National Park Service
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Vegetation Classification and Distribution Mapping Report

Hubbell Trading Post National Historic Site

Natural Resource Technical Report NPS/SCPN/NRTR—2010/301

ON THE COVER

Top: Hubbell Trading Post National Historic Site as seen from Hubbell Hill; photo by Courtney White, www.awestthatworks.com. Bottom left: Hubbell Trading Post National Historic Site; photo by Stephen Monroe. Bottom right: Hubbell Wash, photo by Stephen Monroe.

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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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List of Abbreviations and Acronyms

BOR	Bureau of Reclamation (also USBR)
BRD	Biological Resource Division (of the USGS)
CBI	Center for Biological Informatics (of the USGS/BRD)
cm	centimeter(s)
F	Fahrenheit
FGDC	Federal Geographic Data Committee
ft	foot/feet
GIS	geographic information system
GPS	global positioning system
ha	hectare(s)
HUTR	Hubbell Trading Post National Historic Site
in	inch(es)
km	kilometer(s)
m	meter(s)
mi	mile(s)
MMU	Minimum mapping unit
NPS	U.S. National Park Service
NRCS	Natural Resources Conservation Service (formerly the Soil Conservation Service-SCS)
NVC	National Vegetation Classification
NVCS	National Vegetation Classification Standard
PARK	HUTR
RSGIG	Remote Sensing and Geographic Information Group
SCPN	Southern Colorado Plateau Network Inventorying and Monitoring Program
SWEMP	Southwest Exotic Plant Mapping Program
TNC	The Nature Conservancy
USBR	United States Bureau of Reclamation (also BOR)
USDA-SCS	U.S. Dept. Of Agriculture – Soil Conservation Service
USGS	United States Geological Survey
VMP	Vegetation Mapping Program

Executive Summary

Hubbell Trading Post National Historic Site (HUTR) covers approximately 65 ha (160 acres) in northeastern Arizona, and lies wholly within the borders of the Navajo Nation. The vegetation found at HUTR consists of approximately 184 species of vascular plants, representing 48 families, in a limited set of communities. This mapping project is part of the National Park Service's National Inventory and Monitoring (I&M) Program, and has been designed to provide core, or "baseline" information that park managers need to effectively manage and protect park resources.

The HUTR vegetation classification and distribution mapping was conducted in accordance with the following protocols and standards, specified by the U.S. Geological Survey (USGS)/National Park Service (NPS) Vegetation Mapping Program.

Nationally-defined standards:

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

Additional program-defined standards:

- Classification Accuracy
- Minimum Mapping Unit

Mapping the vegetation at HUTR was a multi-year program that involved two major tasks: (1) the development of a classification system, and (2) the production of a digital vegetation map. To classify the vegetation, representative plots were located throughout the approximately 65-ha project area and sampled during 2006. These plots were compared to existing National Vegetation Classification (NVC) types and assigned an appropriate map unit. Whenever possible, map units directly corresponded to NVC alliances or associations. We derived 16 vegetation map units from the plant alliances and associations assigned, based on the field data. Eight additional map units represented land-use types, as adopted from the Land Use classification system of Anderson et al. (1976).

To produce the digital map, we used 1:12,000-scale true color aerial photographs (acquired on September 14, 2003) in addition to the vegetation information obtained from the 2006 field plots. All map units were developed and directly cross-walked, or matched, to corresponding NVC plant associations and land-use classes. All of the interpreted and remotely-sensed data were converted to Geographic Information System (GIS) databases using ArcGIS© software. Draft maps were printed, reviewed, and revised.

The products that we developed following our work at HUTR are described in this report and provided on the accompanying CD. They include

- a *final report* that details the production steps, results, and discussion
- a *spatial GIS database* containing associated layers derived during this project
- *digital photos* from each observation point, along with representative ground photos for some map classes and miscellaneous park views
- *printable graphics* of all spatial database layers
- *metadata* for spatial database layers that is Federal Geographic Data Committee (FGDC)-compliant
- *vegetation descriptions* of the vegetation communities

In addition, we provided HUTR and the Southern Colorado Plateau Network (SCPN) with copies of

- 9x9-in prints of the 1:12,000-scale Aerial Photography (originally obtained from SCPN)

- uncompressed digital aerial photography
- digital data files and hard copy data sheets of the observation points
- vegetation maps.

The USGS will post this project on its website: http://biology.usgs.gov/npsveg/. For more information on the NVC standards, please go to the Federal Geographic Data Committee (FGDC), National Vegetation Classification Standard website: http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation. For more information on NVC associations in the U.S., please go to NatureServe's website: http://www.natureserve.org. Bureau of Reclamation has numerous services and programs and may be visited at http://www.usbr.gov.

Acknowledgments

Many people provided input and critique, not only for the written portion, but also in regards to the data and format of the geodatabase. The combination of ecologists, geographers, botanists and natural resource professionals in all of the cooperating agencies and organizations created a cooperative work environment that greatly eased the process.

We would specifically like to thank the following people for their efforts:

- Anne Cully for providing critical input on the content and format of this report. In addition, Anne has provided overall leadership to this and many other projects, contributing to their success.
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- Nancy Stone and Anne Worthington of Hubbell Trading Post National Historic Site for their participation in the project and for sharing their local knowledge of the area.
- Yolanda Lincoln of Hubbell Trading Post National Historic Site for her invaluable help in the coordination of field logistics.
- John Blueyes of the Navajo Nation for granting permission to conduct vegetation surveys on tribal land surrounding Hubbell Trading Post National Historic Site.

We also would like to thank Chris Lea for reviewing all aspects of this effort in addition to providing updates to the descriptions of the National Vegetation Classification and National Vegetation Classification Standards.

We would also like to thank Mike Story and Karl Brown and the many scientists of the National Park Service who produced the original study protocols that are associated with this project. As a result, the report for Hubbell Trading Post National Historic Site may be compatible with other National Park units throughout the country.

1 Introduction

1.1 Background

1.1.1 USGS-NPS Vegetation Mapping Program

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

Using the NVC as the standard vegetation classification is central to fulfilling the goals of this national program. The classification is based upon current vegetation, uses a systematic approach to classify along a continuum, emphasizes natural and existing vegetation, uses a combined physiognomic-floristic hierarchy, identifies vegetation units based on both qualitative and quantitative data, and is appropriate for mapping at multiple scales.

The use of NVC and mapping protocols (TNC and ESRI 1994a, 1994b) facilitates effective resource stewardship by ensuring compatibility and widespread use of the information throughout the NPS as well as by other federal and state agencies. These vegetation maps and associated information support a wide variety of resource assessment, park-management, and planning needs, and provide a structure for framing and answering critical scientific questions about vegetation communities and their relationship to environmental processes across the landscape.

The NVC has primarily been developed and implemented by The Nature Conservancy (TNC) and the network of Natural Heritage Programs over the past twenty years, in collaboration with the NPS (Grossman et al. 1998). Refinements to the classification may occur in the vegetation mapping process , leading to ongoing proposed revisions that are reviewed both locally and nationally. The Federal Geographic Data Committee (FGDC) endorsed the NVC in 2008 (http://www.fgdc.gov/ standards/projects/FGDC-standards-projects/vegetation/index_html), and the Vegetation Subcommittee works to keep this standard current.

NatureServe has produced a two volume publication presenting the standardized classification that is available on the internet (http://www.natureserve.org/publications/library.jsp). This document provides a thorough introduction to the classification, its structure, and the list of vegetation types found across the United States as of April 1997 (Grossman et al. 1998). NatureServe has since superseded Volume II (the classification listing) with an online database server that provides regular updates to classification of ecological communities in the United States and Canada. NatureServe Explorer®, can also be found on the Internet at: http://www.natureserve.org/explorer.

1.1.2 Hubbell Trading Post National Historic Site Vegetation Mapping Project

The decision to map the vegetation at Hubbell Trading Post National Historic Site (HUTR) as part of the U.S. Vegetation Mapping Program was made in response to the guidelines issued by the NPS Natural Resources Inventory and Monitoring (I&M) Program in 1992. The vegetation mapping portion of the I&M program recognizes that parks need spatial analysis of vegetation at a scale that is fine enough to aid in the prediction of outcomes, relative to various management issues.

The Southern Colorado Plateau Network (SCPN) Inventory and Monitoring Program (I&M) initiated this project in 2005, asking the U.S. Bureau of Reclamation's Remote Sensing and Geographic Informa-

tion Group (RSGIG) to undertake mapping of HUTR. The objectives were to produce final products consistent with the standards mandated by the USGS-NPS National Vegetation Mapping Program. These standards are:

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

The products derived from these efforts included the spatial data and vegetation information listed below:

Spatial data

- aerial photography
- map classification/descriptions
- spatial database of vegetation communities
- hardcopy maps of vegetation communities
- metadata for spatial databases.
- vegetation information

Vegetation classification

- formal description for each vegetation class
- ground photos of vegetation classes
- field data in database form

1.2. Scope of Work

In 2005, the SCPN entered into an agreement with the U.S. Bureau of Reclamation (USBR) to map approximately 663 ha (1,634 acres) of HUTR and environs, encompassing both the executive boundary of HUTR (65 ha; 160 acres), and a buffer of variable width ranging from 0.8-1.0 km around the executive boundary. Field reconnaissance efforts included the area defined by the project boundary. We used a combination of field data and photointerpretation to map and classify vegetation. The protocols and standards used are described in the USGS-NPS program documents for small parks (TNC and ESRI 1994a).

1.3. The National Vegetation Classification and National Vegetation Classification Standard

In 1994, the USGS -NPS Vegetation Mapping Program (VMP) adopted the U.S. National Vegetation Classification (NVC) (TNC and ESRI 1994 b, Grossman et al. 1998) as a basis for the a priori definition of vegetation units to be inventoried. The FGDC adopted a modified version of the upper (physiognomic) levels as a federal standard (FGDC-STD-005) (FGDC 1997). This standard is termed the National Vegetation Classification Standard (NVCS). The NVCS established a federal standard for a complete taxonomic treatment of vegetation in the United States at physiognomic levels. It also established conceptual taxonomic levels for the floristic units of alliance and association, largely following the NVC. It did not, however, offer a taxonomic treatment for the floristic levels because establishing robust floristic units for the entire United States was an immense job. Table 1 identifies the seven levels of the NVC and their placement in the hierarchical relationship (Maybury 1999).

The FGDC standard requires that federally-funded vegetation classification efforts collect data in a manner that enables crosswalking the data to the NVCS (i.e., the physiognomic levels) and sharing it between agencies. It does not require that agencies use the standard for internal mission needs. NatureServe maintains a treatment of floristic units (alliances and associations), which, though not a federal standard, are used as classification and mapping units by the VMP whenever fea-

Table 1. Summary of the National Vegetation Classification System Hierarchical Approach (Maybury 1999).

Level	Primary Basis For Classification	Example
Class	Structure of vegetation	Woodland
Subclass	Leaf phenology	Evergreen Woodland
Group	Leaf types, corresponding to climate	Temperate or Subpolar Needle-Leaved Evergreen Woodland
Subgroup	Relative human impact (natural/semi-natural, or cultural)	Natural/Semi-natural
Formation	Additional physiognomic and environmental factors, including hydrology	Saturated Temperate or Subpolar Needle-Leaved Evergreen Woodland
Alliance	Dominant/diagnostic species of the uppermost or dominant stratum	Longleaf Pine - (Slash Pine, Pond Pine) Saturated Woodland Alliance
Association	Additional dominant/diagnostic species from any strata	Longleaf Pine / Little Gallberry / Carolina Wiregrass Woodland

sible. For purposes of this document, the federal standard (FGDC 1997) is denoted as the National Vegetation Classification Standard (NVCS)[1]; the U.S. National Vegetation Classification (NVC) will refer exclusively to NatureServe's treatment for vegetation floristic units treatment (alliances and associations only).

Alliances and associations are based on both the dominant species in the upper strata of a stand (greatest canopy cover), as well as on diagnostic species (those consistently found in some types but not others). Associations are the most specific classification and are hierarchically subsumed in alliances. Each association is included in only one alliance, while each alliance typically includes 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 assemblages which 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 the lower strata, or a diagnostic species in any stratum. The species nomenclature for all alliances and associations follows that of Kartesz (1999). Documentation from NatureServe (2005) describes the naming and syntax for all NVC names:

- A hyphen (-) separates names of species occurring in the same stratum.
- A slash (/) 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 Vegetation").

Alliance names also include the class in which they are classified (e.g., "Forest," "Woodland," "Herbaceous"), but are followed by the word "Alliance" to distinguish them from Associations.

[1] The VMP program standards refer to the National Vegetation Classification System (also NVCS). Because of nomenclatural and acronym confusion with the federal (FGDC) National Vegetation Classification Standard, this term is no longer used by the VMP.

