides*, *Sporobolus cryptandrus*, and *Muhlenbergia pungens*. Only scattered forbs are present, such as *Chaetopappa ericoides*, *Ipomopsis longiflora*, and *Senecio spartioides*.

Petrified Forest National Park. The two relevés classified as *Ericameria nauseosa* / *Bouteloua gracilis* Shrub Herbaceous Vegetation had total vegetation cover of 23 and 24%. This vegetation cover was composed of 8 and 9% cover in the shrub stratum and 14 and 16% cover in the herbaceous stratum. The species diversity was 35 and 36 species. The shrub layer was dominated by *Ericameria nauseosa* with low shrub cover of 1 and 3%; the herbaceous layer was dominated by *Bouteloua gracilis* with 1 and 5% cover.

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Ericameria nauseosa</i>	<i>Ericameria nauseosa</i>
Herb (field)	<i>Bouteloua gracilis</i>	<i>Bouteloua gracilis</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Francis 1986, Hansen et al. 2004a, Western Ecology Working Group n.d.

C.4 Herbaceous

C.4.7. *Opuntia whipplei* - *Sporobolus airoides* Shrub Herbaceous Vegetation [Park Special]

Base map class	Whipple Cholla - Alkali Sacaton Shrub Herbaceous Vegetation
NatureServe common name	Rattail Cholla - Alkali Sacaton Shrub Herbaceous Vegetation [Park Special]
NatureServe code	Park Special

Summary:

This *Opuntia whipplei* dominated sand deposit association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. This vegetation community was only sampled from one location. Since this community is unique to the NVCS and has yet to be sampled with enough frequency during this project or at other locations, we were not able to assign it a NVCS association status. Until additional data are collected, this vegetation will be retained as a unique local assemblage or a park special vegetation type.

Vegetation hierarchy:

Physiognomic class	N/A	N/A
Physiognomic subclass	N/A	N/A
Physiognomic group	N/A	N/A
Physiognomic subgroup	N/A	N/A
Formation name	N/A	N/A
Alliance name		N/A

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.775	Inter-Mountain Basins Active and Stabilized Dune

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. *Opuntia whipplei* - *Sporobolus airoides* Shrub Herbaceous Vegetation (Park Special) was sampled from one relevé. It occurred on a sand dune/sandsheet located west of the Rainbow Forest in Petrified Forest National Park.

Environmental summary:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. This vegetation community was sampled at an elevation of 1696 m (5564 ft) on a flat surface. The surface rocks contained a trace of petrified wood.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. Only one relevé was classified as *Opuntia whipplei* - *Sporobolus airoides* Shrub Herbaceous Vegetation (Park Special), with total vegetation cover of 13%. This vegetation cover consisted of 4% cover in the shrub stratum and 9% cover in the herbaceous stratum. The species diversity of this stand was 13 species. In the shrub layer, the vegetation was dominated by *Opuntia whipplei* with 3% cover, and in the herbaceous layer, it was dominated by *Sporobolus airoides* with 4% cover.

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	N/A	<i>Opuntia whipplei</i>
Herb (field)	N/A	<i>Sporobolus airoides</i>

Other noteworthy species:

Global species	PEFO species
N/A	<i>Pleuraphis jamesii</i>

References:

Data are not available.

C.4 Herbaceous

C.4.8. *Pleuraphis jamesii* - *Sporobolus airoides* Herbaceous Vegetation

Base map class	Galleta – Alkali Sacaton Herbaceous Vegetation
NatureServe common name	James' Galleta - Alkali Sacaton Herbaceous Vegetation
NatureServe code	CEGL001778

Summary:

This once-extensive grassland of the northern Chihuahuan Desert, Colorado Plateau, and Great Basin has been described in New Mexico from White Sands Missile Range and the upper Rio Puerco watershed, as well as in north-central Arizona and southeastern Utah. It has, however, experienced significant declines throughout its range. It primarily occurs in swales within open valley bottoms and alluvial flats, although sandsheets and dunes also can support the association. Sites are on level to gentle slopes (<15%) at elevations between 1300-2075 m (4260-6800 ft). Soils are generally deep, with surface textures ranging from loamy sands, fine loams to silty clay loams and clays, derived from substrates that include lava flows, cinders, eolian sands, alluvium and relict Pleistocene river cobbles. The vegetation is characterized by a sparse to moderately dense perennial herbaceous layer that is dominated by *Pleuraphis jamesii* (= *Hilaria jamesii*) with *Sporobolus airoides* as a subdominant. Total vegetation cover in grazed sites generally does not exceed 20% but may be as high as 50% in protected areas. Occasionally, *Sporobolus airoides* may be codominant or dominant over *Pleuraphis jamesii*. This association usually has a sparse but diverse shrub layer that may include scattered *Atriplex canescens*, *Atriplex confertifolia*, *Atriplex obovata*, *Coleogyne ramosissima*, *Ephedra torreyana*, *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Opuntia imbricata*, *Opuntia macrorhiza*, *Opuntia phaeacantha*, *Sarcobatus vermiculatus*, and *Yucca angustissima*. The key graminoid species dominate the herbaceous layer and account for more than 80% of the total plant cover. Associated herbaceous species, such as *Achnatherum hymenoides*, *Bouteloua gracilis*, *Muhlenbergia porteri*, *Muhlenbergia pungens*, *Muhlenbergia torreyi*, *Pascopyrum smithii*, *Scleropogon brevifolius*, *Sphaeralcea coccinea*, and *Sporobolus cryptandrus*, may be present with low cover. Biological soil crusts may be extensive in undisturbed examples of this association.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. In the classification of the plant communities of the upper Rio Puerco watershed, Francis (1986) described two plant communities codominated by *Pleuraphis jamesii* - *Sporobolus airoides* that were separated by the relative dominance of the key species. Both plant communities were combined into this association. *Sporobolus airoides* is larger and often more abundant than *Pleuraphis jamesii* which suggests that this association should be moved to the *Sporobolus airoides* Herbaceous Alliance (A.1267).

Petrified Forest National Park. Listing *Pleuraphis jamesii* first in the association name at Petrified Forest National Park does not indicate higher cover values. *Sporobolus airoides* actually had equal or higher cover in all of the relevés.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.5.	Temperate or subpolar grassland
Physiognomic subgroup	V.A.5.N.	Natural/Semi-natural temperate or subpolar grassland
Formation name	V.A.5.N.e.	Short sod temperate or subpolar grassland
Alliance name		<i>Pleuraphis jamesii</i> Herbaceous Alliance (A.1287), James' Galleta Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.787	Inter-Mountain Basins Semi-Desert Grassland

NatureServe conservation status:

Global rank. G2G3 (14-Nov-2005). This once-extensive grassland of the Great Basin and Chihuahuan Desert ecoregions has been described in New Mexico from the Upper Rio Puerco watershed and White Sands Missile Range, as well as isolated areas in north-central Arizona and southeastern Utah. It has experienced significant declines throughout its range. Remaining examples that have not been negatively impacted by grazing and/or invaded by shrubs are rare. However, this grassland is probably more widespread than is documented and hence the rank of G2G3.

Distribution:

Globally. This once-extensive grassland of the northern Chihuahuan Desert, Colorado Plateau, and Great Basin is reported in New Mexico from White Sands Missile Range and the upper Rio Puerco watershed. More recently, it has been documented in north-central Arizona and southeastern Utah. It has experienced significant declines throughout its range.

Petrified Forest National Park. *Pleuraphis jamesii* - *Sporobolus airoides* Herbaceous Vegetation was identified from three relevés within Petrified Forest National Park and from one relevé south of Dry Wash Tanks on Arizona State Land. This association occurred on various landforms, including sideslopes, lower slopes, plateaus, and sand dunes/sandsheets. These stands were identified from these three locations: near the park road and north of Dry Wash; in the central neck area of the park and east of the park road; and west of Blue Mesa and south of Dry Wash Tanks.

Environmental summary:

Globally. This grassland association is described in New Mexico from White Sands Missile Range and the upper Rio Puerco watershed, as well as in north-central Arizona and southeastern Utah. It primarily occurs in swales within open valley bottoms and alluvial flats, although sandsheets and dunes also can support the association. Sites are on level to gentle slopes (<15%) at elevations between 1300-2075 m (4260-6800 ft). Soils are generally deep, with surface textures ranging from loamy sands, fine loams to silty clay loams and clays, derived from substrates that include lava flows, cinders, eolian sands, alluvium and relict Pleistocene river cobbles.

Petrified Forest National Park. This association occurred between 1650 and 1700 m (5410-5570 ft) elevation. Slopes were low and ranged from 0 to 3% (average 1%). A low cover of petrified wood and selenite was found at one relevé.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association is characterized by a sparse to moderately dense perennial herbaceous layer that is codominated by *Pleuraphis jamesii* (= *Hilaria jamesii*) and *Sporobolus airoides*. Total vegetation cover generally does not exceed 20% in grazed sites but may be as high as 75% in protected areas. Occasionally, *Sporobolus airoides* may be codominant or dominant over *Pleuraphis jamesii*. This association usually has a sparse but diverse shrub layer that may include scattered *Atriplex canescens*, *Atriplex confertifolia*, *Atriplex obovata*, *Coleogyne ramosissima*, *Ephedra torreyana*, *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Opuntia imbricata*, *Opuntia macrorhiza*, *Opuntia phaeacantha*, *Opuntia polyacantha*, *Sarcobatus vermiculatus*, and *Yucca angustissima*. The key graminoid species dominate the herbaceous layer and typically account for more than 80% of the total plant cover. Associated

herbaceous species, such as *Achnatherum hymenoides*, *Chaenactis stevioides*, *Cryptantha* sp., *Cymopterus newberryi*, *Bouteloua gracilis*, *Ipomopsis gunnisonii* (= *Gilia gunnisonii*), *Lappula occidentalis*, *Muhlenbergia porteri*, *Muhlenbergia pungens*, *Muhlenbergia torreyi*, *Pascopyrum smithii*, *Plantago patagonica*, *Scleropogon brevifolius*, *Sphaeralcea coccinea*, and *Sporobolus cryptandrus*, may be present with low cover (Francis 1986, Muldavin et al. 2000b). Biological soil crusts may be extensive in undisturbed examples of this association.

Petrified Forest National Park. Four relevés were classified as *Pleuraphis jamesii* - *Sporobolus airoides* Herbaceous Vegetation. The total vegetation cover of these stands ranged from 13 to 18% (average 15%) and consisted of a shrub stratum with 1 to 6% cover (average 3%) and an herbaceous stratum with 10-15% cover (average 12%). The species diversity ranged from 17 to 33 species (average 25 species). The vegetation was codominated in the herbaceous layer by *Pleuraphis jamesii* with 2-4% cover (average 3%) and *Sporobolus airoides* with 2-8% cover (average 4%).

Most abundant species:

Stratum	Global species	PEFO species
Herb (field)	<i>Pleuraphis jamesii</i> , <i>Sporobolus airoides</i>	<i>Pleuraphis jamesii</i> , <i>Sporobolus airoides</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Driscoll et al. 1984, Francis 1986, Hansen et al. 2004b, Muldavin et al. 1998b, Muldavin et al. 2000b, West et al. 1972, Western Ecology Working Group n.d.

C.4 Herbaceous

C.4.9. *Salsola tragus* Sand Dune Vegetation [Park Special]

Base map class	Russian Thistle Sand Dune Vegetation
NatureServe common name	Prickly Russian-thistle Sand Dune Vegetation [Park Special]
NatureServe code	Park Special

Summary:

This *Salsola tragus* dominated sand deposit association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. This vegetation was designated as a Park Special vegetation community and has not yet been assigned NVCS association status. This is due to the lack of data collected, as well as the dominant species in this association being an annual non-native herbaceous forb. The dominance of *Salsola tragus* in these communities varies seasonally and annually. Although this species is an annual species and may vary significantly in cover, *Salsola tragus* is the dominant species on these relevés and no other species has significant cover or is a good indicator for these sand dune communities.

Vegetation hierarchy:

Physiognomic class	N/A	N/A
Physiognomic subclass	N/A	N/A
Physiognomic group	N/A	N/A
Physiognomic subgroup	N/A	N/A
Formation name	N/A	N/A
Alliance name		N/A

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.775	Inter-Mountain Basins Active and Stabilized Dune

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. *Salsola tragus* Sand Dune Vegetation (Park Special) occurred on two relevés within Petrified Forest National Park. This community type was identified on talus/sand dune landforms. These two relevés were sampled west of the main park road, northeast of Jasper Forest and west of the Lithodendron Wash and Pintado Point in the northern wilderness area.

Environmental summary:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. This vegetation community occurred at about 1660 m (5430-5460 ft) elevation. Slope was none to low (0-5.3%).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. Two relevés were classified as *Salsola tragus* Sand Dune Vegetation (Park Special), with total vegetation cover of 14 and 18%. The vegetation cover consisted of 3 and 4% cover in the shrub stratum and 10 and 15% cover in the herbaceous stratum. The species diversity was 21 and 30 species. The vegetation in the herbaceous layer was dominated by the non-native herbaceous forb *Salsola tragus* with 4 and 9% cover. No other species had significant cover in either the shrub or herbaceous layers.

Most abundant species:

Stratum	Global species	PEFO species
Herb (field)	<i>Data are not available.</i>	<i>Salsola tragus</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Achnatherum hymenoides, Atriplex obovata, Chamaesyce fendleri, Ericameria nauseosa, Gutierrezia sarothrae, Isocoma drummondii, Pleuraphis jamesii, Senecio spartioides, Sporobolus airoides, Townsendia annua, Yucca angustissima</i>

References:

Data are not available.

C.4 Herbaceous

C.4.10. *Sporobolus airoides* - *Bouteloua gracilis* Herbaceous Vegetation

Base map class	Alkali Sacaton – Blue Grama Herbaceous Vegetation
NatureServe common name	Alkali Sacaton - Blue Grama Herbaceous Vegetation
NatureServe code	CEGL001686

Summary:

This grassland association occurs in basins in the northern Chihuahuan Desert in south-central New Mexico and in the southern Colorado Plateau in northwestern New Mexico and northern Arizona at 1570 to 2240 m (5160-7370 ft) elevation. Stands occur on gently sloping (<1%) depressions or swales in alluvial flats and alluvial plains, lower piedmont slopes in southern New Mexico, and on mesas, lower slopes, sand deposits/sandsheets, and terraces in northern Arizona. In desert sites, soils are typically deep and fine silty loams, but not clayey. In other sites, soils range from silty clay loam to clay on alluvial plains to sand. The vegetation is characterized by an open to dense (14-70% cover) herbaceous layer dominated by *Sporobolus airoides* and *Bouteloua gracilis*. Scattered shrubs may be present with low cover (<10%), such as *Atriplex confertifolia*, *Atriplex canescens*, *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Opuntia imbricata*, *Opuntia polyacantha*, and the characteristic desert species *Yucca elata*. Other common graminoid species may include *Achnatherum hymenoides*, *Aristida* spp., *Elymus elymoides*, *Pleuraphis jamesii*, *Scleropogon brevifolius*, and *Sporobolus cryptandrus*. Forb cover is usually low and often diverse.

Classification confidence: 3 - Weak.

Classification comments:

Globally. In desert basins in the northern Chihuahuan Desert, this association is restricted to relatively mesic, non-clayey swales or depressions in desert basins and plains (Muldavin et al. 2000b). The dominant species that characterize this association are widespread in the western U.S. but typically occur in different habitats, e.g., *Bouteloua gracilis* in upland sites and *Sporobolus airoides* in bottomland sites or on sandy substrates. The species codominate in relatively specific habitats (desert swales) in southern New Mexico (Muldavin et al. 2000b) but occur in broader habitats in the Colorado Plateau (Francis 1986). More survey and classification work are needed to clarify the concept of this association.

Petrified Forest National Park. Although *Bouteloua gracilis* was more abundant than *Sporobolus airoides*, *Sporobolus airoides* is the first species listed in the name due to its status in the NVCS.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.5.	Temperate or subpolar grassland
Physiognomic 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
Alliance name		<i>Sporobolus airoides</i> Sod Herbaceous Alliance (A.1241), Alkali Sacaton Sod Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CE5304.787	Inter-Mountain Basins Semi-Desert Grassland

NatureServe conservation status:

Global rank. GNRQ (23-Feb-1994).

Distribution:

Globally. This grassland association occurs in the northern Jornada del Muerto and Tulerosa basins in south-central New Mexico and in the southern Colorado Plateau in the upper Rio Puerco watershed in northwestern New Mexico and at Petrified Forest National Park in northern Arizona.

Petrified Forest National Park. *Sporobolus airoides* - *Bouteloua gracilis* Herbaceous Vegetation was identified from seven relevés within Petrified Forest National Park. This association occurred on lower slopes, sand dunes/sandsheets, and terraces. It was located both north and west of the Blue Mesa road towards the main park road and was also identified south of Newspaper Rock approximately 2 m west of the main park road, west of the southern wilderness area, and south of the Crystal Forest and east of the main park road

Environmental summary:

Globally. This grassland association occurs in basins in the northern Chihuahuan Desert in south-central New Mexico and in the southern Colorado Plateau in northwestern New Mexico and northern Arizona at 1570 to 2240 m (5160-7370 ft) elevation. Stands occur on gently sloping (<1%) depressions or swales in alluvial flats and alluvial plains, lower piedmont slopes in southern New Mexico, and on mesas, lower slopes, sand deposits/sandsheets, and terraces in northern Arizona (Francis 1986, Muldavin et al. 2000b). Substrates are typically deep and fine-textured soils. In desert stands, soils are fine silty loams, but not clayey (Muldavin et al. 2000b). In stands in the Colorado Plateau, soils range from silty clay loam to clay on alluvial flats to sand. The ground surface is largely bare soil.

Petrified Forest National Park. This association was sampled between the elevations of 1640 and 1720 m (5370-5630 ft). Slope ranged from low to moderate (1-9%, average 5%). Two of the relevés had some surface rocks, including petrified wood and gravel.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This swale grassland association is characterized by an open to dense (14-70 % cover) herbaceous layer dominated by *Sporobolus airoides* and *Bouteloua gracilis*. Scattered shrubs may be present, such as *Atriplex confertifolia*, *Atriplex canescens*, *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Opuntia imbricata*, *Opuntia polyacantha*, and the characteristic desert species *Yucca elata*. Other common graminoid species may include *Achnatherum hymenoides*, *Aristida* spp., *Elymus elymoides*, *Pleuraphis jamesii*, *Scleropogon brevifolius*, and *Sporobolus cryptandrus*. Forb cover is usually low and often diverse. Common forbs include *Chaetopappa ericoides*, *Chamaesyce fendleri*, *Chenopodium fremontii*, *Mentzelia* spp., *Pectis angustifolia*, *Phacelia crenulata*, *Senecio spartioides*, or *Sphaeralcea* spp. Introduced annuals *Portulaca oleracea* and *Salsola tragus* are common in some stands.

Petrified Forest National Park. Seven relevés were classified as *Sporobolus airoides* - *Bouteloua gracilis* Herbaceous Vegetation, with total vegetation cover between 16 and 40% (average 21%). The vegetation cover consisted of a shrub stratum with 1-5% cover (average 2%) and an herbaceous stratum with 14-35% cover (average 19%). The species diversity ranged from 24 to 35 species (average 29 species). The vegetation was codominated in the herbaceous layer by *Sporobolus airoides*, with 2-10% cover (average 5%), and *Bouteloua gracilis* with 3-11% cover (average 6%). The herbaceous species *Phacelia* sp. covered 7% of one stand, and *Pectis angustifolia* covered 5% in another.

Most abundant species:

Stratum	Global species	PEFO species
Herb (field)	<i>Bouteloua gracilis</i> , <i>Sporobolus airoides</i>	<i>Bouteloua gracilis</i> , <i>Sporobolus airoides</i>

Other noteworthy species:

Global species	PEFO species
<i>Salsola kali</i> ssp. <i>tragus</i>	<i>Data are not available.</i>

References:

Bourgeron and Engelking 1994, Driscoll et al. 1984, Francis 1986, Muldavin and Mehlhop 1992, Muldavin et al. 2000b, Western Ecology Working Group n.d.

C.4 Herbaceous

C.4.11. *Sporobolus airoides* Southern Plains Herbaceous Vegetation

Base map class	Alkali Sacaton Herbaceous Vegetation
NatureServe common name	Alkali Sacaton Southern Plains Herbaceous Vegetation, Alkali Sacaton Southern Plains Grassland
NatureServe code	CEGL001685

Summary:

This alkali sacaton mesic grassland community is found in the southwestern Great Plains, on the Colorado Plateau, in the southwestern United States, and adjacent Mexico. Stands occur on slightly to moderately saline, nearly level bottomlands and terraces. Additional moisture from washes and sheetflow runoff are important for most stands. Substrates are shallow, moderately well- to poorly drained, silty clay soils formed in alluvium. The community is dominated by medium-tall and short grasses. *Sporobolus airoides* is a dominant, often accompanied by *Symphotrichum subulatum* (= *Aster subulatus*), *Pascopyrum smithii*, *Buchloe dactyloides*, *Distichlis spicata*, *Hordeum jubatum*, and *Bouteloua gracilis*. Scattered shrubs, such as *Atriplex* spp. or *Sarcobatus vermiculatus*, may be present. Forb cover is also minor.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Compare this association with *Sporobolus airoides* - *Bouteloua gracilis* Herbaceous Vegetation (CEGL001686) and *Pleuraphis jamesii* - *Sporobolus airoides* Herbaceous Vegetation (CEGL001778). Stands in Montana are placed with *Sporobolus airoides* Northern Plains Herbaceous Vegetation (CEGL002274), which occurs in the northwestern Great Plains, and this type is restricted to the southwestern Great Plains and southwestern United States. In the southeastern Plains see *Distichlis spicata* - (*Hordeum jubatum*, *Poa arida*, *Sporobolus airoides*) Herbaceous Vegetation (CEGL002042).

Petrified Forest National Park. Data are not available.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.5.	Temperate or subpolar grassland
Physiognomic 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>Sporobolus airoides</i> Herbaceous Alliance (A.1267), Alkali Sacaton Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.781	Inter-Mountain Basins Wash
CES304.775	Inter-Mountain Basins Active and Stabilized Dune
CES304.787	Inter-Mountain Basins Semi-Desert Grassland

NatureServe conservation status:

Global rank. G3Q (9-Apr-1998). The number of occurrences is unknown. The community is reported from Arizona, Colorado (S3), Kansas, New Mexico (S2), Texas, Utah, and Mexico and may occur in California. The community is found on slight to moderately saline, nearly level bottomland and terraces with alluvial silty clay soils.

Distribution:

Globally. This alkali sacaton mesic grassland community is found in the southwestern Great Plains, Colorado Plateau, and elsewhere in the southwestern United States and Mexico, ranging from Kansas and Colorado south to Texas, New Mexico and west to Arizona, Utah, and possibly California.

Petrified Forest National Park. *Sporobolus airoides* Southern Plains Herbaceous Vegetation was identified from two relevés within Petrified Forest National Park. They were located in a drainage channel and on a sand dune/sandsheet. These two relevés were sampled east of Lithodendron Wash and west of Lacey Point and east of Newspaper Rock and east of the main park road.

Environmental summary:

Globally. This grassland community occurs on alluvial toeslopes and flats, terraces, flood-plain depressions, and sandy streambanks and washes in bottomlands throughout the southern Great Plains and Colorado Plateau. Additional moisture from washes and sheetflow runoff are important for most stands. Elevations range from below 1000 m (3050 ft) to over 2000 m (6100 ft). Sites are typically flat to gently sloping but may be as steep as 30% slope. Soils are shallow to moderately deep, moderately well- to poorly drained, alkaline, and often saline with sandy, silty or clay soils (Francis 1986, Johnston 1987, Kittel et al. 1999a, Lauver et al. 1999, Von Loh et al. 2002). Other parent materials include lavaflow, cinders, relict Pleistocene river cobbles, and sandstone.

Petrified Forest National Park. This association was sampled at 1640 and 1650 m (5360-5400 ft) elevation. Both stands had no slope.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association is characterized by a sparse to moderately dense (15-75% cover), medium-tall graminoid layer dominated by *Sporobolus airoides*. Associated species include *Achnatherum hymenoides*, *Symphyotrichum subulatum* (= *Aster subulatus*), *Buchloe dactyloides*, *Distichlis spicata*, *Hordeum jubatum*, *Bouteloua gracilis*, *Panicum obtusum*, *Pleuraphis jamesii*, *Sphaeralcea* spp., *Sporobolus cryptandrus*, and *Pascopyrum smithii* (Francis 1986, Johnston 1987, Kittel et al. 1999a, Lauver et al. 1999, Von Loh et al. 2002). Scattered shrubs may be present, such as *Atriplex canescens*, *Atriplex confertifolia*, *Ephedra* spp., *Ericameria nauseosa*, *Gutierrezia sarothrae*, or *Sarcobatus vermiculatus*. Total shrub cover is low (<10%), and forb cover is minor.

Petrified Forest National Park. Two relevés were classified as *Sporobolus airoides* Southern Plains Herbaceous Vegetation, with total vegetation cover of 19 and 22%. This vegetation cover consisted of a shrub stratum with 0.5 and 4% cover and an herbaceous stratum with 15 and 22% cover. The species diversity was 4 and 15 species. The vegetation in the herbaceous layer was dominated by *Sporobolus airoides* with 7 and 15% cover. In one stand, the annual forb *Chenopodium leptophyllum* had 11% cover.

Most abundant species:

Stratum	Global species	PEFO species
Herb (field)	<i>Sporobolus airoides</i>	<i>Data are not available.</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Aldous and Shantz 1924, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Carsey et al. 2003a, Driscoll et al. 1984, Francis 1986, Hansen et al. 2004b, Johnston 1987, Kittel and Lederer 1993, Kittel et al. 1999b, Lauver et al. 1999, Lindauer 1970, Soil Conservation Service 1978, Steward 1982, Von Loh et al. 2002, Western Ecology Working Group n.d.

C.4 Herbaceous

C.4.12. *Sporobolus coromandelianus* Herbaceous Vegetation [Park Special]

Base map class	<i>Sporobolus coromandelianus</i> Herbaceous Vegetation (Park Special) was not mapped because only one relevé was sampled of this unique community type. This vegetation community could not be identified on the aerial photography; therefore the single relevé was included in the New Mexico Saltbush / Galleta - Alkali Sacaton Shrub Herbaceous Vegetation map class.
NatureServe common name	Target Dropseed Herbaceous Vegetation [Park Special]
NatureServe code	Park Special

Summary:

Data are not available.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. This vegetation was only sampled from one location. *Sporobolus coromandelianus* can be either an annual or a perennial species and does not commonly occur at Petrified Forest National Park. This vegetation has not been seen elsewhere and has not received NVCS association status. If this community is sampled in other locations and additional data are collected, then this community type will be elevated to NVCS association status. Since *Sporobolus coromandelianus* is rare at Petrified Forest National Park, it would be useful to relocate this relevé and re-identify this grass to ensure the correct species identification. It is unlikely that the cover for this species is as high as recorded for this relevé.

Vegetation hierarchy:

Physiognomic class	N/A	N/A
Physiognomic subclass	N/A	N/A
Physiognomic group	N/A	N/A
Physiognomic subgroup	N/A	N/A
Formation name	N/A	N/A
Alliance name	N/A	N/A

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.775	Inter-Mountain Basins Active and Stabilized Dune

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. *Sporobolus coromandelianus* Herbaceous Vegetation (Park Special) was identified from one relevé within Petrified Forest National Park. This one relevé was located on a sand dune/sandsheet east of the main park road and Dry Wash and south of Blue Mesa.

Environmental summary:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. This vegetation community occurred at an elevation of 1650 m (5420 ft) with no slope.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. Only one relevé was classified as *Sporobolus coromandelianus* Herbaceous Vegetation (Park Special), with total vegetation cover of 20%. The vegetation cover consisted of a shrub stratum with 3% cover and an herbaceous stratum with 17% cover. The species diversity for this relevé was 25 species. The vegetation in the herbaceous layer was dominated by *Sporobolus coromandelianus* with 8% cover.

Most abundant species:

Stratum	Global species	PEFO species
Herb (field)	<i>Data are not available.</i>	<i>Sporobolus coromandelianus</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Data are not available.

C.4 Herbaceous

C.4.13. *Sporobolus cryptandrus* Great Basin Herbaceous Vegetation

Base map class	Not mapped. <i>Sporobolus cryptandrus</i> Great Basin Herbaceous Vegetation is known from only one location and was indistinguishable on the aerial photography. This one location was mapped with the Alkali Sacaton Herbaceous Vegetation map unit.
NatureServe common name	Sand Dropseed Great Basin Herbaceous Vegetation
NatureServe code	CEGL002691

Summary:

This plant association is described from the Uinta Basin and Colorado Plateau where it occurs on alluvial terraces of major rivers, sandy upper stream terraces along intermittent washes, and on sand deposits on mesas and plains. Elevation ranges from 1226 to 1630 m. Soils are loamy sands and sandy loams derived from alluvium, eolian deposits, or sandstone residuum. Sites have generally been disturbed by flooding, shifting sands, livestock grazing, or human recreation. The vegetation is dominated by the warm-season perennial graminoid *Sporobolus cryptandrus*. *Hesperostipa comata* (= *Stipa comata*), *Pleuraphis jamesii*, *Sporobolus contractus*, *Sporobolus giganteus*, or *Equisetum variegatum* frequently occur in low abundance. Low cover of native forbs such as *Sphaeralcea grossularifolia* or *Chamaesyce fendleri* may be present. The introduced annual grass *Bromus tectorum* and several other exotic species such as *Bromus rigidus*, *Salsola kali*, *Helianthus annuus*, *Sisymbrium altissimum*, or *Tribulus terrestris* may be present to abundant, especially on disturbed riparian stands. Occasional *Brickellia* spp. or other shrubs may occur, but they are not dense enough to form a shrub layer.

Classification confidence: 1 - Strong.

Classification comments:

Globally. The association is broadly defined to include *Sporobolus cryptandrus*-dominated stands from both riparian and sandy upland sites. This plant association is similar to the threatened, regionally endemic *Sporobolus cryptandrus* plant associations from the Columbia Basin and lower Snake River that have declined significantly due to loss of habitat from hydroelectric dam construction and conversion of land to cultivation. Many of the riparian stands in these associations are in poor condition because of past management and invasion of introduced species.

Petrified Forest National Park. Although only one relevé was sampled, this community has already been described from other locations and is a previously described vegetation association. Therefore, this vegetation was classified as an NVCS association.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.5.	Temperate or subpolar grassland
Physiognomic 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>Sporobolus cryptandrus</i> Herbaceous Alliance (A.1252), Sand Dropseed Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.775	Inter-Mountain Basins Active and Stabilized Dune
CES304.787	Inter-Mountain Basins Semi-Desert Grassland

NatureServe conservation status:

Global rank. GNR (26-Jul-2001).

Distribution:

Globally. The association is found on terraces of large rivers in the Colorado Plateau and Uinta Basin and likely occurs elsewhere in the southwestern U.S.

Petrified Forest National Park. *Sporobolus cryptandrus* Great Basin Herbaceous Vegetation was sampled from just one relevé. It occurred on a sand dune/sandsheet located just east of the NPS boundary in the central neck of Petrified Forest National Park, south of the railroad tracks and north of the Puerco River.

Environmental summary:

Globally. This grassland is described from the Uinta Basin and Colorado Plateau where it occurs on alluvial terraces of large rivers, sandy upper stream terraces along intermittent washes, and on sand deposits on mesas and plains. Elevation ranges from 1226-1630 m. Sites are flat to gently sloping valley bottoms, plains or plateaus. Soils are loamy sands and sandy loams derived from alluvium, eolian deposits, or sandstone residuum. Biological soil crusts are generally present and may provide up to 30% cover. Stands have generally been disturbed by flooding, shifting sands, livestock grazing, or human recreation.

Petrified Forest National Park. This association occurred at an elevation of 1630 m (5350 ft) with no slope.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This plant association is found on alluvial terraces of large rivers and on sand deposits on mesas and plains. The sparse to moderately dense (10-30% cover) herbaceous layer is characterized by the dominance of the warm-season perennial graminoid *Sporobolus cryptandrus*. *Hesperostipa comata* (= *Stipa comata*), *Pleuraphis jamesii*, *Sporobolus contractus*, *Sporobolus giganteus*, or *Equisetum variegatum* may occur in low abundance. Low cover of native forbs, such as *Abronia fragrans*, *Chamaesyce fendleri*, *Plantago patagonica*, *Sphaeralcea grossulariifolia*, *Sphaeralcea parvifolia*, or the succulent *Opuntia polyacantha* may be present. The widespread introduced annual grass *Bromus tectorum* and several other exotic species such as *Bromus rigidus*, *Salsola kali*, *Helianthus annuus*, *Sisymbrium altissimum*, or *Tribulus terrestris* may be present to abundant, especially on disturbed riparian stands. An occasional *Brickellia* spp. or other shrubs may occur, but they are not dense enough to form a shrub layer. Moss is important in some stands.

Petrified Forest National Park. Only one relevé was classified as *Sporobolus cryptandrus* Great Basin Herbaceous Vegetation, with total vegetation cover of 73% consisting of low cover of shrubs (3%) and high herbaceous cover (70%). The species diversity was low with 7 species. The vegetation in the herbaceous layer was almost solely dominated by *Sporobolus cryptandrus* with 70% cover.

Most abundant species:

Stratum	Global species	PEFO species
Herb (field)	<i>Sporobolus cryptandrus</i>	<i>Sporobolus cryptandrus</i>

Other noteworthy species:

Global species	PEFO species
<i>Bromus tectorum</i>	<i>Data are not available.</i>

References:

Cogan et al. 2004, Cowardin et al. 1979, USFS 1937, Von Loh et al. 2002, Western Ecology Working Group n.d.

C.5 Sparse

C.5.1. *Atriplex obovata* Badland Sparse Vegetation

Base map class	New Mexico Saltbush Badlands Sparse Vegetation
NatureServe common name	New Mexico Saltbush Badland Sparse Vegetation
NatureServe code	CEGL002928

Summary:

This sparsely vegetated badland association occurs in the southern Colorado Plateau in northern Arizona between the elevations of 1300 and 1741 m (4265-5712 ft). Sites are flat to gently sloping and range between 0 and 9% (average 3%). Substrates are clays derived from shale. Many of the stands have some cover of surface rocks, including sandstone, basalt, desert pavement, and petrified wood. The vegetation cover is characterized by sparse total vegetation cover (<10%) of scattered low shrubs dominated by *Atriplex obovata*. Locally, shrub cover may range up to about 15% cover, but in general, shrub cover is <5% with scattered grasses and forbs (<5% cover). Additionally, total cover may temporarily exceed 10% following rain events due to blooms of annuals. In some stands, cover of *Sporobolus airoides* or *Pleuraphis jamesii* ranges between 0 and 4% and may actually have slightly higher cover than *Atriplex obovata*, although total cover is low. The exotic annual forb *Salsola tragus* is often present in sampled stands.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Total vegetation cover for sparse vegetation associations is often very sparse and patchy. Therefore, it is important to assess a large area when classifying this community type and to expect a large degree of variation in species coverage. In some instances, *Atriplex obovata* may act as an indicator species for this sparse badland association.

Petrified Forest National Park. The total vegetation cover for this association was very sparse and patchy. Due to the sparse patchiness of this vegetation association, the cover of *Atriplex obovata* and the cover of the associated species can vary significantly. Therefore, it is important to assess a large area when classifying this community type and to expect a large degree of variation in species coverage. In some instances, *Atriplex obovata* may act as an indicator species for this sparse badland association.

Vegetation hierarchy:

Physiognomic class	VII	Sparse Vegetation
Physiognomic subclass	VII.C.	Unconsolidated material sparse vegetation
Physiognomic group	VII.C.3.	Sparsely vegetated soil slopes
Physiognomic subgroup	VII.C.3.N.	Natural/Semi-natural sparsely vegetated soil slopes
Formation name	VII.C.3.N.b.	Dry slopes
Alliance name		Painted Desert Sparsely Vegetated Alliance (A.2545), Painted Desert Sparsely Vegetated Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.789	Inter-Mountain Basins Shale Badland

NatureServe conservation status:

Global rank. GNR (29-Aug-2002).

Distribution:

Globally. This association is currently known from Arizona.

Petrified Forest National Park. *Atriplex obovata* Badland Sparse Vegetation was identified from twelve relevés and occurred mostly on plateaus and sand dunes/sandsheets within Petrified Forest National Park. A few relevés were located near or in a drainage channel, on a flat plain, or in an area with talus. This association ranged the entire extent of the project boundary, including the northern wilderness area between Wildhorse Wash and Lithodendron Wash, south of Lithodendron Wash and north of Chinde Point, north of Old Route 66 and northwest of Alley Way Tank, southwest of Blue Mesa, northeast of The Flattops, east of Dry Wash and Agate Bridge, east of The Haystacks, south of Cottonwood Wash, and northwest of the Crystal Forest.

Environmental summary:

Globally. This sparsely vegetated badland association occurs in the southern Colorado Plateau in northern Arizona between the elevations of 1300 and 1741 m (4265-5712 ft). Sites are flat to gently sloping and range between 0 and 9% (average 3%). Substrates are clays derived from shale. Many of the stands have some cover of surface rocks, including sandstone, basalt, desert pavement, and petrified wood (Hansen et al. 2004b).

Petrified Forest National Park. This association occurred between the elevations of 1630 and 1741 m (5348-5712 ft) with no or a low slope ranging between 0 and 9% (average 3%). Many of the stands have some cover of surface rocks, including sandstone, basalt, desert pavement, and petrified wood.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. The vegetation is characterized by sparse total cover (<10%) of scattered low shrubs dominated by *Atriplex obovata*. Locally, shrub cover may range up to about 15% cover, but in general, shrub cover is <5% with scattered grasses and forbs (<5% cover). Additionally, total cover may temporarily exceed 10% following rain events due to blooms of annuals. In some stands, cover of *Sporobolus airoides* or *Pleuraphis jamesii* ranges in cover between 0 and 4% and may actually have slightly higher cover than *Atriplex obovata*, although total cover is low. Other species present may include *Atriplex canescens*, *Opuntia macrorhiza*, and annuals such as *Cryptantha crassisejala*, *Eriogonum divaricatum*, *Plantago patagonica*, and *Townsendia annua*. The exotic annual forb *Salsola tragus* is often present in sampled stands (Hansen et al. 2004b).

Petrified Forest National Park. Twelve relevés were classified as *Atriplex obovata* Badland Sparse Vegetation, with total vegetation cover ranging from very sparse to low total vegetation cover 0.5-9% (average 5%). This vegetation cover consisted of a shrub stratum with 0.5-4% (average 2%) and an herbaceous stratum with 0.5-6% (average 3%). The species diversity for this association ranged from 4 to 34 species (average 15 species). The vegetation was dominated almost entirely by *Atriplex obovata* and it ranged from 0.5 to 4% cover (average 2%). In some stands, *Sporobolus airoides* actually had slightly higher cover than *Atriplex obovata* and ranged in cover from 0 to 4% (average 1%).

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Atriplex obovata</i>	<i>Atriplex obovata</i>

Other noteworthy species:

Global species	PEFO species
<i>Salsola kali</i> ssp. <i>tragus</i>	<i>Data are not available.</i>

References:

Hansen et al. 2004b, Western Ecology Working Group n.d.

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

References:

Western Ecology Working Group n.d.

C.5 Sparse

C.5.2. *Ephedra torreyana* - *Artemisia bigelovii* Sparse Vegetation

Base map class	Torrey's Jointfir – Bigelow's Sagebrush Sparse Vegetation
NatureServe common name	Torrey's Joint-fir - Bigelow Sagebrush Sparse Vegetation
NatureServe code	CEGL002350

Summary:

This Colorado Plateau association has been described from Petrified Forest National Park in northern Arizona and Capitol Reef National Park in southeastern Utah, where it is widespread. Stands occur on plateaus, mesas, ridges, hills, cliffs, rocky colluvial slopes, benches, terraces, and near drainage channels that are gently sloping to steep (3-50%) between 1402 and 1915 m elevation on all aspects. The unvegetated surface has moderate to high cover of gravel and low to moderate cover of large rocks and litter. Cryptogams are typically absent, but one stand has 75% cover. Parent materials include sandstones and shale. Soils are rapidly drained and variable in texture, including loams, sands, and clays, but are unified by a coating of fine to coarse gravels composed of sandstone, shale, basalt, or petrified wood. The vegetation is typically sparse (<10% total cover) and is characterized by an open, mixed shrub canopy that is dominated or codominated by *Ephedra torreyana* and *Artemisia bigelovii*. Locally, shrub cover may range up to about 20% cover, but in general, shrub cover is <10% with scattered grasses and forbs (<5% cover). Additionally, total cover may temporarily exceed 10% following rain events due to blooms of annuals. Associated shrubs are diverse but characteristically include all or some of *Atriplex confertifolia*, *Chrysothamnus viscidiflorus*, *Ephedra viridis*, *Ericameria nauseosa*, *Eriogonum corymbosum*, and *Gutierrezia sarothrae*. Occasional *Juniperus osteosperma* may be present as saplings. The herbaceous layer is characteristically depauperate and sparse. Species recorded from plots include *Achnatherum hymenoides*, *Aristida purpurea*, *Bouteloua gracilis*, *Hesperostipa comata*, and *Pleuraphis jamesii*. Forbs present include *Phacelia crenulata* and *Tetranneuris acaulis*. The exotic annual grass *Bromus tectorum* is common in many of the sampled stands.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. Both *Artemisia bigelovii* and *Ephedra torreyana* generally occurred in every relevé; however, *Ephedra torreyana* did not always consistently occur and neither species is required to be dominant in a stand for it to be classified as this association. Therefore, both *Artemisia bigelovii* and *Ephedra torreyana* may act as indicator species.

Vegetation hierarchy:

Physiognomic class	VII	Sparse Vegetation
Physiognomic subclass	VII.C.	Unconsolidated material sparse vegetation
Physiognomic group	VII.C.3.	Sparsely vegetated soil slopes
Physiognomic subgroup	VII.C.3.N.	Natural/Semi-natural sparsely vegetated soil slopes
Formation name	VII.C.3.N.b.	Dry slopes
Alliance name		<i>Ephedra torreyana</i> Sparsely Vegetated Alliance (A.2571), Torrey's Joint-fir Sparsely Vegetated Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.765	Colorado Plateau Mixed Bedrock Canyon and Tableland
CES304.788	Inter-Mountain Basins Semi-Desert Shrub-Steppe

NatureServe conservation status:

Global rank. GNR (21-Mar-2005).

Distribution:

Globally. This association occurs in Petrified Forest National Park in northern Arizona and Capitol Reef National Park in southeastern Utah. It is likely to occur on suitable habitat throughout the central Colorado Plateau.

Petrified Forest National Park. *Ephedra torreyana* - *Artemisia bigelovii* Sparse Vegetation was sampled from twelve relevés. It occurred throughout the park, mostly on terraces, cliffs and plateaus, near drainage channels, on rocky slopes, rock piles, and sandy surfaces. Two of the stands occurred on midslopes. This association occurred throughout the entire project area, with relevés sampled from north of the Lithodendron Wash at Pilot Rock in the northern wilderness area, to the central neck of the park, The Flattops, and near Jim Camp Wash in the southern part of the park.

Environmental summary:

Globally. This Colorado Plateau association has been described from Petrified Forest National Park in northern Arizona and Capitol Reef National Park in southeastern Utah, where it is widespread. Stands occur on plateaus, mesas, ridges, hills, cliffs, rocky colluvial slopes, benches, terraces, and near drainage channels that are gently sloping to steep (3-50%) between 1402 and 1915 m elevation. Aspect is not an important factor in determining the distribution of this association. The unvegetated surface has moderate to high cover of gravel and low to moderate cover of large rocks and litter. Cryptogams are typically absent, but one stand had 75% cover. Parent materials include sandstones and shale of the Summerville, Entrada, Curtis, Chinle, Carmel, Salt Wash Member and Emery formations. Soils are rapidly drained and variable in texture, including loams, sands, and clays, but are unified by a coating of fine to coarse gravels composed of sandstone, shale, basalt, or petrified wood.

Petrified Forest National Park. This association occurred between 1655 and 1880 m (5430-6170 ft) elevation. Slopes ranged from none to steep (0-43%, average 8%). Several of the relevés had surface rocks that consisted of sandstone, basalt, various gravel, and petrified wood.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This vegetation association is typically sparse (<10% total cover) and is characterized by an open, mixed shrub canopy that is dominated or codominated by *Ephedra torreyana* and *Artemisia bigelovii*. Locally, shrub cover may range up to about 20% cover, but in general, shrub cover is <10% with scattered grasses and forbs (<5% cover). Additionally, total cover may temporarily exceed 10% following rain events due to the blooms of annuals. Associated shrubs are diverse but characteristically include all or some of *Atriplex confertifolia*, *Chrysothamnus viscidiflorus*, *Ephedra viridis*, *Ericameria nauseosa*, *Eriogonum corymbosum*, and *Gutierrezia sarothrae*. Occasional *Juniperus osteosperma* may be present as saplings. Other shrubs species that may be present with low cover are *Artemisia tridentata*, *Atriplex canescens*, *Atriplex gardneri*, *Coleogyne ramosissima*, *Krascheninnikovia lanata*, *Opuntia polyacantha*, *Purshia stansburiana*, *Rhus trilobata*, *Shepherdia rotundifolia*, *Tetradymia glabrata*, and *Tetradymia spinosa*. The herbaceous layer is characteristically depauperate and sparse. Species recorded from plots include *Achnatherum hymenoides*, *Achnatherum speciosum*, *Aristida purpurea*, *Bouteloua gracilis*, *Bouteloua eriopoda*, *Hesperostipa comata*, *Hesperostipa neomexicana*, *Pleuraphis jamesii*, *Sporobolus airoides*, and *Vulpia octoflora*. Forbs present may include *Astragalus amphioxys*, *Chaetopappa ericoides*, *Chamaesyce fendleri*, *Cryptantha crassise-pala*, *Lepidium montanum*, *Parryella filifolia*, *Phacelia crenulata*, *Plantago patagonica*, *Senecio spartioides*, and *Tetraneuris acaulis*. The exotic annual grass *Bromus tectorum* is common in many of the sampled stands.

Petrified Forest National Park. Ten relevés were classified as *Ephedra torreyana* - *Artemisia bigelovii* Sparse Vegetation, with total vegetation cover ranging from 10 to 40% (average 20%). The vegetation cover consisted of 9-20% within the shrub stratum (average 13%) and <1 to 20% within the herbaceous stratum (average 6%). One relevé also had 2% tree cover. The species diversity ranged from 13 to 34 species (average 24 species). The vegetation in the shrub layer was most often dominated by *Artemisia bigelovii* with 1-7% cover (average 4%). *Ephedra torreyana* also occasionally dominated or codominated the shrub layer, and its cover ranged from none to moderate (0-4%, average 2%).

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Atriplex confertifolia</i> , <i>Chrysothamnus viscidiflorus</i> , <i>Ericameria nauseosa</i> , <i>Artemisia bigelovii</i> , <i>Atriplex canescens</i> , <i>Ephedra torreyana</i> , <i>Ephedra viridis</i>	<i>Artemisia bigelovii</i> , <i>Ephedra torreyana</i>
Herb (field)	<i>Eriogonum corymbosum</i> , <i>Eriogonum leptocladon</i> , <i>Gutierrezia sarothrae</i> , <i>Achnatherum hymenoides</i> , <i>Bouteloua gracilis</i> , <i>Hesperostipa comata</i> , <i>Pleuraphis jamesii</i>	N/A

Other noteworthy species:

Global species	PEFO species
<i>Bromus tectorum</i>	Data are not available.

References:

Western Ecology Working Group n.d.

C.5 Sparse

C.5.3. *Eriogonum leptophyllum* Sparse Vegetation

Base map class	Slender Buckwheat Sparse Vegetation
NatureServe common name	Slenderleaf Wild Buckwheat Sparse Vegetation
NatureServe code	CEGL004013

Summary:

This sparsely vegetated badland association occurs at Petrified Forest National Park in northern Arizona and likely occurs elsewhere in the southern Colorado Plateau. Elevations at the national park range from 1710 to 1770 m (5620-5810 ft). Stands are found on gentle to moderately steep slopes and range between 4 and 65%. This association occurs on various landforms, including lower slopes, sideslopes, midslopes, bajadas, slick rock, buttes, cliffs, and plateaus. Substrates are clays derived from shale. The ground surface has high cover of bare soil. A few stands have surface rocks with substrates including petrified wood, sandstone, and mudstone. The vegetation cover is characterized by generally sparse (<10%) total vegetation cover. The vegetation cover can range from 7 to 23% cover, and it is composed of scattered low shrubs (5-17% cover) dominated by *Eriogonum leptophyllum*. Other shrubs present with low cover may include *Atriplex confertifolia*, *Atriplex obovata*, *Ephedra torreyana*, *Eriogonum subreniforme*, *Gutierrezia sarothrae*, and *Yucca angustissima*. A sparse herbaceous cover may be present with scattered *Eriogonum divaricatum*, *Parryella filifolia*, *Pleuraphis jamesii*, and *Sporobolus airoides*. Exotic species are present on some stands, such as *Bromus tectorum* and *Sisymbrium altissimum*.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Total vegetation cover for sparse vegetation associations is often very sparse and patchy. Therefore, it is important to assess a large area when classifying this community type and to expect a large degree of variation in species coverage. In some instances, *Eriogonum leptophyllum* may act as an indicator species for this sparse badland association.

Petrified Forest National Park. *Eriogonum leptophyllum* Sparse Shrubland is classified as sparse. This means that the total vegetation cover is generally less than 15% cover. For vegetation communities that are sparse, the dominant species can change quickly due to the low cover of all species in a stand. It is often better to use an indicator species for this lifeform and use the composition consistency as the main driver to determine the association nomenclature. *Eriogonum leptophyllum* was selected as an indicator species and was often the dominant species in these stands. However, a few of them had higher cover of other species.

Vegetation hierarchy:

Physiognomic class	VII	Sparse Vegetation
Physiognomic subclass	VII.C.	Unconsolidated material sparse vegetation
Physiognomic group	VII.C.3.	Sparsely vegetated soil slopes
Physiognomic subgroup	VII.C.3.N.	Natural/Semi-natural sparsely vegetated soil slopes
Formation name	VII.C.3.N.b.	Dry slopes
Alliance name		Painted Desert Sparsely Vegetated Alliance (A.2545), Painted Desert Sparsely Vegetated Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.789	Inter-Mountain Basins Shale Badland

NatureServe conservation status:

Global rank. GNR (14-Feb-2007).

Distribution:

Globally. This association has only been described from Petrified Forest National Park in northeastern Arizona and likely occurs elsewhere in the Painted Desert of the southern Colorado Plateau. Until further inventory is completed, there is no global information.

Petrified Forest National Park. *Eriogonum leptophyllum* Sparse Shrubland was identified from six relevés within Petrified Forest National Park. The association occurred on various landforms, including lower slopes, sideslopes, midslopes, bajadas, slick rock, buttes, cliffs, and plateaus. These relevés were located in the northern wilderness area, east of Tiponi Point, east of Tawa Point, and east of Old Route 66 in the northeastern section. They were also located in the central neck area of park, east of the park road in the badlands, as well as north of the Giant Logs and west of Jim Camp Wash.

Environmental summary:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. This association occurred between the elevations of 1710 and 1770 m (5620-5810 ft). Slopes ranged from moderate to steep (4-65%, average 21%), with varying aspects. Most the stands occurred in badland areas throughout the project boundary. A few stands had surface rocks with substrates including petrified wood, sandstone, and mudstone.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Petrified Forest National Park. Until further inventory is completed, there is no global information.

Petrified Forest National Park. Six relevés were classified as *Eriogonum leptophyllum* Sparse Shrubland, with total vegetation cover ranging from 7 to 23% (average 11%) and consisting of a shrub stratum with 5-17% cover and an herbaceous stratum with 1-5% cover. The species diversity ranged between 11 and 31 species (average 23 species). The vegetation in the shrub layer was dominated by *Eriogonum leptophyllum*, with between 2 and 4% cover (average 3%). Three species codominated the shrub layer in three distinct relevés, including *Eriogonum subreniforme* with 4% cover, *Sisymbrium altissimum* with 3% cover, and *Gutierrezia sarothrae* with 3% cover.

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Data are not available.</i>	<i>Eriogonum leptophyllum</i>

Other noteworthy species:

Global species	PEFO species
<i>Bromus tectorum</i>	<i>Bromus tectorum, Sisymbrium altissimum</i>

References:

Western Ecology Working Group n.d.

C.5 Sparse

C.5.4. *Zuckia brandegeei* Sparse Vegetation

Base map class	Arizona Siltbush Sparse Vegetation
NatureServe common name	Siltbush Sparse Vegetation
NatureServe code	CEGL002493

Summary:

This sparsely vegetated association is common on plateaus at Petrified Forest National Park but occurs elsewhere on plains, alluvial fans, steep colluvial and badlands slopes, or shale hogbacks in the Colorado Plateau of northern Arizona and eastern Utah. Elevation ranges from 1341-1890 m (4397-6200 ft). The soil is a rapidly drained clay loam derived from shales such as the Salt Wash Member of the Morrison Formation or Chinle, Moenkopi and Curtis formations. The unvegetated surface typically has high cover of shale chips, sandstone rocks, basalt gravel, conglomerate, or petrified wood forming a desert pavement surface. Exposure of bare soil is low. The vegetation has a sparse canopy consisting of *Zuckia brandegeei* with scattered *Atriplex confertifolia* and *Gutierrezia microcephala*. The herbaceous layer is low in diversity and provides sparse cover. The bunch grasses *Leymus salinus* and *Pleuraphis jamesii* are present. Forbs include *Platyschukhria integrifolia* and *Xylorhiza venusta*.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. Data are not available.

Petrified Forest National Park. *Zuckia brandegeei* Sparse Vegetation was classified based on the sparse badland vegetation, as well as having a low cover of *Zuckia brandegeei*. This association did commonly contain another badland indicator species, *Atriplex obovata*; however, *Atriplex obovata* never dominates the vegetation.

During the classification fieldwork, the *Zuckia* species was identified to the subspecies level as *Zuckia brandegeei* var. *arizonica*, a species endemic to northeastern Arizona and the southern Colorado Plateau. However, since an NVCS association already existed for *Zuckia brandegeei* at the species level, we decided to include these relevés in this pre-defined association. It is interesting to note, however, that this species is unique to this area and could be defined as a unique association if classified beyond the species level.

Vegetation hierarchy:

Physiognomic class	VII	Sparse Vegetation
Physiognomic subclass	VII.C.	Unconsolidated material sparse vegetation
Physiognomic group	VII.C.3.	Sparsely vegetated soil slopes
Physiognomic subgroup	VII.C.3.N.	Natural/Semi-natural sparsely vegetated soil slopes
Formation name	VII.C.3.N.b.	Dry slopes
Alliance name	<i>Zuckia brandegeei</i> Sparse Vegetation Alliance (A.2653), Siltbush Sparse Vegetation Alliance	

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.789	Inter-Mountain Basins Shale Badland

NatureServe conservation status:

Global rank. GNR (29-Mar-2005).

Distribution:

Globally. This association is known from Arches, Capitol Reef, and Petrified Forest national parks but is also likely widespread in the Painted Desert and canyonlands regions of the Colorado Plateau in eastern Utah and northern Arizona.

Petrified Forest National Park. *Zuckia brandegeei* Sparse Vegetation was identified from 17 relevés within Petrified Forest National Park and on the Navajo Nation. This common association occurred mostly on plateaus, with one stand occurring on a bajada and another in the plains. The relevés in Petrified Forest National Park were located in the northern wilderness area northwest of Nizhoni Point, southwest of Lacey Point, in the Black Forest, north of Onyx Bridge and the Black Forest, and southwest of Chinde Mesa. This association was also identified from the northern half of the project boundary east of Lithodendron Wash and west of Lacey Point. Several of the stands were located near The Flattops, including east of The Flattops in the southern wilderness area, in The Flattops north of the main park road, southwest of The Flattops and south of the main park road, and north of Jim Camp Wash and west of The Flattops. In the southern half of the project boundary, this association is also found west of Dry Wash and the main park road, in the Crystal Forest in the southern wilderness area, west of the main park road in the Jasper Forest, south of the main road and north of Long Logs, and in the Rainbow Forest west of Giant Logs. The relevé that was sampled on the Navajo Nation land was located on the northeastern slopes of Chinde Mesa.

Environmental summary:

Globally. This sparsely vegetated association is common on plateaus at Petrified Forest National Park but occurs elsewhere on plains, alluvial fans, steep colluvial and badlands slopes, or shale hogbacks in the Colorado Plateau of northern Arizona and eastern Utah. Elevation ranges from 1341-1890 m (4397-6200 ft). The soil is a rapidly drained clay loam derived from shales. Parent materials include the Salt Wash Member of the Morrison Formation; Chinle, Moenkopi and Curtis formations; or mixed colluvium. The unvegetated surface typically has high cover of shale chips, sandstone rocks, basalt gravel, conglomerate, or petrified wood forming a desert pavement surface. Exposure of bare soil is low.

Petrified Forest National Park. This association was sampled between the elevations of 1660 and 1790 m (5430-5880 ft). Slope ranged from none to moderately high (0-19%, average 6%). Most of the stands had surface rocks that included petrified wood and desert pavement; two had conglomerate and basalt gravel surface rocks.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has a sparse canopy consisting of *Zuckia brandegeei* with scattered *Artemisia bigelovii*, *Atriplex confertifolia*, *Atriplex obovata*, *Chrysothamnus viscidiflorus*, *Coleogyne ramosissima*, *Ericameria nauseosa*, *Eriogonum corymbosum*, *Eriogonum leptocladon*, *Ephedra torreyana*, *Ephedra viridis*, *Xylorhiza glabriuscula*, *Gutierrezia microcephala*, and *Gutierrezia sarothrae*. The herbaceous layer is low in diversity and provides sparse cover. The bunch grasses *Achnatherum hymenoides*, *Leymus salinus*, and *Pleuraphis jamesii* are present. Forbs include *Arabis holboellii*, *Cryptantha* sp., *Cymopterus acaulis*, *Eriogonum inflatum*, *Galium coloradoense*, *Penstemon barbatus*, *Platyschkuhria integrifolia*, and *Xylorhiza venusta*. The exotic annual grass *Bromus tectorum* may be present in some stands.

Petrified Forest National Park. Seventeen relevés were classified as *Zuckia brandegeei* Sparse Vegetation with total vegetation cover ranging from 1 to 6% (average 2%). The vegetation cover consisted of a shrub stratum with 0.5-4% cover (average 2%) and an herbaceous stratum with 0.5-3% cover (average 1%). The species diversity ranged from 4 to 23 species (average 11 species). *Zuckia brandegeei* was commonly the dominant species; however, it could also act as an indicator species in these sparsely vegetated areas. It ranged in cover from 0 to 3% (average 1%).

Most abundant species:

Stratum	Global species	PEFO species
Short shrub/ sapling	<i>Zuckia brandegeei</i>	N/A
Herb (field)	<i>Pleuraphis jamesii</i>	<i>Zuckia brandegeei</i>

Other noteworthy species:

Global species	PEFO species
<i>Data are not available.</i>	<i>Data are not available.</i>

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Appendix D

Plant species list

The species list was compiled during the Petrified Forest National Park vegetation mapping project from data collected on classification relevés and from accuracy assessment observation sites, and observations of photointerpreters. Locations for each plant were recorded in the respective databases for these field efforts.

In some cases, the taxonomy of the species has changed since the original field work. We have kept the taxonomy used in the database, but have annotated this list to indicate where there have been updates in the International Taxonomic Information System (ITIS, <http://www.itis.gov>) as of July 2008.

This species list was compared to the currently published flora of the park (Hansen and Thomas 2006). Some species in the list were identified to subspecies or variety level, but that taxonomic level has not been identified in flora. Also, some species were not identified to the subspecies level, where they are in the flora. Some species appear to be new additions to the flora; however, they were not verified as no voucher specimen was collected.

This list can be used as one guide to querying the field databases. In most cases, the species list gives a direct reference to the plant as it occurs in both the classification and accuracy assessment databases. For example, if the identity of a potentially new species to the flora, e.g. *Yucca glauca*, was to be verified in the field and a voucher collected, the field locations of the plant can be accessed by querying either database using the scientific name or TSN code.

Two hundred seventy-six species, representing 42 families, were found during the field work. Asteraceae was represented by the most species (73), followed by Poaceae (50 species), Chenopodiaceae (19 species), and Polygonaceae (14 species). Eleven non-native species were noted.

In the following table, the fields and their contents and sources are

- Family and scientific name. The taxonomic name for the plant according to Integrated Taxonomic Information System (ITIS, <http://www.itis.gov>) at the time of the field work.
- Common name. The common name for the plant according to ITIS. In some cases the ITIS common name is not the common name used regionally or by NatureServe. Where that is the case, we have included other regional common names.
- TSN code. The ITIS Taxonomic Serial Number (TSN), accessed July 2008.
- Synonym. The taxonomic name for the plant current to July 2008, if the taxonomy for the plant has changed since the fieldwork.
- Non-native. Plants that are listed as non-native by the USDA PLANTS Database (<http://plants.usda.gov/>) are indicated.