Examples of alliance names from the HUTR vegetation mapping project include

- *Populus deltoides* (eastern cottonwood) Temporarily Flooded Forest Alliance
- *Juniperus osteosperma* (Utah juniper) Woodland Alliance
- *Atriplex canescens* (fourwing saltbush) Shrubland Alliance

Examples of association names from the HUTR vegetation mapping project include

- *Populus deltoides* / *Ericameria nauseosa* (rubber rabbitbrush) Forest
- *Juniperus osteosperma* / *Bouteloua gracilis* (blue grama) Woodland
- *Atriplex canescens* Shrubland

In addition to the NVC, NatureServe has created standardized Ecological Systems Classification for describing sites, based on both the vegetation and the ecological processes that drive them. Ecological systems are mid-scale biological communities that occur in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding. They are not conceptually a unit within the NVC and do not occupy a place in the NVC hierarchy. However, within each ecological system resides a specific list of NVC associations that are likely to occur. Because the structure of the NVC is hierarchical, each association occurs in only one alliance. 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 much like the map units used for the map legend; they are a broader scale concept that embodies the concepts of several highly specific associations that might be found in a particular setting.

1.4 Natural Heritage Program Methodology and Element Ranking

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

The multidisciplinary team of scientists, planners, and information managers at the heritage programs uses a standardized methodology to gather information on the rare, threatened, and endangered species and significant plant communities that occur in each state. The species and plant communities for which each program maintains data are referred to as "elements of natural diversity", or simply, "elements." Life history, status, and locational data are regularly updated in a comprehensive shared data system. Sources of element data include published and unpublished literature, museum and herbaria labels, and field surveys conducted by knowledgeable naturalists, experts, agency personnel, and the heritage staff of botanists, ecologists, and zoologists.

1.4.1 The Natural Heritage Ranking System

The cornerstone of natural heritage methodology is the use of a standardized element-imperilment ranking system. Ranking species and ecological communities according to their imperilment status provides guidance for where natural heritage programs should focus their information-gathering activities and provides data users with a concise, meaningful decision-making tool. To determine the status of an element within Arizona, HDMS gathers information on plants, animals, and plant communities. Each of these elements of natural diversity is assigned a rank that indicates its relative degree of imperilment on a five-point scale (1 = critically imperiled, 5 = demonstrably secure). The criteria used to define the element-imperilment

rank are number of occurrences, size of population, and quality of population. The primary criterion is the number of occurrences (i.e., the number of known distinct localities or populations). This factor is weighted more heavily than other factors because an element found in only one place is more imperiled than something found in, for example, 21 places. Also important are the size of the geographic range, the number of individuals, the trends in both population and distribution, identifiable threats, and the number of protected occurrences.

Element-imperilment ranks are assigned in terms of the element's degree of imperilment, both within Arizona (the state-, or S-rank), and over its entire range (its global, or G-rank). Taken together, these two ranks indicate an element's degree of imperilment. For example, the gray catbird (*Dumetella carolinensis*), thought to be secure in northern North America, but critically imperiled in Arizona, is ranked G5/S1(globally-secure, but critically imperiled in this state). The Little Princess agave (*Agave parviflora*) is ranked a G3/S3 (vulnerable both in the state and globally). Saiya (*Amoreuxia gonzalezii*) on the other hand, is ranked G1/S1 (critically imperiled, both in the state and globally).

HDMS actively collects, maps, and electronically processes specific occurrence information for animal and plant species considered extremely imperiled-to-vulnerable in the state (S1–S3). Certain elements are "watchlisted,"

Table 2. Definitions of Natural Heritage Imperilment Ranks*

G/S1	Critically Imperiled globally/state because of rarity (5 or fewer occurrences in the world/state; or 1,000 or fewer individuals), or because some factor of its biology makes it especially vulnerable to extinction
G/S2	Imperiled globally/state because of rarity (6 to 20 occurrences, or 1,000 to 3,000 individuals), or because other factors demonstrably make it very vulnerable to extinction throughout its range
G/S3	Vulnerable through its range or found locally in a restricted range (21 to 100 occurrences, or 3,000 to 10,000 individuals)
G/S4	Apparently Secure globally/state, though it may be quite rare in parts of its range, especially at the periphery. Usually more than 100 occurrences and 10,000 individuals
G/S5	Demonstrably secure globally/state, though it may be quite rare in parts of its range, especially at the periphery
G/SX	Presumed extinct globally, or extirpated within the state
G#?	Indicates uncertainty about an assigned global rank
G/SU	Unable to assign rank due to lack of available information
GQ	Indicates uncertainty about taxonomic status
G/SH	Historically known, but usually not verified for an extended period of time
G#T#	Trinomial rank (T) is used for subspecies or varieties. These taxa are ranked on the same criteria as G1-G5
S#B	Refers to the breeding season imperilment of elements that are not residents
S#N	Refers to the non-breeding season imperilment of elements that are not permanent residents. Where no consistent location can be discerned for migrants or non-breeding populations, a rank of SZN is used
SZ	Migrant whose occurrences are too irregular, transitory, and/or dispersed to be reliably identified, mapped, and protected
SA	Accidental in the state
SR	Reported to occur in the state but unverified
S?	Unranked, some evidence that species may be imperiled, but awaiting formal rarity ranking

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

meaning that specific occurrence data are periodically analyzed to determine whether more active tracking is warranted. A complete description of each natural heritage rank is provided in Table 2.

This single rank system works readily for all elements except migratory animal species. Animals that migrate may spend only a portion of their life cycles within the state. In these cases, it is necessary to distinguish between breeding, non-breeding, and resident species. As noted in Table 2, ranks followed by a "B," for example S1B, indicate that the rank applies only to the status of breeding occurrences. Similarly, ranks followed by an "N" refer to non-breeding status, typically during migration and winter. Elements without this notation are believed to be year-round residents within the state.

1.4.2. Element Occurrences and Their Ranking

Actual locations of elements, whether they are single organisms, populations, or plant communities, are referred to as element occurrences. The element occurrence is considered the most fundamental unit of conservation interest and is at the heart of the Natural Heritage methodology. To prioritize element occurrences for a given species, an element occurrence rank (EO-Rank) is assigned, according to the size, ecological quality and landscape context of the occurrences, whenever sufficient information is available. This ranking system is designed to indicate which occurrences are the healthiest and the most ecologically viable, thus focusing conservation efforts where they will be most successful.

The EO-Rank is based on three factors:

1. **Size** – a measure of the area or abundance of the element's occurrence. EO-Rank takes into account factors, such as area of occupancy, population abundance, population density, population fluctuation, and minimum dynamic area (which is the area needed to ensure survival or re-establishment of an element after natural disturbance). This factor for an occurrence is evaluated relative to other known, and/or presumed viable, examples.
2. **Condition/quality** – an integrated measure of the composition, structure, and biotic interactions that characterize the occurrence. This includes such measures as reproduction, age structure, biological composition (e.g. the presence of exotic versus native species), structure (e.g. canopy, understory, and ground cover in a forest community), and biotic interactions (e.g. levels of competition, predation, and disease).
3. **Landscape context** – an integrated measure of the dominant environmental regimes and the processes that establish and maintain the element and connectivity. Dominant environmental regimes and processes include herbivory, hydrologic and water chemistry regimes (surface and groundwater), geomorphic processes, climatic regimes (temperature and precipitation), fire regimes, and many kinds of natural disturbances. Connectivity includes such factors as a species' access to habitats and resources needed for life cycle completion; fragmentation of ecological communities and systems; and the ability of the species to respond to environmental change through dispersal, migration, or re-colonization.

Each of these factors is rated on a scale of A through D, with A representing an excellent rank and D representing a poor rank. These ranks for each factor are then averaged to determine an appropriate EO-Rank for the occurrence. If not enough information is available to rank an element occurrence, an EO-Rank of E is assigned. EO-Ranks and their definitions are summarized in Table 3.

Table 3. Averaged element occurrence ranks and their definitions

A	Excellent viability
B	Good viability
C	Fair viability
D	Poor viability
H	Historic: known from historical record, but not verified for an extended period of time
X	Extirpated (extinct within the state)
E	Extant: the occurrence does exist but not enough information is available to rank
F	Failed to find: the occurrence could not be relocated

1.5. Project Area

1.5.1. Location and regional setting

Hubbell Trading Post National Historic Site lies in Apache County in northeastern Arizona, about 64 km (40 miles) north of Interstate 40 (fig. 1). The park is adjacent to the intersection of Arizona highways 191 and 264, and lies wholly within the Navajo Nation, near the town of Ganado. The nearest metropolitan center of any size is Gallup, NM, about 97 km (60 miles) to the east. Of the 65 ha (160 ac) within the park, approximately 62 ha (154 ac) are held by the NPS in fee title and 2.4 ha (6 ac) as scenic easement.

1.5.2. History

Hubbell Trading Post was officially established as a National Historic Site by the NPS in 1965, to preserve and protect its cultural and historic value. At that time, it was the oldest continuously operating trading post on the Navajo Reservation, dating back to the mid-1870s (Manchester and Manchester 1993).

This history of anthropogenic activities at HUTR has significantly influenced the structure and composition of vegetative communities in the park and surrounding areas. Archaeological sites within the park boundary attest to thousands of years of habitation prior to European settlement of the area (Manchester and Manchester 1993). In addition to serving as the location for a trading post, much of the land encompassed within the current park boundary was actively farmed. Furthermore, the vegetation mapping project area extends up to, and includes a large portion of the town of Ganado, Arizona. As a result of these various anthropogenic disturbances in the project area, a large portion of the vegetation at HUTR may be considered as not natural. Currently, HUTR continues to operate as a trading post and is visited both by interested tourists and by local Navajos (Manchester and Manchester 1993).

1.5.3. Climate and Weather

Winters in HUTR and the surrounding area can be cold and are generally dry, with periods of snow and rain. Winter temperatures usually range from 0 to 40 degrees F. Summers are warm and tend to be dry, until the monsoons start in late July. Daytime summer temperatures range from the low 50s to the high 90s (degrees F) from May through September. Humidity is generally low, with summer thunderstorms occurring between July and August. The area is often subject to high winds, frequent sand storms, high evaporation rates, and frequent droughts (Froeschauer-Nelson 1998). Average precipitation (snowmelt and rain) is 25.4 -30.5 cm (10 -12 in) per year (fig. 2). Just north of HUTR, Balakai Mesa receives 30.5 -35.6 cm (12 -14 in) per year (National Climatic Data Center (NCDC) 1991). Precipitation increases as one approaches the Defiance Plateau to the east (http://www.nps.gov/HUTR/pphtml/weather.html).

Figure 1. Location map for Hubbell Trading Post National Historic Site (Scale 1:2,000,000)

1.5.4. Topography

HUTR is at an elevation of 1,932 m (6,340 ft) (fig. 3) and lies within the south-central portion of the Colorado Plateau physiographic province (Bailey 1995). The topography of the park and the surrounding area varies, and includes flat valleys, eroding slopes, incised canyons, and dry arroyos. North of HUTR, a broad valley stretches between Balakai Mesa to the west and Defiance Plateau to the east. Pueblo Colorado Wash, formed by the confluence of Lone Tule Creek and Kinlichee Creek, which flow from the northeast, runs southwest through HUTR, joining up with Cottonwood Wash, and eventually draining into the Little Colorado River (fig. 4). The wash has changed significantly since Hubbell Trading Post was established. A period of down cutting has been replaced by a period of deposition (N. Stone personal communication 2005). The wash has been under intensive restoration since 1998 (Roth 2004).