Appendix D

Scientific Name	Common Name	Family Name	Synonym	TSN code	Nonnative
<i>Abronia elliptica</i>	fragrant white sand verbena	Nyctaginaceae		19556	native
<i>Achnatherum hymenoides</i>	Indian ricegrass	Poaceae		507943	native
<i>Achnatherum</i> sp.	needlegrass	Poaceae		21128	native
<i>Acroptilon repens</i>	hardheads	Asteraceae		36459	native
<i>Allenrolfea occidentalis</i>	iodinebush	Chenopodiaceae		20677	native
<i>Allium macropetalum</i>	largeflower onion	Liliaceae		42682	native
<i>Amaranthus albus</i>	pigweed	Amaranthaceae		20719	native
<i>Amaranthus</i> sp.	pigweed	Amaranthaceae		20715	native
<i>Ambrosia acanthicarpa</i>	annual bursage	Asteraceae		36497	native
<i>Andropogon gerardii</i>	bluejoint	Poaceae		40462	native
<i>Andropogon</i> sp.	bluestem	Poaceae		40450	native
<i>Arabis</i> sp.	rockcress	Brassicaceae		22671	unknown
<i>Arenaria eastwoodiae</i>	Eastwood's sandwort	Caryophyllaceae		20244	native
<i>Arenaria eastwoodiae</i> var. <i>adenophora</i>	Eastwood's sandwort	Caryophyllaceae		184228	native
<i>Arenaria eastwoodiae</i> var. <i>eastwoodiae</i>	Eastwood's sandwort	Caryophyllaceae		184227	native
<i>Aristida adscensionis</i>	sixweeks threeawn	Poaceae		41401	native
<i>Aristida purpurea</i>	purple three-awn	Poaceae		41429	native
<i>Aristida purpurea</i> var. <i>fendleriana</i>	fendler threeawn	Poaceae		531154	native
<i>Aristida purpurea</i> var. <i>longiseta</i>	Fendler threeawn	Poaceae		185314	native
<i>Aristida</i> sp.	threeawn	Poaceae		41400	native
<i>Artemisia biennis</i>	biennial sagewort	Asteraceae		35451	native
<i>Artemisia bigelovii</i>	Bigelow sage	Asteraceae		35452	native
<i>Artemisia dracunculus</i> ssp. <i>dracunculus</i>	wormwood	Asteraceae		183730	native
<i>Artemisia filifolia</i>	sand sagebrush	Asteraceae		35463	native
<i>Artemisia frigida</i>	fringed sagebrush	Asteraceae		35465	native
<i>Artemisia ludoviciana</i>	cudweed sagewort	Asteraceae		35474	native
<i>Artemisia tridentata</i>	big sagebrush	Asteraceae		35498	native
<i>Asteraceae</i> sp.	sunflowers	Asteraceae		35420	unknown
<i>Astragalus albulus</i>	cibola milkvetch	Fabaceae		25407	native
<i>Astragalus amphioxys</i>	crescent milkvetch	Fabaceae		25414	native
<i>Astragalus kentrophyta</i> var. <i>elatus</i>	tall spiny milkvetch	Fabaceae		526905	native

Appendix D *continued*

Scientific name	Common name	Family name	TSN code	Nonnative
<i>Astragalus mollissimus</i> var. <i>thompsoniae</i>	Thompson woolly milkvetch	Fabaceae	192649	native
<i>Astragalus</i> sp.	astragalus	Asteraceae	25392	native
<i>Atriplex argentea</i>	silverscale	Chenopodiaceae	20512	native
<i>Atriplex canescens</i>	fourwing saltbush	Chenopodiaceae	20518	native
<i>Atriplex confertifolia</i>	shadscale	Chenopodiaceae	20519	native
<i>Atriplex obovata</i>	mound saltbush	Chenopodiaceae	20552	native
<i>Atriplex powellii</i>	Powell's saltbush	Chenopodiaceae	20561	native
<i>Atriplex saccaria</i>	sack saltbush	Chenopodiaceae	20564	native
<i>Boerhavia spicata</i>	creeping spiderling	Nyctaginaceae	19678	native
<i>Bouteloua barbata</i>	sixweeks grama	Poaceae	41498	native
<i>Bouteloua curtipendula</i>	sideoats grama	Poaceae	41500	native
<i>Bouteloua eriopoda</i>	black grama	Poaceae	41501	native
<i>Bouteloua gracilis</i>	blue grama	Poaceae	41493	native
<i>Bouteloua hirsuta</i>	hairy grama	Poaceae	41502	native
<i>Bouteloua simplex</i>	hairy grama	Poaceae	41507	native
Brassicaceae	mustards	Brassicaceae	22669	unknown
<i>Brickellia oblongifolia</i> var. <i>linifolia</i>	Narrowleaf brickellbush	Asteraceae	526986	native
<i>Bromus japonicus</i>	Japanese brome	Poaceae	40479	native
<i>Bromus rubens</i>	foxtail brome	Poaceae	40518	non-native
<i>Bromus</i> sp.	brome	Poaceae	40478	unknown
<i>Bromus tectorum</i>	cheat grass	Poaceae	40524	non-native
Cactaceae	cactus	Cactaceae	19685	unknown
<i>Caesalpinia jamesii</i>	james rushpea	Fabaceae	26505	native
<i>Calamovilfa gigantea</i>	Giant sandreed, big sandreed	Poaceae	41538	native
<i>Calochortus aureus</i>	golden mariposa lily	Liliaceae	42836	native
<i>Calochortus</i> sp.	mariposa lily	Liliaceae	42823	unknown
<i>Castilleja integra</i>	squawfeather, wholeleaf Indian paintbrush	Scrophulariaceae	33131	native
<i>Castilleja linariifolia</i>	Wyoming Indian paintbrush	Scrophulariaceae	33138	native
<i>Castilleja</i> sp.	Indian paintbrush	Scrophulariaceae	33049	unknown
<i>Chaenactis stevioides</i>	Steve's dusty maiden	Asteraceae	36998	native
<i>Chaetopappa ericoides</i>	rose heath	Asteraceae	501376	native

Appendix D continued

Scientific name	Common name	Family name	TSN code	Nonnative
<i>Chaetopappa</i> sp.	least daisy	Asteraceae	37004	unknown
<i>Chamaesyce albomarginata</i>	rattlesnake weed	Euphorbiaceae	501400	native
<i>Chamaesyce fendleri</i>	Fendler's sandmat	Euphorbiaceae	501419	native
<i>Chamaesyce parryi</i>	Parry's sandmat	Euphorbiaceae	501448	native
<i>Chamaesyce revoluta</i>	threadstem spurge	Euphorbiaceae	501456	native
<i>Chenopodium berlandieri</i>	netseed lambsquarters	Chenopodiaceae	20594	native
<i>Chenopodium fremontii</i>	Fremont goosefoot	Chenopodiaceae	20607	native
<i>Chenopodium leptophyllum</i>	narrowleaf goosefoot	Chenopodiaceae	20616	native
<i>Chrysothamnus depressus</i>	dwarf rabbitbrush	Asteraceae	37051	native
<i>Chrysothamnus greenei</i>	Greene rabbitbrush	Asteraceae	37052	native
<i>Cirsium</i> sp.	thistle	Asteraceae	36334	unknown
<i>Comandra umbellata</i> ssp. <i>pallida</i>	bastard toadflax	Santalaceae	523879	native
<i>Conyza canadensis</i>	Canada horseweed	Asteraceae	37113	native
<i>Cordylanthus wrightii</i>	Wright's bird's-beak	Scrophulariaceae	33577	native
<i>Corispermum nitidum</i>	shiny bugseed	Chenopodiaceae	565088	native
<i>Croton texensis</i>	croton	Euphorbiaceae	28291	native
<i>Cryptantha crassisepala</i>	deertongue	Boraginaceae	31800	native
<i>Cryptantha fulvocanescens</i> var. <i>fulvocanescens</i>	tawny cryptantha	Boraginaceae	527561	native
<i>Cryptantha micrantha</i>	purpleroot pick-me-not	Boraginaceae	31836	native
<i>Cryptantha</i> sp.	cryptantha	Boraginaceae	31765	unknown
<i>Cymopterus</i> sp.	cymopterus	Apiaceae	29625	unknown
<i>Cystopteris fragilis</i>	brittle bladder fern	Dryopteridaceae	17482	native
<i>Dalea candida</i> var. <i>oligophylla</i>	white dalea	Fabaceae	192889	native
<i>Dalea lanata</i> var. <i>terminalis</i>	wooley praire clover	Fabaceae	192900	native
<i>Dasyochloa pulchella</i>	fluffgrass	Poaceae	512087	native
<i>Datura wrightii</i>	sacred datura	Solanaceae	30521	native
<i>Descurainia pinnata</i>	green tansymustard	Brassicaceae	22826	native
<i>Dimorphocarpa wislizeni</i>	spectacle pod	Brassicaceae	502067	native
<i>Distichlis spicata</i>	desert saltgrass	Poaceae	40662	native
<i>Echinocereus coccineus</i> var. <i>coccineus</i>	Bisbee cactus	Cactaceae	527813	native
<i>Echinocereus</i> sp.	hedgehog cactus	Cactaceae	19803	unknown
<i>Elaeagnus angustifolia</i>	oleaster	Elaeagnaceae	27770	non-native

Appendix D *continued*

Scientific name	Common name	Family name	TSN code	Nonnative	
<i>Elymus elymoides</i>	bottlebrush squirreltail	Poaceae	502264	native	
<i>Elymus elymoides</i> ssp. <i>elymoides</i>	bottlebrush squirreltail	Poaceae	525113	native	
<i>Ephedra nevadensis</i>	Nevada <i>Ephedra</i>	<i>Ephedraceae</i>	502316	native	
<i>Ephedra</i> sp.	<i>Ephedra</i>	<i>Ephedraceae</i>	183496	unknown	
<i>Ephedra torreyana</i>	Torrey <i>Ephedra</i>	<i>Ephedraceae</i>	502318	native	
<i>Ephedra viridis</i>	green <i>Ephedra</i>	<i>Ephedraceae</i>	502319	native	
<i>Eragrostis</i> sp.	lonegrass	Poaceae	40716	native	
<i>Eragrostis spectabilis</i>	purple lovegrass	Poaceae	40717	native	
<i>Ericameria nauseosa</i>	goldenbush	Asteraceae	507594	native	
<i>Ericameria nauseosa</i> ssp. <i>nauseosa</i> var. <i>nauseosa</i>	rubber rabbitbush	Asteraceae	<i>Ericameria nauseosa</i> var. <i>nauseosa</i>	531871	native
<i>Ericameria pulchella</i>	southwest rabbitbrush	Asteraceae	<i>Chrysothamnus pluchellus</i>	37084	native
<i>Erigeron compactus</i>	cushion daisy	Asteraceae	35842	native	
<i>Erigeron concinnus</i>	Navajo feabane	Asteraceae	502385	native	
<i>Erigeron divergens</i>	spreading daisy	Asteraceae	35852	native	
<i>Erigeron</i> sp.	feabane	Asteraceae	35803	unknown	
<i>Eriogonum alatum</i>	wind wildbuckwheat	Polygonaceae	21057	native	
<i>Eriogonum corymbosum</i>	corymbed buckwheat	Polygonaceae	21103	native	
<i>Eriogonum corymbosum</i> var. <i>aureum</i>	crispleaf buckwheat	Polygonaceae	195444	native	
<i>Eriogonum corymbosum</i> var. <i>glutinosum</i>	crispleaf buckwheat	Polygonaceae	535113	native	
<i>Eriogonum deflexum</i>	Flatcrown buckwheat	Polygonaceae	21111	native	
<i>Eriogonum divaricatum</i>	divergent buckwheat	Polygonaceae	21117	native	
<i>Eriogonum ericifolium</i>	Yavapai buckwheat	Polygonaceae	21128	native	
<i>Eriogonum ericifolium</i> var. <i>pulchrum</i>	Mexican panicgrass	Poaceae	40939	native	
<i>Eriogonum ericifolium</i> var. <i>pulchrum</i>	Yavapai buckwheat	Polygonaceae	195461	native	
<i>Eriogonum jamesii</i> var. <i>jamesii</i>	James buckwheat	Polygonaceae	195499	native	
<i>Eriogonum leptocladon</i>	fine branched buckwheat	Polygonaceae	21179	native	
<i>Eriogonum leptocladon</i> var. <i>ramosissimum</i>	sand buckwheat	Polygonaceae	528007	native	
<i>Eriogonum leptophyllum</i>	slender-leaf buckwheat	Polygonaceae	21180	native	
<i>Eriogonum microthecum</i>	slender buckwheat	Polygonaceae	21192	native	
<i>Eriogonum</i> sp.	buckwheat	Polygonaceae	21054	native	

Appendix D continued

Scientific name	Common name	Family name	TSN code	Nonnative
<i>Eriogonum subreniforme</i>	kidneyshape buckwheat	Polygonaceae	21251	native
<i>Erodium cicutarium</i>	alfilaree	Geraniaceae	29147	non-native
<i>Evolvulus nuttallianus</i>	shaggy dwarf morningglory	Convolvulaceae	502573	native
<i>Forestiera pubescens</i> var. <i>pubescens</i>	New Mexico forestiera	Oleaceae	528175	native
<i>Gaillardia pinnatifida</i>	blanketflower	Asteraceae	37409	native
<i>Gilia multiflora</i>	many-flower gilia	Polemoniaceae	<i>Ipomopsis multi- flora</i>	503187 native
<i>Gilia</i> sp.	gilia	Polemoniaceae	31075	unknown
<i>Gutierrezia microcephala</i>	threadleaf snakeweed	Asteraceae	37482	native
<i>Gutierrezia sarothrae</i>	broom snakeweed	Asteraceae	37483	native
<i>Helianthus annuus</i>	annual sunflower	Asteraceae	36616	native
<i>Heliomeris multiflora</i> var. <i>multiflora</i>	showy goldeneye	Asteraceae	528364	native
<i>Hesperostipa comata</i> ssp. <i>comata</i>	needle and thread	Poaceae	525116	native
<i>Hesperostipa neomexicana</i>	New Mexico feathergrass	Poaceae	507976	native
<i>Hesperostipa</i> sp.	needle and thread	Poaceae	500937	unknown
<i>Heterotheca</i> sp.	false goldenaster	Asteraceae	37652	unknown
<i>Heterotheca villosa</i>	hairy false goldaster	Asteraceae	37689	native
<i>Hordeum jubatum</i>	foxtail barley	Poaceae	40871	non-native
<i>Hordeum pusillum</i>	little barley	Poaceae	40866	native
<i>Hordeum</i> sp.	hordeum	Poaceae	<i>Agrohordeum</i>	41366 unknown
<i>Hymenopappus filifolius</i> var. <i>lugens</i>	Idaho hymenopappus	Asteraceae	528521	native
<i>Hymenopappus filifolius</i> var. <i>pauciflorus</i>	fineleaf hymenopappus	Asteraceae	528527	native
<i>Hymenopappus flavescens</i> var. <i>canotomentosus</i>	college flower	Asteraceae	528530	native
<i>Hymenopappus</i> sp.	hymenopappus	Asteraceae	37763	unknown
<i>Hymenoxys richardsonii</i>	Colorado rubberweed	Asteraceae	37785	native
<i>Hymenoxys richardsonii</i> var. <i>floribunda</i>	Colorado rubberweed	Asteraceae	528536	native
<i>Hymenoxys</i> sp.	rubberweed	Asteraceae	37778	unknown
<i>Ipomopsis longiflora</i>	flaxflowered gilia	Polemoniaceae	31198	native
<i>Ipomopsis longiflora</i> ssp. <i>longiflora</i>	flaxflowered gilia	Polemoniaceae	524182	native
<i>Ipomopsis multiflora</i>	many-flower gilia	Polemoniaceae	503187	native
<i>Ipomopsis polycladon</i>	manybranched gilia	Polemoniaceae	31216	native
<i>Ipomopsis pumila</i>	dwarf gilia	Polemoniaceae	31217	native

Appendix D *continued*

Scientific name	Common name	Family name	TSN code	Nonnative	
<i>Ipomopsis</i> sp.	gilia	Polemoniaceae	31191	unknown	
<i>Isocoma acradenia</i>	alkali goldenbush,alkali jimmyweed	Asteraceae	503207	native	
<i>Isocoma drummondii</i>	drummond goldenweed	Asteraceae	37803	native	
<i>Isocoma</i> sp.	sunflower	Asteraceae	<i>Anisocoma</i>	36530	unknown
<i>Iva acerosa</i>	copperweed	Asteraceae	36026	native	
<i>Juniperus monosperma</i>	oneseed juniper	Cupressaceae	194853	native	
<i>Kochia americana</i>	green molly	Chenopodiaceae	20694	native	
<i>Krascheninnikovia lanata</i>	winterfat	Chenopodiaceae	503290	native	
<i>Lappula occidentalis</i>	flat-spine sheepbur	Boraginaceae	503329	native	
<i>Lappula occidentalis</i> var. <i>cupulata</i>	flat-spine sheepburr	Boraginaceae	528677	native	
<i>Lepidium montanum</i>	Montana pepperweed	Brassicaceae	503381	native	
<i>Lesquerella fendleri</i>	Fendler bladderpod	Brassicaceae	23180	native	
<i>Linum aristatum</i>	bristle flax	Linaceae	29231	native	
<i>Lycium pallidum</i>	pale desert-thorn	Solanaceae	30544	native	
<i>Lygodesmia</i> sp.	skeleton plant	Asteraceae	500397	unknown	
<i>Machaeranthera bigelovii</i>	Bigelow's machaeranthera	Asteraceae	37980	native	
<i>Machaeranthera canescens</i>	hoary aster	Asteraceae	37984	native	
<i>Machaeranthera canescens</i> ssp. <i>glabra</i> var. <i>glabra</i>	hoary tansyaster	Asteraceae	<i>Machaeranthera canescens</i> var. <i>glabra</i>	566721	native
<i>Machaeranthera canescens</i> ssp. <i>canescens</i> var. <i>canescens</i>	hoary tansyaster	Asteraceae	<i>Machaeranthera canescens</i> var. <i>canescens</i>	531699	native
<i>Machaeranthera gracilis</i>	slender goldentweed	Asteraceae	37991	native	
<i>Machaeranthera grindelioides</i> var. <i>grindelioides</i>	rayless aster	Asteraceae	529072	native	
<i>Machaeranthera pinnatifida</i>	cutleaf goldenweed	Asteraceae	38005	native	
<i>Machaeranthera tanacetifolia</i>	tanseyleaf goldenweed	Asteraceae	38103	native	
<i>Malacothrix</i> sp.	desert dandelion	Asteraceae	38043	unknown	
<i>Mentzelia albicaulis</i>	white blazingstar	Loasaceae	503757	native	
<i>Mentzelia multiflora</i>	Adonis blazingstar	Loasaceae	503788	native	
<i>Mentzelia pumila</i>	dwarf blazingstar	Loasaceae	503800	native	
<i>Mentzelia pumila</i> var. <i>pumila</i>	dwarf mentzelia	Loasaceae	529155	native	
<i>Mirabilis linearis</i>	linearleaf four-o'clock	Nyctaginaceae	19651	native	

Appendix D continued

Scientific name	Common name	Family name	TSN code	Nonnative
<i>Mirabilis multiflora</i>	Colorado four o'clock	Nyctaginaceae	19654	native
<i>Monroa squarrosa</i>	false buffalo grass	Poaceae	41882	native
<i>Monroa squarrosa</i>	false buffalo grass	Poaceae	41882	native
<i>Muhlenbergia porteri</i>	bush muhly	Nyctaginaceae	41933	native
<i>Muhlenbergia pungens</i>	sandhill muhly	Poaceae	41934	native
<i>Muhlenbergia</i> sp.	muhly	Poaceae	41883	native
<i>Muhlenbergia torreyi</i>	ring muhly	Poaceae	503886	native
<i>Oenothera albicaulis</i>	halfshrub sundrop	Onagraceae	27373	native
<i>Oenothera caespitosa</i>	tufted eveningprimrose	Onagraceae	27382	native
<i>Oenothera caespitosa</i> ssp. <i>caespitosa</i>	tufted evening-primrose	Onagraceae	566058	native
<i>Oenothera flava</i>	long-tube evening primrose	Onagraceae	27397	native
<i>Oenothera pallida</i>	pale evening primrose	Onagraceae	27436	native
<i>Oenothera pallida</i> ssp. <i>runcinata</i>	pale eveningprimrose	Onagraceae	27439	native
<i>Oenothera</i> sp.	evening primrose	Onagraceae	27367	native
<i>Opuntia erinacea</i>	grizzlybear pricklypear	Cactaceae	19705	native
<i>Opuntia polyacantha</i>	plains pricklypear	Cactaceae	19726	native
<i>Opuntia polyacantha</i> var. <i>polyacantha</i>	hair-spine prickly-pear	Cactaceae	195296	native
<i>Opuntia polyacantha</i> var. <i>rufispina</i>	hairspine pricklypear	Cactaceae	195298	native
<i>Opuntia</i> sp.	Cactus	Cactaceae	19686	native
<i>Opuntia whipplei</i>	Whipple cholla	Cactaceae	19745	native
<i>Orobanche</i> sp.	broomrape	Orobanchaceae	34277	unknown
<i>Panicum capillare</i>	annual witchgrass	Poaceae	40914	native
<i>Panicum hirticaule</i>	Mexican panicgrass	Poaceae	40939	native
<i>Parryella filifolia</i>	common dunebroom	Fabaceae	26831	native
<i>Pascopyrum smithii</i>	pubescent wheatgrass	Poaceae	504124	native
<i>Pectis angustifolia</i>	lemonscent	Asteraceae	38176	native
<i>Petradoria pumila</i>	rock goldenrod	Asteraceae	38233	native
<i>Phacelia crenulata</i>	caterpillarweed	Hydrophyllaceae	31478	native
<i>Phacelia crenulata</i> var. <i>corrugata</i>	cleftleaf scorpion-weed	Hydrophyllaceae	529549	native
<i>Phacelia integrifolia</i>	gypsum phacelia	Hydrophyllaceae	504272	native
<i>Phacelia</i> sp.	phacelia	Hydrophyllaceae	31433	unknown
<i>Phoradendron juniperinum</i>	juniper mistletoe	Viscaceae	27866	native

Appendix D *continued*

Scientific name	Common name	Family name	TSN code	Nonnative
<i>Physaria newberryi</i>	Newberry's twinpod	Brassicaceae	23281	native
<i>Pinus edulis</i>	Colorado pinyon	Pinaceae	183336	native
<i>Plantago argyraea</i>	salt-meadow plantain	Plantaginaceae	32898	native
<i>Plantago patagonica</i>	woolly Indianwheat	Plantaginaceae	32907	native
<i>Pleuraphis jamesii</i>	galleta	Poaceae	507993	native
<i>Polypogon monspeliensis</i>	annual rabbitsfoot	Poaceae	41171	non-native
<i>Populus fremontii</i>	cottonwood	Salicaceae	22459	native
<i>Portulaca oleracea</i>	akulikuli-kula, purslane	Portulacaceae	20422	native
<i>Pseudocymopterus</i> sp.	false spring parseley	Apiaceae	29835	unknown
<i>Psilostrophe sparsiflora</i>	greenstem paperflower	Asteraceae	38315	native
<i>Psoralidium lanceolatum</i>	dune scurfpea	Fabaceae	504645	native
<i>Purshia stansburiana</i>	Stansbury cliffrose	Rosaceae	195901	native
<i>Rhus trilobata</i>	Skunkbush	Anacardiaceae	28791	native
<i>Salix exigua</i>	coyote willow	Salicaceae	22529	native
<i>Salsola kali</i> ssp. <i>tragus</i>	prickly Russian thistle	Chenopodiaceae	<i>Salsola tragus</i> 525004	non-native
<i>Salsola tragus</i>	prickly Russian thistle	Chenopodiaceae	520950	non-native
<i>Salvia pachyphylla</i>	blue sage	Lamiaceae	32730	native
<i>Sanvitalia aberti</i>	albert creeping zinnia	Asteraceae	38356	native
<i>Sarcobatus vermiculatus</i>	black greasewood	Chenopodiaceae	20707	native
<i>Senecio flaccidus</i> var. <i>flaccidus</i>	threadleaf groundsel	Asteraceae	530313	native
<i>Senecio</i> sp.	groundsel	Asteraceae	36084	unknown
<i>Senecio spartioides</i>	groundsel	Asteraceae	36184	native
<i>Senecio spartioides</i> var. <i>multicapitatus</i>	broomlike ragwort	Asteraceae	531525	native
<i>Senecio spartioides</i> var. <i>spartioides</i>	broomlike ragwort	Asteraceae	531235	native
<i>Sisymbrium altissimum</i>	Jim Hill mustard	Brassicaceae	23312	non-native
<i>Solanum elaeagnifolium</i>	silverleaf nightshade	Solanaceae	30429	native
<i>Solanum jamesii</i>	wild potato	Solanaceae	30437	native
<i>Sonchus asper</i>	perennial sowthistle	Asteraceae	38424	non-native
<i>Sphaeralcea ambigua</i>	desert globemallow	Malvaceae	21910	native
<i>Sphaeralcea coccinea</i>	copper mallow	Malvaceae	21920	native
<i>Sphaeralcea hastulata</i>	spear globemallow	Malvaceae	21942	native

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Scientific name	Common name	Family name	TSN code	Nonnative
<i>Sphaeralcea incana</i>	gray globemallow	Malvaceae	21943	native
<i>Sphaeralcea incana</i> ssp. <i>incana</i>	gray globemallow	Malvaceae	21944	native
<i>Sphaeralcea parvifolia</i>	smallflower globemallow	Malvaceae	21953	native
<i>Sphaeralcea</i> sp.	globemallow	Malvaceae	21909	native
<i>Sporobolus airoides</i>	alkali sacaton	Poaceae	42128	native
<i>Sporobolus contractus</i>	spike dropseed	Poaceae	42131	native
<i>Sporobolus coromandelianus</i>	Madagascar dropseed	Poaceae	507183	native
<i>Sporobolus cryptandrus</i>	sand dropseed	Poaceae	42132	native
<i>Sporobolus flexuosus</i>	mesa dropseed	Poaceae	42137	native
<i>Sporobolus giganteus</i>	giant dropseed	Poaceae	42138	native
<i>Stanleya pinnata</i>	desert prince'splume	Brassicaceae	23329	native
<i>Stephanomeria exigua</i>	wire lettuce	Asteraceae	38445	native
<i>Suaeda moquinii</i>	alkali seepweed	Chenopodiaceae	505404	native
<i>Tamarix chinensis</i>	China tamarisk	Tamaricaceae	22308	non-native
<i>Tetranuris ivesiana</i>	Ivers' four-nerve-daisy	Asteraceae	38512	native
<i>Thelesperma megapotamicum</i>	green threads	Asteraceae	38525	native
<i>Townsendia annua</i>	annual townsendia daisy	Asteraceae	38538	native
<i>Townsendia</i> sp.	Townsend daisy	Asteraceae	38535	unknown
<i>Typha domingensis</i>	southern cattail	Typhaceae	42327	native
<i>Vulpia octoflora</i>	eight-flower six-weeks grass	Poaceae	42264	native
<i>Vulpia octoflora</i> var. <i>hirtella</i>	sixweeks fescue	Poaceae	530862	native
<i>Wyethia scabra</i>	badland mulesears	Asteraceae	38687	native
<i>Xanthium strumarium</i>	cocklebur	Asteraceae	38692	native
<i>Xanthium strumarium</i> var. <i>canadense</i>	Canada cocklebur	Asteraceae	530872	native
<i>Yucca angustissima</i>	narrowleaf yucca	Agavaceae	43131	native
<i>Yucca baccata</i>	banana yucca	Agavaceae	43134	native
<i>Yucca glauca</i>	beargrass	Agavaceae	43142	native
<i>Yucca</i> sp.	yucca	Agavaceae	43116	native
<i>Zinnia grandiflora</i>	plains zinnia	Asteraceae	38715	native
<i>Zuckia brandegeei</i>	siltbush	Chenopodiaceae	505810	native
<i>Zuckia brandegeei</i> var. <i>arizonica</i>	Arizona siltbush	Chenopodiaceae	530924	native

Appendix E

Plant community and map class key

The plant community and map class key, developed to identify plant communities (NVC associations, alliances and park specials) and map classes (base, group, management, and macrogroup) was used in the field during accuracy assessment of the Petrified Forest National Park vegetation mapping project. It can be used at Petrified Forest NP in areas of at least 0.5 ha in size (e.g. a circle within a 40-m radius). Most base map classes key to one plant community, but some are aggregations of more than one plant community and may appear in several places in the dichotomous key.

Because the group, management, and macrogroup map classes are aggregations of base map classes, they also appear multiple times in the key. The group class may represent aggregations of the base map classes to the group level of the National Vegetation Classification Standard (NVCS), version 2 (2008). Terrestrial ecological systems, as described by NatureServe, were used as a first approximation of the group level. The macrogroup map classes represent aggregations of base map classes to the macrogroup level of the NVCS Version 2, as approximated by the project team. The management map classes were developed in consultation with park staff, with the intent of preserving high map accuracy while maintaining base map classes that are of importance to park managers.

The key begins with a lifeform key that separates the observed vegetation or land cover into one of four lifeform types, each with a subkey. The subkeys consist of decision couplets that describe the vegetation characteristics and typical geomorphic setting. Communities containing the same species may be separated into different associations, or even lifeforms, due to differences in cover and/or habitat. Because of this, both parts of the couplet should be considered before proceeding through the key. As is the case with a botanical key, often it is important to follow the key a few couplets beyond the point where you believe you may have correctly identified a map label or association because you may find a better fit in subsequent steps, or you may gain increased confidence that your initial choice was correct.

At Petrified Forest National Park, fluctuations in precipitation between drought and wet years affects the cover of vegetation. Herbaceous perennial plants may be driven into dormancy and show lower cover than expected. during droughts. Alternatively, a flush of annual forb growth may follow a wet period. This fluctuations in cover needs to be considered when using a key developed for average conditions.

Some map labels are based on landforms, such as “Barren Badlands”, where existing vegetation is very sparse. However, it is important to remember that the vegetation at Petrified Forest National Park can be very sparse (<10% total vegetation cover) for many of the associations in each of the four lifeform categories. If you use the key below and find yourself in the sparse vegetation lifeform category you should continue to use the key to determine if the vegetation is better characterized by a vegetated lifeform type rather than the sparse vegetation lifeform. Each of the subkeys has plant communities that are sparse (<10% generally and sometimes <15% cover) and may better characterize the site than the sparse landform based map class.

Lifeform Key

- 1a. Site is either barren (non-vegetated), sparsely vegetated ($\leq 2\%$ vegetation), or characterized by a geomorphic feature or an anthropogenic land use with up to 10% vegetation cover. The site may be characterized by a barren geomorphic feature, i.e. sand or barren wash, or a sparsely vegetated to vegetated anthropogenic land use, i.e. park facilities and railroad. SPARSE VEGETATION AND BARREN (Key A, go to 4a)
 - 1b. Site with $>2\%$ vegetation or not characterized by a geomorphic feature or an anthropogenic land use with up to 10% vegetation. (2a)
 - 2a. Site characterized by tree and/or shrub cover. If tree or shrub cover is $>15\%$ cover, grasses and forbs may have higher cover than trees or shrubs. If tree or shrub cover is $<15\%$, grasses and forbs generally have less cover than either trees or shrubs. (3a)
 - 2b. Site characterized by grasses and forbs. Trees or shrubs may be present, but with $<15\%$ cover and with less cover than grasses and forbs. HERBACEOUS VEGETATION (Key B, go to 9a)
 - 3a. Site characterized by trees, including evergreen and deciduous species. Includes stands with sparse tree cover ($<10\%$ cover) when trees dominate the site. WOODLANDS (Key C, go to 29a)
 - 3b. Site characterized by shrubs. SHRUBLANDS (Key D, go to 31a)
-

Key A: Sparse Vegetation and Barren

Cover of vascular plants is low to none, often with $<2\%$ total vegetation cover. In some cases, the total vegetation cover may be as high as 10% cover in areas characterized by a geomorphic feature or an anthropogenic land use; however, in these cases a geomorphic feature or anthropogenic land use is the dominant feature.

- 4a. Site characterized by a geomorphic feature. (5a)
 - 4b. Site characterized by anthropogenic land use. (7a)
 - 5a. Site characterized by barren clay badlands.
 - Base map class: Barren Badlands
 - Group map class: Inter-Mountain Basins Shale Badland
 - Management map class: Badland Sparse Vegetation
 - Association: NA
 - 5b. Site not characterized by the feature listed above. (6a)
 - 6a. Site is either permanently flooded or is subject to intermediate flooding, limiting vegetation establishment. This map class occurs in barren wash bottoms throughout the mapping area
 - Base map class: Barren Wash
 - Group map class: Inter-Mountain Basins Wash
 - Management map class: Barren Wash
 - Association: NA
 - 6b. Site characterized by unvegetated sand. If annual species are present in high cover (dead or alive), use the herbaceous key (Key B, 9a).
 - Base map class: Sand
 - Group map class: Inter-Mountain Basins Shale Badland
 - Management map class: Sand / Mudflat
 - Association: NA
 - 7a. Site characterized by one of the following land uses:
 - a. Park Facilities – This map class consists of Petrified Forest National Park infrastructure, including National Park Service buildings, park housing, sewage ponds, and visitor-use buildings.
 - Base map class: Park Facilities
 - Group map class: Park Facilities
-

- Management map class: Park Facilities
 - Association: NA
 - b. Park Sites – This map class consists of the tourist sites in Petrified Forest National Park, including the Puerco River pueblo and the overlooks.
 - Base map class: Park Sites
 - Group map class: Park Facilities
 - Management map class: Park Sites
 - Association: NA
 - c. Railroad – This map class consists of the railroad that bisects the park and travels east/west through the project boundary.
 - Base map class: Railroad
 - Group map class: Transportation
 - Management map class: Railroad
 - Association: NA
 - d. Roads – This map class consists of paved and non-paved roads.
 - Base map class: Roads
 - Group map class: Transportation
 - Management map class: Roads
 - Association: NA
 - e. Run-off Control Feature – This map class contains human features that were developed to divert water flow to particular areas.
 - Base map class: Run-off Control Feature
 - Group map class: Agriculture
 - Management map class: Run-off Control Feature
 - Association: NA
 - f. Stock Ponds – This map class contains water tanks and stock ponds used for cattle and other agricultural purposes.
 - Base map class: Stock Ponds
 - Group map class: Agriculture
 - Management map class: Stock Ponds
 - Association: NA
- 7b. Site not characterized as above. If vegetated, but with low cover (<10% cover), return to the Lifeform Key and select the lifeform that represents the vegetation that is present.

Key B: Herbaceous Vegetation

Grasses and forbs are the dominant lifeform. Total vegetation cover is generally >10% cover; in particularly dry sites vegetation cover can be as low as 2%. Tree and shrub total cover must be <15% cover. In sites that have low total vegetation cover, the tree cover must be less than the total herbaceous cover. If not, continue to Key C: Woodlands.

- 9a. A mix of herbaceous species occurring on a mesa rim or on/near a wash. First, go to 10a and try to select the appropriate map class. If none of the map classes work, go to (28a).
- 9b. Herbaceous species not as above. (10a)
- 10a. Shrub or tree cover is less than half of the total herbaceous cover. (11a)
- 10b. Shrub or tree cover is greater than half of the total herbaceous cover, less than the total herbaceous cover, and <15% cover. (25a)

If these requirements do not fit, continue to either Key C: Woodlands or Key D: Shrublands.