1.5.5. Geology

The park falls entirely within the Chinle Formation (Late Triassic). This was confirmed locally by a soil erosion study

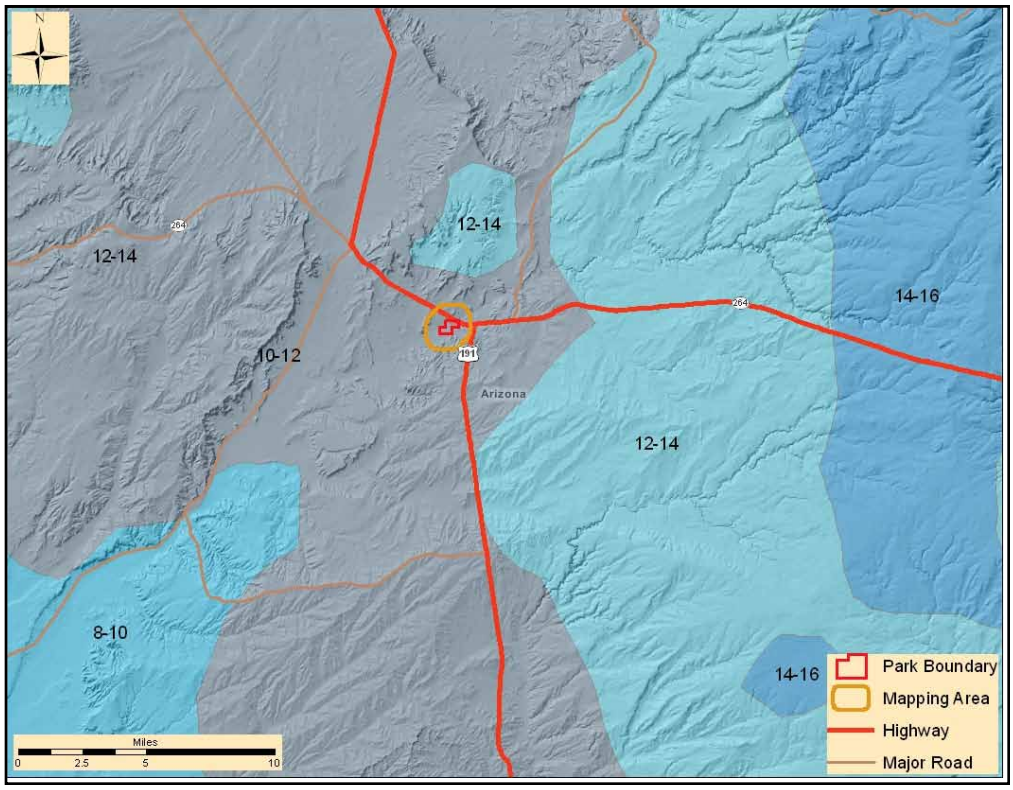

Figure 2. Average annual precipitation (in.) in east central Arizona for the period 1961 - 1990. (National Climatic Data Center (NCDC) 1991) (Scale 1:225,000)

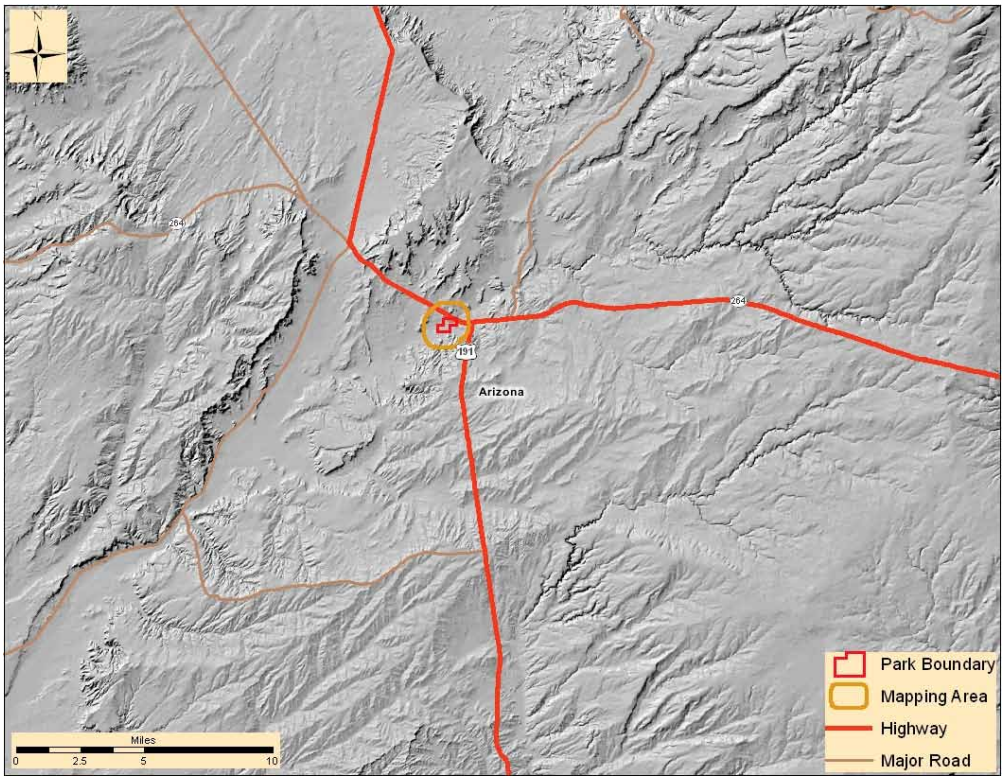

Figure 3. Topography of HUTR and surrounding area (1:225,000 scale)

Figure 4. Oblique aerial view of Hubbell Trading Post National Historic Site looking from the southwest towards the northeast

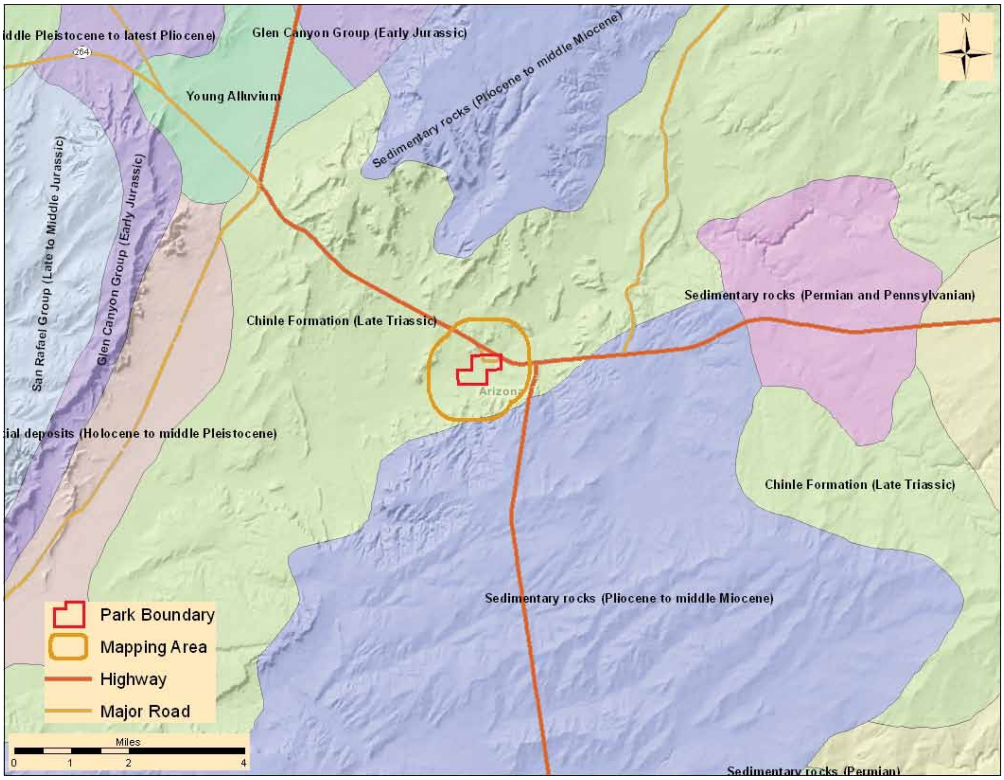

Figure 5. Geologic formations in the immediate vicinity of Hubbell Trading Post National Historic Site (1:100,000 scale)

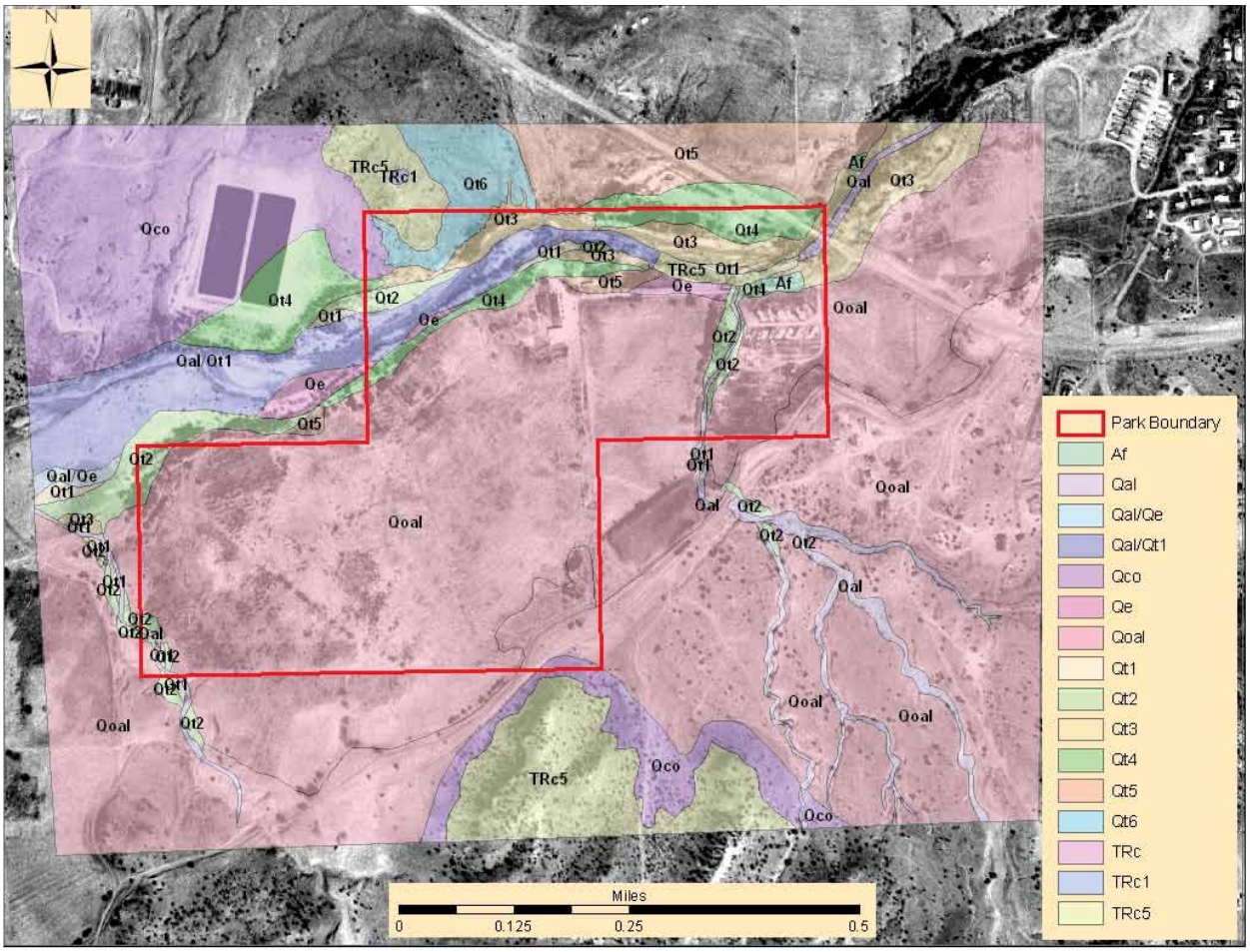

Figure 6. Localized geologic map of Hubbell Trading Post National Historic Site (1:8,000 scale) (Ertec Western, Inc. 1983)

(Ertec Western, Inc. 1983) which reported that the surficial geology exposed in the study area is part of the Triassic-age Chinle formation and is comprised of a complex stratigraphy, consisting of claystone, clayey sandstone, and ledge forming sandstones. Just to the south of the park are sedimentary rocks of Cenozoic age. These sedimentary rocks, parts of the Bidahochi and Bouse formations commonly capped by patches of Quaternary surficial deposits, date from Pliocene to middle Miocene and were deposited during and after late Tertiary normal faulting (Reynolds 1988) (fig. 5). The primary surficial deposits are Quaternary in age and include unconsolidated alluvium along Pueblo Colorado Wash (Ertec Western, Inc. 1983). Chinle Formation is exposed at the surface on Hubbell Hill and on Red Point to the south of the park. The Ertec Western, Inc. (1983) report includes much more detailed information regarding the local geology and we refer the reader to that report for more in-depth analysis. A digitized version of the Ertec map is shown in Figure 6.

1.5.6. Soils

The soils within Pueblo Colorado Wash consist of deep loamy, sandy, clayey soils. Immediately adjacent to the floodplains, shallow fine-grained soils overlie the Chinle sandstones and claystones. Stream bank erosion is a problem along the Pueblo Colorado Wash, but has been addressed in recent control measures, such as bank stabilization, diversion dikes, exotic plant species removal, and native plant species restoration. Entisols (young

mineral soils lacking significant profile development; (Brady 1974)) occur along the floodstreams. Aridisols (dry mineral soils; Brady 1974) cover plateau tops, older terraces, and alluvial fans. Badlands of rough broken land are extensive in the mountains and on plateaus. Ertec Western, Inc. (1983) reported four general soil categories in and around the park, which include:

- active stream alluvium
- eolean deposits and deflation areas
- colluvium and minor alluvial fan deposits
- terrace deposits

No NRCS data exist for this area, therefore we are not providing a soils map.

1.5.7. Wildlife

HUTR is included in the Colorado Plateau Semi-desert Province (USFS 2005). This province encompasses three states—Arizona, New Mexico, and Utah—and covers approximately 195,000 km^2 (75,300 mi^2). Fauna, typical of the province and inhabiting the region around HUTR, include the following mammals: *Odecoileus hemionus* (mule deer), *Canis latrans* (coyote), *Lepus californicus* (blacktail jackrabbit), *Urocyon cinereoargenteus* (gray fox), and others. In a recent biological inventory of HUTR, Haymond and Sherwin (2005) documented a total of 32 mammalian species—eight species of bats, including *Tadarida molassa* (big free-tailed bat); 15 species of rodents, including *Cynomys gunnisoni* (Gunnison's prairie dog)and *Dipodomys ordi* (Ord's kangaroo rat); two species of lagomorph, including blacktail jackrabbit and *Sylvalagus audoboni* (desert cottontail); 6 species of carnivore, including *Urocyon cinereoargenteus* (gray fox) and *Canis latrans* (coyote); and one artiodactyl—*Odocoileus hemionus* (mule deer). The piñon mouse (*Peromyscus truei*) was the most abundant species of mammal during 2003, while the deer mouse (*Peromyscus maniculatus*) was the most abundant species in 2004.

Birds typical of the Colorado Plateau Semi-desert Province include *Gymnorhinus cyanocephalus* (pinyon jay), *Parus inornatus* (plain titmouse), *Archilocus alexandri* (black-chinned hummingbird) *Buteo jamaicensis* (red-tailed hawk), *Aquila chrysaetos* (golden eagle), *Colaptes auratus* (northern flicker), and *Salpinctes obsoletus* (rock wren), as well as other summer residents and migrants (USDA 2005). In 2006, LaRue and Mikesic (2006) documented a total of 66 avian species at HUTR. The most commonly detected species were *Myiarchus cinerascens* (ash-throated flycatcher), *Corvus brachyrhynchos* (American crow), *Icterus galbula* (Bullock's (Northern) oriole), and *Corvus corax* (common raven) were the most commonly detected species.

Crotaphytus collaris (collared lizard), *Phrynosoma* spp. (horned lizard), and *Crotalis viridis* (prairie rattlesnake) are common in the Colorado Plateau Semi-Desert Province (see fig. 7). Mikesic (2004) documented a total of eight reptile species (five lizards, three snakes) and three amphibian species at HUTR. *Sceloporus graciosus* (sagebrush lizard) and *Cnemidophorus velox* (plateau striped whiptail) were the most common reptiles, and *Bufo woodhousii* (Woodhouse's toad) was the most common amphibian.

1.5.8. Vegetation

The vegetation within the HUTR project area has been classified differently, depending upon the scale and the author. For example, at broad regional scales, HUTR can be described as Arizona/New Mexico Plateau using the ecoregion conept of Omernik (1987)(fig. 8); or Navajo Canyonlands using Bailey's (1995) ecoregion concept (fig. 9). Descriptions of these two types are listed in Table 4 , which includes links to additional information.

More specific information is available from Arizona GAP Vegetation (Graham 1995) and the Brown, Lowe and Pace (1983) digital maps. Arizona GAP shows HUTR lying in the Great Basin Conifer Woodland – Pinyon-Juniper Series which appears o be an error (fig. 10). Only the southern and northern extents of the mapped area

Figure 7. Rattlesnake (*Crotalus* sp.) observed during HUTR field visit (8/2006)

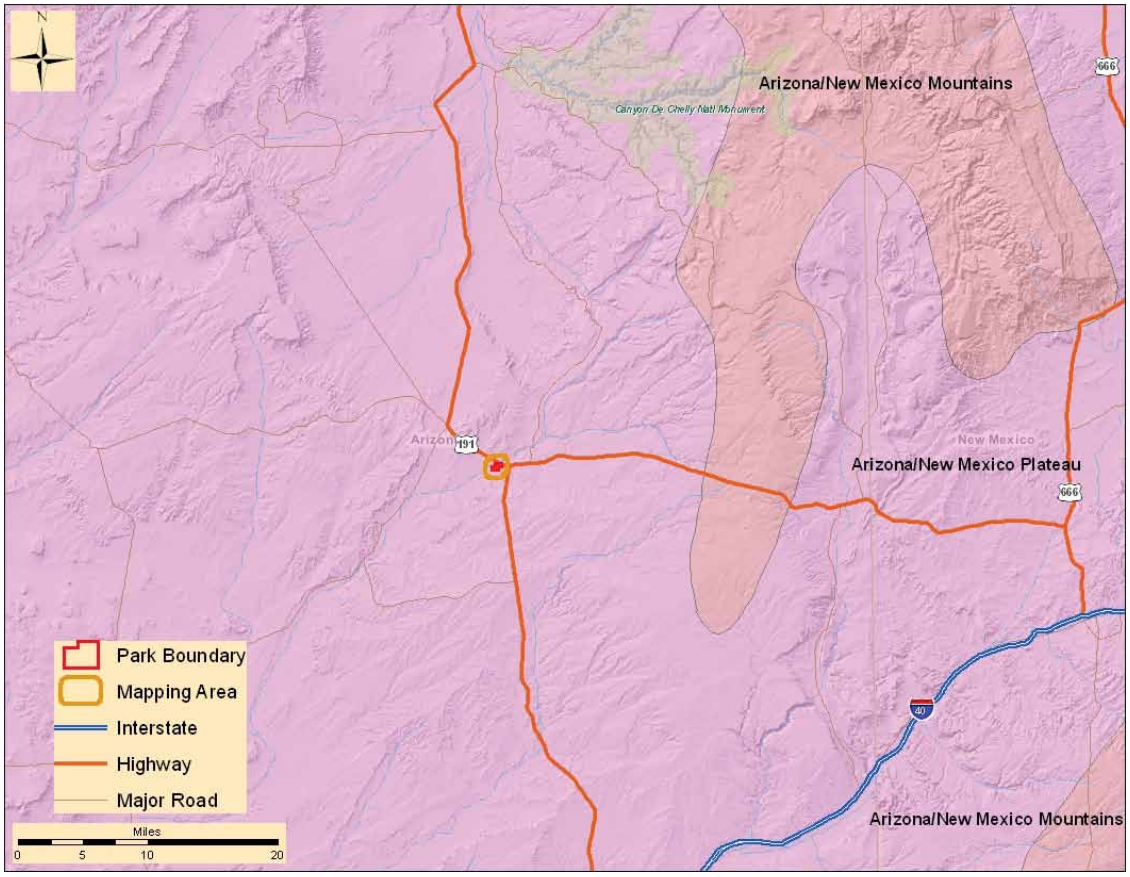

Figure 8. View of Omernik's (1987) ecoregions in the region surrounding Hubbell Trading Post National Historic Site (1:500,000 scale)

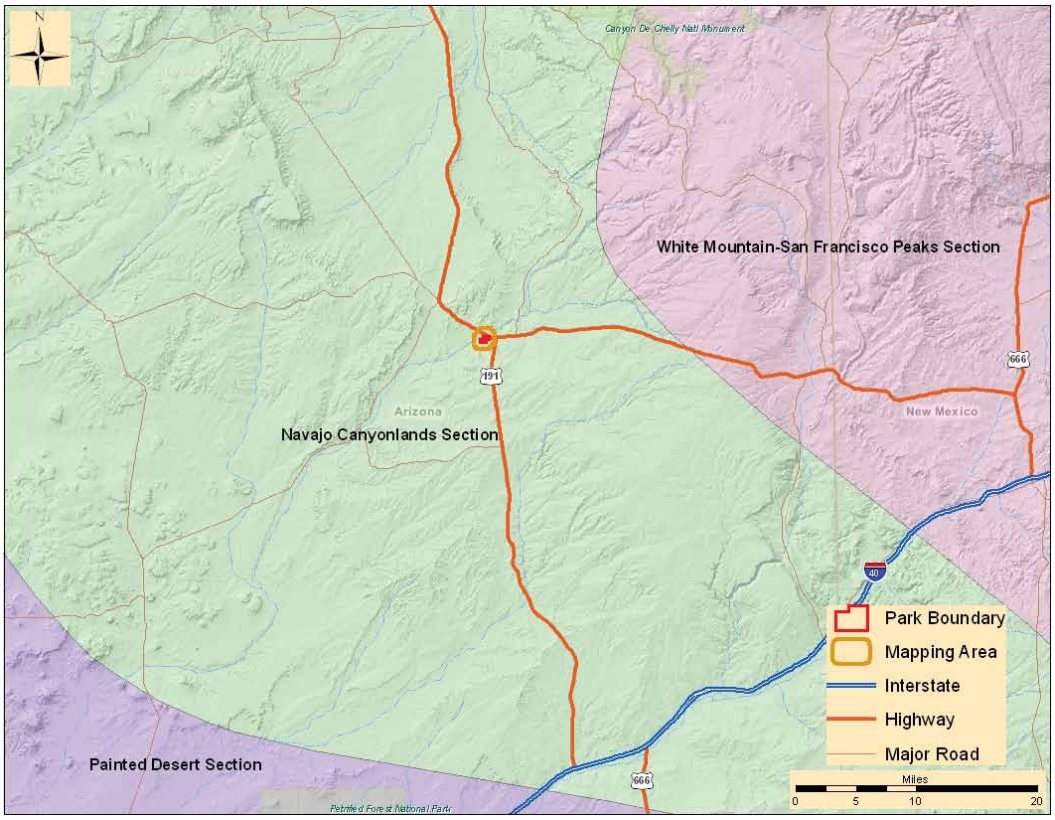

Figure 9. A view of Bailey's (1995) ecoregions in the region surrounding Hubbell Trading Post National Historic Site (1:500,000 scale)

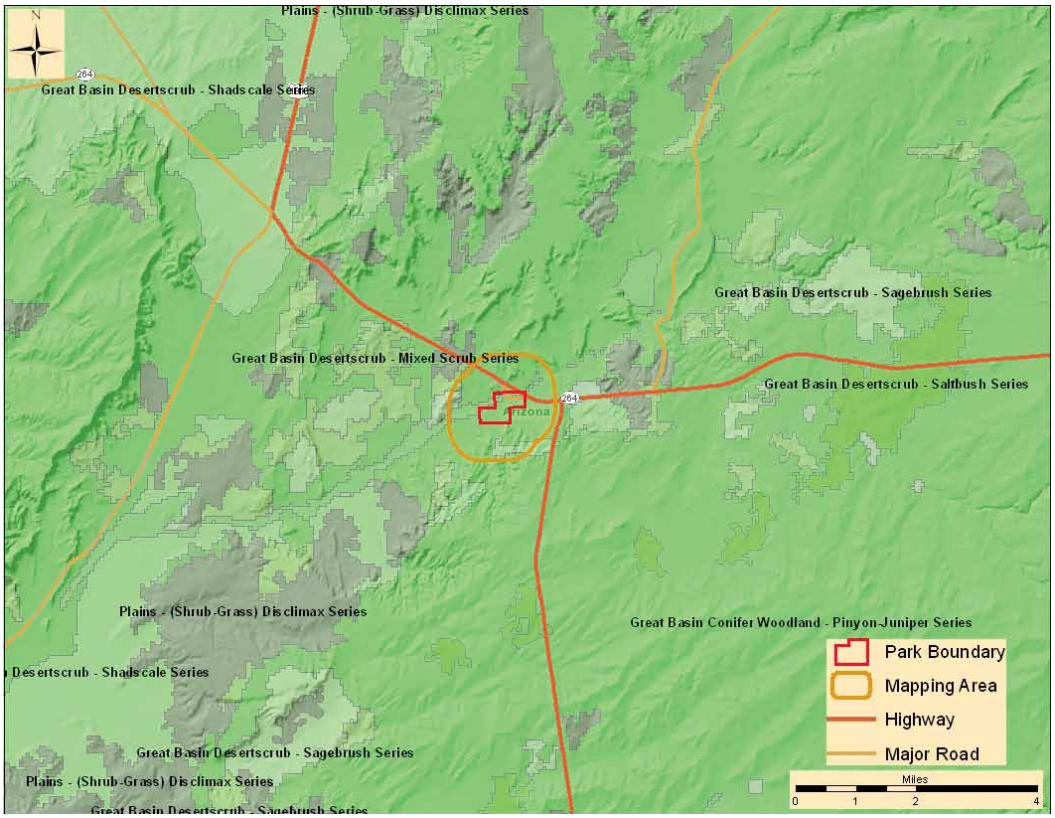

Figure 10. Arizona Gap Vegetation map of the region surrounding Hubbelll Trading Post National Historic Site (1:100,000 scale)

Table 4. Overview of Omernik's (1987) and Bailey's (1995) ecoregion descriptions for the site of Hubbell Trading Post National Historic Site on the Arizona/New Mexico Plateau

Ecoregions - Omernik (1987)	
Ecoregion Code	22
Ecoregion Name	Arizona/New Mexico Plateau
Description	The Arizona/New Mexico Plateau represents a large transitional region between (1) the semiarid grasslands and low relief tablelands of the Southwestern Tablands ecoregion in the east, (2) drier shrublands and woodland-covered higher relief tablelands of the Colorado Plateau in the north, (3) the lower, hotter, less vegetated Mojave Basin and Range in the west, and (4) the Chihuahuan Deserts in the south. Higher, more forest-covered, mountainous ecoregions border the region on the northeast and southwest. Local relief in the region varies from a few meters on plains and mesa tops to well over 300 meters along tableland side slopes.
Ecoregions - Bailey (1995)	
Domain	Dry Domain
Division	Tropical/Subtropical Steppe Division
Province	Colorado Plateau Semi-Desert Province
Section	Navajo Canyonlands Section

area within the buffer area actually contain pinyon-juniper woodland. The GAP map also shows an extensive water area around the arroyo, which is also erroneous. The Brown, Lowe and Pace map (1983) shows the park within a Great Basin Scrub type, which has a number of series types that include shadscale, sagebrush, blackbrush, winterfat, mixed scrub, and saltbush. The region just north of the park is described as "Plains and Great Basin Grasslands" while the area to the south is described as "Great Basin Conifer Woodland" (fig. 11).