- 11a. *Bouteloua gracilis* is the dominant or co-dominant grass. (12a)
- 11b. *Bouteloua gracilis* is not the dominant or co-dominant grass. (14a)

- 12a. *Bouteloua gracilis* is the only dominant species; no other perennial herbaceous species codominates. Other herbaceous species, including annual species, may cover over half of the herbaceous cover. This map class tends to occur in various substrates and ranges from moderate to low total vegetation cover.
- Base map class: Blue Grama Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Semi-Desert Grassland
 - Management Map Class: Blue Grama Steppe and Mixed Grasslands
 - Association: *Bouteloua gracilis* Herbaceous Vegetation
- 12b. *Bouteloua gracilis* is not the only dominant species. Other grass species codominate the herbaceous cover. (13a)
- 13a. Herbaceous cover is co-dominated by *Pleuraphis jamesii*. This map class commonly occurs on sandy soils and may have a low cover of native shrubs.
- Base map class: Blue Grama - Galleta Herbaceous Vegetation
 - Groupmap class: Inter-Mountain Basins Semi-Desert Grassland
 - Management map class: Blue Grama Steppe and Mixed Grasslands
 - Association: *Bouteloua gracilis* - *Pleuraphis jamesii* Herbaceous Vegetation
- 13b. *Sporobolus airoides* is the co-dominant species. This map class commonly occurs on sandy soils and may have a low cover of native shrubs.
- Base Map Class: Alkali Sacaton - Blue Grama Herbaceous Vegetation
 - Group Map Class: Inter-Mountain Basins Semi-Desert Grassland
 - Management Map Class: Alkali Sacaton Steppe and Mixed Grasslands
 - Association: *Sporobolus airoides* - *Bouteloua gracilis* Herbaceous Vegetation
- 14a. *Sporobolus airoides* is the dominant or co-dominant species. (15a)
- 14b. *Sporobolus airoides* is not the dominant or co-dominant species. (17a)
- 15a. *Sporobolus airoides* is the only dominant species. Other herbaceous and shrub species may occur, but never with significant cover. This map class tends to occur on various substrates and ranges from fairly dense patches to low total vegetation cover.
- Base map class: Alkali Sacaton Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Semi-Desert Grassland
 - Management map class: Alkali Sacaton Steppe and Mixed Grasslands
 - Association: *Sporobolus airoides* Southern Plains Herbaceous Vegetation
- 15b. *Sporobolus airoides* is not the only dominant species. Other grass species codominate the herbaceous cover. (16a)
- 16a. *Pleuraphis jamesii* is co-dominant with *Sporobolus airoides*. Commonly occurs on sandy soils and may have a low cover of native shrubs.
- Base map class: Galleta - Alkali Sacaton Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Semi-Desert Grassland
 - Management map class: Alkali Sacaton Steppe and Mixed Grasslands
 - Association: *Pleuraphis jamesii* - *Sporobolus airoides* Herbaceous Vegetation
- 16b. *Bouteloua gracilis* is co-dominant with *Sporobolus airoides*. Commonly occurs on a variety of substrates and may have a low cover of native shrubs.
- Base map class: Alkali Sacaton - Blue Grama Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Semi-Desert Grassland
 - Management map class: Alkali Sacaton Steppe and Mixed Grasslands
 - Association: *Sporobolus airoides* - *Bouteloua gracilis* Herbaceous Vegetation
- 17a. *Pleuraphis jamesii* is the dominant or co-dominant species. (18a)
- 17b. *Pleuraphis jamesii* is not the dominant or co-dominant species. (20a)
- 18a. *Bouteloua eriopoda* is the next most abundant grass after *Pleuraphis jamesii*, and in some areas is the two species codominate. A low cover of native shrubs may also occur.
- Base map class: Black Grama - Galleta Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Semi-Desert Grassland
 - Management map class: Alkali Sacaton Steppe and Mixed Grasslands

- Association: *Bouteloua eriopoda* - *Pleuraphis jamesii* Herbaceous Vegetation
- 18b. Herbaceous species cover not as above. (19a)
- 19a. *Sporobolus airoides* is the next most abundant grass after *Pleuraphis jamesii* and in some areas is the two species codominate. Commonly occurs on sandy soils and may have a low cover of native shrubs.
- Base map class: Galleta - Alkali Sacaton Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Semi-Desert Grassland
 - Management map class: Alkali Sacaton Steppe and Mixed Grasslands
 - Association: *Pleuraphis jamesii* - *Sporobolus airoides* Herbaceous Vegetation
- 19b. *Bouteloua gracilis* is the next most abundant grass after *Pleuraphis jamesii* and in some areas the two species codominate. Commonly occurs on sandy soils and may have a low cover of native shrubs.
- Base map class: Alkali Sacaton - Blue Grama Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Semi-Desert Grassland
 - Management map class: Alkali Sacaton Steppe and Mixed Grasslands
 - Association: *Sporobolus airoides* - *Bouteloua gracilis* Herbaceous Vegetation
- 20a. *Bouteloua eriopoda* is the dominant herbaceous species, and *Pleuraphis jamesii* commonly occurs as a significant component of the herbaceous cover. This map class typically has a low cover of shrubs as well.
- 20b. Dominant herbaceous vegetation not as above. (21a)
- 21a. *Calamovilfa gigantea* is the dominant herbaceous species. This tall grass commonly occurs in long linear stretches along washes and in areas with periodic water flow.
- Base map class: Giant Sandreed Desert Wash Shrub Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Wash
 - Management map class: Vegetated Wash Complex
 - Association: *Calamovilfa gigantea* Desert Wash Shrub Herbaceous Vegetation
- 21b. Dominant herbaceous vegetation not as above. (22a)
- 22a. *Sporobolus cryptandrus* is the dominant herbaceous species. Typically occurs on sandy soils or on sand dunes and is found in small patches throughout the park. Where it occurred, it was mapped as part of the polygon describing the vegetation surrounding it.
- Association: *Sporobolus cryptandrus* Great Basin Herbaceous Vegetation
- 22b. Dominant herbaceous vegetation not as above. (23a)
- 23a. *Sporobolus coromandelianus* is the dominant herbaceous species and composes over half of the total herbaceous cover. No perennial grasses occur with >1% of the total cover. This grass is an annual species and its cover may fluctuate depending on the growing season and year. Where it occurred, it was mapped as part of the polygon describing the vegetation surrounding it.
- Association: *Sporobolus coromandelianus* Herbaceous Vegetation [Park Special]
- 23b. Dominant herbaceous species not as above. (24a)
- 24a. *Salsola tragus*, an annual exotic species, is the dominant herbaceous species. A very low cover of perennial species may occur, however *Salsola tragus* generally has >90% of the total vegetation cover. If a low cover of perennial species occurs on the site, use the Lifeform Key above to determine if the perennial vegetation better defines the site. *Salsola tragus* varies significantly in cover depending on seasonality and annual precipitation. This map class tends to be restricted to sites that are almost entirely homogenous patches of *Salsola tragus* and occurs on unstable, disturbed surfaces, and/or sandy substrates. It typically occurs on sand dunes or in human disturbed areas, such as along roads or pipeline corridors.
- Base map class: Russian Thistle Sand Dune Vegetation
 - Group map class: Inter-Mountain Basins Active and Stabilized Dune
 - Management map class: Russian Thistle Sand Dune Vegetation
 - Association: *Salsola tragus* Sand Dune Vegetation [Park Special]

- 24b. Dominant herbaceous species not as above, or shrub or tree cover is greater than half of the total herbaceous cover, less than the total herbaceous cover, and <15% cover. (25a)
- 25a. *Atriplex obovata* is the dominant shrub. The main grasses are *Sporobolus airoides* and *Pleuraphis jamesii*; either grass species can dominate or they can co-dominate, depending on site conditions. *Sporobolus airoides* is almost always present, even with low cover, whereas *Pleuraphis jamesii* is often present, but does not need to occur. This map class occurs throughout the project boundary and ranges from badlands to sandy soils.
- Base map class New Mexico Saltbush / Alkali Sacaton – Galleta Shrub Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Semi-Desert Shrub-Steppe
 - Management map class: Alkali Sacaton Steppe and Mixed Grasslands
 - Association: *Atriplex obovata* / *Sporobolus airoides* - *Pleuraphis jamesii* Shrub Herbaceous Vegetation
- 25b. Dominant shrub species not as above. (26a)
- 26a. Dominant shrub species is *Opuntia whipplei*. The main grass is *Sporobolus airoides*. Other grasses may also occur and co-dominate. This map class is limited to a few areas in the project boundary.
- Base map class: Whipple Cholla - Alkali Sacaton Shrub Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Semi-Desert Grassland
 - Management map class: Alkali Sacaton Steppe and Mixed Grasslands
 - Association: *Opuntia whipplei* - *Sporobolus airoides* Shrub Herbaceous Vegetation [Park Special]
- 26b. Dominant shrub species not as above. (27a)
- 27a. The dominant shrub species is *Ericameria nauseosa*. The dominant herbaceous species is most commonly *Bouteloua gracilis*; however in some cases other herbaceous species may dominate, including, *Sporobolus airoides* and the non-native forb *Salsola tragus*. This map class is common in upland areas throughout the project boundary.
- Base map class: Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Active and Stabilized Dune
 - Management map class: Alkali Sacaton Steppe and Mixed Grasslands
 - Association: *Ericameria nauseosa* / *Bouteloua gracilis* Shrub Herbaceous Vegetation
- 27b. *Atriplex canescens* is the dominant shrub. Other shrub species can also be present, such as *Ericameria nauseosa*, *Gutierrezia sarothrae*, and *Artemisia bigelovii*. The understory consists of a mix of native grasses with *Pleuraphis jamesii* often occurring as the dominant herbaceous species. This map class occurs throughout the project boundary and occurs on various substrates ranging from clay to sandy soils and sand dunes.
- Base map class: Four-wing Saltbush / Galleta Shrubland
 - Group map class: Southern Colorado Plateau Sand Shrubland
 - Management map class: Sandsage - Fourwing Saltbush Colorado Plateau Shrubland
 - Association: *Atriplex canescens* / *Pleuraphis jamesii* Shrubland
- 28a. None of the individual associations included in the key above define this map class. This map class is distinguished by its landform characteristic; it occurs on mesa rims and contains a mix of herbaceous and shrub species. A wide range of species can occur in this habitat. No one individual association was determined to represent this map class, which contains a complex of associations and unique communities. Associations that can occur in this complex include, but are not limited to, *Juniperus monosperma* / *Artemisia bigelovii* Woodland, *Artemisia bigelovii* - *Ephedra torreyana* Shrubland, and *Ephedra viridis* - *Rhus trilobata* Talus Shrubland. This map class contains a mix of species and associations and was defined as a heterogeneous group of associations.
- Base map class: Vegetated Rim Complex
 - Group map class: Colorado Plateau Mixed Bedrock and Tableland
 - Management map class: Vegetated Rim Complex
 - Association: NA
- 28b. None of the individual associations included in the key above define this map class. This map

class is distinguished by its landform characteristic and occurs in areas of intermittent flooding, such as washes, along wash banks, and on wash terraces. This map class contains a mix of herbaceous and shrub species. No one individual association was determined to represent this map class which contains a complex of associations and unique communities. Associations that can occur in this complex include, but are not limited to, *Allenrolfea occidentalis* Shrubland, *Calamovilfa gigantea* Desert Wash Shrub Herbaceous Vegetation, *Ericameria nauseosa* Desert Wash Shrubland, *Ericameria nauseosa* / *Bouteloua gracilis* Shrub Herbaceous Vegetation, *Isocoma drummondii* / *Pleuraphis jamesii* Shrubland, *Salix exigua* / Barren Shrubland, *Sarcobatus vermiculatus* / *Atriplex obovata* Shrubland, *Sarcobatus vermiculatus* / *Suaeda moquinii* Shrubland, *Suaeda moquinii* Shrubland, *Tamarix* spp. Semi-Natural Temporarily Flooded Shrubland. This map class contains a mix of species and associations and was defined as a heterogeneous group of associations.

- Base map class: Vegetated Wash Complex
- Group map class: Inter-Mountain Basins Wash
- Management map class: Vegetated Wash Complex
- Association: NA

Key C: Woodlands

Trees are the dominant lifeform. Total vegetation cover is generally >10% cover, except in dry sites where vegetation cover can be as low as 2% cover. Trees dominate the woodlands and generally have >10% canopy cover. If shrub cover is more than tree cover, go to Key D: Shrubs.

- 29a. *Juniperus monosperma* dominates the tree species. *Juniperus monosperma* is a short tree that tends to have a tall shrub-like appearance and occurs in low density. *Artemisia bigelovii* typically occurs as an indicator species in the understory of this map class. Occasionally *Artemisia bigelovii* dominates the understory, but it does not have to occur. The understory typically consists of a sparse cover of shrub and herbaceous species.
- Base map class: One-seed Juniper / Bigelow's Sagebrush Shrubland
 - Group map class: Colorado Plateau Pinyon-Juniper Woodland
 - Management map class: One-seed Juniper / Bigelow's Sagebrush Shrubland
 - Association: *Juniperus monosperma* / *Artemisia bigelovii* Woodland
- 29b. Tree species not as above. (30a)
- 30a. Tree species are dominated by *Pinus edulis* and/or *Juniperus osteosperma*. Both of these tree species occur in low densities. The understory tends to have a low cover of herbaceous and shrub species. The herbaceous cover often consists of a low to moderate cover of *Bouteloua gracilis*. This map class is restricted to the higher elevations of the northern half of the project boundary.
- Association: *Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland
- 30b. *Populus fremontii* is the dominant tree species. *Ericameria nauseosa* commonly occurs as a tall shrub in the understory. This community is restricted to areas with intermittent stream flow and mostly commonly occurs along the banks of the Puerco River.
- Base map class: Cottonwood / Rubber Rabbitbrush Woodland
 - Group map class: Inter-Mountain Basins Riparian Woodland and Shrubland
 - Management map class: Cottonwood / Rubber Rabbitbrush Woodland
 - Association: *Populus fremontii* / *Ericameria nauseosa* Woodland

Key D: Shrublands

Shrubs are the dominant lifeform. Total vegetation cover is generally >10% cover; in particularly dry sites vegetation cover can be as low as 2% cover. Tree cover is less than the total shrub cover and <10% cover; if tree cover is more than shrub cover, go to Key C: Woodlands. The herbaceous cover is either equal to or less than the total shrub cover; if more, go to Key B: Herbaceous.

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- 31a. A mix of shrub species occurring on a mesa rim or on/near a wash. First go to 32a and try to select the appropriate map class. If none of the map classes work, proceed to 56a.
- 31b. Shrub species not as above. (32a)
- 32a. *Artemisia bigelovii* and/or *Ephedra torreyana* are either dominant or co-dominant shrubs. This map class occurs throughout the mapping area and more commonly occurs on or near sandstone. If *Purshia stansburiana* is also present with 2% cover, go to 42a.
- Base map class: - Torrey's Jointfir - Bigelow's Sagebrush Sparse Vegetation
 - Group map class: Inter-Mountain Basins Semi-Desert Shrub-Steppe
 - Management map class: Vegetated Rim Complex
 - Association: *Ephedra torreyana* - *Artemisia bigelovii* Sparse Vegetation
- 32b. Dominant shrub species not as above. (33a)
- 33a. *Artemisia filifolia* is the dominant shrub species. (34a)
- 33b. Dominant shrub species not as above. (35a)
- 34a. *Artemisia filifolia* is the dominant shrub species. The understory is a mix of shrub and herbaceous species. This map class occurs commonly throughout the park, typically on sandy soils or sand dunes.
- Base map class: Sandsage Colorado Plateau Shrubland
 - Group map class: Southern Colorado Plateau Sand Shrubland
 - Management map class: Sandsage - Fourwing Saltbush Colorado Plateau Shrubland
 - Association: *Artemisia filifolia* Colorado Plateau Shrubland
- 34b. *Artemisia filifolia* is the dominant shrub species. The understory is dominated by the native grass *Bouteloua eriopoda*. This map class is restricted to a few areas in the park. Where it occurred, it was mapped as part of the polygon describing the vegetation surrounding it.
- Association: *Artemisia filifolia* / *Bouteloua eriopoda* Shrubland
- 35a. *Atriplex canescens* is the dominant shrub. Other shrub species can also be present, such as *Ericameria nauseosa*, *Gutierrezia sarothrae*, and *Artemisia bigelovii*. The understory consists of a mix of native grasses. *Pleuraphis jamesii* often occurs in the understory, but does not have to occur. *Bouteloua gracilis* and *Sporobolus airoides* are also common grasses in the understory. This map class occurs throughout the project boundary and on various substrates, ranging from clay to sandy soils and sand dunes.
- Base map class: Four-wing Saltbush / Galleta Shrubland
 - Group map class: Southern Colorado Plateau Sand Shrubland
 - Management map class: Sandsage - Fourwing Saltbush Colorado Plateau Shrubland
 - Association: *Atriplex canescens* / *Pleuraphis jamesii* Shrubland
- 35b. Dominant shrub species not as above. (36a)
- 36a. *Ericameria nauseosa* is the dominant shrub species. (37a)
- 36b. Dominant shrub species not as above. (38a)
- 37a. *Ericameria nauseosa* is the dominant shrub species and occurs as a tall shrub (generally at least 1m tall). The shrubs often occur in large patches along the banks of washes and rivers.
- Base map class: Rubber Rabbitbrush Desert Wash Shrubland
 - Group map class: Inter-Mountain Basins Wash
 - Management map class: Vegetated Wash Complex
 - Association: *Ericameria nauseosa* Desert Wash Shrubland
- 37b. *Ericameria nauseosa* is the dominant shrub and it typically has a short-statured growth form (generally less than 1m tall). The understory can consist of other shrub and herbaceous species. This map class occurs on a variety of upland environments, including sand dune and mesa tops.
- Base map class: Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Active and Stabilized Dune
 - Management map class: Alkali Sacaton Steppe and Mixed Grasslands
 - Association: *Ericameria nauseosa* / *Bouteloua gracilis* Shrub Herbaceous Vegetation
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- 38a. *Atriplex obovata* is the dominant shrub species. (39a) If *Sarcobatus vermiculatus* is also present with > 2% cover, go to 47a.
- 38b. Dominant shrub species not as above. (40a)
- 39a. *Atriplex obovata* is the dominant shrub. The understory tends to be very sparse. Occasional shrub and grass species may occur, but never with more cover than *Atriplex obovata*. This map class typically occurs in badland areas with very low cover.
- Base map class: New Mexico Saltbush Badland Sparse Vegetation
 - Group map class: Inter-Mountain Basins Semi-Desert Shrub-Steppe
 - Management map class: Badland Sparse Vegetation
 - Association: *Atriplex obovata* Badland Sparse Vegetation
- 39b. *Atriplex obovata* is the dominant shrub. The understory has a low to moderate cover of native grasses. The native grasses often consist of *Pleuraphis jamesii* and *Sporobolus airoides*. This map class typically occurs on clay badland soils.
- Base map class: New Mexico Saltbush / Alkali Sacaton – Galleta Shrub Herbaceous Vegetation
 - Group map class: Inter-Mountain Basins Semi-Desert Shrub-Steppe
 - Management map class: Alkali Sacaton Steppe and Mixed Grasslands
 - Association: *Atriplex obovata* / *Sporobolus airoides* - *Pleuraphis jamesii* Shrub Herbaceous Vegetation
- 40a. *Krascheninnikovia lanata* is the dominant shrub. (41a)
- 40b. Dominant shrub species not as above. (42a)
- 41a. *Krascheninnikovia lanata* is the main shrub with no other shrubs occurring or with a very low shrub cover. Where it occurred, it was mapped as part of the polygon describing the vegetation surrounding it.
- Association: *Krascheninnikovia lanata* Dwarf-shrubland
- 41b. The understory consists of a mix of native grasses. Often *Bouteloua gracilis* occurs as one of the dominant grass species. Other shrub species can occur, such as *Gutierrezia sarothrae*.
- Base map class: Winter-fat / Blue Grama Dwarf-shrubland
 - Group map class: Inter-Mountain Basins Semi-Desert Shrub-Steppe
 - Management map class: Blue Grama Steppe and Mixed Grasslands
 - Association: *Krascheninnikovia lanata* / *Bouteloua gracilis* Dwarf-shrub Herbaceous Vegetation
- 42a. *Purshia stansburiana* is the dominant tall shrub. The understory tends to have a mix of herbaceous species and smaller shrubs, often including *Artemisia bigelovi*. *Eriogonum corymbosum* typically occurs as an indicator sub-shrub for this map class. This map class is restricted to the higher elevations of the park and environs, and typically occurs on the basaltic soils of Headquarter's Mesa.
- Base map class: Cliff-rose - Crispleaf Buckwheat Shrubland
 - Group map class: Colorado Plateau Mixed Bedrock and Tableland
 - Management map class: Cliff-rose - Crispleaf Buckwheat Shrubland
 - Association: *Purshia stansburiana* - *Eriogonum corymbosum* Shrubland
- 42b. The dominant shrub is not *Purshia stansburiana*. (43a)
- 43a. *Isocoma drummondii* is the dominant shrub. The understory has an herbaceous component that can include *Pleuraphis jamesii*. This map class is restricted to a few areas in the park and environs.
- Base map class: Drummond Goldenweed - Galleta Shrubland
 - Group map class: Inter-Mountain Basins Wash
 - Management map class: Vegetated Wash Complex
 - Association: *Isocoma drummondii* - *Pleuraphis jamesii* Shrubland [Park Special]
- 43b. The dominant shrub is not *Isocoma drummondii*. (44a)
- 44a. *Iva acerosa*, a tall suffrutescent shrub, is the dominant species. The herbaceous layer is domi-

- nated by *Sporobolus airoides*. This map class is restricted to a few areas in northern part of the park and environs in washes and areas with seasonal stream flow.
- Base map class: Copperweed - Alkali Sacaton Shrubland
 - Group map class: Inter-Mountain Basins Wash
 - Management map class: Vegetated Wash Complex
 - Association: *Iva acerosa* - *Sporobolus airoides* Shrubland [Park Special]
- 44b. The dominant shrub is not *Iva acerosa*. (45a)
- 45a. *Allenrolfea occidentalis* is the dominant shrub. The understory tends to be sparse. This map class typically occurs on saline or alkaline soils in areas with periodic sheet flow.
- Base map class: Iodine Bush Shrubland
 - Group map class: Inter-Mountain Basins Greasewood Flat
 - Management map class: Greasewood Flats
 - Association: *Allenrolfea occidentalis* Shrubland
- 45b. The dominant shrub not as above. (46a)
- 46a. *Sarcobatus vermiculatus* is the dominant or co-dominant shrub. (47a)
- 46b. The dominant shrub is not *Sarcobatus vermiculatus*. (48a)
- 47a. *Sarcobatus vermiculatus* is co-dominant with the native dwarf-shrub *Atriplex obovata*. This map class generally occurs on saline and alkaline soils and in areas with periodic sheet flow, often near a wash system.
- Base map class: Greasewood / New Mexico Saltbush Shrubland
 - Group map class: Inter-Mountain Basins Greasewood Flat
 - Management map class: Greasewood Flats
 - Association: *Sarcobatus vermiculatus* / *Atriplex obovata* Shrubland
- 47b. *Sarcobatus vermiculatus* is the dominant tall shrub and the native suffrutescent shrub *Suaeda moquinii* is the dominant species in the understory. This map class is generally restricted to the alkaline soils around the Puerco River corridor.
- Base map class: Greasewood / Shrubby Seepweed Shrubland
 - Group map class: Inter-Mountain Basins Greasewood Flat
 - Management map class: Greasewood Flats
 - Association: *Sarcobatus vermiculatus* / *Suaeda moquinii* Shrubland
- 48a. *Suaeda moquinii*, a suffrutescent shrub, is the dominant species. This map class is generally restricted to the alkaline soils around the Puerco River corridor. Where it occurred, it was mapped as part of the polygon describing the vegetation surrounding it.
- Association: *Suaeda moquinii* Shrubland
- 48b. The dominant shrub is not as above. (49a)
- 49a. Either *Ephedra viridis* or *Rhus trilobata* is the dominant shrub, or they are co-dominant. This map class tends to occur on sparse talus slopes or on rocky outcrops.
- Base map class: Three-leafed Sumac - Mormon Tea Talus Shrubland
 - Group map class: Colorado Plateau Mixed Bedrock and Tableland
 - Management map class: Vegetated Rim Complex
 - Association: *Rhus trilobata* - *Ephedra (viridis, torreyana)* Talus Shrubland
- 49b. The dominant shrub(s) are not as above. (50a)
- 50a. *Zuckia brandegeei* is the dominant species. This map class tends to occur in very sparse areas on clay badland soils. Other shrub and herbaceous species may occur, but never with high cover and never as the dominant species.
- Base map class: Arizona Siltbush Sparse Vegetation
 - Group map class: Inter-Mountain Basins Shale Badland
 - Management map class: Badland Sparse Vegetation
 - Association: *Zuckia brandegeei* Sparse Vegetation
- 50b. The dominant shrub not as above. (51a)
- 51a. *Eriogonum leptophyllum* is the dominant species or is an indicator species in very sparsely

vegetated areas. Other shrub species that tend to occur in this map class include *Atriplex confertifolia*, *Artemisia bigelovii*, and *Gutierrezia sarothrae*. This map class tends to occur in sparse areas on whitish clay badland soils.

- Base Map Class: Slender Buckwheat Sparse Vegetation
- Group Map Class: Inter-Mountain Basins Shale Badland
- Management Map Class: Vegetated Rim Complex
- Association: *Eriogonum leptophyllum* Sparse Vegetation

51b. The dominant shrub species not as above. (52a)

52a. *Salvia pachyphylla* is the dominant shrub species. The understory tends to be sparse. This map class is restricted to the higher elevations of the northern half of the project boundary near Chinde Mesa.

- Base map class: Blue Sage Dwarf-shrubland
- Group map class: Inter-Mountain Basins Shale Badland
- Management map class: Blue Sage Dwarf-shrubland
- Association: *Salvia pachyphylla* Dwarf-shrubland [Park Special]

52b. The dominant shrub species not as above. (53a)

53a. *Forestiera pubescens* is the dominant shrub. This species tends to grow in large dense patches. This map class is isolated to a few small patches near the Puerco River.

- Association: *Forestiera pubescens* Temporarily Flooded Shrubland Alliance

53b. The dominant shrub species not as above. (54a)

54a. *Salix exigua* is the dominant shrub species. Other shrub species may occur, including *Ericameria nauseosa* and *Isocoma drummondii*. The understory tends to have a sparse herbaceous layer. This map class is restricted to areas with periodic stream flow and is most common in the Puerco River corridor.

- Base map class: Coyote Willow Shrubland
- Group map class: Inter-Mountain Basins Riparian Woodland and Shrubland
- Management map class: Coyote Willow Shrubland
- Association: *Salix exigua* / Barren Shrubland

54b. The dominant shrub species not as above. (55a)

55a. *Tamarix* sp. dominates the shrub layer. This species often occurs as a tall shrub or a short tree and forms dense monocultures. This community generally occurs in riparian areas or in areas with a high water table, such as in washes or near stock tanks.

- Base map class: Tamarisk Shrubland
- Group map class: Inter-Mountain Basins Riparian Woodland and Shrubland
- Management map class: Vegetated Wash Complex
- Association: *Tamarix* spp. Semi-Natural Temporarily Flooded Shrubland

55b. *Gutierrezia sarothrae* is the dominant species and no other shrub species has even a low cover in this map class. A very low cover of *Opuntia* spp. can occasionally occur. The herbaceous layer is often present, but does not have to occur, with a low cover of the grass *Pleuraphis jamesii*.

- Base map class: Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland
- Association: *Gutierrezia sarothrae* - (*Opuntia* spp.) - *Pleuraphis jamesii* Dwarf-shrubland

56a. None of the individual associations included in the key above define this map class. This map class is distinguished by its landform characteristic and occurs on mesa rims. A wide range of herbaceous and shrub species can occur in this habitat. No one individual association was determined to represent this map class which contains a complex of associations and unique communities. Associations that can occur in this complex include, but are not limited to, *Juniperus monosperma* / *Artemisia bigelovii* Woodland, *Artemisia bigelovii* - *Ephedra torreyana* Shrubland, and *Ephedra viridis* - *Rhus trilobata* Talus Shrubland. This map class contains a mix of species and associations and was defined as a heterogeneous group of associations.

- Base map class: Vegetated Rim Complex
- Group map class: Colorado Plateau Mixed Bedrock and Tableland
- Management map class: Vegetated Rim Complex

- Association: NA
- 56b. None of the individual associations included in the key above define this map class. It contains a mix of herbaceous and shrub species and is distinguished by its landform characteristic. It occurs in areas of intermittent flooding, such as in washes, along wash banks, and on wash terraces. No one individual association represents this map class as it contains a complex of associations and unique communities. Associations that can occur in this complex include, but are not limited to, *Allenrolfea occidentalis* Shrubland, *Calamovilfa gigantea* Desert Wash Shrub Herbaceous Vegetation, *Ericameria nauseosa* Desert Wash Shrubland, *Ericameria nauseosa* / *Bouteloua gracilis* Shrub Herbaceous Vegetation, *Isocoma drummondii* / *Pleuraphis jamesii* Shrubland, *Salix exigua* / Barren Shrubland, *Sarcobatus vermiculatus* / *Atriplex obovata* Shrubland, *Sarcobatus vermiculatus* / *Suaeda moquinii* Shrubland, *Suaeda moquinii* Shrubland, *Tamarix* spp. Semi-Natural Temporarily Flooded Shrubland. This map class contains a mix of species and associations and was defined as a heterogeneous group of associations.
- Base Map Class: Vegetated Wash Complex
 - Group Map Class: Inter-Mountain Basins Wash
 - Management Map Class: Vegetated Wash Complex
 - Association: NA

Appendix F

Plant community and map class crosswalk

This table provides a crosswalk between the plant communities of Petrified Forest National Park (associations, alliances, and park species) and their base, group, management, and macrogroup map class assignments. Each plant community is in only one map class for each schema, but each map class may contain more than one plant community.

Appendix F

Plant community (associations and park specials)

		Base map class	Group map class	Macrogroup map class	Management map class
WOODLAND					
1	<i>Juniperus monosperma</i> / <i>Artemisia bigelovii</i> Woodland	B2	One-seed Juniper / Bigelow's Sagebrush Shrubland	G3 Colorado Plateau Pinyon-Juniper Woodland	MG3 Colorado Plateau Pinyon-Juniper Woodland MN12 One-seed Juniper / Bigelow's Sagebrush Shrubland
2	<i>Pinus edulis</i> - (<i>Juniperus osteosperma</i>) / <i>Bouteloua gracilis</i> Woodland	B2	One-seed Juniper / Bigelow's Sagebrush Shrubland	G3 Colorado Plateau Pinyon-Juniper Woodland	MG3 Colorado Plateau Pinyon-Juniper Woodland MN12 One-seed Juniper / Bigelow's Sagebrush Shrubland
3	<i>Populus fremontii</i> / <i>Ericameria nauseosa</i> Woodland	B1	Cottonwood / Rubber Rabbitbrush Woodland	G7 Inter-Mountain Basins Riparian Woodland and Shrubland	MG7 Inter-Mountain Basins Riparian Woodland and Shrubland MN9 Cottonwood / Rubber Rabbitbrush Woodland
SHRUBLAND					
4	<i>Allenrolfea occidentalis</i> Shrubland	B11	Iodine Bush Shrubland	G6 Inter-Mountain Basins Greasewood Flat	MG6 Inter-Mountain Basins Greasewood Flat MN11 Greasewood Flats
5	<i>Artemisia filifolia</i> / <i>Bouteloua eriopoda</i> Shrubland		Mapped with Sand-sage Colorado Plateau Shrubland and Torrey's Jointfir - Bigelow's Sagebrush Shrubland	NA	NA
6	<i>Artemisia filifolia</i> Colorado Plateau Shrubland	B13	Sandsage Colorado Plateau Shrubland	G14 Southern Colorado Plateau Sand Shrubland	MG12 Southern Colorado Plateau Sand Shrubland MN21 Sandsage - Fourwing Saltbush Colorado Plateau Shrubland
7	<i>Atriplex canescens</i> / <i>Pleuraphis jamesii</i> Shrubland	B8	Four-wing Saltbush / Galleta Shrubland	G14 Southern Colorado Plateau Sand Shrubland	MG12 Southern Colorado Plateau Sand Shrubland MN21 Sandsage - Fourwing Saltbush Colorado Plateau Shrubland
8	<i>Ericameria nauseosa</i> Desert Wash Shrubland	B12	Rubber Rabbitbrush Desert Wash Shrubland	G8 Inter-Mountain Basins Wash	MG9 Inter-Mountain Basins Wash MN24 Vegetated Wash Complex
9	<i>Forestiera pubescens</i> Shrubland		Not mapped as unique base map class	NA	NA
10	<i>Gutierrezia sarothrae</i> - (<i>Opuntia</i> spp.) / <i>Pleuraphis jamesii</i> Dwarf-shrubland	B14	Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland	G10 Inter-Mountain Basins Semi-Desert Shrub-Steppe	MG8 Inter-Mountain Basins Semi-Desert Grassland and Steppe MN2 Alkali Sacaton Steppe and Mixed Grasslands
11	<i>Isocoma drummondii</i> - <i>Pleuraphis jamesii</i> Shrubland	B7	Drummond Goldenweed - Galleta Shrubland	G8 Inter-Mountain Basins Wash	MG9 Inter-Mountain Basins Wash MN24 Vegetated Wash Complex
12	<i>Iva acerosa</i> - <i>Sporobolus airoides</i> Shrubland	B5	Copperweed - Alkali Sacaton Shrubland	G8 Inter-Mountain Basins Wash	MG9 Inter-Mountain Basins Wash MN24 Vegetated Wash Complex
13	<i>Krascheninnikovia lanata</i> / <i>Bouteloua gracilis</i> Dwarf-shrub Herba-ceous Vegetation	B17	Winter-fat / Blue Grama Dwarf-shrubland	G10 Inter-Mountain Basins Semi-Desert Shrub-Steppe	MG8 Inter-Mountain Basins Semi-Desert Grassland and Steppe MN5 Blue Grama Steppe and Mixed Grasslands
14	<i>Krascheninnikovia lanata</i> Dwarf-shrubland		Not mapped as unique base map class	NA	NA

Appendix F continued

Plant community (associations and park specials)

		Base map class	Group map class	Macrogroup map class		Management map class			
15	<i>Purshia stansburiana</i> - <i>Eriogonum corymbosum</i> Shrubland	B4	Cliff-rose - Crispleaf Buckwheat Shrubland	G2	Colorado Plateau Mixed Bedrock and Tableland	MG2	Colorado Plateau Mixed Bedrock and Tableland	MN7	Cliff-rose - Crispleaf Buckwheat Shrubland
16	<i>Rhus trilobata</i> - <i>Ephedra (viridis, torreyana)</i> Talus Shrubland	B16	Three-leafed Sumac - Mormon Tea Talus Shrubland	G2	Colorado Plateau Mixed Bedrock and Tableland	MG2	Colorado Plateau Mixed Bedrock and Tableland	MN23	Vegetated Rim Complex
17	<i>Salix exigua</i> / Barren Shrubland	B6	Coyote Willow Shrubland	G7	Inter-Mountain Basins Riparian Woodland and Shrubland	MG7	Inter-Mountain Basins Riparian Woodland and Shrubland	MN10	Coyote Willow Shrubland
18	<i>Salvia pachyphylla</i> Dwarf-shrubland	B3	Blue Sage Dwarf-shrubland	G11	Inter-Mountain Basins Shale Badland	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN6	Blue Sage Dwarf-shrubland
19	<i>Sarcobatus vermiculatus</i> / <i>Atriplex obovata</i> Shrubland	B9	Greasewood / New Mexico Saltbush Shrubland	G6	Inter-Mountain Basins Greasewood Flat	MG6	Inter-Mountain Basins Greasewood Flat	MN11	Greasewood Flats
20	<i>Sarcobatus vermiculatus</i> / <i>Suaeda moquinii</i> Shrubland	B10	Greasewood / Shrubby Seepweed Shrubland	G6	Inter-Mountain Basins Greasewood Flat	MG6	Inter-Mountain Basins Greasewood Flat	MN11	Greasewood Flats
21	<i>Suaeda moquinii</i> Shrubland		Not mapped as unique base map class		NA		NA		NA
22	<i>Tamarix</i> spp. Temporarily Flooded Semi-natural Shrubland	B15	Tamarisk Shrubland	G7	Inter-Mountain Basins Riparian Woodland and Shrubland	MG7	Inter-Mountain Basins Riparian Woodland and Shrubland	MN24	Vegetated Wash Complex
HERBACEOUS									
23	<i>Atriplex obovata</i> / <i>Sporobolus airoides</i> - <i>Pleuraphis jamesii</i> Shrub Herbaceous Vegetation	B25	New Mexico Saltbush / Alkali Sacaton - Galleta Shrub Herbaceous Vegetation	G10	Inter-Mountain Basins Semi-Desert Shrub-Steppe	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN2	Alkali Sacaton Steppe and Mixed Grasslands
24	<i>Bouteloua eriopoda</i> - <i>Pleuraphis jamesii</i> Herbaceous Vegetation	B20	Black Grama - Galleta Herbaceous Vegetation	G9	Inter-Mountain Basins Semi-Desert Grassland	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN2	Alkali Sacaton Steppe and Mixed Grasslands
25	<i>Bouteloua gracilis</i> - <i>Pleuraphis jamesii</i> Herbaceous Vegetation	B22	Blue Grama - Galleta Herbaceous Vegetation	G9	Inter-Mountain Basins Semi-Desert Grassland	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN5	Blue Grama Steppe and Mixed Grasslands
26	<i>Bouteloua gracilis</i> Herbaceous Vegetation	B21	Blue Grama Herbaceous Vegetation	G9	Inter-Mountain Basins Semi-Desert Grassland	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN5	Blue Grama Steppe and Mixed Grasslands
27	<i>Calamovilfa gigantea</i> Desert Wash Shrub Herbaceous Vegetation	B24	Giant Sandreed Desert Wash Shrub Herbaceous Vegetation	G8	Inter-Mountain Basins Wash	MG9	Inter-Mountain Basins Wash	MN24	Vegetated Wash Complex
28	<i>Ericameria nauseosa</i> / <i>Bouteloua gracilis</i> Shrub Herbaceous Vegetation	B26	Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation	G5	Inter-Mountain Basins Active and Stabilized Dune	MG5	Inter-Mountain Basins Active and Stabilized Dune	MN2	Alkali Sacaton Steppe and Mixed Grasslands

Appendix F continued

Plant community (associations and park specials)

		Base map class		Group map class		Macrogroup map class		Management map class	
29	<i>Opuntia whipplei</i> - <i>Sporobolus airoides</i> Shrub Herbaceous Vegetation	B28	Whipple Cholla - Alkali Sacaton Shrub Herbaceous Vegetation	G9	Inter-Mountain Basins Semi-Desert Grassland	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN2	Alkali Sacaton Steppe and Mixed Grasslands
30	<i>Pleuraphis jamesii</i> - <i>Sporobolus airoides</i> Herbaceous Vegetation	B23	Galleta - Alkali Sacaton Herbaceous Vegetation	G9	Inter-Mountain Basins Semi-Desert Grassland	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN2	Alkali Sacaton Steppe and Mixed Grasslands
31	<i>Salsola tragus</i> Sand Dune Vegetation	B27	Russian Thistle Sand Dune Vegetation	G5	Inter-Mountain Basins Active and Stabilized Dune	MG5	Inter-Mountain Basins Active and Stabilized Dune	MN19	Russian Thistle Sand Dune Vegetation
32	<i>Sporobolus airoides</i> - <i>Bouteloua gracilis</i> Herbaceous Vegetation	B19	Alkali Sacaton - Blue Grama Herbaceous Vegetation	G9	Inter-Mountain Basins Semi-Desert Grassland	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN2	Alkali Sacaton Steppe and Mixed Grasslands
33	<i>Sporobolus airoides</i> Southern Plains Herbaceous Vegetation	B18	Alkali Sacaton Herbaceous Vegetation	G9	Inter-Mountain Basins Semi-Desert Grassland	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN2	Alkali Sacaton Steppe and Mixed Grasslands
34	<i>Sporobolus coromandelianus</i> Herbaceous Vegetation		Not mapped as unique base map class	NA			NA	NA	
35	<i>Sporobolus cryptandrus</i> Great Basin Herbaceous Vegetation		Not mapped as unique base map class	NA			NA	NA	
SPARSE									
36	<i>Atriplex obovata</i> Badland Sparse Vegetation	B30	New Mexico Saltbush Badland Sparse Vegetation	G10	Inter-Mountain Basins Semi-Desert Shrub-Steppe	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN3	Badland Sparse Vegetation
37	<i>Ephedra torreyana</i> - <i>Artemisia bigelovii</i> Sparse Vegetation	B32	Torrey's Jointfir - Bigelow's Sagebrush Sparse Vegetation	G10	Inter-Mountain Basins Semi-Desert Shrub-Steppe	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN23	Vegetated Rim Complex
38	<i>Eriogonum leptophyllum</i> Sparse Vegetation	B31	Slender Buckwheat Sparse Vegetation	G11	Inter-Mountain Basins Shale Badland	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN23	Vegetated Rim Complex
39	<i>Zuckia brandegeei</i> Sparse Vegetation	B29	Arizona Siltbush Sparse Vegetation	G11	Inter-Mountain Basins Shale Badland	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN3	Badland Sparse Vegetation
	Land cover/Land use type without a plant community assignment	B33	Airstrip	G15	Transportation	MG13	Transportation	MN1	Airstrip
	Land cover/Land use type without a plant community assignment	B34	Barren Badlands	G11	Inter-Mountain Basins Shale Badland	MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN2	Badland Sparse Vegetation
	Land cover/Land use type without a plant community assignment	B35	Barren Wash	G8	Inter-Mountain Basins Wash	MG9	Inter-Mountain Basins Wash	MN4	Barren Wash
	Land cover/Land use type without a plant community assignment	B36	Park Facilities	G12	Park Facilities	MG10	Park Facilities	MN13	Park Facilities
	Land cover/Land use type without a plant community assignment	B37	Park Sites	G12	Park Facilities	MG10	Park Facilities	MN14	Park Sites

Appendix F continued

Plant community (associations and park specials)

	Base map class	Group map class	Macrogroup map class	Management map class
Land cover/Land use type without a plant community assignment	B38 Railroad	G15 Transportation	MG13 Transportation	MN15 Railroad
Land cover/Land use type without a plant community assignment	B39 Residences	G13 Residential	MG10 Park Facilities	MN13 Park Facilities
Land cover/Land use type without a plant community assignment	B40 Roads	G15 Transportation	MG13 Transportation	MN16 Residences
Land cover/Land use type without a plant community assignment	B41 Run-off Control Feature	G1 Agriculture	MG1 Agriculture	MN18 Run-off Control Feature
Land cover/Land use type without a plant community assignment	B42 Sand	G11 Inter-Mountain Basins Shale Badland	MG8 Inter-Mountain Basins Semi-Desert Grassland and Steppe	MN20 Sand / Mudflat
Land cover/Land use type without a plant community assignment	B43 Stock Ponds	G1 Agriculture	MG1 Agriculture	MN22 Stock Ponds
Land cover/Land use type without a plant community assignment	B44 Vegetated Rim Complex	G2 Colorado Plateau Mixed Bedrock and Tableland	MG2 Colorado Plateau Mixed Bedrock and Tableland	MN23 Vegetated Rim Complex
Land cover/Land use type without a plant community assignment	B45 Vegetated Wash Complex	G8 Inter-Mountain Basins Wash	MG9 Inter-Mountain Basins Wash	MN24 Vegetated Wash Complex
Land cover/Land use type without a plant community assignment	B46 Commercial Development	G4 Development	MG4 Development	MN8 Commercial Development

Appendix G

Map Class Summaries

These map class summaries provide statistics for each base map class, list the group and management classes for each base map class, and show accuracy results for all four map class levels. The photointerpreter provided examples of the base map-class photosignature and commented on the aerial photo interpretation of the base map class. The gray toned aerial photography views are from panchromatic imagery, and the colored views are from the 2003/04 1:6,000 true color imagery. Field photographs and photosignature images appear to the left of the summaries.

B1 Cottonwood / Rubber Rabbitbrush Woodland.....	G4
B2 One-seed Juniper / Bigelow’s Sagebrush Shrubland.....	G5
B3 Blue Sage Dwarf-Shrubland.....	G6
B4 Cliff-rose - Crispleaf Buckwheat Shrubland.....	G7
B5 Copperweed - Alkali Sacaton Shrubland.....	G8
B6 Coyote Willow Shrubland.....	G9
B7 Drummond Goldenweed - Galleta Shrubland.....	G10
B8 Four-wing Saltbush / Galleta Shrubland.....	G11
B9 Greasewood / New Mexico Saltbush Shrubland.....	G12
B10 Greasewood / Shrubby Seepweed Shrubland.....	G13
B11 Iodine Bush Shrubland.....	G14
B12 Rubber Rabbitbrush Desert Wash Shrubland.....	G15
B13 Sandsage Colorado Plateau Shrubland.....	G16
B14 Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland.....	G17
B15 Tamarisk Shrubland.....	G18
B16 Three-leafed Sumac - Mormon Tea Talus Shrubland.....	G19
B17 Winter-fat / Blue Grama Dwarf-shrubland.....	G20
B18 Alkali Sacaton Herbaceous Vegetation.....	G21
B19 Alkali Sacaton - Blue Grama Herbaceous Vegetation.....	G22
B20 Black Grama - Galleta Herbaceous Vegetation.....	G23
B21 Blue Grama Herbaceous Vegetation.....	G24
B22 Blue Grama - Galleta Herbaceous Vegetation.....	G25
B23 Galleta - Alkali Sacaton Herbaceous Vegetation	G26
B24 Giant Sandreed Desert Wash Shrub Herbaceous Vegetation.....	G27
B25 New Mexico Saltbush / Alkali Sacaton – Galleta Shrub Herbaceous Vegetation....	G28
B26 Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation.....	G29
B27 Russian Thistle Sand Dune Vegetation.....	G30
B28 Whipple Cholla - Alkali Sacaton Shrub Herbaceous Vegetation.....	G31
B29 Arizona Siltbush Sparse Vegetation.....	G32
B30 New Mexico Saltbush Badland Sparse Vegetation.....	G33
B31 Slender Buckwheat Sparse Vegetation.....	G34
B32 Torrey’s Jointfir – Bigelow’s Sagebrush Sparse Vegetation.....	G35
B33 Airstrip.....	G36
B34 Barren Badlands.....	G37
B35 Barren Wash.....	G38

B36 Park Facilities.....	G39
B37 Park Sites.....	G40
B38 Railroad.....	G41
B39 Residences.....	G42
B40 Roads.....	G43
B41 Run-off Control Feature.....	G44
B42 Sand.....	G45
B43 Stock Ponds.....	G46
B44 Vegetated Rim Complex.....	G47
B45 Vegetated Wash Complex.....	G48
B46 Commercial Development.....	G49

B1 Cottonwood / Rubber Rabbitbrush Woodland



Figure G1. Ground photo for map class B1, Cottonwood / Rubber Rabbitbrush Woodland.



Figure G2. Photosignature for map class B1, Cottonwood / Rubber Rabbitbrush Woodland.

Location: This map class was only mapped along the Puerco River corridor but it was also seen in small patches near a cattle tank in the northwestern corner of the environs and in the southwestern corner of the park along Highway 180.

Photosignature: This map class was restricted to areas with intermittent stream flow. *Populus fremontii* trees appeared as large, bright green, globular crowns. *Ericameria nauseosa* shrubs appeared as large, gray green shrubs in the understory.

Plant communities	<i>Populus fremontii</i> / <i>Ericameria nauseosa</i> Woodland
Group map class	Inter-Mountain Basins Riparian Woodland and Shrubland (1 of 3)
Management map class	Cottonwood / Rubber Rabbitbrush Woodland (1 of 1)
Macrogroup map class	Inter-Mountain Basins Riparian Woodland and Shrubland (1 of 3)
Number of map units in park	4
Number of map units in park & environs	11
Number of map units less than 0.5 ha	5 (5.5% of total map class area)
Area of map class in park	1.7 ha / 4.3 ac
Area of map class in park & environs	15.2 ha / 37.6 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	88.5%
Base map class accuracy	user 100.0 (42.5 - 100.0), producer 66.7 (25.4 - 92.2)
Group map class accuracy	user 40.9 (25.6 - 58.2), producer 81.8 (57.3 - 93.8)
Management map class accuracy	user 100.0 (42.5 - 100.0), producer 66.7 (25.4 - 92.2)
Macrogroup map class accuracy	user 40.9 (25.6 - 58.2), producer 81.8 (57.3 - 93.8)
Documentation for base map class	2 2003 relevés, 0 1996 relevés, 3 AA observation sites

B2 One-seed Juniper / Bigelow's Sagebrush Shrubland



Figure G3. Ground photo for map class B2, One-seed Juniper / Bigelow's Sagebrush Shrubland.

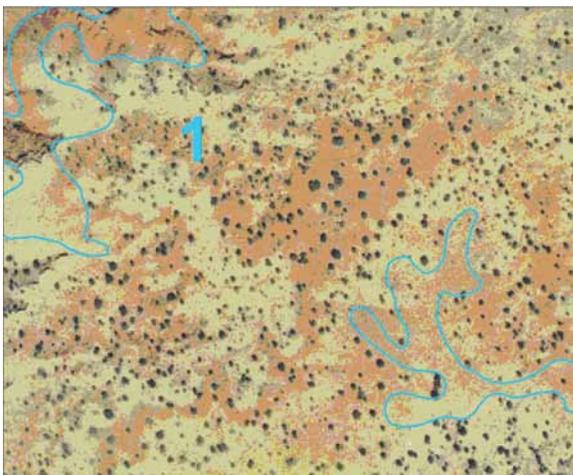


Figure G4. Photostature for map class B2, One-seed Juniper / Bigelow's Sagebrush Shrubland.

Location: One-seed Juniper / Bigelow's Sagebrush Shrubland was located throughout the park and its environs in a few small to large map units. These map units tended to occur on higher elevation mesas and plateaus and were most frequent on Chinde Mesa, Headquarters Mesa, and in the southwestern corner of the project area.

Photosignature: *Juniperus monosperma* appeared as small, globular, green trees. They tended to be the tallest vegetation in the uplands and were easily identified. *Artemisia bigelovii*, a gray green dwarf shrub, was not easily identifiable. In areas where the soil had a strong color, *Artemisia bigelovii* were not always observable. In these areas, the dwarf shrubs were inferred to co-occur with *Juniperus monosperma*. In other areas, a uniform, gray green, smooth, speckled signature indicative of *Artemisia bigelovii* could be seen. *Artemisia bigelovii* did not always occur as a dominant species in the understory; in some areas it occurred only as an indicator species.

Plant communities	<i>Juniperus monosperma</i> / <i>Artemisia bigelovii</i> Woodland
Group map class	Colorado Plateau Pinyon-Juniper Woodland (1 of 1)
Management map class	One-seed Juniper / Bigelow's Sagebrush Shrubland (1 of 1)
Macrogroup map class	Colorado Plateau Pinyon-Juniper Woodland (1 of 1)
Number of map units in park	11
Number of map units in park & environs	27
Number of map units less than 0.5 ha	16 (1.6% of total map class area)
Area of map class in park	70.8 ha / 174.9 ac
Total area of map class	211.4 ha / 522.3 ac
Proportion of land cover in park	0.2%
Proportion of map class in project environs	66.5%
Base map class accuracy	user 81.8 (57.3 - 93.8), producer 100.0 (NA)
Group map class accuracy	user 81.8 (57.3 - 93.8), producer 100.0 (76.9 - 100.0)
Management map class accuracy	user 81.8 (57.3 - 93.8), producer 100.0 (76.9 - 100.0)
Macrogroup map class accuracy	user 81.8 (57.3 - 93.8), producer 100.0 (76.9 - 100.0)
Documentation for base map class	2 2003 relevés, 0 1996 relevés, 12 AA observation sites

B3 Blue Sage Dwarf-Shrubland



Figure G5. Ground photo for map class B3, Blue Sage Dwarf-Shrubland.

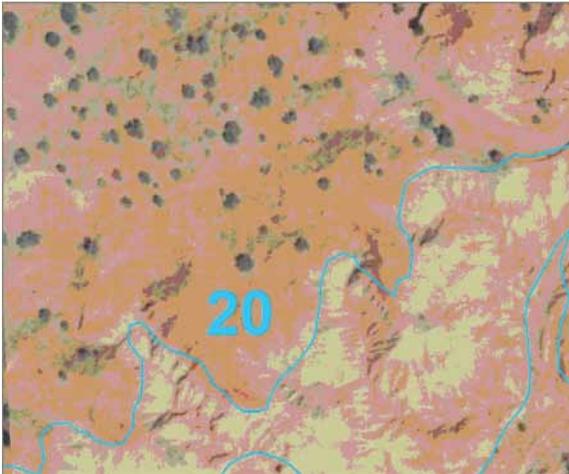


Figure G6. Photosignature for map class B3, Blue Sage Dwarf-Shrubland.

Location: This map class was restricted to Chinde Mesa and its associated drainages. It occurred on the steep slopes of the mesa.

Photosignature: This map class commonly occurred on deep, red clay soils. The shrubs appeared as grayish green, small, regularly spaced specks. *Salvia pachyphylla* was not easily distinguishable from other shrubs on the photos. Field data and locality information were used to determine the extent of this map class in the Chinde Mesa area. This map class also had occasional *Juniperus osteosperma* and *Pinus edulis* trees that appeared as large, globular trees that gradated from higher elevations.

Plant communities	<i>Salvia pachyphylla</i> Dwarf-shrubland
Group map class	Inter-Mountain Basins Shale Badland (1 of 5)
Management map class	Blue Sage Dwarf-shrubland (1 of 1)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	6
Number of map units in park & environs	12
Number of map units less than 0.5 ha	4 (0.8% of total map class area)
Area of map class in park	69.2 ha / 171.0 ac
Total area of map class	122.8 ha / 303.5 ac
Proportion of land cover in park	0.2%
Proportion of map class in project environs	43.7%
Base map class accuracy	user 100.0 (68.9 - 100.0), producer 100.0 (68.9 - 100.0)
Group map class accuracy	user 60.2 (51.5 - 68.4), producer 62.4 (53.5 - 70.5)
Management map class accuracy	user 100.0 (68.9 - 100.0), producer 100.0 (68.9 - 100.0)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	2 2003 relevés, 0 1996 relevés, 6 AA observation sites

B4 Cliff-rose - Crispleaf Buckwheat Shrubland



Figure G7. Ground photo for map class B4, Cliff-rose - Crispleaf Buckwheat Shrubland.

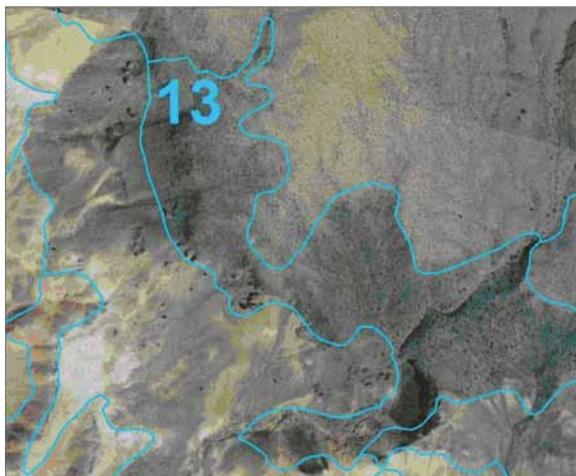


Figure G8. Photosignature for map class B4, Cliff-rose - Crispleaf Buckwheat Shrubland.

Location: Cliff-rose - Crispleaf Buckwheat Shrubland was restricted to Headquarters Mesa on the basalt-capped terraces.

Photosignature: This map class was distinguished by the dark color of the underlying basaltic soils. *Purshia stansburiana* appeared on the photos as a large, dark green, scraggly shrub, and it occurred in low abundance with a patchy distribution. The understory, including *Eriogonum corymbosum*, was not easy to distinguish and typically looked like a mixture of dark green shrubs between the basaltic rocks.

Plant communities	<i>Purshia stansburiana</i> - <i>Eriogonum corymbosum</i> Shrubland
Group map class	Colorado Plateau Mixed Bedrock and Tableland (1 of 3)
Management map class	Cliff-rose - Crispleaf Buckwheat Shrubland (1 of 1)
Macrogroup map class	Colorado Plateau Mixed Bedrock and Tableland (1 of 3)
Number of map units in park	11
Number of map units in park & environs	11
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	57.1 ha / 141.1 ac
Total area of map class	57.1 ha / 141.1 ac
Proportion of land cover in park	0.2%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 66.7 (43.1 - 84.1), producer 88.9 (62.3 - 97.5)
Group map class accuracy	user 52.9 (41.6 - 64.0), producer 73.0 (59.7 - 83.1)
Management map class accuracy	user 66.7 (43.1 - 84.1), producer 88.9 (62.3 - 97.5)
Macrogroup map class accuracy	user 52.9 (41.6 - 64.0), producer 77.1 (63.8 - 86.6)
Documentation for base map class	5 2003 relevés, 0 1996 relevés, 7 AA observation sites

B5 Copperweed - Alkali Sacaton Shrubland



Figure G9. Ground photo for map class B5, Copperweed - Alkali Sacaton Shrubland

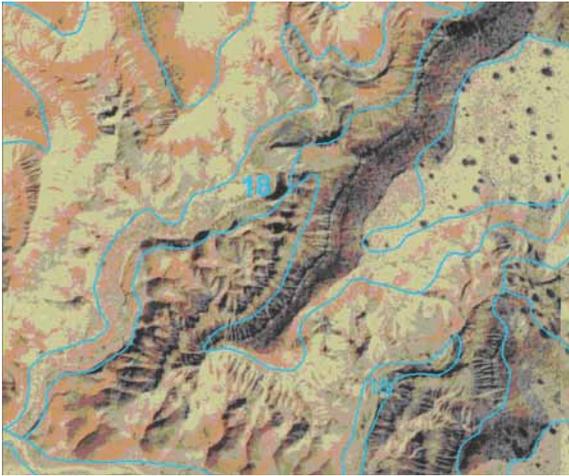


Figure G10. Photosignature for map class B5, Copperweed - Alkali Sacaton Shrubland.

Location: Copperweed - Alkali Sacaton Shrubland was only mapped in two locations, both near the one classification relevé measured of this map class. This community type was not easily identified on aerial photography and was delineated based on field data from the southwestern slopes of Chinde Mesa. This map class occurred on the bank of a wash and likely occurs in small patches in other areas.

Photosignature: The photosignature consisted of a dense patch of vegetation along the banks and in the middle of a wash. The vegetation appeared to be a bright green, homogenous color. This signature is typical of washes, and since it was not distinct enough to identify in other areas, we restricted our delineations of this map class to the one area with field data and extrapolated from there.

Plant communities	<i>Iva acerosa</i> - <i>Sporobolus airoides</i> Shrubland
Group map class	Inter-Mountain Basins Wash (1 of 6)
Management map class	Vegetated Wash Complex (1 of 6)
Macrogroup map class	Inter-Mountain Basins Wash (1 of 6)
Number of map units in park	2
Number of map units in park & environs	2
Number of map units less than 0.5 ha	1 (12.1% of total map class area)
Area of map class in park	2.0 ha / 4.9 ac
Total area of map class	2.0 ha / 4.9 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 0.0, producer 0.0
Group map class accuracy	user 66.3 (57.7 - 73.9), producer 69.4 (60.7 - 76.9)
Management map class accuracy	user 70.2 (61.5 - 77.7), producer 80.8 (72.2 - 87.2)
Macrogroup map class accuracy	user 66.3 (57.5 - 73.9), producer 69.4 (60.7 - 76.9)
Documentation for base map class	1 2003 relevés, 0 1996 relevés, 2 AA observation sites

B6 Coyote Willow Shrubland



Figure G11. Ground photo for map class B6, Coyote Willow Shrubland.

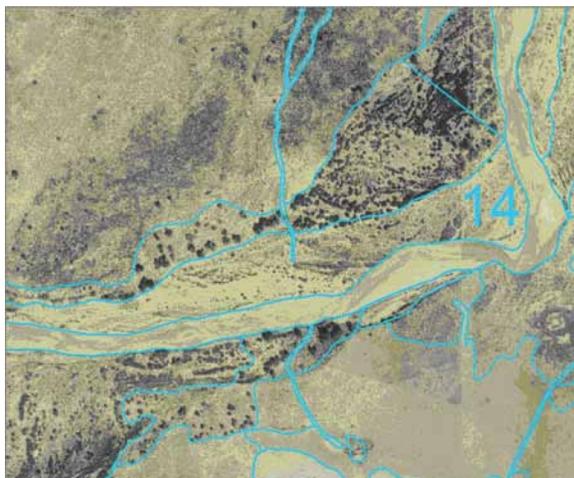


Figure G12. Photosignature for map class B6, Coyote Willow Shrubland.

Location: Coyote Willow Shrubland occurred in a few small patches near the Puerco River in the park and several map units in the park environs. This map class had higher abundance and coverage outside the park boundary. It requires habitats with periodic stream flow.

Photosignature: This type appeared as pale green, shrubby vegetation of medium height on islands in the channels of the Puerco River and large tributaries and along their margins. It often occurred alongside young saltcedar stands.

Plant communities	<i>Salix exigua</i> / Barren Shrubland
Group map class	Inter-Mountain Basins Riparian Woodland and Shrubland (1 of 3)
Management map class	Coyote Willow Shrubland (1 of 1)
Macrogroup map class	Inter-Mountain Basins Riparian Woodland and Shrubland (1 of 3)
Number of map units in park	3
Number of map units in park & environs	6
Number of map units less than 0.5 ha	4 (7.7% of total map class area)
Area of map class in park	2.2 ha / 5.4 ac
Total area of map class	13.2 ha / 32.5 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	83.4%
Base map class accuracy	user 100.0 (27.0 - 100.0), producer 100.0 (27.0 - 100.0)
Group map class accuracy	user 40.9 (25.6 - 58.2), producer 81.8 (57.3 - 93.8)
Management map class accuracy	user 100.0 (27.0 - 100.0), producer 100.0 (27.0 - 100.0)
Macrogroup map class accuracy	user 40.9 (25.6 - 58.2), producer 81.8 (57.3 - 93.8)
Documentation for base map class	2 2003 relevés, 0 1996 relevés, 1 AA observation sites

B7 Drummond Goldenweed - Galleta Shrubland



Figure G13. Ground photo for map class B7, Drummond Goldenweed - Galleta Shrubland.

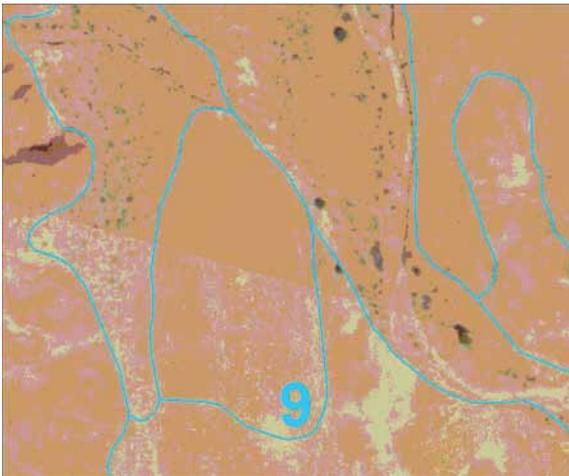


Figure G14. Photosignature for map class B7, Drummond Goldenweed - Galleta Shrubland.

Location: This map class typically occurred in washes and areas with temporary stream flow. Only one relevé was sampled of this map class and it is known to occur on the terrace between two washes.

Photosignature: This map class did not have a distinct tone, texture, or color. It was identified solely by field observation.

Plant communities	<i>Isocoma drummondii</i> - <i>Pleuraphis jamesii</i> Shrubland
Group map class	Inter-Mountain Basins Wash (1 of 6)
Management map class	Vegetated Wash Complex (1 of 6)
Macrogroup map class	Inter-Mountain Basins Wash (1 of 6)
Number of map units in park	0
Number of map units in park & environs	1
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	0.0 ha / 0.0 ac
Total area of map class	0.8 ha / 1.9 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	100.0%
Base map class accuracy	user NS, producer 0.0
Group map class accuracy	user 66.3 (57.7 - 73.9), producer 69.4 (60.7 - 76.9)
Management map class accuracy	user 70.2 (61.5 - 77.7), producer 80.8 (72.2 - 87.2)
Macrogroup map class accuracy	user 66.3 (57.5 - 73.9), producer 69.4 (60.7 - 76.9)
Documentation for base map class	1 2003 relevés, 3 1996 relevés, 8 AA observation sites

B8 Four-wing Saltbush / Galleta Shrubland



Figure G15. Ground photo for map class B8, Four-wing Saltbush / Galleta Shrubland.



Figure G16. Photosignature for map class B8, Four-wing Saltbush / Galleta Shrubland.

Location: This map class was one of the most common steppe vegetation communities in the mapping area. It occurred throughout the project area on sandy soils and sand dunes. The only areas in the park that seemed to lack this map class were locations with sparse badland clay soils.

Photosignature: *Atriplex canescens* appeared as a distinct, crisp speck on the photos. It tended to have a brownish green appearance. Although the sandy soils tended to mask the graminoids, the photosignature for this type often included patches of dense, green grasses. *Pleuraphis jamesii* cannot be isolated from other grass species, so the understory for this map class is a mix of herbaceous species. The understory often appeared as a light reddish/tan/brownish color and had a smooth appearance. Depending on where this community occurred, the abundance and cover of shrubs varies.

Plant communities	<i>Atriplex canescens</i> / <i>Pleuraphis jamesii</i> Shrubland
Group map class	Southern Colorado Plateau Sand Shrubland (1 of 2)
Management map class	Sandsage - Fourwing Saltbush Colorado Plateau Shrubland (1 of 2)
Macrogroup map class	Southern Colorado Plateau Sand Shrubland (1 of 2)
Number of map units in park	635
Number of map units in park & environs	803
Number of map units less than 0.5 ha	217 (0.8% of total map class area)
Area of map class in park	5473.8 ha / 13526.2 ac
Total area of map class	7339.8 ha / 18137.0 ac
Proportion of land cover in park	14.4%
Proportion of map class in project environs	25.4%
Base map class accuracy	user 40.0 (26.7 - 54.9), producer 26.7 (17.4 - 38.9)
Group map class accuracy	user 67.8 (57.2 - 76.8), producer 55.6 (45.9 - 64.8)
Management map class accuracy	user 67.8 (57.3 - 76.8), producer 55.6 (45.9 - 64.8)
Macrogroup map class accuracy	user 67.8 (57.2 - 76.8), producer 56.3 (46.6 - 65.6)
Documentation for base map class	4 2003 relevés, 5 1996 relevés, 51 AA observation sites

B9 Greasewood / New Mexico Saltbush Shrubland



Figure G17. Ground photo for map class B9, Greasewood / New Mexico Saltbush Shrubland

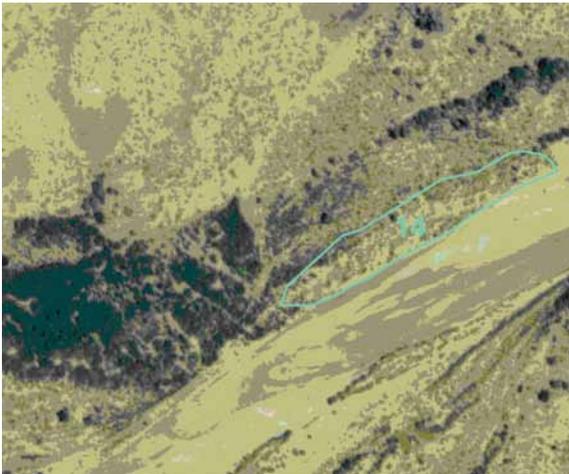


Figure G18. Photosignature for map class B9, Greasewood / New Mexico Saltbush Shrubland.

Location: This type occurred in the Puerco River corridor in areas with high salinity and periodic water flow.

Photosignature: *Sarcobatus vermiculatus* shrubs occurred as bright green, large, smooth shrubs. The spaces between the shrubs were often bright white, due to the high soil salinity. *Sarcobatus vermiculatus* also appeared to have a sprawling pattern. This map class also had smaller, light green, speckled shrubs of *Atriplex obovata* that were occasionally visible, depending on their contrast with the soil coloration.