The vegetation type is also described by Kearney and Peebles (1942) as "Great Basin Microphyll Desert". They report that the soils have more influence than elevation in determining the vegetation. They also report that smaller drainages, such as Pueblo Colorado Wash, "are without distinctive plants and do not have a marginal fringe of upland plants growing more densely than elsewhere. *Forestiera neomexicana* (New Mexico olive) and *Sarcobatus vermiculatus* (greasewood) are sometimes found in such situations, but no perennials assume the role played in southern Arizona by *Populus* spp. (cottonwood), *Prosopis* (mesquite), *Cercidium floridum* (blue paloverde), and *Baccharis* (baccharis)". They do not discuss the influence of *Tamarix* sp. (tamarisk; saltcedar), since their observations preceded the invasion.

Generally, the native vegetation includes *Pinus edulis* (two-needle pinyon), *Juniperus osteosperma* and *Juniperus monosperma* (one-seed juniper), *Atriplex canescens* (fourwing saltbush), *Artemisia tridentata* spp. *tridentata* (basin big sagebrush), and *Ericameria nauseosa* (rubber rabbitbrush). The introduced and weedy species component is quite high in and around the park and includes *Ulmus pumila* (Siberian elm), *Elaeagnus angustifolia* (Russian olive), *Ribes* sp. (currant), *Malus* sp. (apple), *Cuscuta umbellata* (alfalfa dodder), *Centaurea repens* (Russian knapweed), *Helianthus ciliaris* (Texas blueweed), *Chorispora tenella* (blue mustard), *Convolvolus arvensis* (bindweed), *Salsola tragus* (tumbleweed), and *Descurainia sophia* (flixweed), to name a only a few (Roth 2004).

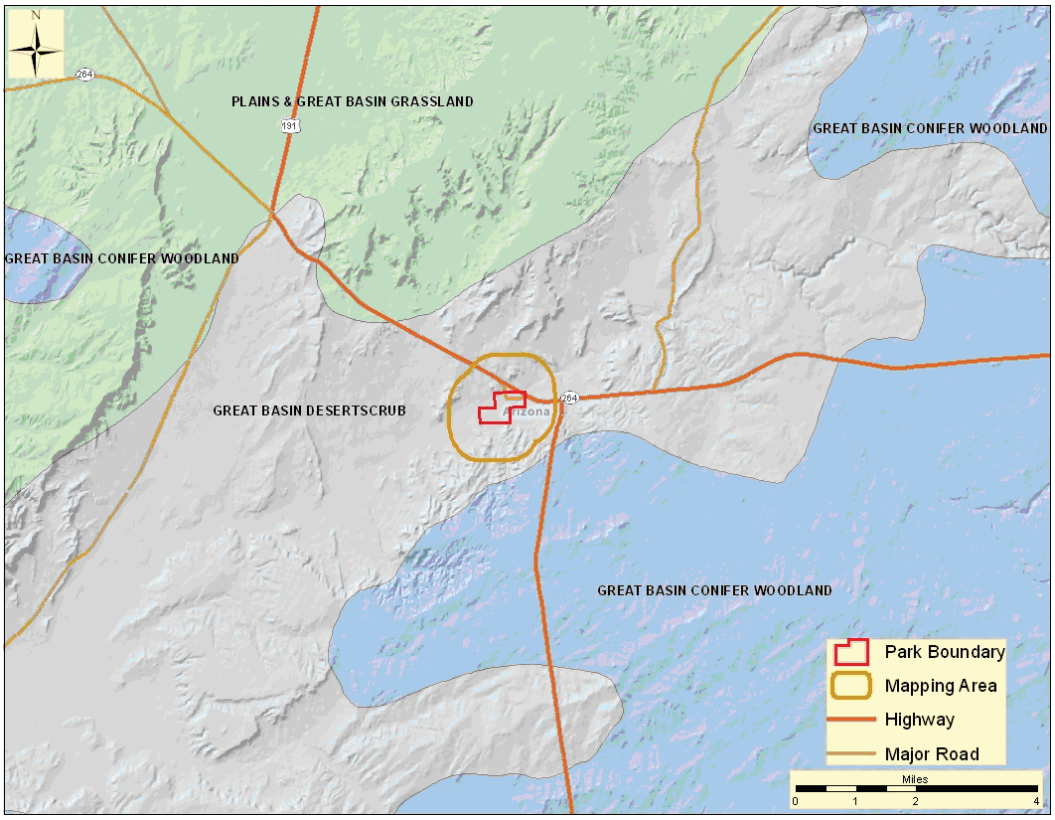

Figure 11. A view of the Brown, Lowe and Pace Biotic Communities of the Southwest map (1983) (1:100,000 scale) in the area surrounding Hubbell Trading Post National Historic Site

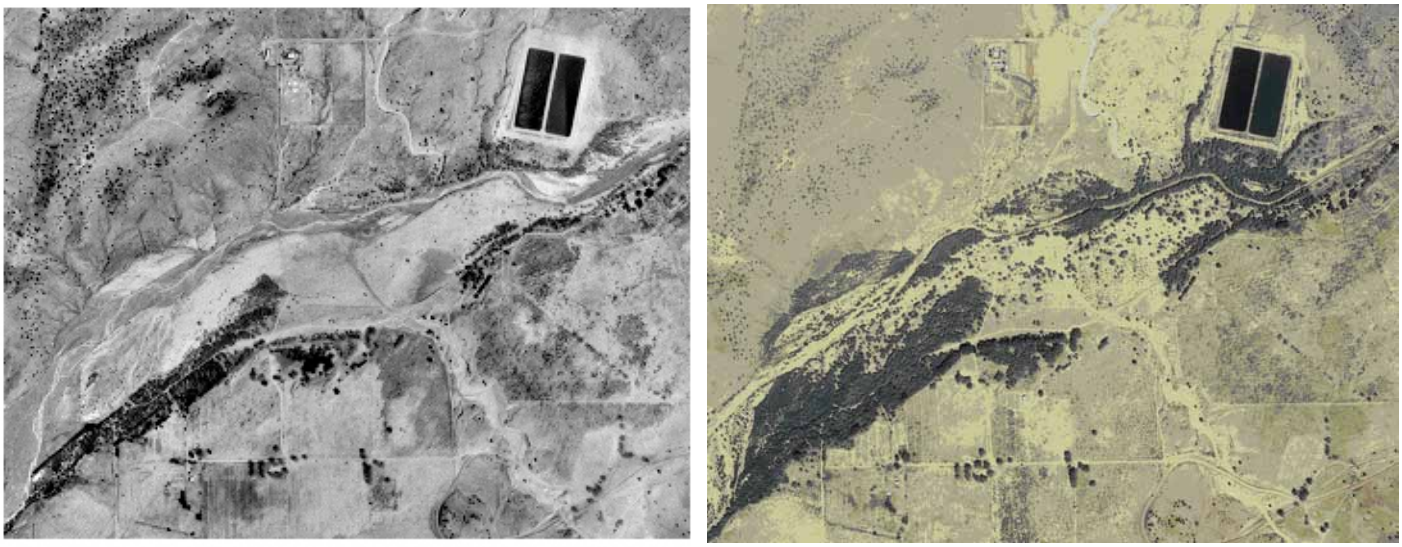

Figure 12. A comparison of the two images above reveals the increase in woody vegetation along Pueblo Colorado Wash from 1988 to 2003. The image on the left is a1988 USDA-FSA-APFO Digital Ortho Mosaic. The image on the right is a 2003 color aerial photography acquired for this project.

A comparison of the 1988 digital orthophotos with the 2003 aerial photography collected for this project reveals a considerable increase in the woody vegetation in and around Pueblo Colorado Wash (fig. 12). In the 1980s, an attempt was made to control flood and erosion damage using artificial structures. While this effort was a failure, some benefit may have been derived from it, as stream down cutting has been reduced considerably since then, resulting in a greater amount of stream and stream bank vegetation (N. Stone, Superintendent, personal communication. 2005).

2. Methods

The methods used to produce a vegetation map for a small area, such as the Hubbell Trading Post National Historic Site (HUTR) project area, are quite different from those used for larger parks (TNC and ESRI 1994a). HUTR falls into the "small park" type, which is defined as less than 1 km^2. If we include the environs, the area becomes 6.6 km^2. For the larger parks the sampling area is the entire park, with data points collected using a stratified approach. For this project, we collected observation points throughout the park. This is described in more detail below.

2.1. Planning and Scoping

On May 11, 2005, a general planning and scoping meeting was held at HUTR to discuss the vegetation mapping needs for several small parks, including HUTR. The following details of the vegetation mapping project were discussed:

- project background – National Program Standards
- unit overviews
- task overviews
  - compilation and preparation of existing data
  - preliminary classification and data review
  - data collection
  - map classification
  - available photographs
  - data base for information
  - local descriptions
  - metadata
  - map production
- field season

2.2. Responsibilities and Deliverables

BOR assumed the primary responsibility for all the tasks for this project. Project deliverables included a full report and metadata, which was distributed to the appropriate NPS offices and websites. The data will ultimately be made available through the USGS website (http://biology.usgs.gov/npsveg/) and through the NPS website (http://science.nature.nps.gov/im/units/scpn/products.cfm). Data and report were reviewed and accepted by the Southern Colorado Plateau Network Coordinator, the HUTR Superintendent, and an internal BOR peer review.

2.3. Preliminary Data Collection and Review of Existing Information

Although no detailed maps of the vegetation at HUTR exist, two vascular plant inventories had been conducted previously by Gandhi and Hatch (1987) and by Roth (2004). Roth reported 184 plant taxa, representing 48 plant families. Of these, 53 species had not been previously reported as occurring in the park. Unfortunately, many of these new species were considered either exotic or weedy species. Approximately 15% of the flora is considered to be exotic by the Southwest Exotic Plant Mapping Program (SWEMP) (Roth 2004; SWEMP 2000).

2.4. Aerial Photography

All aerial photography was collected on September 14, 2003, at a scale of 1:12,000, in natural color. The aerial photography collected for HUTR was part of a region-wide USDA-NPS contract for several park units within the SCPN. The scanned photographs are included in Appendix A of this report, and the digital .tiff files are provided in a separate folder on the CD accompanying this report.

2.5. Photointerpretation

We used the aerial photography to distinguish photo signatures of vegetation types and to delineate preliminary polygons for the project area.

The color photographs (9x9 in, 1:12,000 scale) were interpreted in the following manner:

- We used a stereoscope to aid in rec-

ognizing complex photo signatures and topographic features on the aerial photos.

- We placed Mylar® overlays on each aerial photo and made notes and delineated polygons directly on the the overlay. Polygons were delineated using homogenous ground features as mapable units. No attempt was made at the initial photointerpretation stage to label polygons. After the collection of field data, the polygons were revisited and assigned a map unit (vegetation type) and other polygon attributes.

These preliminary polygons formed the basis of the distribution of sampling, or observation points, throughout the project area.

2.6. Preliminary Vegetation Types

NatureServe developed a preliminary list of potential vegetation types, based on the NVC to aid in the vegetation mapping process. We used this list to develop the initial polygons and to evaluate data collected during the field survey described below.