Plant communities	<i>Sarcobatus vermiculatus</i> / <i>Atriplex obovata</i> Shrubland
Group map class	Inter-Mountain Basins Greasewood Flat (1 of 3)
Management map class	Greasewood Flats (1 of 3)
Macrogroup map class	Inter-Mountain Basins Greasewood Flat (1 of 3)
Number of map units in park	42
Number of map units in park & environs	48
Number of map units less than 0.5 ha	6 (0.8% of total map class area)
Area of map class in park	186.5 ha / 460.8 ac
Total area of map class	212.3 ha / 524.6 ac
Proportion of land cover in park	0.5%
Proportion of map class in project environs	12.2%
Base map class accuracy	user 41.9 (28.6 - 56.6), producer 81.3 (61.2 - 92.2)
Group map class accuracy	user 47.1 (36.0 - 58.4), producer 85.7 (71.7 - 93.4)
Management map class accuracy	user 47.1 (36.0 - 58.4), producer 85.7 (71.7 - 93.4)
Macrogroup map class accuracy	user 47.1 (36.0 - 58.4), producer 85.7 (71.7 - 93.4)
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 15 AA observation sites

B10 Greasewood / Shrubby Seepweed Shrubland



Figure G19. Ground photo for map class B10, Greasewood / Shrubby Seepweed Shrubland

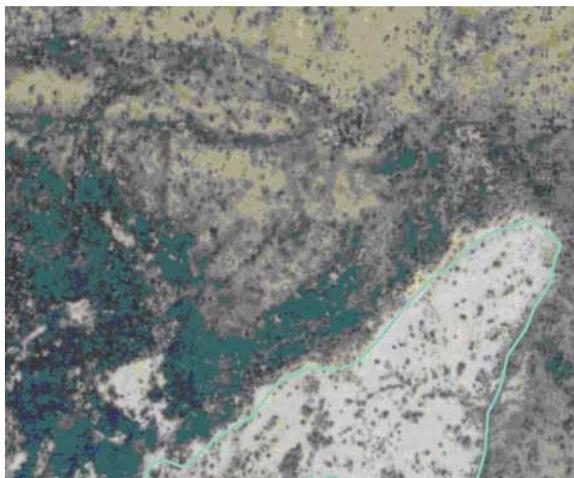


Figure G20. Photosignature for map class B10, Greasewood / Shrubby Seepweed Shrubland.

Location: This type was found in low areas of poor drainage and high salinity, with periodic water flow. The areas were located south of the Puerco River in the river corridor.

Photosignature: *Sarcobatus vermiculatus* shrubs appeared as large, bright green, and smooth on the aerial photos. *Suaeda torreyana* were small, slightly darker, and less rounded than *Atriplex obovata*. This type occurred in proximity to Greasewood / New Mexico Saltbush Shrubland.

Plant communities	<i>Sarcobatus vermiculatus</i> / <i>Suaeda moquinii</i> Shrubland
Group map class	Inter-Mountain Basins Greasewood Flat (1 of 3)
Management map class	Greasewood Flats (1 of 3)
Macrogroup map class	Inter-Mountain Basins Greasewood Flat (1 of 3)
Number of map units in park	2
Number of map units in park & environs	3
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	6.3 ha / 15.6 ac
Total area of map class	7.4 ha / 18.3 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	14.9%
Base map class accuracy	user 100.0 (27.0 - 100.0), producer 20.0 (4.6 - 56.5)
Group map class accuracy	user 47.1 (36.0 - 58.4), producer 85.7 (71.7 - 93.4)
Management map class accuracy	user 47.1 (36.0 - 58.4), producer 85.7 (71.7 - 93.4)
Macrogroup map class accuracy	user 47.1 (36.0 - 58.4), producer 85.7 (71.7 - 93.4)
Documentation for base map class	1 2003 relevés, 0 1996 relevés, 5 AA observation sites

B11 Iodine Bush Shrubland



Figure G21. Ground photo for map class B11, Iodine Bush Shrubland.

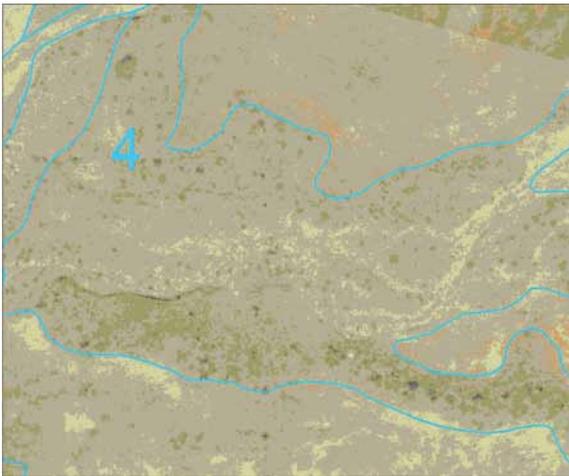


Figure G22. Photosignature for map class B11, Iodine Bush Shrubland.

Location: *Allenrolfea occidentalis* typically occurred in areas with saline and alkaline soils, mostly where there was temporary stream flow. It was mapped in the Painted Desert Wilderness area in larger washes and areas with sheetflow.

Photosignature: *Allenrolfea occidentalis* appeared as a dark green, globular shrub on the photos. Since it was the dominant shrub in this map class with little other vegetative cover, this map class had large spaces between the shrubs, creating a mottled signature. The other prominent feature in this map class was the soil. The soil was often whitish due to the high salt content. Evidence of intermittent stream flow was also apparent on the photos, with water flow patterns appearing as striations on the whitish soils.

Plant communities	<i>Allenrolfea occidentalis</i> Shrubland
Group map class	Inter-Mountain Basins Greasewood Flat (1 of 3)
Management map class	Greasewood Flats (1 of 3)
Macrogroup map class	Inter-Mountain Basins Greasewood Flat (1 of 3)
Number of map units in park	25
Number of map units in park & environs	27
Number of map units less than 0.5 ha	9 (4.6% of total map class area)
Area of map class in park	49.6 ha / 122.6 ac
Total area of map class	56.1 ha / 138.7 ac
Proportion of land cover in park	0.1%
Proportion of map class in project environs	11.6%
Base map class accuracy	user 21.1 (9.8 - 39.5), producer 66.7 (34.7 - 88.3)
Group map class accuracy	user 47.1 (36.0 - 58.4), producer 85.7 (71.7 - 93.4)
Management map class accuracy	user 47.1 (36.0 - 58.4), producer 85.7 (71.7 - 93.4)
Macrogroup map class accuracy	user 47.1 (36.0 - 58.4), producer 85.7 (71.7 - 93.4)
Documentation for base map class	1 2003 relevés, 0 1996 relevés, 8 AA observation sites

B12 Rubber Rabbitbrush Desert Wash Shrubland



Figure G23. Ground photo for map class B12, Rubber Rabbitbrush Desert Wash Shrubland.

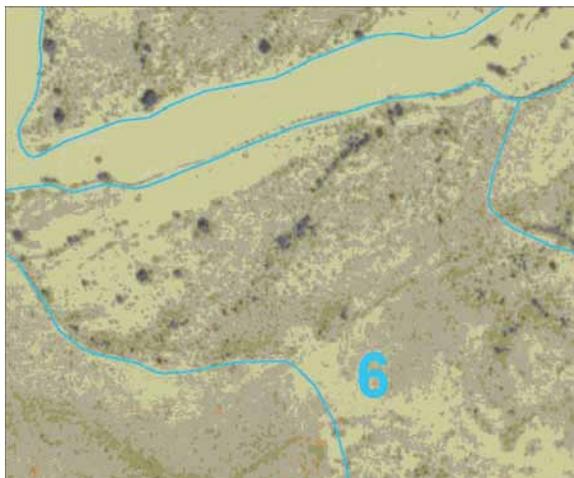


Figure G24. Photosignature for map class B12, Rubber Rabbitbrush Desert Wash Shrubland.

Location: This map class was almost always restricted to areas adjacent to washes. It typically occurred on terraces, banks of washes, or in areas with temporary stream flow, including the tributary washes of the Puerco River, Dry Wash, Cottonwood Wash, and Jim Camp Wash.

Photosignature: This map class was distinguished by the large shrub *Ericameria nauseosa*. This shrub was often much larger than the surrounding vegetation. *Ericameria nauseosa* tended to have a light green color and a fairly smooth texture. The associated vegetation varied significantly depending on the location. In some areas, high shrub and herbaceous cover could be seen. However, in all areas of this map class the tall height of *Ericameria nauseosa* stood out in contrast to the height of other shrubs.

Plant communities	<i>Ericameria nauseosa</i> Desert Wash Shrubland
Group map class	Inter-Mountain Basins Wash (1 of 6)
Management map class	Vegetated Wash Complex (1 of 6)
Macrogroup map class	Inter-Mountain Basins Wash (1 of 6)
Number of map units in park	161
Number of map units in park & environs	224
Number of map units less than 0.5 ha	55 (2.7% of total map class area)
Area of map class in park	343.5 ha / 848.9 ac
Total area of map class	508.4 ha / 1256.4 ac
Proportion of land cover in park	0.9%
Proportion of map class in project environs	32.4%
Base map class accuracy	user 35.5 (23.0 - 50.3), producer 64.7 (44.9 - 80.5)
Group map class accuracy	user 66.3 (57.7 - 73.9), producer 69.4 (60.7 - 76.9)
Management map class accuracy	user 70.2 (61.5 - 77.7), producer 80.8 (72.2 - 87.2)
Macrogroup map class accuracy	user 66.3 (57.5 - 73.9), producer 69.4 (60.7 - 76.9)
Documentation for base map class	8 2003 relevés, 10 1996 relevés, 17 AA observation sites

B13 Sandsage Colorado Plateau Shrubland



Figure G25. Ground photo for map class B13, Sandsage Colorado Plateau Shrubland.

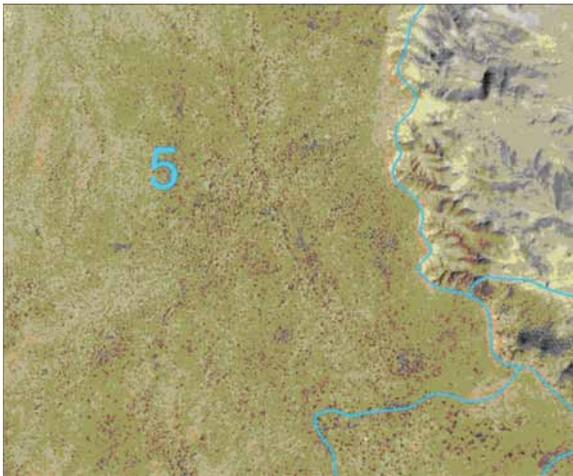


Figure G26. Photostsignature for map class B13, Sandsage Colorado Plateau Shrubland.

Location: This map class occurred frequently throughout the park. It mainly occurred on sandy soils and on sand dunes. This map class was one of the most common map classes outside of the badlands, occurring in areas with alluvial soil development. The highest number of map units occurred in the park and its environs from the central hourglass portion to the southern project boundary.

Photosignature: *Artemisia filifolia* appeared as a soft, smooth, gray green shrub. It typically appeared on the photos as a regularly spaced shrub. The herbaceous and associated species in the shrub layer were highly variable. In some areas, small shrubs could co-occur with *Artemisia filifolia*, which appeared as a smooth, light brown herbaceous cover, and/or a sparse understory. The most reliable feature of this map class was typically the sandy soils. The sandy soils were light brown with a soft texture. In areas with active sand dunes, the bumpy relief of the dunes was apparent on the photos.

Plant communities	<i>Artemisia filifolia</i> Colorado Plateau Shrubland
Group map class	Southern Colorado Plateau Sand Shrubland (1 of 2)
Management map class	Sandsage - Fourwing Saltbush Colorado Plateau Shrubland (1 of 2)
Macrogroup map class	Southern Colorado Plateau Sand Shrubland (1 of 2)
Number of map units in park	747
Number of map units in park & environs	1032
Number of map units less than 0.5 ha	413 (2.3% of total map class area)
Area of map class in park	2577.8 ha / 6369.8 ac
Total area of map class	4492.3 ha / 11100.8 ac
Proportion of land cover in park	6.8%
Proportion of map class in project environs	42.6%
Base map class accuracy	user 58.6 (43.5 - 72.3), producer 63.0 (47.2 - 76.4)
Group map class accuracy	user 67.8 (57.2 - 76.8), producer 55.6 (45.9 - 64.8)
Management map class accuracy	user 67.8 (57.3 - 76.8), producer 55.6 (45.9 - 64.8)
Macrogroup map class accuracy	user 67.8 (57.2 - 76.8), producer 56.3 (46.6 - 65.6)
Documentation for base map class	8 2003 relevés, 6 1996 relevés, 28 AA observation sites

B14 Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland



Figure G27. Ground photo for map class B14, Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland.

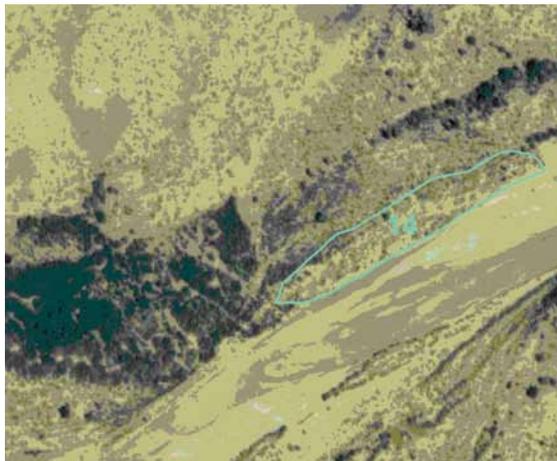


Figure G28. Photosignature for map class B14, Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland.

Location: This map class commonly occurs in disturbed areas. It occurred outside of the park boundary in areas with grazing impacts and within the park in areas with human disturbance, such as along pipelines, road corridors, and near developments.

Photosignature: *Gutierrezia sarothrae* appeared as a mottled, patchy signature of a greenish brown shrub. It often appeared to have a low cover of herbaceous species. The light brownish hue may have indicated *Pleuraphis jamesii*. In some areas, the total vegetation cover was low and the low cover was characteristic of this class. This map class tended to occur on deep, red clay soil. This signature was not particularly strong and its identification was often based on field data and extrapolated to surrounding areas.

Plant communities	<i>Gutierrezia sarothrae</i> - (<i>Opuntia</i> spp.) / <i>Pleuraphis jamesii</i> Dwarf-shrubland
Group map class	Inter-Mountain Basins Semi-Desert Shrub-Steppe (1 of 5)
Management map class	Alkali Sacaton Steppe and Mixed Grasslands (1 of 8)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	30
Number of map units in park & environs	48
Number of map units less than 0.5 ha	4 (0.2% of total map class area)
Area of map class in park	169.7 ha / 419.4 ac
Total area of map class	438.7 ha / 1084.1 ac
Proportion of land cover in park	0.4%
Proportion of map class in project environs	61.3%
Base map class accuracy	user 0.0, producer NS
Group map class accuracy	user 41.8 (34.7 - 49.2), producer 38.1 (31.5 - 45.1)
Management map class accuracy	user 73.0 (66.9 - 78.3), producer 64.0 (58.0 - 69.5)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	2 2003 relevés, 13 1996 relevés, 0 AA observation sites

B15 Tamarisk Shrubland



Figure G29. Ground photo for map class B15, Tamarisk Shrubland.

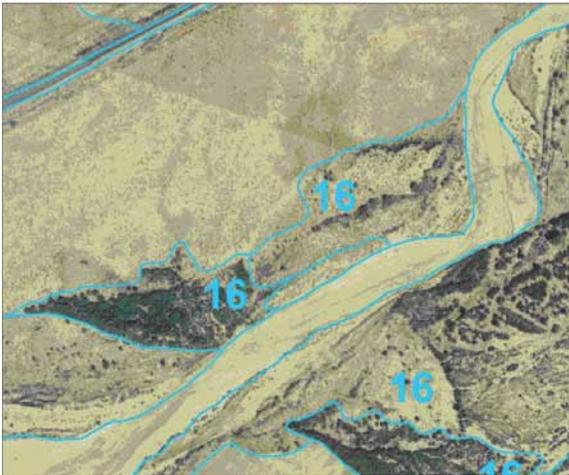


Figure G30. Photosignature for map class B15, Tamarisk Shrubland.

Location: Tamarisk Shrubland occurred in small patches along riparian corridors, predominately in the Puerco River corridor, and in small patches in the northern wilderness area in areas with a high water table. It is also known to occur in areas with human development, such as near residences and stock ponds.

Photosignature: *Tamarix* spp. appeared as small tree with a smooth texture and a bright green crown. It often occurred in thick patches or linear stands, without any other obvious understory species.

Plant communities	<i>Tamarix</i> spp. Semi-Natural Temporarily Flooded Shrubland
Group map class	Inter-Mountain Basins Riparian Woodland and Shrubland (1 of 3)
Management map class	Vegetated Wash Complex (1 of 6)
Macrogroup map class	Inter-Mountain Basins Riparian Woodland and Shrubland (1 of 3)
Number of map units in park	30
Number of map units in park & environs	59
Number of map units less than 0.5 ha	19 (3.0% of total map class area)
Area of map class in park	62.0 ha / 153.3 ac
Total area of map class	154.6 ha / 382.1 ac
Proportion of land cover in park	0.2%
Proportion of map class in project environs	59.9%
Base map class accuracy	user 31.6 (17.3 - 50.4), producer 85.7 (54.8 - 96.7)
Group map class accuracy	user 40.9 (25.6 - 58.2), producer 81.8 (57.3 - 93.8)
Management map class accuracy	user 70.2 (61.5 - 77.7), producer 80.8 (72.2 - 87.2)
Macrogroup map class accuracy	user 40.9 (25.6 - 58.2), producer 81.8 (57.3 - 93.8)
Documentation for base map class	2 2003 relevés, 1 1996 relevés, 6 AA observation sites

B16 Three-leafed Sumac - Mormon Tea Talus Shrubland



Figure G31. Ground photo for map class B16, Three-leafed Sumac - Mormon Tea Talus Shrubland.

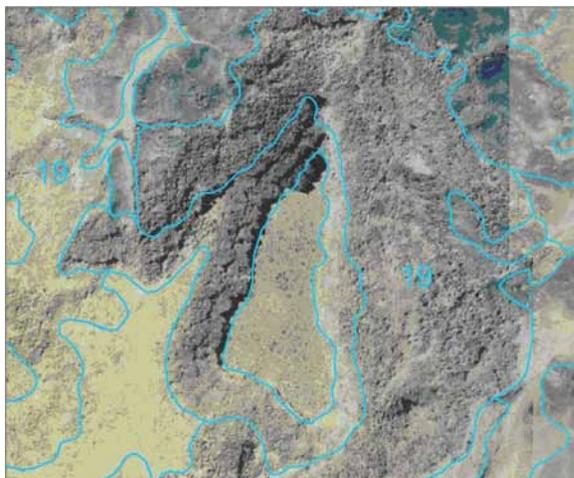


Figure G32. Photosignature for map class B16, Three-leafed Sumac - Mormon Tea Talus Shrubland.

Location: Mormon Tea - Three-leafed Sumac Talus Shrubland occurred in a few small areas throughout the mapping area, including the southwestern corner of the northern section of the park, the northwestern corner of the southern section of the park near Jasper Forest, and in several rocky outcrops in the southern section of the park south of Jasper Forest. It was found on talus slopes and often in areas with large sandstone boulders.

Photosignature: Large boulders and bedrock were the most distinct features in this map class. They appeared as large blocks on the edges and slopes of mesas. *Ephedra viridis* and *Rhus trilobata* both appeared as a deep green color. The talus slopes were often sparsely vegetated with a few individual specks of shrubs scattered between the boulder cracks. Because it was difficult to distinguish different plant characteristics among the talus slopes, this class was often lumped in with the Rim Complex.

Plant communities	<i>Rhus trilobata</i> - <i>Ephedra</i> (<i>viridis</i> , <i>torreyana</i>) Talus Shrubland
Group map class	Colorado Plateau Mixed Bedrock and Tableland (1 of 3)
Management map class	Vegetated Rim Complex (1 of 4)
Macrogroup map class	Colorado Plateau Mixed Bedrock and Tableland (1 of 3)
Number of map units in park	19
Number of map units in park & environs	24
Number of map units less than 0.5 ha	6 (1.3% of total map class area)
Area of map class in park	36.2 ha / 89.5 ac
Total area of map class	98.3 ha / 242.8 ac
Proportion of land cover in park	0.1%
Proportion of map class in project environs	63.2%
Base map class accuracy	user 9.1 (2.1 - 32.3), producer 20.0 (4.6 - 56.5)
Group map class accuracy	user 52.9 (41.6 - 64.0), producer 73.0 (59.7 - 83.1)
Management map class accuracy	user 72.4 (63.9 - 79.5), producer 77.8 (69.0 - 84.2)
Macrogroup map class accuracy	user 52.9 (41.6 - 64.0), producer 77.1 (63.8 - 86.6)
Documentation for base map class	3 2003 relevés, 0 1996 relevés, 5 AA observation sites

B17 Winter-fat / Blue Grama Dwarf-shrubland



Figure G33. Ground photo for map class B17, Winter-fat / Blue Grama Dwarf-shrubland.

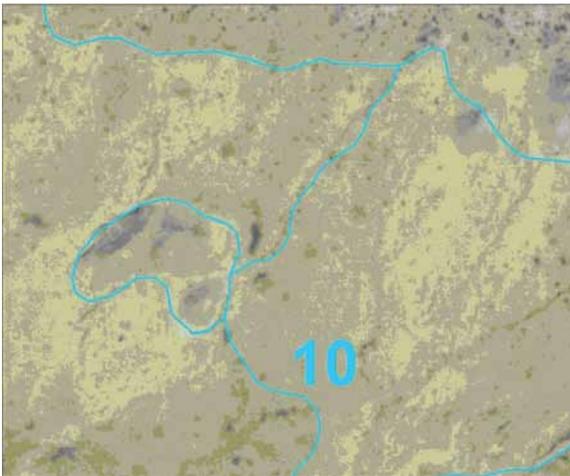


Figure G34. Photosignature for map class B17, Winter-fat / Blue Grama Dwarf-shrubland.

Location: Winter-fat / Blue Grama Dwarf-shrubland was mapped at one location in the park: northeast of The Flattops. This map class occurred intermittently in the sandy soils of the project area.

Photosignature: *Krascheninnikovia lanata* tended to appear on the photos as a dark, gray green, smooth dwarf-shrub. In some areas the interspaces have a tan or pale tan color and a smooth texture, indicating herbaceous bunch grasses and sandy soils. *Bouteloua gracilis* was not distinguishable from other grasses and was not easily identifiable on the photos. In other areas, the cover of *Krascheninnikovia lanata* was particularly high and the texture appeared smooth with one solid, gray green color.

Plant communities	<i>Krascheninnikovia lanata</i> / <i>Bouteloua gracilis</i> Dwarf-shrub Herbaceous Vegetation
Group map class	Inter-Mountain Basins Semi-Desert Shrub-Steppe (1 of 5)
Management map class	Blue Grama Steppe and Mixed Grasslands (1 of 3)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	1
Number of map units in park & environs	1
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	3.0 ha / 7.4 ac
Total area of map class	3.0 ha / 7.4 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 0.0 (NA), producer 0.0 (NA)
Group map class accuracy	user 41.8 (34.7 - 49.2), producer 38.1 (31.5 - 45.1)
Management map class accuracy	user 40.0 (22.3 - 60.7), producer 27.3 (14.8 - 44.7)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	1 2003 relevés, 0 1996 relevés, 6 AA observation sites

B18 Alkali Sacaton Herbaceous Vegetation



Figure G35. Ground photo for map class B18, Alkali Sacaton Herbaceous Vegetation.

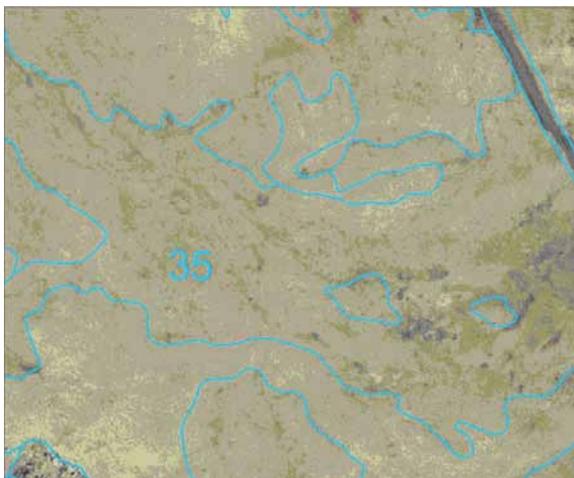


Figure G36. Photosignature for map class B18, Alkali Sacaton Herbaceous Vegetation.

Location: Alkali Sacaton Herbaceous Vegetation occurred in small patches throughout the project area. This map class mainly occurred in the grasslands in the northeastern, central, and southern sections of the park. It was often found in habitats with a little extra moisture such as areas with periodic sheet flow and in small drainages.

Photosignature: This photosignature stands out in the short-grass prairie. It commonly appeared in dense linear patches that follow small washes or sheet-flow features. The color tended to be a light yellow to greenish brown. Although *Sporobolus airoides* commonly occurred throughout the park, this map class tended to have a higher cover and could be easily distinguished from mixed herbaceous associations of the adjacent map classes.

Plant communities	<i>Sporobolus airoides</i> Southern Plains Herbaceous Vegetation
Group map class	Inter-Mountain Basins Semi-Desert Grassland (1 of 7)
Management map class	Alkali Sacaton Steppe and Mixed Grasslands (1 of 8)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	47
Number of map units in park & environs	59
Number of map units less than 0.5 ha	24 (4.6% of total map class area)
Area of map class in park	92.3 ha / 228.0 ac
Total area of map class	125.3 ha / 309.6 ac
Proportion of land cover in park	0.2%
Proportion of map class in project environs	26.3%
Base map class accuracy	user 20.0 (10.1 - 35.8), producer 13.5 (6.7 - 25.3)
Group map class accuracy	user 69.3 (60.8 - 76.7), producer 44.9 (38.0 - 51.9)
Management map class accuracy	user 73.0 (66.9 - 78.3), producer 64.0 (58.0 - 69.5)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	2 2003 relevés, 3 1996 relevés, 36 AA observation sites

B19 Alkali Sacaton - Blue Grama Herbaceous Vegetation



Figure G37. Ground photo for map class B19, Alkali Sacaton - Blue Grama Herbaceous Vegetation.

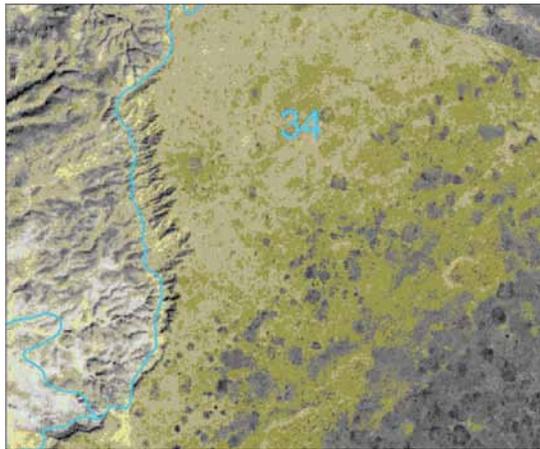


Figure G38. Photosignature for map class B19, Alkali Sacaton - Blue Grama Herbaceous Vegetation.

Location: Alkali Sacaton - Blue Grama Herbaceous Vegetation occurred throughout the project area. Three main areas of this association occurred, including the northeastern section of the project area, the central neck area between the Puerco River and Interstate 40, and east of The Flattops. This map class was almost equally distributed between the NPS land and the project environs.

Photosignature: Grass species were not easily identifiable on the aerial photography. The photosignature appeared to have a smooth texture and depending on the herbaceous cover, the color appeared to have a green to grayish brown color. This map class was difficult to distinguish from the most of the other short-grass herbaceous map classes. It was most commonly identified during the photointerpretation from the field data collection and extrapolated from these locations.

Plant communities	<i>Sporobolus airoides</i> - <i>Bouteloua gracilis</i> Herbaceous Vegetation
Group map class	Inter-Mountain Basins Semi-Desert Grassland (1 of 7)
Management map class	Alkali Sacaton Steppe and Mixed Grasslands (1 of 8)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	24
Number of map units in park & environs	42
Number of map units less than 0.5 ha	12 (0.9% of total map class area)
Area of map class in park	284.2 ha / 702.3 ac
Total area of map class	377.1 ha / 931.8 ac
Proportion of land cover in park	0.7%
Proportion of map class in project environs	24.6%
Base map class accuracy	user 37.5 (20.8 - 57.8), producer 15.0 (8.0 - 26.5)
Group map class accuracy	user 69.3 (60.8 - 76.7), producer 44.9 (38.0 - 51.9)
Management map class accuracy	user 73.0 (66.9 - 78.3), producer 64.0 (58.0 - 69.5)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	7 2003 relevés, 6 1996 relevés, 41 AA observation sites

B20 Black Grama - Galleta Herbaceous Vegetation



Figure G39. Ground photo for map class B20, Black Grama - Galleta Herbaceous Vegetation.

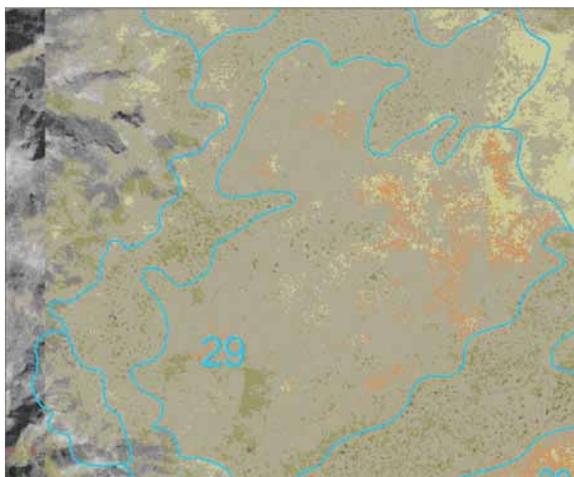


Figure G40. Photosignature for map class B20, Black Grama - Galleta Herbaceous Vegetation.

Location: Black Grama - Galleta Herbaceous Vegetation was only mapped in the park in five locations, four by the northern headquarters office and one in the central neck section of the park.

Photosignature: Because the different grass species (especially the *Bouteloua*) were difficult to distinguish from one another on the aerial photos, this type was not mapped. Black grama was observed to occur in patches in the midst of other vegetation types and was usually incorporated into the surrounding map classes (e.g. Sadsage Colorado Plateau Shrubland).

Plant communities	<i>Bouteloua eriopoda</i> - <i>Pleuraphis jamesii</i> Herbaceous Vegetation
Group map class	Inter-Mountain Basins Semi-Desert Grassland (1 of 7)
Management map class	Alkali Sacaton Steppe and Mixed Grasslands (1 of 8)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	5
Number of map units in park & environs	5
Number of map units less than 0.5 ha	1 (0.8% of total map class area)
Area of map class in park	23.6 ha / 58.3 ac
Total area of map class	23.6 ha / 58.3 ac
Proportion of land cover in park	0.1%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 0.0, producer NS
Group map class accuracy	user 69.3 (60.8 - 76.7), producer 44.9 (38.0 - 51.9)
Management map class accuracy	user 73.0 (66.9 - 78.3), producer 64.0 (58.0 - 69.5)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	4 2003 relevés, 1 1996 relevés, 1 AA observation sites

B21 Blue Grama Herbaceous Vegetation



Figure G41. Ground photo for map class B21, Blue Grama Herbaceous Vegetation.

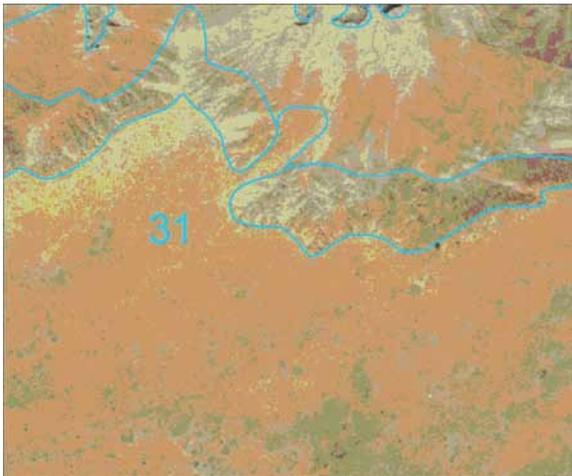


Figure G42. Photostature for map class B21, Blue Grama Herbaceous Vegetation.

Location: Blue Grama Herbaceous Vegetation occurred in a few small patches throughout the mapping area, including the northwestern corner around Pilot Rock, the southwestern portion of the northern half of the park, the central neck area of the project boundary, and the southern half of the park near The Flat-tops and Agate House. The majority of this map class occurred in the project environs, outside of the park boundary.