2.7. Field Survey

We collected vegetation and environmental data in selected polygons on August 15 and 16, 2006. The field survey extended outside the HUTR boundary into the project-defined environs. Given the small size of HUTR, and the subsequent low probability of finding new associations, we decided against using a formalized data collection process, and, instead, used an abbreviated protocol. We used an "observation point" form to collect enough data to assign an existing vegetation association to a particular plot.

Prior to the field visit, all polygons were assigned an identification number. While the field crew tried to visit each polygon, it was not possible to visit all polygons, due to time constraints. So the field crew concentrated on the larger and more ecologically interesting polygons. At each polygon that we visited, we

1. established an observation point within the visited polygons and collected data on the observation point forms.
2. took four photographs at each observation point, facing each of the cardinal directions. (Due to camera problems, some visited polygons do not have digital photographs associated with them.)
3. recorded notes on the vegetation structure and composition within polygons.

Each reference note directly corresponded to one or more polygon identification numbers. The majority of reference notes described vegetation alliances or associations that had previously been sampled in the project area at observation points. Using a combination of observation points and informal reference notes, the field crew recorded information on a majority of the polygons in the project area. All observation point data, as well as point files associated with the GIS database, are included in the attached Microsoft Access database.

2.8. Map Units and Polygon Attribution

When possible, the map units assigned to the delineated polygons on the aerial photographs were derived from the preliminary list of NVC types provided by NatureServe. Additional data and information were gleaned from a field visit and incorporated into the final list of map units. Because of the small size of HUTR and the large amount of field data, the map units are equivalent to existing NVC vegetation alliances and associations or local associations/descriptions.

Four attributes were associated with each polygon: (1) map unit, (2) height, (3) den-

Table 5. Structural categories for vegetation photointerpretation

Code	Height	
1	< 1 m	
2	1 - 5 m	
3	5 - 15 m	
4	15 - 30 m	
5	> 30 m	
	Coverage Density	
1	Closed Canopy/Continuous	75 – 100 %
2	Discontinuous	50 – 75 %
3	Dispersed	25 – 50 %
4	Sparse	< 25 %
	Coverage Patterns	
1	Evenly Dispersed	
2	Clumped / Bunched	
3	Gradational / Transitional	
4	Alternating	

sity, and (4) coverage pattern of the vegetation. The structural categories and codes we used are listed in Table 5. Each polygon has a number of attributes that are stored in the associated table within the GIS database. Many of these attributes were derived from the photointerpretation; acres and hectares were calculated using XTools Pro for ArcGIS Desktop (see www.xtoolspro.com), and others were calculated or cross-walked from other classifications. Table 6 lists all the attributes and their sources. Anderson et al. (1976) Level 1 and 2 land-use codes are also included. These codes should permit a more regional perspective on the vegetation types. Appendix B is a lookup table which provides extensive information about each map unit, including:

- the names associated with the map codes
- NVC formation information

Table 6. Polygon attribute items and descriptions used in the Hubbell Trading Post National Historic Site spatial database (GIS coverage)

Attribute	Description
AREA*	Surface area of the polygon (m^2)
PERIMETER*	Perimeter of the polygon (m)
HUTR_VEG*	Unique internal polygon coding
HUTR_VEG_ID*	Unique internal polygon coding
VEGCODE	Final Map Unit Codes - BOR derived, project specific.
VEG_NAME	Final Map Unit Names – BOR derived, NVC defined, project specific.
HEIGHT	Height range of the dominant vegetation layer.
	(Height classes: <1 m, 1-5 m, 5-15 m, 15-30 m, >30 m)
DENSITY	Density of the tallest strata.
	(Density classes: <25%, 25-50%, 50-75%, >75%)
PATTERN	Vegetation pattern within the polygon.
	(Vegetation pattern classes: Evenly dispersed, Clumped/bunched, Gradational, Alternating)
AND_LEV1	Land Use and Land Cover Classification System (USGS, Anderson et al. 1976) Level 1.
AND_LEV2	Land Use and Land Cover Classification System (USGS, Anderson et al. 1976) Level 2.
EL_CODE_1	Ecological Systems Classification Code - NatureServe Ecological Classification.
EL_CODE_2	Ecological Systems Classification Code - NatureServe Ecological Classification.
ACRES	Area in acres
HECTARES	Area in hectares

(*ArcInfo© default items)

- alliance names
- unique IDs
- ecological system codes (El_Code) for associations (an association may be related to more than one ecological system)
- Anderson et al. (1976) land-use classifications, completed by cross-walking from the existing vegetation classification
- numeric land-use codes (Anderson et al. 1976)
- the NatureServe conservation status

2.9. Digital Transfer

Because HUTR covers a limited area, we used "heads-up digitizing" on an existing USGS digital orthophoto basemap. This technique is ordinarily too time consuming for larger parks, but works well for projects in smaller parks. From the digitized vectors we created polygons by building topology in the GIS program. Finally, we created labels for each polygon and used these to add the attribute information. Attribution for all the polygons at HUTR included information pertaining to map units, NVC associations, Anderson land-use classes, and other relevant data. Attribute data were taken directly from the interpreted photos or were added later using the orthophotos as a guide.

2.10. Plot Data Management And Classification Analysis

2.10.1. Plot Data Management

Following the field season, and prior to data entry, all plot forms were checked to ensure quality control (QC). Particular attention was paid to ensure that the recorded plot location was correct and that all relevant fields were filled in.

Following the QC check of the datasheets, the data were entered into the PLOTS database, and all plots were subjected to a second QC check to eliminate any data entry errors. During this second check, the database was examined, sorted, and queried to find missing data, misspellings, duplicate entries, and typos. The species lists were carefully checked to make sure that only names and acronyms consistent with the USDA PLANTS database (NRCS 2005) were used, and that species' names and assignments to strata were consistent and logical. Plant lists were compared to the assigned association name to ensure correlation.

In order to provide a more complete picture of the vegetation present at HUTR, we developed a species list (Appendix C) of vouchered plant specimens collected by Roth (2004) and others, that were included in NPSpecies (https://science1.nature.nps.gov/npspecies/web/main/start (accessed 11/3/2008).

2.10.2. Vegetation Classification

We reviewed each observation point collected and compared each to known vegetation associations within the NVC, in order to assign a vegetation name to each field plot and, by proxy, to each polygon that intersected a specific plot. Polygons that did not receive a field visit were assigned to a map unit based solely on photointerpretation.

2.11. Map Verification

Map verification is required for all NPS vegetation mapping projects. The larger parks usually require some sort of stratified random sample in order to derive a statistically valid statement regarding the accuracy of the entire map and of each map unit. For the purposes of a park the size of HUTR, a representative sample across the park sufficed to establish an assumption of 100% accuracy.

3. Results

3.1. Field Data Collection

The field crew visited a majority of the

polygons in the project area. Crew members documented a total of thirteen observation field plots, describing dominant vegetation associations of Hubbell Trading Post National Historic Site (HUTR) (fig. 13). They recorded an additional sixty-nine field notes, referenced to polygon identification numbers, to aid in the classification of delineated vegetation polygons. The field notes were used to describe vegetation types that had already been sampled in a formal observation field plot. Using this combination of observation field plots and field notes, the crew was able to efficiently assess a larger portion of the project area.

3.2. Vegetation Classification

Initially, NatureServe had prepared a report that listed the NVC vegetation types that local experts had reason to believe might exist in the area of HUTR. An analysis of the observation point information and field notes collected at HUTR in August of 2006 identified some of those vegetation types from the NatureServe report, as well as others not on the preliminary list. In some cases, there was only enough field data to identify a vegetation type to the alliance level of classification.

Using the vegetation plot data (i.e., observation field plot information and field notes) collected in 2006, polygons were classified into distinct vegetation types, based on species composition, structure, and environmental characteristics. A total of 24 map units were used to map both vegetated and non-vegetated/anthropogenic-dominated land areas at HUTR (table 7):

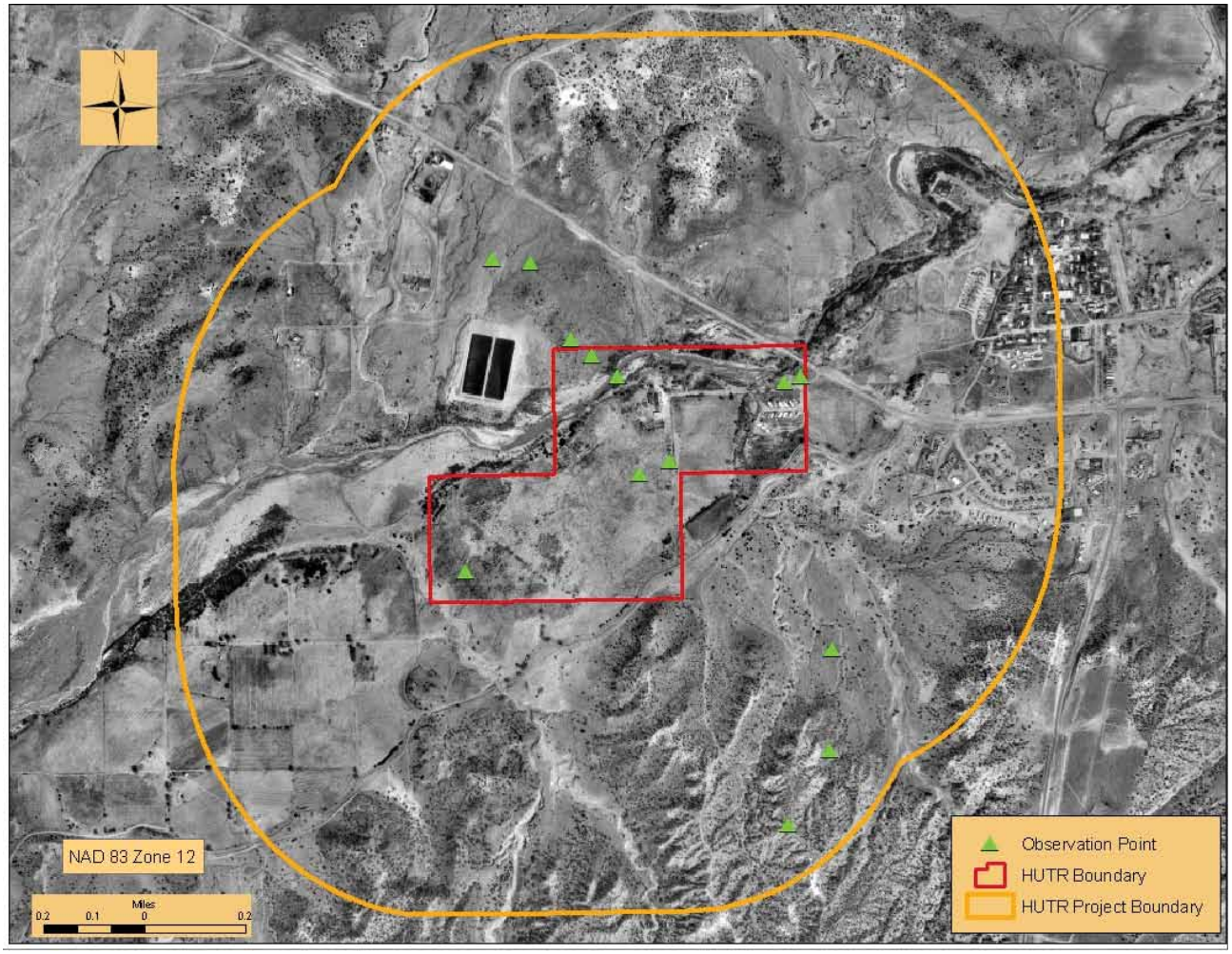

Figure 13. Location of vegetation observation field plots at HUTR

- eleven recognized NVC types, of which five are at the alliance level and 6 at the association level
- five "local" types, specific to the park, but not yet recognized in the NVC.
  - *Artemisia* sp. (sagebrush) Dwarf-shrubland (based on presence of unidentified Artemisia species)
  - *Lycium pallidum* (pale desert-thorn) Shrubland
  - Restoration Area (Planted native riparian trees and/or shrubs)
  - *Ulmus pumila* Woodland
  - Weedy Forbs - Abandoned Agriculture Field (Disturbed Area)
- Eight other non-vegetated or heavily human-influenced land cover types, based on Anderson's land-use (Anderson et al. 1976) level 2 classifications, for a total of 24 map units (land cover types)

Table 7 lists the map units of the HUTR vegetation map, the frequency (i.e., number of polygons representing each map unit), and the summary statistics for each map unit area.

Table 7. Map units, frequency, and area statistics for Hubbell Trading Post National Historic Site and project area (park + buffer area)

		Park			Project Area		
	Map Unit	**freq.**	**ha**	**ac**	**freq.**	**ha**	**ac**
1	*Artemisia* sp. Dwarf-shrubland Alliance	0	0	0	1	24.3	60.0
2	*Atriplex canescens* Shrubland	2	22.7	56.0	3	29.4	72.8
3	Bare Exposed Rock	0	0	0	1	1.0	2.6
4	Commercial and Services	0	0	0	2	13.5	33.4
5	Cropland and Pasture	2	5.5	13.7	3	59.8	147.8
6	*Elaeagnus angustifolia* Semi-natural Woodland Alliance	3	2.3	5.7	13	37.8	93.5
7	*Ericameria nauseosa* Shrubland	10	11.6	28.8	29	170.4	421.0
8	*Gutierrezia sarothrae* Dwarf-shrubland Alliance	2	1.6	4.1	7	9.2	22.7
9	*Juniperus osteosperma* / *Artemisia tridentata* ssp. *tridentata* Woodland	1	0.4	0.9	1	2.7	6.8
10	*Juniperus osteosperma* Woodland Alliance	1	0.3	0.8	23	71.2	175.9
11	*Lycium pallidum* Shrubland Alliance	1	0.1	0.4	3	4.7	11.5
12	Mixed Urban or Built-up Land	0	0	0	5	18.9	46.7
13	Other Urban or Built-up Land	1	1.6	4.0	2	3.8	9.5
14	*Pinus edulis* - *Juniperus osteosperma* / Sparse Understory Woodland	1	<0.01	<0.01	6	84.6	209.1
15	*Pinus edulis* - *Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland	0	0	0	4	7.6	18.9
16	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	0	0	0	8	34.9	86.3
17	*Populus deltoides* / *Ericameria nauseosa* Forest	2	0.5	1.3	2	0.6	1.4
18	*Populus deltoides* Temporarily Flooded Forest Alliance	2	0.01	0.03	4	6.4	15.8
19	Residential	3	1.9	4.7	14	25.6	63.4
20	Restoration Area (Planted Native Riparian Trees and/or Shrubs)	2	1.8	4.5	2	2.1	5.2
21	Streams and Canals	3	2.1	5.2	5	13.9	34.4
22	Transportation, Communications, and Utilities	1	0.1	0.4	3	8.9	22.0
23	*Ulmus pumila* Woodland Alliance	1	1.0	2.6	4	3.1	7.8
24	Weedy Forbs - Abandoned Agriculture Field (Disturbed Area)	3	11.0	27.1	7	28.5	70.5
	Totals	41	64.7	159.9	152	663.2	1638.9

For each map unit that represents an NVC alliance rather than an association, one or more local component associations may be present in the field in each particular polygon. Table 8 lists the component association(s) that are encompassed within each map class.

3.3. Vegetation Alliances and Associations

Local and global descriptions for each map unit (i.e., alliance or association) represented in the HUTR vegetation map are described in the following sections, including a description of the vegetation alliance or association (http://www.natureserve.org/explorer/). These de-

Table 8. Vegetation associations encompassed within each map class.

	Map Unit Name	Component Association(s)	El_code(s)
1	***Artemisia sp***. Dwarf-shrubland Alliance	n/a (Non-NVC; Local Type)	n/a
2	*Atriplex canescens* Shrubland	n/a	CEGL001281
3	Bare Exposed Rock	n/a (Anderson's Land Use)	n/a
4	Commercial and Services	n/a (Anderson's Land Use)	n/a
5	Cropland and Pasture	n/a (Anderson's Land Use)	n/a
6	*Elaeagnus angustifolia* Semi-natural Woodland Alliance	n/a	A.3566
7	*Ericameria nauseosa* Shrubland	n/a	CEGL002713
8	*Gutierrezia sarothrae* Dwarf-shrubland Alliance	n/a	A.2528
9	*Juniperus osteosperma / Artemisia tridentata* ssp. *tridentata* Woodland	n/a	CEGL002360
10	*Juniperus osteosperma* Woodland Alliance	*Juniperus osteosperma / Artemisia tridentata* ssp. *tridentata* Woodland	A.536 / CEGL002360
		Juniperus osteosperma / Bouteloua gracilis Woodland	CEGL002361
11	*Lycium pallidum* Shrubland Alliance	n/a (Non-NVC; Local Type)	n/a
12	Mixed Urban or Built-up Land	n/a (Anderson's Land Use)	n/a
13	Other Urban or Built-up Land	n/a (Anderson's Land Use)	n/a
14	*Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland	n/a	CEGL002148
15	*Pinus edulis - Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland	n/a	CEGL000776
16	*Pinus edulis - (Juniperus* spp.) Woodland Alliance	*Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland	A.516 / CEGL002148
		Pinus edulis - Juniperus spp. / *Artemisia tridentata (*ssp. *wyomingensis,* ssp. *vaseyana*)	CEGL000776
17	*Populus deltoides / Ericameria nauseosa* Forest	n/a	CEGL005969
18	*Populus deltoides* Temporarily Flooded Forest Alliance	*Populus deltoides / Ericameria nauseosa* Forest	A.290 / CEGL005969
19	Residential	n/a (Anderson's Land Use)	n/a
20	Restoration Area (Planted Native Riparian Trees and/or Shrubs)	n/a (Non-NVC; Local Type)	n/a
21	Streams and Canals	n/a (Anderson's Land Use)	n/a
22	Transportation, Communications, and Utilities	n/a (Anderson's Land Use)	n/a
23	*Ulmus pumila* Woodland Alliance	n/a (Non-NVC; Local Type)	n/a
24	Weedy Forbs - Abandoned Agriculture Field (Disturbed Area)	n/a (Non-NVC; Local Type)	n/a

scriptions have been modified to include local classification comments and/or local vegetation summaries. In some cases the NatureServe classification confidence is weak and the only description available is the local description. Comments and summaries can provide new information that may or may not be included in further reviews of the salient types.

3.3.1. Shrubland Vegetation

3.3.1.1. *Atriplex canescens* Shrubland Alliance

Translated name	Unique identifier	Classification approach
Fourwing Saltbush Shrubland Alliance	A.869	International Vegetation Classification (IVC)

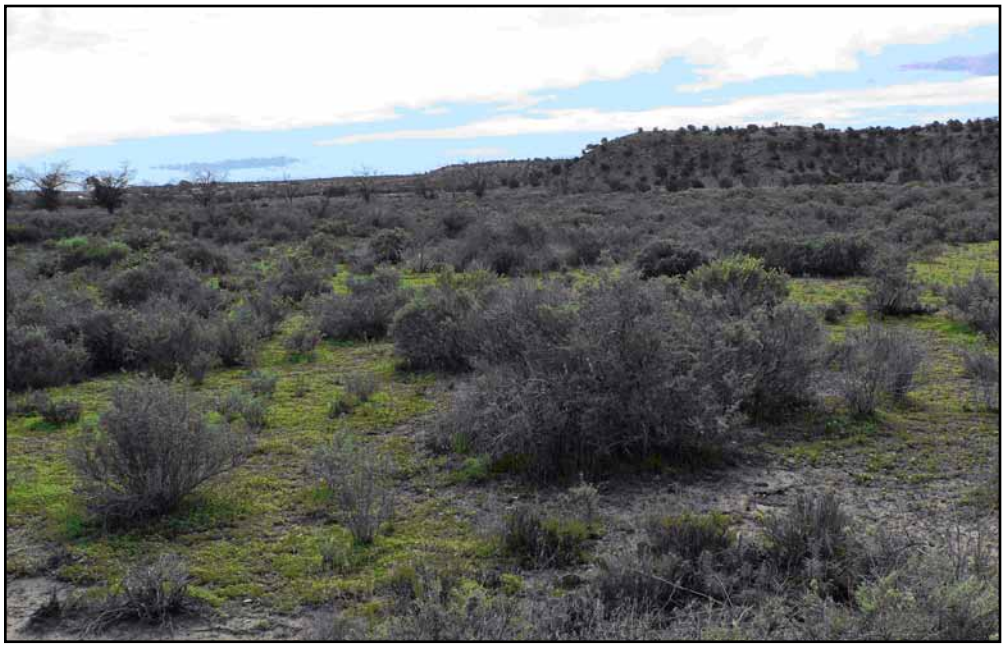

Figure 14. *Atriplex canescens* Shrubland Alliance at HUTR

Atriplex canescens Shrubland

Translated name	Unique identifier	Classification approach
Fourwing Saltbush Shrubland	CEGL001281	International Vegetation Classification (IVC)

Summary: This shrubland association is known from the Great Basin north into the southern Columbia Basin and east into Wyoming and the Colorado Plateau. It is common at middle elevations on alluvial fans and toeslopes in deep, sandy soils, but will occur at lower elevations along alluvial benches where soils are often finer-textured and possibly saline/alkaline. Parent materials are variable. The vegetation is characterized by a sparse to moderately dense short-shrub layer (10-35% cover), dominated or codominated by *Atriplex canescens*, typically with a variable and often sparse herbaceous layer. Notable codominants in the shrub layer include *Chrysothamnus viscidiflorus* (green rabbitbrush), *Coleogyne ramosissima* (blackbrush), *Ephedra nevadensis* (Nevada jointfir), *Eriogonum nummulare* (= *Eriogonum kearneyi*) (money buckwheat), *Grayia spinosa* (spiny hopsage), *Gutierrezia sarothrae* (snakeweed), *Lycium pallidum*, or *Psorothamnus* spp. *Ephedra viridis* (mormon tea) may be present but is not a codominant. The herbaceous layer includes low cover of species such as *Achnatherum hymenoides* (Indian ricegrass), *Aristida purpurea* (purple threeawn), *Elymus elymoides* (squirreltail), *Pleuraphis jamesii* (James' galleta), and S*porobolus cryptandrus* (sand dropseed). Introduced species, especially *Bromus tectorum* (cheatgrass), *Bromus diandrus* (ripgut brome), and *Salsola kali (*Russian thistle)*,* are common on disturbed sites and can create an herbaceous layer much more dense than that on undisturbed sites. Winter annual forb cover is variable depending on annual precipitation.

Classification confidence: 2 - Moderate

Vegetation hierarchy

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

Ecological systems placement

Ecological system unique ID	Ecological system name
CES302.749	Sonora-Mojave Mixed Salt Desert Scrub
CES304.784	Inter-Mountain Basins Mixed Salt Desert Scrub

Global status	G5 (23Feb1994)
Rounded global status	G5 - Secure
United States distribution	CA, CO, NV, UT, WY
Global distribution	United States
Global range	This shrubland association may occur throughout much of the interior western U.S. It is known from the southern Columbia Basin and Great Basin east into Wyoming and the Colorado Plateau.

Vegetation summary: This association is characterized by a sparse to moderately dense shrub layer (10-35% cover) dominated or codominated by *Atriplex canescens*, typically with a variable and often sparse herbaceous layer. Total vegetation cover ranges from sparse to moderate (5-56% cover). Notable codominants in the shrub layer include Chryso*thamnus viscidiflorus, Coleogyne ramosissima, Ephedra nevadensis, Eriogonum nummulare* (= *Eriogonum kearney*i), *Grayia spinosa, Gutierrezia sarothrae, Lycium pallidum, Psorothamnus fremontii* (Fremont's dalea), or *Psorothamnus polydenius* (Nevada dalea). *Ephedra viridis* may be present but is not a codominant. The typically sparse herbaceous layer includes low cover of species such as *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Aristida purpurea, Elymus elymoides, Pleuraphis jamesii* (= *Hilaria jamesii*), and *Sporobolus cryptandrus*. Common forb species on sandy sites include *Cymopterus ripleyi* (Ripley's springparsley), *Dalea searlsiae* (Searls' prairie clover), *Lesquerella ludoviciana* (foothill bladderpod), and *Oenothera pallida* (pale evening-primrose). Winter annual forb cover is variable depending on annual precipitation. Introduced species such as *Bromus tectorum, Bromus diandrus*, and *Salsola kali* are common on disturbed sites and may form a moderately dense herbaceous stratum.

Wetland indicator: N

Environmental summary: This shrubland association is found on bajadas, low stream terraces, valley floors and toeslopes. Sites are flat to gently sloping with any aspect. It is commonly found on deep, sandy soils at middle elevations (1,235-2,256 m; 4,050-7,400 ft) but will occur at lower elevations (down to 610 m; 2,000 ft) along alluvial benches where soils are often finer-textured and possibly saline/alkaline (Beatley 1976). The unvegetated surface is predominantly bare soil and/or sand. Larger rocks and organic material are rare. Parent materials include volcanic tuff, shale and sandstone. At lower elevations, it may occur as a mosaic with *Lycium pallidum - Grayia spinosa*- or *Atriplex confertifolia* (shadscale)-dominated shrublands.

Dynamics: Stands of this association may be affected during large flood events.