Photosignature: *Bouteloua gracilis* was not easily identifiable on the aerial photos from other short stature grasses at Petrified Forest NP. Field data was used to extrapolate the boundaries of this map class within adjacent herbaceous communities. This map class had a similar color and texture to other herbaceous map classes. Depending on the soil color and vegetative cover, the color of the map class varied from a light red to a light brown. The vegetation was patchy with low total herbaceous cover in areas. Where the herbaceous cover was present, the grasses had a homogenous texture.

Plant communities	<i>Bouteloua gracilis</i> Herbaceous Vegetation
Group map class	Inter-Mountain Basins Semi-Desert Grassland (1 of 7)
Management map class	Blue Grama Steppe and Mixed Grasslands (1 of 3)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	17
Number of map units in park & environs	28
Number of map units less than 0.5 ha	8 (0.1% of total map class area)
Area of map class in park	33.6 ha / 83.0 ac
Total area of map class	261.1 ha / 645.1 ac
Proportion of land cover in park	0.1% park land cover
Proportion of map class in project environs	87.1%
Base map class accuracy	user 0.0, producer 0.0
Group map class accuracy	user 69.3 (60.8 - 76.7), producer 44.9 (38.0 - 51.9)
Management map class accuracy	user 40.0 (22.3 - 60.7), producer 27.3 (14.8 - 44.7)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	9 2003 relevés, 21 1996 relevés, 2 AA observation sites

B22 Blue Grama - Galleta Herbaceous Vegetation



Figure G43. Ground photo for map class B22, Blue Grama - Galleta Herbaceous Vegetation.

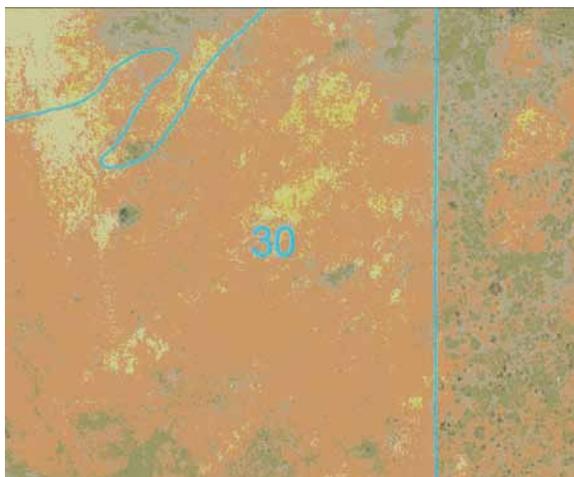


Figure G44. Photosignature for map class B22, Blue Grama - Galleta Herbaceous Vegetation.

Location: Blue Grama - Galleta Herbaceous Vegetation occurred in a few small patches throughout the mapping area, including the northwestern corner around Pilot Rock, the area near the northern headquarters office, central neck area, and in the southern portion of the park.

Photosignature: Individual grass species were not identifiable and together they combined into one solid color, varying from light green to brown. Depending on the soil color, the herbaceous cover was more or less prominent. The texture could be patchy depending on the total vegetation cover.

Plant communities	<i>Bouteloua gracilis</i> - <i>Pleuraphis jamesii</i> Herbaceous Vegetation
Group map class	Inter-Mountain Basins Semi-Desert Grassland (1 of 7)
Management map class	Blue Grama Steppe and Mixed Grasslands (1 of 3)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	17
Number of map units in park & environs	31
Number of map units less than 0.5 ha	4 (0.1% of total map class area)
Area of map class in park	145.0 ha / 358.3 ac
Total area of map class	544.1 ha / 1344.5 ac
Proportion of land cover in park	0.4%
Proportion of map class in project environs	73.4%
Base map class accuracy	user 33.3 (14.2 - 30.2), producer 18.8 (7.8 - 38.8)
Group map class accuracy	user 69.3 (60.8 - 76.7), producer 44.9 (38.0 - 51.9)
Management map class accuracy	user 40.0 (22.3 - 60.7), producer 27.3 (14.8 - 44.7)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	3 2003 relevés, 13 1996 relevés, 16 AA observation sites

B23 Galleta - Alkali Sacaton Herbaceous Vegetation



Figure G45. Ground photo for map class B23, Galleta - Alkali Sacaton Herbaceous Vegetation.

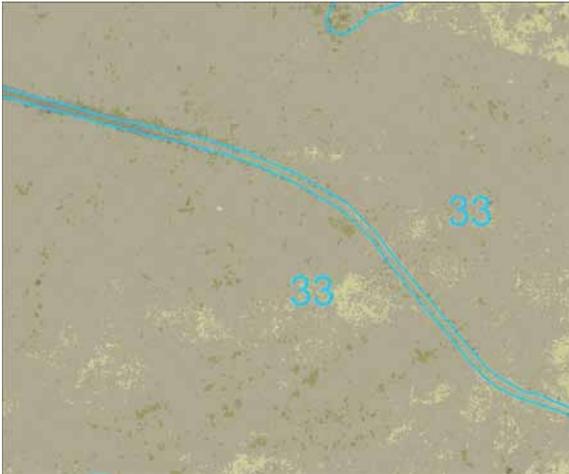


Figure G46. Photosignature for map class B23, Galleta - Alkali Sacaton Herbaceous Vegetation .

Location: Galleta - Alkali Sacaton Herbaceous Vegetation was located throughout the park and project environs. This map class was most abundant in the central and southern parts of the park and was more abundant in both size and number of map units in the park environs than inside the park boundary. It was often found on sandy soils.

Photosignature: This photosignature had a smooth texture and depending on its cover, the color appeared as a green to grayish color. This map class was difficult to distinguish from the other herbaceous map classes and was most commonly identified from the field data collection and extrapolated from these locations. This type commonly occurred in areas adjacent to the Four-wing Saltbush / Galleta Shrubland.

Plant communities	<i>Pleuraphis jamesii</i> - <i>Sporobolus airoides</i> Herbaceous Vegetation
Group map class	Inter-Mountain Basins Semi-Desert Grassland (1 of 7)
Management map class	Alkali Sacaton Steppe and Mixed Grasslands (1 of 8)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	253
Number of map units in park & environs	535
Number of map units less than 0.5 ha	97 (0.7% of total map class area)
Area of map class in park	1586.0 ha / 3919.2 ac
Total area of map class	4143.3 ha / 10238.3 ac
Proportion of land cover in park	4.2%
Proportion of map class in project environs	61.7%
Base map class accuracy	user 55.2 (40.2 - 69.3), producer 37.2 (26.2 - 49.8)
Group map class accuracy	user 69.3 (60.8 - 76.7), producer 44.9 (38.0 - 51.9)
Management map class accuracy	user 73.0 (66.9 - 78.3), producer 64.0 (58.0 - 69.5)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	4 2003 relevés, 29 1996 relevés, 45 AA observation sites

B24 Giant Sandreed Desert Wash Shrub Herbaceous Vegetation



Figure G47. Ground photo for map class B24, Giant Sandreed Desert Wash Shrub Herbaceous Vegetation.



Figure G48. Photosignature for map class B24 Giant Sandreed Desert Wash Shrub Herbaceous Vegetation.

Location: Giant Sandreed Desert Wash Shrub Herbaceous Vegetation was limited to the southern half of the project boundary and was mostly located in Dry Wash and its side drainages. In some cases it was not distinguishable and was likely included in the Wash Complex map class.

Photosignature: This map class had a light yellow signature with a feathery look to the vegetation. It typically occurred along linear corridors, following washes. It was sometimes difficult to distinguish from the adjacent riparian vegetation and may have been included into the Wash Complex map class. This map class was mainly identified from field data and extrapolated out to adjacent areas.

Plant communities	<i>Calamovilfa gigantea</i> Desert Wash Shrub Herbaceous Vegetation
Group map class	Inter-Mountain Basins Wash (1 of 6)
Management map class	Vegetated Wash Complex (1 of 6)
Macrogroup map class	Inter-Mountain Basins Wash (1 of 6)
Number of map units in park	18
Number of map units in park & environs	32
Number of map units less than 0.5 ha	15 (13.6% of total map class area)
Area of map class in park	17.7 ha / 43.7 ac
Total area of map class	33.0 ha / 81.5 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	46.4%
Base map class accuracy	user 0.0, producer NS
Group map class accuracy	user 66.3 (57.7 - 73.9), producer 69.4 (60.7 - 76.9)
Management map class accuracy	user 70.2 (61.5 - 77.7), producer 80.8 (72.2 - 87.2)
Macrogroup map class accuracy	user 66.3 (57.5 - 73.9), producer 69.4 (60.7 - 76.9)
Documentation for base map class	3 2003 relevés, 0 1996 relevés, 0 AA observation sites

B25 New Mexico Saltbush / Alkali Sacaton – Galleta Shrub Herbaceous Vegetation



Figure G49. Ground photo for map class B25, New Mexico Saltbush / Alkali Sacaton – Galleta Shrub Herbaceous Vegetation.



Figure G50. Photosignature for map class B25, New Mexico Saltbush / Alkali Sacaton – Galleta Shrub Herbaceous Vegetation.

Location: New Mexico Saltbush / Galleta - Alkali Sacaton Shrub Herbaceous Vegetation had the largest area mapped of any of the map classes and occurred throughout the park and the environs. This map class tended to favor clay and sandy clay soils; however, it also appeared less commonly in sand dunes or in heavy sandy soils.

Photosignature: This photosignature appeared to have a light tan to brownish gray color. The texture appeared smooth and individual shrubs and grasses were not easily identifiable. This map class was typically used in badlands areas where the vegetation was more than sparse (2-15% cover), where the area appeared to have a shrub component, and where the soils do not mask the vegetation.

Plant communities	<i>Atriplex obovata</i> / <i>Sporobolus airoides</i> - <i>Pleuraphis jamesii</i> Shrub Herbaceous Vegetation
Group map class	Inter-Mountain Basins Semi-Desert Shrub-Steppe (1 of 5)
Management map class	Alkali Sacaton Steppe and Mixed Grasslands (1 of 8)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	607
Number of map units in park & environs	712
Number of map units less than 0.5 ha	117 (0.3% of total map class area)
Area of map class in park	9218.0 ha / 22778.2 ac
Total area of map class	11046.0 ha / 27295.3 ac
Proportion of land cover in park	24.2%
Proportion of map class in project environs	16.5%
Base map class accuracy	user 40.0 (27.7 - 54.9), producer 19.4 (12.5 - 28.8)
Group map class accuracy	user 41.8 (34.7 - 49.2), producer 38.1 (31.5 - 45.1)
Management map class accuracy	user 73.0 (66.9 - 78.3), producer 64.0 (58.0 - 69.5)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	12 2003 relevés, 17 1996 relevés, 62 AA observation sites

B26 Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation



Figure G51. Ground photo for map class B26, Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation.



Figure G52. Photosignature for map class B26, Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation.

Location: Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation occurred in the northwestern and north central sections of the mapping area. It was with heavily abundant in the neck of the mapping area and scattered throughout the southern half of the mapping area. It commonly occurred on sand dunes, in disturbance areas, or on terraces.

Photosignature: This map class was distinguished by the small, green, speckled appearance of *Ericameria nauseosa* and the moderate herbaceous cover. The herbaceous cover tended to have a light brown/yellowish hue with a patchy distribution. *Bouteloua gracilis* likely is a dominant component to the herbaceous understory; however, it could not be distinguished from the other herbaceous cover on the imagery.

Plant communities	<i>Ericameria nauseosa</i> / <i>Bouteloua gracilis</i> Shrub Herbaceous Vegetation
Group map class	Inter-Mountain Basins Active and Stabilized Dune (1 of 2)
Management map class	Alkali Sacaton Steppe and Mixed Grasslands (1 of 8)
Macrogroup map class	Inter-Mountain Basins Active and Stabilized Dune (1 of 2)
Number of map units in park	236
Number of map units in park & environs	338
Number of map units less than 0.5 ha	105 (1.6% of total map class area)
Area of map class in park	850.7 ha / 2102.2 ac
Total area of map class	1530.3 ha / 3781.5 ac
Proportion of land cover in park	2.2%
Proportion of map class in project environs	44.4%
Base map class accuracy	user 6.9 (2.3 - 18.8), producer 40.0 (14.3 - 72.8)
Group map class accuracy	user 36.7 (26.4 - 48.5), producer 78.3 (61.6 - 89.0)
Management map class accuracy	user 73.0 (66.9 - 78.3), producer 64.0 (58.0 - 69.5)
Macrogroup map class accuracy	user 36.7 (26.4 - 48.5), producer 81.8 (65.1 - 92.6)
Documentation for base map class	2 2003 relevés, 0 1996 relevés, 6 AA observation sites

B27 Russian Thistle Sand Dune Vegetation



Figure G53. Ground photo for map class B27, Russian Thistle Sand Dune Vegetation.

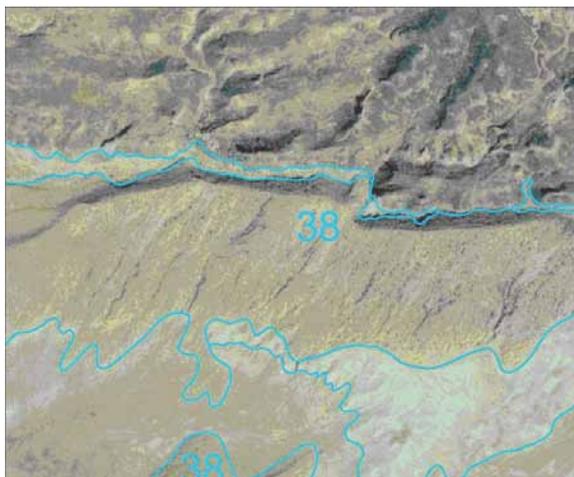


Figure G54. Photosignature for map class B27, Russian Thistle Sand Dune Vegetation.

Location: Russian Thistle Sand Dune Vegetation was located in several small map units throughout the project boundary. It was most frequent south of the neck area and north of The Flattops. This map class occurred most commonly on unstable surfaces, such as active sand dunes and areas with sandy soils and recent human disturbance. It was also found along roadsides and on pipeline corridors.

Photosignature: The landscape features of this map class were often easier to distinguish than the vegetation. Sand dunes and human disturbance areas with sandy soils that are dominated by herbaceous cover tended to be classified as this map class. This map class appeared to have a blotchy texture due to the barren spaces between the vegetation. Where these areas were vegetated, the herbaceous cover had a distinctive golden-yellow to light brown color.

Plant communities	<i>Salsola tragus</i> Sand Dune Vegetation
Group map class	Inter-Mountain Basins Active and Stabilized Dune (1 of 2)
Management map class	Russian Thistle Sand Dune Vegetation (1 of 1)
Macrogroup map class	Inter-Mountain Basins Active and Stabilized Dune (1 of 2)
Number of map units in park	37
Number of map units in park & environs	39
Number of map units less than 0.5 ha	7 (1.9% of total map class area)
Area of map class in park	95.9 ha / 236.9 ac
Total area of map class	100.7 ha / 248.9 ac
Proportion of land cover in park	0.3%
Proportion of map class in project environs	4.8%
Base map class accuracy	user 50.0 (32.7 - 67.3), producer 55.6 (36.9 - 72.8)
Group map class accuracy	user 36.7 (26.4 - 48.5), producer 78.3 (61.6 - 89.0)
Management map class accuracy	user 50.0 (32.7 - 67.3), producer 55.6 (36.9 - 72.8)
Macrogroup map class accuracy	user 36.7 (26.4 - 48.5), producer 81.8 (65.1 - 92.6)
Documentation for base map class	2 2003 relevés, 0 1996 relevés, 13 AA observation sites

B28 Whipple Cholla - Alkali Sacaton Shrub Herbaceous Vegetation



Figure G55. Ground photo for map class B28, Whipple Cholla - Alkali Sacaton Shrub Herbaceous Vegetation.

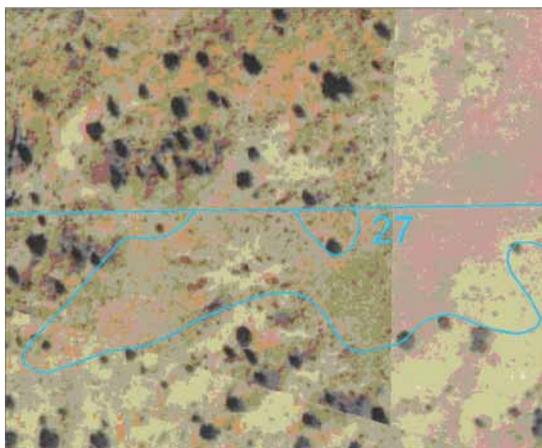


Figure G56. Photosignature for map class B28, Whipple Cholla - Alkali Sacaton Shrub Herbaceous Vegetation.

Location: Whipple Cholla / Alkali Sacaton Shrub Herbaceous Vegetation was restricted to one small map unit on the northern project boundary on Chinde Mesa. Mapping was based on field data from the classification relevés.

Photosignature: This type was difficult to distinguish on the photos from other herbaceous vegetation with various shrubby components. Many occurrences were small inclusions in a matrix of Rubber Rabbitbrush / Blue Grama or other types of shrub herbaceous vegetation.

Plant communities	<i>Opuntia whipplei</i> - <i>Sporobolus airoides</i> Shrub Herbaceous Vegetation
Group map class	Inter-Mountain Basins Semi-Desert Grassland (1 of 7)
Management map class	Alkali Sacaton Steppe and Mixed Grasslands (1 of 8)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	0
Number of map units in park & environs	1
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	0.0 ha / 0.0 ac
Total area of map class	0.6 ha / 1.6 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	100.0%
Base map class accuracy	Not assessed
Group map class accuracy	user 69.3 (60.8 - 76.7), producer 44.9 (38.0 - 51.9)
Management map class accuracy	user 73.0 (66.9 - 78.3), producer 64.0 (58.0 - 69.5)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	1 2003 relevés, 0 1996 relevés, 0 AA observation sites

B29 Arizona Siltbush Sparse Vegetation



Figure G57. Ground photo for map class B29, Arizona Siltbush Sparse Vegetation.

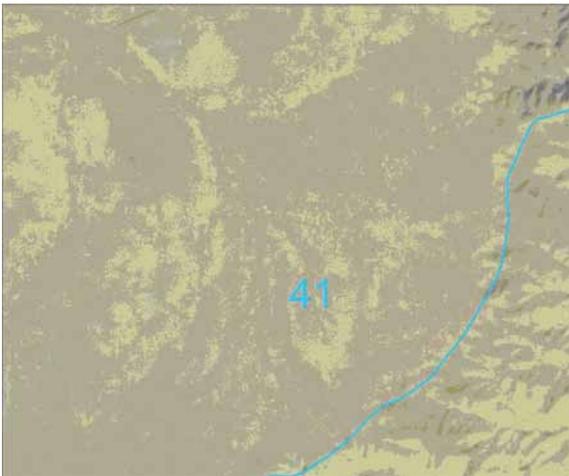


Figure G58. Photosignature for map class B29, Arizona Siltbush Sparse Vegetation.

Location: Arizona Siltbush Sparse Vegetation, one of the most common map classes in the badlands of the park, occurred in large areas. It occurred in the northern half of the northern wilderness area, and to the south from The Tepees all the way into the southern project environs. It most commonly occurred on white, grey blue, and reddish clay soil and in areas with periodic sheet flow.

Photosignature: This map class was most commonly identified by the washed out striations in the white and grey blue to reddish clay soils. The low total vegetation cover and the strong color signature of the soils made it difficult to pick out the vegetation on the aerial photos. Where the vegetation could be seen, it appeared as small, light, grey brown specks with very large and irregular spaces between plants.

Plant communities	<i>Zuckia brandegeei</i> Sparse Vegetation
Group map class	Inter-Mountain Basins Shale Badland (1 of 5)
Management map class	Badland Sparse Vegetation (1 of 3)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	180
Number of map units in park & environs	213
Number of map units less than 0.5 ha	37 (0.3% of total map class area)
Area of map class in park	2165.3 ha / 5350.7 ac
Total area of map class	2685.0 ha / 6634.8 ac
Proportion of land cover in park	5.68%
Proportion of map class in project environs	19.4%
Base map class accuracy	user 13.3 (6.1 - 26.6), producer 33.3 (15.9 - 56.9)
Group map class accuracy	user 60.2 (51.5 - 68.4), producer 62.4 (53.5 - 70.5)
Management map class accuracy	user 71.0 (62.7 - 78.0), producer 72.5 (64.6 - 79.5)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	17 2003 relevés, 12 1996 relevés, 12 AA observation sites

B30 New Mexico Saltbush Badland Sparse Vegetation



Figure G59. Ground photo for map class B30, New Mexico Saltbush Badland Sparse Vegetation.

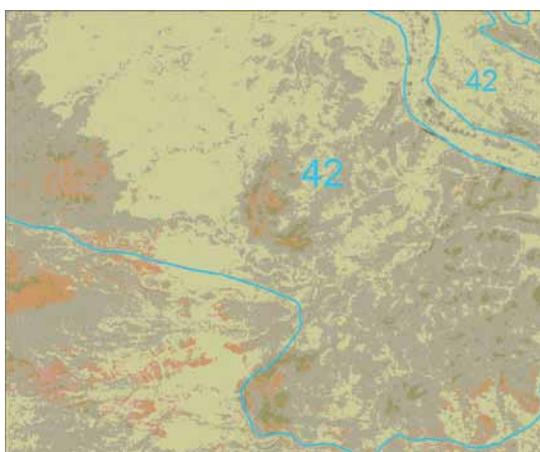


Figure G60. Photostignature for map class B30, New Mexico Saltbush Badland Sparse Vegetation.

Location: New Mexico Saltbush Sparse Vegetation was a very common map class. It was characteristically found on bentonite clay soils in the badlands, but it occurred throughout the entire project boundary.

Photosignature: This map class was often the default map class assigned to the vegetated badlands in the project boundary. It occurred on all of the various badland soils and occurred throughout the project boundary. The vegetation cover ranged from a low to moderate cover. In most areas, the vegetation was not easily identified due to its sparseness and the strong soil signature masking the vegetation. In some areas *Atriplex obovata* appeared as small specks with large spaces between plants and a light greenish/gray color.

Plant communities	<i>Atriplex obovata</i> Badland Sparse Vegetation
Group map class	Inter-Mountain Basins Semi-Desert Shrub-Steppe (1 of 5)
Management map class	Badland Sparse Vegetation (1 of 3)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	770
Number of map units in park & environs	624
Number of map units less than 0.5 ha	162 (0.7% of total map class area)
Area of map class in park	6815.6 ha / 16841.7 ac
Total area of map class	5497.4 ha / 13584.5 ac
Proportion of land cover in park	14.4%
Proportion of map class in project environs	19.3%
Base map class accuracy	user 16.1 (8.1 - 29.6), producer 17.9 (9.0 - 32.4)
Group map class accuracy	user 41.8 (34.7 - 49.2), producer 38.1 (31.5 - 45.1)
Management map class accuracy	user 71.0 (62.7 - 78.0), producer 72.5 (64.6 - 79.5)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	11 2003 relevés, 15 1996 relevés, 33 AA observation sites

B31 Slender Buckwheat Sparse Vegetation



Figure G61. Ground photo for map class B31, Slender Buckwheat Sparse Vegetation.

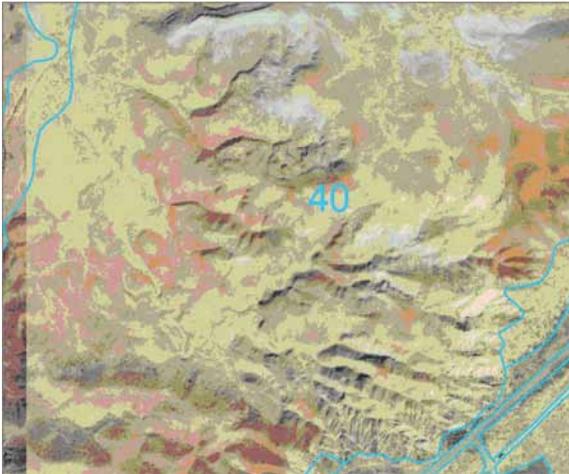


Figure G62. Photosignature for map class B31, Slender Buckwheat Sparse Vegetation.

Location: Slender Buckwheat Sparse Dwarf-shrubland Vegetation occurred in small patches throughout the project area. It was most common in the park badland environments near Headquarters Mesa and near The Flattops and the Crystal Forest in the south. It commonly occurred on the white and/or light-colored pinkish soils in the badlands.

Photosignature: This map class was most commonly identified by the light colored soils of the badlands. The white and pink soils commonly washed out most of the vegetation signature, making it difficult to identify the vegetation. The total vegetation cover was always sparse to low cover. Where the vegetation could be seen, it appeared as small, light brown and green specks with very large spaces between plants.

Plant communities	<i>Eriogonum leptophyllum</i> Sparse Vegetation
Group map class	Inter-Mountain Basins Shale Badland (1 of 5)
Management map class	Vegetated Rim Complex (1 of 4)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	20
Number of map units in park & environs	21
Number of map units less than 0.5 ha	4 (0.7% of total map class area)
Area of map class in park	113.3 ha / 280.0 ac
Total area of map class	114.0 ha / 281.8 ac
Proportion of land cover in park	0.3%
Proportion of map class in project environs	0.6%
Base map class accuracy	user 38.9 (22.7 - 58.0), producer 50.0 (30.0 - 70.1)
Group map class accuracy	user 60.2 (51.5 - 68.4), producer 62.4 (53.5 - 70.5)
Management map class accuracy	user 72.4 (63.9 - 79.5), producer 77.8 (69.0 - 84.2)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	6 2003 relevés, 4 1996 relevés, 10 AA observation sites

B32 Torrey's Jointfir – Bigelow's Sagebrush Sparse Vegetation



Figure G63. Ground photo for map class B32, Torrey's Jointfir – Bigelow's Sagebrush Sparse Vegetation.

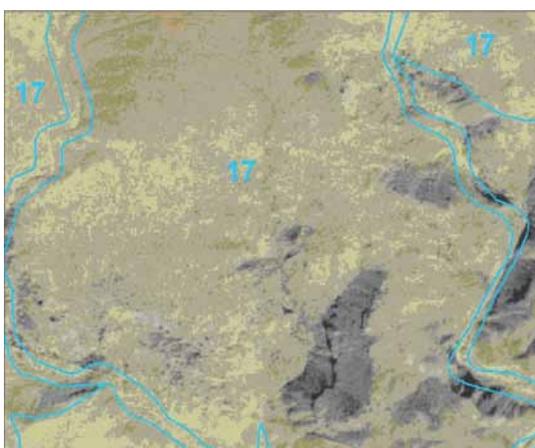


Figure G64. Photosignature for map class B32 Torrey's Jointfir – Bigelow's Sagebrush Sparse Vegetation.

Location: Torrey's Jointfir – Bigelow's Sagebrush Sparse Vegetation occurred widely throughout the park, with the greatest concentration of map units located on the tops of sandstone mesas and plateaus.

Photosignature: *Artemisia bigelovii*, a gray green dwarf shrub, had a uniform, gray green, smooth speckled signature. It tended to occur in a regular pattern. In some areas it was difficult to identify *Artemisia bigelovii*; however, the bedrock striations of the sandstone tended to indicate this map class. It also tended to occur on the lighter white-to-gray clay soils. *Ephedra torreyana* does not have a strong signature and was not reliably identified on the aerial photos.

Plant communities	<i>Ephedra torreyana</i> – <i>Artemisia bigelovii</i> Sparse Vegetation
Group map class	Inter-Mountain Basins Semi-Desert Shrub Steppe (1 of 5)
Management map class	Vegetated Rim Complex (1 of 4)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	516
Number of map units in park & environs	668
Number of map units less than 0.5 ha	236 (1.8% of total map class area)
Area of map class in park	2119 ha / 5237 ac
Total area of map class	3227 ha / 7975 ac
Proportion of land cover in park	66%
Proportion of map class in project environs	34%
Base map class accuracy	user 56.7 (41.9 – 70.4), producer 17.9 (9.0 – 32.4)
Group map class accuracy	user 41.8 (34.7 – 49.2), producer 38.1 (31.5 – 45.1)
Management map class accuracy	user 72.4 (63.9 - 79.5), producer 77.8 (69.0 - 84.2)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	12 2003 relevés, 12 1996 relevés, 38 AA observation sites

B33 Airstrip

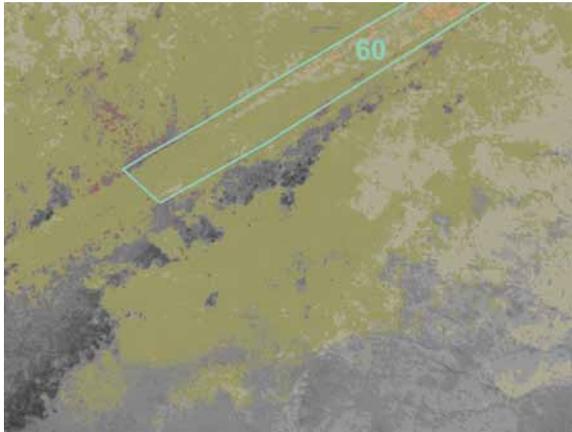


Figure G65. Photosignature for map class B33, Airstrip.

Location: Southwest of the south park entrance, southwestern corner of study area, outside of park boundaries.

Photosignature: This map unit appeared as two bladed dirt strips perpendicular to each other, running northeast-southwest and northwest-southeast.

Plant communities	NA
Group map class	Transportation (1 of 3)
Management map class	Airstrip (1 of 1)
Macrogroup map class	Transportation (1 of 1)
Number of map units in park	0
Number of map units in park & environs	1
Number of map units less than 0.5 ha	0
Area of map class in park	0
Total area of map class	2.6 ha / 6.5 ac
Proportion of land cover in park	0
Proportion of map class in project environs	100%
Base map class accuracy	Not assessed
Group map class accuracy	Not assessed
Management map class accuracy	Not assessed
Macrogroup map class accuracy	Not assessed
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B34 Barren Badlands



Figure G66. Ground photo for map class B34, Barren Badlands.



Figure G67. Photosignature for map class B34, Barren Badlands.

Location: This was the most common non-vegetated map class in the badlands within the project boundary. It occurred throughout the project boundary in areas that had less than 2% vegetation cover.

Photosignature: The map class was identified on colorful clay soils without any speckles of vegetation.

Plant communities	NA
Group map class	Inter-Mountain Basins Shale Badland (1 of 5)
Management map class	Badland Sparse Vegetation (1 of 3)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	364
Number of map units in park & environs	440
Number of map units less than 0.5 ha	133 (0.6% of total map class area)
Area of map class in park	4664.9 ha / 11527.3 ac
Total area of map class	5587.5 ha / 13807.1 ac
Proportion of land cover in park	12.3%
Proportion of map class in project environs	16.5%
Base map class accuracy	user 87.5 (74.9 - 94.3), producer 53.8 (42.6 - 64.7)
Group map class accuracy	user 60.2 (51.5 - 68.4), producer 62.4 (53.5 - 70.5)
Management map class accuracy	user 71.0 (62.7 - 78.0), producer 72.5 (64.6 - 79.5)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B35 Barren Wash



Figure G68. Ground photo for map class B35, Barren Wash.

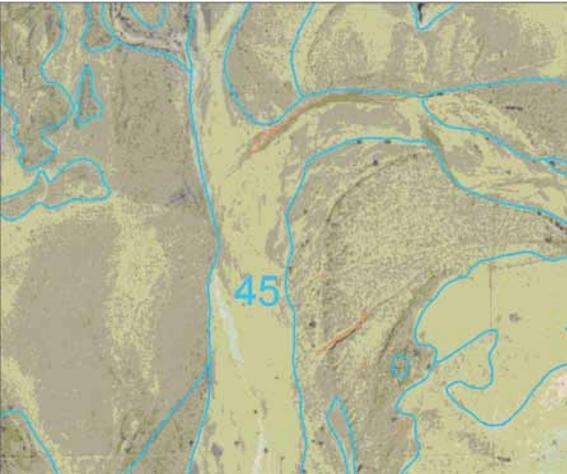


Figure G69. Photosignature for map class B35, Barren Wash.

Location: This map class occurred in the project boundary in sandy wash bottoms washes that have no to little vegetation. It occurred mainly in areas where periodic water flow limits vegetation establishment. The ground photo shows the barren wash bottom with adjacent vegetation.

Photosignature: This map class was identified in wash bottoms as a light brownish, tan color without any speckles of vegetation.

Plant communities	NA
Group map class	Inter-Mountain Basins Wash (1 of 6)
Management map class	Barren Wash (1 of 1)
Macrogroup map class	Inter-Mountain Basins Wash (1 of 6)
Number of map units in park	35
Number of map units in park & environs	47
Number of map units less than 0.5 ha	5 (0.3% of total map class area)
Area of map class in park	319.4 ha / 789.1 ac
Total area of map class	498.7 ha / 1232.4 ac
Proportion of land cover in park	0.8%
Proportion of map class in project environs	36.0%
Base map class accuracy	user 70.8 (54.1 - 83.3), producer 85.0 (67.8 - 93.8)
Group map class accuracy	user 66.3 (57.7 - 73.9), producer 69.4 (60.7 - 76.9)
Management map class accuracy	user 70.8 (54.1 - 83.3), producer 85.0 (67.8 - 93.8)
Macrogroup map class accuracy	user 66.3 (57.5 - 73.9), producer 69.4 (60.7 - 76.9)
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B36 Park Facilities



Figure G70. Photosignature for map class B36, Park Facilities.

Location: This map class occurred in areas where the park had developed infrastructure. The map class describes National Park Service buildings, housing, and visitor-use buildings.

Photosignature: This map class appeared in developed areas within the park as tall structures in the form of buildings or other park infrastructure.

Plant communities	NA
Group map class	Park Facilities (1 of 2)
Management map class	Park Facilities (1 of 1)
Macrogroup map class	Park Facilities (1 of 2)
Number of map units in park	21
Number of map units in park & environs	21
Number of map units less than 0.5 ha	15 (10.5% of total map class area)
Area of map class in park	16.0 ha / 39.5 ac
Total area of map class	16.0 ha / 39.5 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	Not assessed
Group map class accuracy	Not assessed
Management map class accuracy	Not assessed
Macrogroup map class accuracy	Not assessed
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B37 Park Sites



Figure G71. Photosignature for map class B37, Park Sites.

Location: This map class identified the tourist site at the archeological site of the Puerco River pueblo.

Photosignature: This map class appeared as linear lines that form old building structures with walls outlining the prehistoric pueblo.

Plant communities	NA
Group map class	Park Facilities (1 of 2)
Management map class	Park Sites (1 of 1)
Macrogroup map class	Park Facilities (1 of 2)
Number of map units in park	2
Number of map units in park & environs	2
Number of map units less than 0.5 ha	1 (5.4% of total map class area)
Area of map class in park	0.8 ha / 1.9 ac
Total area of map class	0.8 ha / 1.9 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	Not assessed
Group map class accuracy	Not assessed
Management map class accuracy	Not assessed
Macrogroup map class accuracy	Not assessed
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B38 Railroad



Figure G72. Photosignature for map class B38, Railroad.

Location: This map class identified the railroad that goes east/west through the project area.

Photosignature: This map class appeared as two linear tracks with a fence line paralleling the linear tracks.

Plant communities	NA
Group map class	Transportation (1 of 3)
Management map class	Railroad (1 of 1)
Macrogroup map class	Transportation (1 of 3)
Number of map units in park	2
Number of map units in park & environs	2
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	2.3 ha / 5.7 ac
Total area of map class	5.2 ha / 12.9 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	56.0%
Base map class accuracy	Not assessed
Group map class accuracy	Not assessed
Management map class accuracy	Not assessed
Macrogroup map class accuracy	Not assessed
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B39 Residences

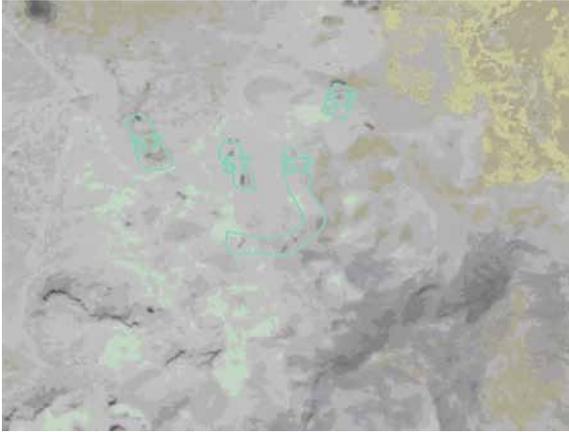


Figure G73. Photosignature for map class B39, Residences.

Location: This map class appeared outside of the park boundary in the project environs. This map class was not very common and occurred mainly in small map units.

Photosignature: This map class typically appeared as square/rectangular houses or buildings. These structures stood out due to their regularity and height.

Plant communities	NA
Group map class	Residential (1 of 1)
Management map class	Residences (1 of 1)
Macrogroup map class	Residential (1 of 1)
Number of map units in park	1
Number of map units in park & environs	23
Number of map units less than 0.5 ha	22 (76.8% of total map class area)
Area of map class in park	0.1 ha / 0.2 ac
Total area of map class	2.4 ha / 6.0 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	96.9%
Base map class accuracy	Not assessed
Group map class accuracy	Not assessed
Management map class accuracy	Not assessed
Macrogroup map class accuracy	Not assessed
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B40 Roads



Figure G74. Photosignature for map class B40, Roads.

Location: This map class occurred throughout the entire project boundary. The main paved road runs north and south, bisecting the park.

Photosignature: This map class appeared as a dark linear feature in areas where the roads are paved. In the unpaved areas, the roads appeared un-vegetated. Often a two-track could be seen on the photos where cars drive on unpaved ground.

Plant communities	NA
Group map class	Transportation (1 of 3)
Management map class	Roads (1 of 1)
Macrogroup map class	Transportation (1 of 3)
Number of map units in park	23
Number of map units in park & environs	52
Number of map units less than 0.5 ha	17 (1.6% of total map class area)
Area of map class in park	143.6 ha / 354.9 ac
Total area of map class	217.6 ha / 537.6 ac
Proportion of land cover in park	0.4%
Proportion of map class in project environs	34.0%
Base map class accuracy	Not assessed
Group map class accuracy	Not assessed
Management map class accuracy	Not assessed
Macrogroup map class accuracy	Not assessed
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B41 Run-off Control Feature

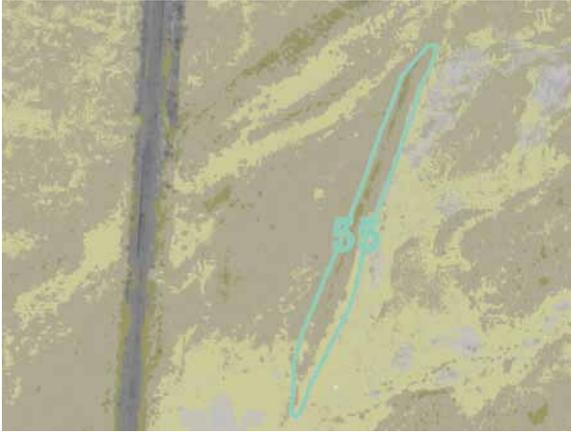


Figure G75. Photosignature for map class B41, Run-off Control Feature.

Location: These features were found in and alongside washes and in other areas of high erosion potential. They were apparently constructed to divert water into particular areas to protect culverts and other structures.

Photosignature: These features were identified by their location and shape, i.e. linear, raised areas along drainages.

Plant communities	NA
Group map class	Agriculture (1 of 2)
Management map class	Run-off Control Feature (1 of 1)
Macrogroup map class	Agriculture (1 of 2)
Number of map units in park	2
Number of map units in park & environs	2
Number of map units less than 0.5 ha	2 (100.0% of total map class area)
Area of map class in park	0.5 ha / 1.3 ac
Total area of map class	0.5 ha / 1.3 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	Not assessed
Group map class accuracy	Not assessed
Management map class accuracy	Not assessed
Macrogroup map class accuracy	Not assessed
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B42 Sand

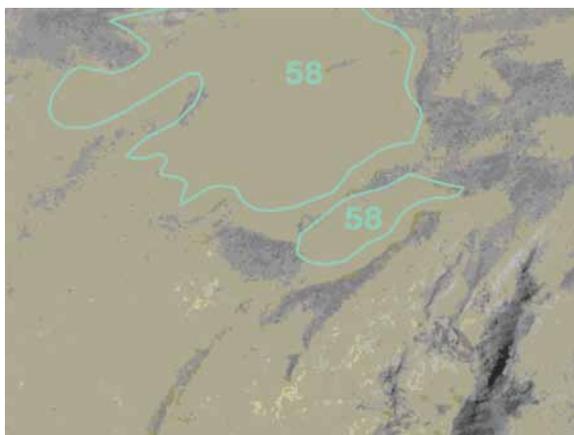


Figure G76. Photosignature for map class B42, Sand.

Location: This map class appeared mainly in the northern half of the project boundary.

Photosignature: This map class was used in areas where there was a lot of sand and the vegetation was sparse to absent. The sand appeared as a light brown, reddish color and did not have any speckling of vegetation.

Plant communities	NA
Group map class	Inter-Mountain Basins Shale Badland (1 of 5)
Management map class	Sand / Mudflat (1 of 1)
Macrogroup map class	Inter-Mountain Basins Semi-Desert Grassland and Steppe (1 of 17)
Number of map units in park	2
Number of map units in park & environs	2
Number of map units less than 0.5 ha	1 (9.3% of total map class area)
Area of map class in park	2.8 ha / 6.9 ac
Total area of map class	2.8 ha / 6.9 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 100.0 (42.5 - 100.0), producer 100.0 (42.5 - 100.0)
Group map class accuracy	user 60.2 (51.5 - 68.4), producer 62.4 (53.5 - 70.5)
Management map class accuracy	user 100.0 (42.5 - 100.0), producer 100.0 (42.5 - 100.0)
Macrogroup map class accuracy	user 93.0 (90.1 - 95.0), producer 77.2 (73.3 - 80.6)
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B43 Stock Ponds

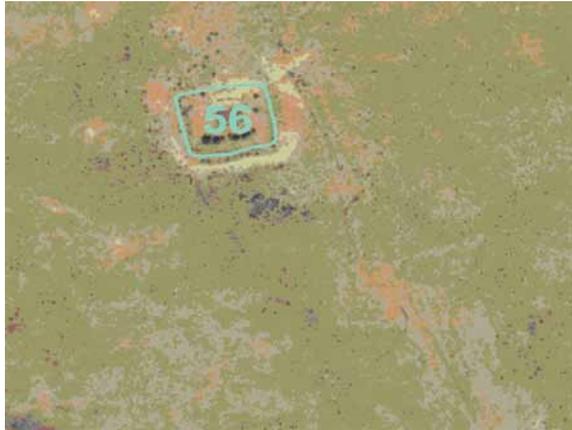


Figure G77. Photosignature for map class B43, Stock Ponds.

Location: This map class appeared outside of the park boundary in the project environs. This map class was not very common and often occurred in small patches.

Photosignature: This map class typically appeared as round depressions in the soil. The vegetation was commonly not present or present with low cover. The stock tanks tended to have a light hue due to the extra salinity in the soil.

Plant communities	NA
Group map class	Agriculture (1 of 2)
Management map class	Stock Ponds (1 of 1)
Macrogroup map class	Agriculture (1 of 2)
Number of map units in park	0
Number of map units in park & environs	25
Number of map units less than 0.5 ha	19 (42.9% of total map class area)
Area of map class in park	0.0 ha / 0.0 ac
Total area of map class	8.8 ha / 21.8 ac
Proportion of land cover in park	0.0%
Proportion of map class in project environs	100.0%
Base map class accuracy	Not assessed
Group map class accuracy	Not assessed
Management map class accuracy	Not assessed
Macrogroup map class accuracy	Not assessed
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B44 Vegetated Rim Complex



Figure G78. Ground photo for map class B44, Vegetated Rim Complex.

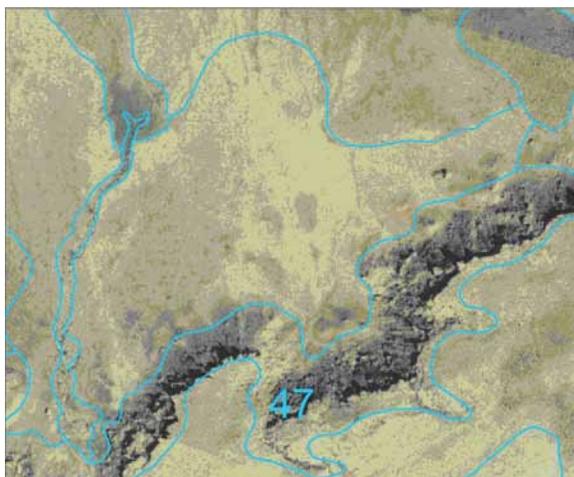


Figure G79. Photosignature for map class B44, Vegetated Rim Complex.

Location: This map class occurred on the mesa rims, commonly in long linear patches.

Photosignature: This map class was identified by a mixed signature of various dwarf-shrub and herbaceous species adjacent to the mesa rims. The signature was not consistent and appeared to have a mixed tone, texture, and color.

Plant communities	NA
Group map class	Colorado Plateau Mixed Bedrock and Tableland (1 of 3)
Management map class	Vegetated Rim Complex (1 of 4)
Macrogroup map class	Colorado Plateau Mixed Bedrock and Tableland (1 of 3)
Number of map units in park	36
Number of map units in park & environs	55
Number of map units less than 0.5 ha	8 (0.9% of total map class area)
Area of map class in park	167.4 ha / 413.6 ac
Total area of map class	223.2 ha / 551.5 ac
Proportion of land cover in park	0.4%
Proportion of map class in project environs	25.0%
Base map class accuracy	user 42.9 (28.8 - 58.2), producer 52.2 (35.7 - 68.2)
Group map class accuracy	user 52.9 (41.6 - 64.0), producer 73.0 (59.7 - 83.1)
Management map class accuracy	user 72.4 (63.9 - 79.5), producer 77.8 (69.0 - 84.2)
Macrogroup map class accuracy	user 52.9 (41.6 - 64.0), producer 77.1 (63.8 - 86.6)
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B45 Vegetated Wash Complex



Figure G80. Ground photo for map class B45, Vegetated Wash Complex.

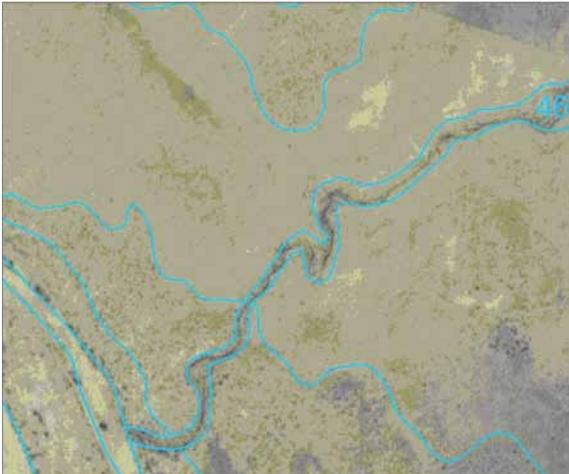


Figure G81. Photosignature for map class B45, Vegetated Wash Complex.

Location: This map class occurred on the banks of washes, often in linear patches. This map class extended throughout the entire project boundary.

Photosignature: This map class appeared as a mixed signature of various shrub and herbaceous species within drainages. It was a combination of multiple map classes, and the photointerpreters used it only when the associated plant communities were not distinguishable on the photos as distinct map units. Vegetated wash communities tended to vary in height, color, tone, and texture.

Plant communities	NA
Group map class	Inter-Mountain Basins Wash (1 of 6)
Management map class	Vegetated Wash Complex (1 of 6)
Macrogroup map class	Inter-Mountain Basins Wash (1 of 6)
Number of map units in park	363
Number of map units in park & environs	478
Number of map units less than 0.5 ha	140 (1.8% of total map class area)
Area of map class in park	1385.8 ha / 3424.5 ac
Total area of map class	1873.2 ha / 4628.7 ac
Proportion of land cover in park	3.6%
Proportion of map class in project environs	26.0%
Base map class accuracy	user 67.9 (52.3 - 80.2), producer 50.0 (37.1 - 62.9)
Group map class accuracy	user 66.3 (57.7 - 73.9), producer 69.4 (60.7 - 76.9)
Management map class accuracy	user 70.2 (61.5 - 77.7), producer 80.8 (72.2 - 87.2)
Macrogroup map class accuracy	user 66.3 (57.5 - 73.9), producer 69.4 (60.7 - 76.9)
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

B46 Commercial Development

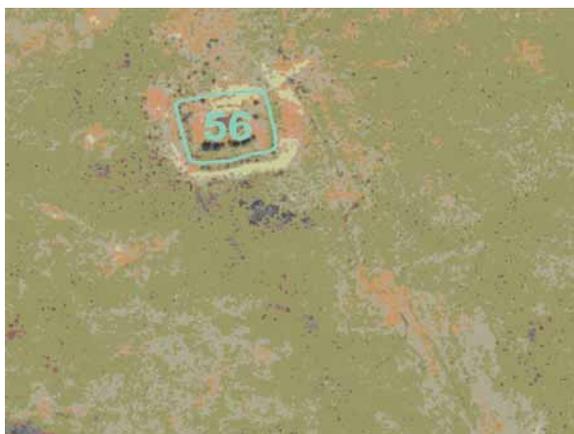


Figure G82. Photosignature for map class B46, Commercial Development.

Location: Turnoff from Highway 189 to south entrance of park, and along Highway 189 at western boundary of study area.

Photosignature: This map class represents retail stores, residences, and parking lots in the park environs. The areas were detected by shape and known location.

Plant communities	NA
Group map class	Development (1 of 1)
Management map class	Commercial Development (1 of 1)
Macrogroup map class	Development (1 of 1)
Number of map units in park	1
Number of map units in park & environs	6
Number of map units less than 0.5 ha	5 (64.3% of total map class area)
Area of map class in park	< .5 ha
Total area of map class	1.4 ha / 3.5 ac
Proportion of land cover in park	< .5%
Proportion of map class in project environs	> 99.5%
Base map class accuracy	Not assessed
Group map class accuracy	Not assessed
Management map class accuracy	Not assessed
Macrogroup map class accuracy	Not assessed
Documentation for base map class	0 2003 relevés, 0 1996 relevés, 0 AA observation sites

Appendix H

Accuracy assessment data

Appendix H consists of four contingency tables, also known as error matrices, showing the accuracy assessment for the base map classes (H-1), group map classes (H-2), macrogroup map classes (H-3), and management map classes (H-4). Each table includes rows representing the map classes for polygons in the vegetation map database (Vegetation Map Database Map Class), and columns representing the accuracy assessment made in the field for that polygon (Field Assessment Map Class). A perfect correspondence between the map and the field is indicated by a tally in the matrix where the row and column intersect for the same map class. For example, in Table H-1, the intersection of row and column B32 shows a tally of 17, indicating that in the field accuracy assessment, six of the polygons on the map were found to be the same map class in the field as that mapped. The contingency table also shows the source of error in the map. In row B32, the table shows that the field crew found some of the the polygons mapped as B32 to be actually other map classes. Column B32 indicates that some areas not mapped as B32, were found to be map unit B32 in the field.

The number of correctly mapped polygons, as determined in the accuracy assessment, occur on the shaded diagonal of the contingency table. User and producer accuracy, 90% confidence intervals for each, overall accuracy, Kappa accuracy, and Kappa accuracy standard error are reported. The Kappa accuracy and standard error do not include vegetation map database map classes that were not field assessed.

Each table is accompanied by a key code for the map classes. In the example given above, B32 is Torrey's Jointfir Bigelow's Sagebrush Sparse Shrubland.

For each table, the following notations are used:

- NTF - None that fits; the assessment in the field did not match any existing map classes.
- NA - Not applicable; unable to compute confidence intervals because there were no polygons assessed as correct in the field.
- N/S - Not sampled; unable to compute producer or user accuracy assessment since the polygons were not sampled.

Note: Due to their size, Tables H-1 and H-4 are spread across two pages and should be read accordingly. The keys for Tables H-1 and H-4 appear on the page that follows the table.

Table H-1. Contingency table: Base map classes.

Field assessment map class

Map code	<>	Field assessment map class																		
		B32	B3	B4	B16	B44	B27	B29	B34	B30	B24	B31	B35	B5	B7	B42	B12	B45	B19	
B32		17				2		1				1							1	
B3			6																	
B4		2		8																
B16	2	1			1	2			2			2								1
B44		5			4	12			2		2	1								1
B27	1						10											1	1	
B29						1		4		12		3								1
B34								1	28	2								1		
B30	1					1		1	13	5								1	2	
B24											2									
B31	1	5				2		1	1			7								
B35								1	3	2			17							
B5								1						0						
B7															0					
B42																0	1	2		
B12														2			11	1	1	
B45					1					2			1	2			2	19		
B19																			6	
B18	1						1											1	5	
B20																				
B22																				1
B21																				
B23									1	2										1
B9																			3	
B10																				
B11	2																	1	1	1
B25	1	1				1		2	1	3								1	4	
B26		4					6		1							2		1		6
B14															1					4
B1																				
B6																				
B15	1												2				1	7		
B8		2				1	1													2
B13		1																		1
B17																				1
B2				1																
Number of samples	10	38	6	9	5	23	18	12	52	28	2	14	20	2	7	0	17	38	40	
Producer accuracy / omission error (%correct)	NTF	44.7	100.0	88.9	20.0	52.2	55.6	33.3	53.8	17.9	100.0	50.0	85.0	0.0	0.0	N/S	64.7	50.0	15.0	
90% confidence interval (-)	NTF	32.3	68.9	62.3	4.6	35.7	36.9	15.9	42.6	9.0	42.5	30.0	67.8	N/A	N/A	N/S	44.9	37.1	8.0	
90% confidence interval (+)	NTF	57.9	100.0	97.5	56.5	68.2	72.8	56.9	64.7	32.4	100.0	70.1	93.8	N/A	N/A	N/S	80.5	62.9	26.5	

Overall accuracy = 40.6% Kappa index = 42.2% Standard error = 0.22

																			Number of samples	User accuracy/ commission error (% correct)	90% Confidence intervals	
B18	B20	B22	B21	B23	B9	B10	B11	B25	B26	B14	B1	B6	B15	B8	B13	B17	B2	-			+	
		1						3						3	1			30	56.7	41.9	70.4	
																		6	100.0	68.9	100.0	
														2				12	66.7	43.1	84.1	
																		11	9.1	2.1	32.3	
								1										28	42.9	28.8	58.2	
	1		2		1			1						1	1			20	50.0	32.7	67.3	
			2					7										30	13.3	6.1	26.6	
																		32	87.5	74.9	94.3	
					1			6										31	16.1	8.1	29.6	
																		2	100.0	42.5	100.0	
								1										18	38.9	22.7	58.0	
														1				24	70.8	54.1	83.3	
																		1	0.0	N/A	N/A	
																		0	N/S	N/S	N/S	
														2				5	0.0	N/A	N/A	
	1		1					2	1					9	2			31	35.5	23.0	50.3	
														1				28	67.9	52.3	80.2	
	5				4									1				16	37.5	20.8	57.8	
	5		1		2		2	7										25	20.0	10.1	35.8	
	2	0			2													4	0.0	N/A	N/A	
			3		2													9	33.3	14.2	30.2	
	2			0	1			2										5	0.0	N/A	N/A	
	1		2		16			6										29	55.2	40.2	69.3	
	4				1	13	2	2	6									31	41.9	28.6	56.6	
							1											1	100.0	27.0	100.0	
						1		4	3									19	21.1	9.8	39.5	
	1		1		2				12									30	40.0	27.7	54.9	
			1					3	2		1			1	1			29	6.9	2.3	18.8	
	11		1		11			1		0							1	30	0.0	N/A	N/A	
											2							2	100.0	42.5	100.0	
												1						1	100.0	27.0	100.0	
						1								6	1			19	31.6	17.3	50.4	
	3		1			1			2					12	5			30	40.0	26.7	54.9	
	1			1				1						5	17	2		29	58.6	43.5	72.3	
																0		1	0.0	N/A	N/A	
														1			9	11	81.8	57.3	93.8	
	37	0	16	1	43	16	5	6	62	5	0	3	1	7	45	27	6	9	Total number of samples: 630 Total samples where the field classification and the map classification matched: 256			
	13.5	N/S	18.8	0.0	37.2	81.3	20.0	66.7	19.4	40.0	N/S	66.7	100.0	85.7	26.7	63.0	0.0	100.0				
	6.7	N/S	7.8	N/A	26.2	61.2	4.6	34.7	12.5	14.3	N/S	25.4	27.0	54.8	17.4	47.2	N/A	N/A				
	25.3	N/S	38.8	N/A	49.8	92.2	56.5	88.3	28.8	72.8	N/S	92.2	100.0	96.7	38.9	76.4	N/A	N/A				

Key to base map class codes in Table H-1

B1	Cottonwood / Rubber Rabbitbrush Woodland
B2	One-seed Juniper / Bigelow's Sagebrush Shrubland
B3	Blue Sage Dwarf-shrubland
B4	Cliff-rose - Crispleaf Buckwheat Shrubland
B5	Copperweed / Alkali Sacaton Shrubland
B6	Coyote Willow Shrubland
B7	Drummond Goldenweed / Galleta Shrubland
B8	Four-wing Saltbush / Galleta Shrubland
B9	Greasewood / New Mexico Saltbush Shrubland
B10	Greasewood / Shrubby Seepweed Shrubland
B11	Iodine Bush Shrubland
B12	Rubber Rabbitbrush Desert Wash Shrubland
B13	Sandsage Colorado Plateau Shrubland
B14	Snakeweed - (Prickly Pear) / Galleta Dwarf-shrubland
B15	Tamarisk Shrubland
B16	Three-leafed Sumac - Mormon Tea Talus Shrubland
B17	Winter-fat / Blue Grama Dwarf-shrubland
B18	Alkali Sacaton Herbaceous Vegetation
B19	Alkali Sacaton - Blue Grama Herbaceous Vegetation
B20	Black Grama - Galleta Herbaceous Vegetation
B21	Blue Grama Herbaceous Vegetation
B22	Blue Grama - Galleta Herbaceous Vegetation
B23	Galleta - Alkali Sacaton Herbaceous Vegetation
B24	Giant Sandreed Desert Wash Shrub Herbaceous Vegetation
B25	New Mexico Saltbush / Galleta - Alkali Sacaton Shrub Herbaceous Vegetation
B26	Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation
B27	Russian Thistle Sand Dune Vegetation
B29	Arizona Siltbush Sparse Vegetation
B30	New Mexico Saltbush Badland Sparse Vegetation
B31	Slender Buckwheat Sparse Vegetation
B32	Torrey's Jointfir Bigelow's Sagebrush Sparse Shrubland
B34	Barren Badlands
B35	Barren Wash
B42	Sand
B44	Vegetated Rim Complex
B45	Vegetated Wash Complex

Table H-2. Contingency table: Group map classes.

Field assessment map class												Number of samples	User accuracy/commission error (% correct)	90% Confidence intervals		
Vegetation map database map class	Map code	<>	G2	G11	G10	G5	G9	G6	G8	G7	G14			G3	-	+
	G2	2	27	8	9		2		1		2		51	52.9	41.6	64.0
	G11	1	3	53	27		3		1				88	60.2	51.5	68.4
	G10	2	4	17	51		40		4		4		122	41.8	34.7	49.2
	G5	1		1	8	18	12		4	1	4		49	36.7	26.4	48.5
	G9	1		1	20	1	61	2	1		1		88	69.3	60.8	76.7
	G6	2			8		6	24	5		6		51	47.1	36.0	58.4
	G8		1	5	6	1	3		59	1	13		89	66.3	57.7	73.9
	G7	1						1	10	9	1		22	40.9	25.6	58.2
	G14		1		5	3	9	1			40		59	67.8	57.2	76.8
	G3		1								1	9	11	81.8	57.3	93.8
Number of samples		10	37	85	134	23	136	28	85	11	72	9	Total number of samples: 630 Total correct: 351			
Producer accuracy/omission error (%correct)	NTF	73.0	62.4	38.1	78.3	44.9	85.7	69.4	81.8	55.6	100.0					
90% confidence interval (-)	NTF	59.7	53.5	31.5	61.6	38.0	71.7	60.7	57.3	45.9	76.9					
90% confidence interval (+)	NTF	83.1	70.5	45.1	89.0	51.9	93.4	76.9	93.8	64.8	100.0					

Overall accuracy = 55.7% Kappa index = 49.9% Standard error = 0.02

Key to group map class codes in Table H-2

G2 Colorado Plateau Mixed Bedrock and Tableland

G3 Colorado Plateau Pinyon-Juniper Woodland

G5 Inter-Mountain Basins Active and Stabilized Dune

G6 Inter-Mountain Basins Greasewood Flat

G7 Inter-Mountain Basins Riparian Woodland and Shrubland

G8 Inter-Mountain Basins Wash

G9 Inter-Mountain Basins Semi-Desert Grassland

G10 Inter-Mountain Basins Semi-Desert Shrub-Steppe

G11 Inter-Mountain Basins Shale Badland

G14 Southern Colorado Plateau Sand Shrubland

Table H-3. Contingency table: Macrogroup map classes.

Vegetation map database map class	Field assessment map class									Number of samples	User accuracy/commission error (% correct)	90% Confidence intervals	
	Map code	↔	MG2	MG8	MG5	MG6	MG9	MG7	MG12			MG3	-
MG2	2	27	19			1		2		51	52.9	41.6	64.0
MG8	4	5	277		2	6		4		88	60.2	51.5	68.4
MG5	1		21	18		4	1	4		122	41.8	34.7	49.2
MG6	2		14		24	5		6		49	36.7	26.4	48.5
MG9		1	14	1		59	1	13		88	69.3	60.8	76.7
MG7	1				1	10	9	1		51	47.1	36.0	58.4
MG12		1	14	3	1			40		89	66.3	57.7	73.9
MG3		1						1	9	22	40.9	25.6	58.2
Number of samples	10	35	359	22	28	85	11	71	9	Total number of samples: 630 Total correct: 463			
Producer accuracy/omission error (% correct)	NTF	77.1	77.2	81.8	85.7	69.4	81.8	56.3	100.0				
90% confidence interval (-)	NTF	63.8	73.3	65.1	71.7	60.7	57.3	46.6	76.9				
90% confidence interval (+)	NTF	86.6	80.6	92.6	93.4	76.9	93.8	65.6	100.0				

Overall accuracy = 73.5% Kappa index = 62.9% Standard error = 0.02

Key to macrogroup map class codes in Table H-3

MG2	Colorado Plateau Mixed Bedrock and Tableland
MG3	Colorado Plateau Pinyon-Juniper Woodland
MG5	Inter-Mountain Basins Active and Stabilized Dune
MG6	Inter-Mountain Basins Greasewood Flat
MG7	Inter-Mountain Basins Riparian Woodland and Shrubland
MG8	Inter-Mountain Basins Semi-Desert Grassland and Steppe
MG9	Inter-Mountain Basins Wash
MG12	Southern Colorado Plateau Sand Shrubland

Table H-4. Contingency table: Management map classes.

		Field assessment map class															Number of samples	User accuracy/commission error (% correct)	90% Confidence intervals		
		Map code <>	MN6	MN7	MN23	MN19	MN20	MN3	MN4	MN24	MN2	MN5	MN11	MN9	MN10	MN21			MN12	-	+
Vegetation map database map class	MN6		6														6	100.0	68.9	100.0	
	MN7			8	2										2		12	66.7	43.1	84.1	
	MN23	3			63			6	2		8	1			4		87	72.4	63.9	79.5	
	MN19	1				10				1	4	2			2		20	50.0	32.7	67.3	
	MN20						2										2	100.0	42.5	100.0	
	MN3	1			5			66		2	17	2					93	71.0	62.7	78.0	
	MN4							6	17						1		24	70.8	54.1	83.3	
	MN24				1			3	1	59	5	1	1		13		84	70.2	61.5	77.7	
	MN2	2			6	7		10		6	119	7	2	1	3		163	73.0	66.9	78.3	
	MN5										9	6					15	40.0	22.3	60.7	
	MN11	2								5	14		24			6		51	47.1	36.0	58.4
	MN9													2				2	100.0	42.5	100.0
	MN10														1			1	100.0	27.0	100.0
	MN21				4	1					10	3	1			40		59	67.8	57.3	76.8
MN12			1												1	9	11	81.8	57.3	93.8	
Number of samples	9.0	6.0	9.0	81.0	18.0	2.0	91.0	20.0	73.0	186.0	22.0	28.0	3.0	1.0	72.0	9.0	Total number of samples: 630 Total correct: 432				
Producer accuracy/omission error (%correct)	NTF	100.0	88.9	77.8	55.6	100.0	72.5	85.0	80.8	64.0	27.3	85.7	66.7	100.0	55.6	100.0					
90% confidence interval (-)	NTF	68.9	62.3	69.0	36.9	42.5	64.6	67.8	72.2	58.0	14.8	71.7	25.4	27.0	45.9	76.9					
90% confidence interval (+)	NTF	100.0	97.5	84.2	72.8	100.0	79.5	93.8	87.2	69.5	44.7	93.4	92.2	100.0	64.8	100.0					

Overall accuracy = 68.6% Kappa index = 64.1% Standard error = 0.02

Key to management map class codes in Table H-4

MN2	Alkali Sacaton Steppe and Mixed Grasslands
MN3	Badland Sparse Vegetation
MN4	Barren Wash
MN5	Blue Grama Steppe and Mixed Grasslands
MN6	Blue Sage Dwarf-shrubland
MN7	Cliff-rose - Crispleaf Buckwheat Shrubland
MN9	Cottonwood / Rubber Rabbitbrush Woodland
MN10	Coyote Willow Shrubland
MN11	Greasewood Flats
MN12	One-seed Juniper / Bigelow's Sagebrush Shrubland
MN19	Russian Thistle Sand Dune Vegetation
MN20	Sand / Mudflat
MN21	Sandsage - Fourwing Saltbush Colorado Plateau
MN23	Vegetated Rim Complex
MN24	Vegetated Wash Complex

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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