Local description: This association is described by two field plots in the park mapping project area. Both plots were located in the large disturbed abandoned agricultural/pasture area immediately south of the administrative buildings of Hubbell Trading Post National Historic Site. A total of only three polygons were mapped as this association in the project area. *Atriplex canescens* was the dominant shrub and ranged in cover from 10-25% (fig. 15). Locally associated shrubs within this association included *Ericameria nauseosa* and *Gutierrezia sarothrae*. In both plots, associated shrubs represented less than 5% cover. The herbaceous layer for a large portion of the pasture area was dominated by several exotic species, as defined by the protocols described by the SWEMP (SWEMP 2000). Herbaceous strata cover for the two plots ranged from 30-60% cover. Notable exotic species dominating the herbaceous stratum included *Convolvulus arvensis, Portulaca oleracea* (little hogweed), and *Salsola tragus* (prickly Russian thistle). One additional unknown forb species often occurred as a codominant species and is assumed to be an exotic.

Figure 15. *Atriplex canescens* Shrubland at HUTR

3.3.1.2. *Ericameria nauseosa* **Shrubland Alliance**

Translated name	Unique identifier	Classification approach
Rubber Rabbitbrush Shrubland Alliance	A.835	International Vegetation Classification (IVC)

Figure 16. *Ericameria nauseosa* Shrubland (HUTR-4; East)

Ericameria nauseosa **Shrubland**

Translated name	Unique identifier	Classification approach
Rubber Rabbitbrush Shrubland	CEGL002713	International Vegetation Classification (IVC)

Summary: This is a broadly defined, semi-arid upland shrubland association, currently described from western Colorado and Nevada, but it is likely more widespread. Elevations range from 1,191 m in Nevada to 2,291-2,312 m in Colorado. Stands occur on flat to gently sloping (<8%), dry alluvial terraces above ephemeral washes or perennial stream and river channels, or may form a band in the alluvial flats above playas. Substrates are deep, moderately well- to well-drained silty clay loam, to sandy loam soils derived from stratified alluvium. The ground surface has moderate to high cover of bare soil. The vegetation is characterized by a moderately dense to dense (40-70% cover) shrub canopy dominated by *Ericameria nauseosa* shrubs 0.5-3 m tall, with a relatively sparse herbaceous layer. In Colorado, stands have low diversity. Additional associated short and dwarf-shrubs are *Artemisia frigida* (fringed sagebrush), *Artemisia tridentata* ssp. *Wyomingensis* (Wyoming big sagebrush), and *Rosa woodsii* (Woods' rose). In Nevada, stands are more diverse, and several other shrubs, such as *Atriplex canescens*, *Psorothamnus polydenius*, *Sarcobatus vermiculatus*, and *Tetradymia tetrameres* (fourpart horsebrush), may be important. The sparse herbaceous layer is a mixture of grasses and forbs. Introduced annual grass *Bromus tectorum* and native grasses *Pseudoroegneria spicata* (bluebunch wheatgrass) and *Sporobolus airoides* (alkali sacaton) are typically absent or have low cover.

Classification confidence: 3 - Weak

Classification comments: This broadly defined upland *Ericameria nauseosa* association is not a wash or dune/sand-sheet shrubland. Diagnostic of this type is a sparse herbaceous layer that is not dominated by the widespread introduced annual grass *Bromus tectorum,* or the native grasses *Pseudoroegneria spicata* or *Sporobolus airoides*. One of the stands classified by Bundy et al. (1996) is codominated by *Tetradymia tetrameres*. These transitional types are difficult to classify, and further survey and classification work are needed to fully characterize this association.

Vegetation hierarchy

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

Ecological systems placement

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

Global status	G5 (26Jun2001)
Rounded global status	G5 - Secure
United States distribution	CO, NV
Global distribution	United States
Global range	This is a broadly defined upland shrubland association currently described from western Colorado and Nevada, but it likely occurs more widely in the western U.S.

Vegetation summary: The vegetation is characterized by a moderately dense to dense (40-70% cover) shrub canopy, dominated by *Ericameria nauseosa* shrubs 0.5-3 m tall, with a relatively sparse herbaceous layer. In Colorado, stands have low diversity. Additional associated short and dwarf-shrubs are *Artemisia frigida*, *Artemisia tridentata* ssp. *wyomingensis*, and *Rosa woodsii*. In Nevada, stands are more diverse, and several other shrubs, such as *Atriplex canescens*, *Psorothamnus polydenius*, *Sarcobatus vermiculatus*, and *Tetradymia tetrameres*, may be important. The sparse herbaceous layer is a mixture of grasses and forbs. Native grasses include *Achnatherum hymenoides*, *Distichlis spicata* (saltgrass), and *Elymus elymoides*. Common forbs may include the non-natives *Cirsium arvense* (Canada thistle), *Descurainia incana* ssp. *incise* (mountain tansymustard), *Erodium cicutarium* (redstem stork's bill), *Lepidium campestre* (field pepperweed), *Iva axillaris* (povertyweed), *Salsola tragus*, *Sisymbrium altissimum* (tall tumblemustard), and the natives *Eriogonum hookeri* (Hooker's buckwheat), *Rumex salicifolius* (willow dock), and *Verbesina encelioides* (golden crownbeard). The introduced annual grass *Bromus tectorum* and native grasses *Pseudoroegneria spicata* and *Sporobolus airoides* are typically absent or have low cover.

Wetland indicator: N

Environmental summary: This is a broadly defined, semi-arid, upland shrubland association, currently described from western Colorado and Nevada, but it is likely more widespread. Elevations range from 1,191 m in Nevada to 2,291-2,312 m in Colorado. Stands occur on flat to gently sloping (<8%), dry alluvial terraces above ephemeral washes or perennial stream and river channels or may form a band in the alluvial flats above playas. Substrates are deep, moderately well- to well-drained silty clay loam to sandy loam soils derived from stratified alluvium. Sand or other coarse-textured material may underlay finer-textured layers (Bundy et al. 1996). The ground surface has moderate to high cover of bare soil.

Dynamics: *Ericameria nauseosa* is considered a shrub of depleted range and disturbed areas (McArthur et al. 1977). A fire-adapted species that is typically unharmed or enhanced by fire, it is often one of the first species to colonize burned areas by sprouting from adventitious buds on its stems and root crown, or from off-site seed (FEIS 2006). Stands appear to be dependent on disturbance, such as receding lake beds, past prairie dog use, abandoned agriculture or heavy grazing, which favors *Ericameria nauseosa* (USFS 1937).

Local description: A total of three field plots, representing a large portion of the mapping area, were described as *Ericameria nauseosa* Shrubland at HUTR. Each of three field plots represented three distinct areas where this association occurred. The first field plot (HUTR-1) was located just outside (east) of the fenced abandoned agriculture/pasture area that is south of the HUTR's administrative buildings. This plot represented a tall shrubland (1-2 m) dominated by *Ericameria nauseosa* (35% cover), with *Atriplex canescens* occurring as a codominant (15%). The herbaceous layer (5%) consisted of several SWEMP-defined exotic species, such as *Convolvulus arvensis*, *Portulaca oleracea*, and *Salsola tragus*. One additional unknown forb species occurred as a codominant species and was assumed to be an exotic. This plot may be considered similar to the field

plots (HUTR-2, HUTR-3) located in the abandoned agricultural/pasture area, which were classified as the "*Atriplex canescens* Shrubland" association.

The second field plot (HUTR-4) captured additional local variability in vegetation structure and composition within this association (fig. 16). This field plot represents a tall floodplain shrubland (1-2 m) located adjacent to Pueblo Colorado Wash. *Ericameria nauseosa* (20%) was the dominant shrub. The dwarf shrub *Gutierrezia sarothrae* was also present at low densities (2%). The herbaceous layer (40%) was largely composed of the exotic *Portulaca oleraceae* (35%). Additional species in the herbaceous layer included *Malva* sp. (mallow) and *Salsola tragus*. Notable species representing the adjacent bankside stream vegetation included *Salix exigua* (narrowleaf willow), *Salix* sp.(willow), and *Ulmus pumila*. Additional disturbance in the vicinity of the plot was the somewhat recent clearing and burning of *Elaeagnus angustifolia* and/or *Tamarix* sp.

Finally, the third field plot (HUTR-5) represented a toeslope/midslope shrubland community (fig. 17). Differences between the geologic substrates of the field plots characterizing this association may largely influence the local variability observed within this association. The plot was located on a rocky slope of 10% with an aspect of 140 degrees. Unvegetated ground cover was dominated by small and large rocks (45%) in addition to bare soil (40%). The short shrub stratum was dominated by *Ericameria nauseosa* (10%). *Atriplex canescens* was also present (< 1% cover). The dwarf shrub *Gutierrezia sarothrae* codominated the area with an estimated cover of 10%. The herbaceous stratum (5%) consisted of several sparse graminoid species.

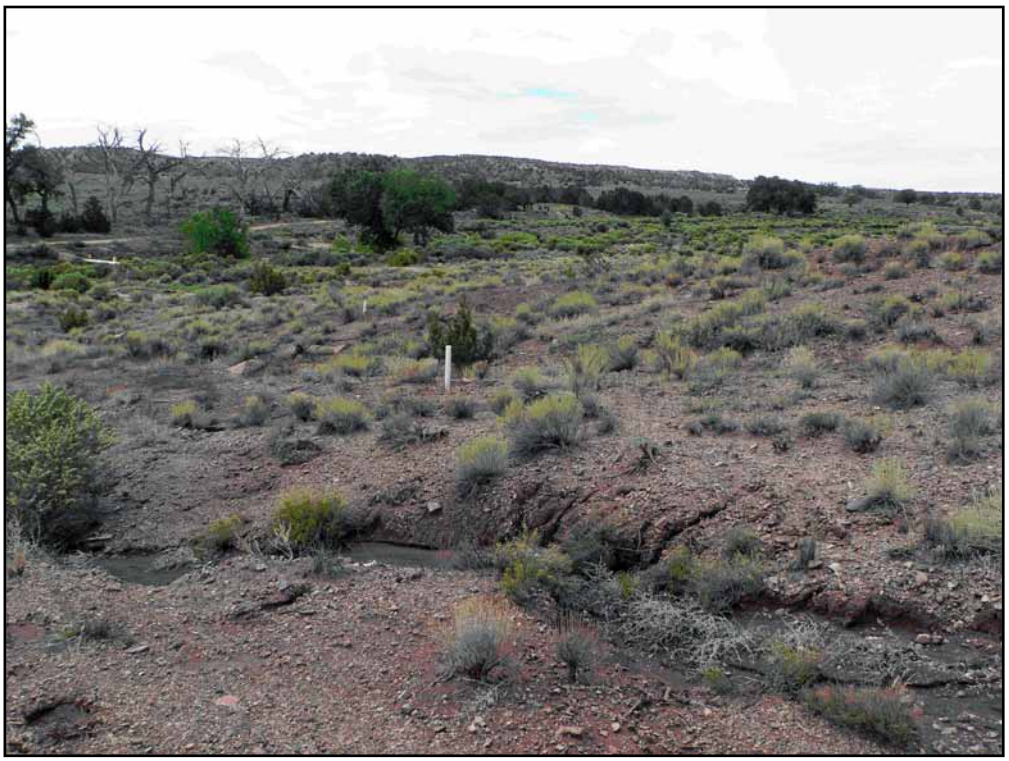

Figure 17. *Ericameria nauseosa* Shrubland (HUTR-5; West)

3.3.1.3. *Gutierrezia sarothrae* Dwarf-shrubland Alliance

Translated name	Unique identifier	Classification approach
Snakeweed Dwarf-shrubland Alliance	A.2528	International Vegetation Classification (IVC)

Summary: This dwarf-shrubland alliance was described from Utah and Arizona where it occurs on stream terraces, plains, gently sloping hillslopes, ridges, plateaus and bluffs on all aspects. Elevations range from 1,350-2,000 m. Soils are variable, ranging from sandy loam to clay derived from alluvium or colluvium. Disturbance may be important in maintaining this vegetation community as some stands have been created by chaining of trees and improper grazing by livestock. This broadly defined alliance is characterized by an open to moderately dense dwarf-shrub canopy (10-50% cover) that is dominated by *Gutierrezia sarothrae* frequently with *Opuntia* (pricklypear) spp., and a sparse to moderately dense herbaceous layer (1-45% 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 *Achnatherum hymenoides*, *Aristida purpurea*, *Bouteloua gracilis*, *Elymus elymoides*, *Hesperostipa comata* (needle-and-thread grass), *Pascopyrum smithii* (western wheatgrass), *Pleuraphis jamesii*, or *Sporobolus airoides*. There is usually only sparse cover of native forbs like *Chamaesyce* (sandmat) spp. or *Sphaeralcea coccinea* (scarlet globemallow); however, introduced species such as *Bromus tectorum* or *Salsola kali* may dominate the herbaceous layer of some disturbed stands.

Classification comments: This broadly defined dwarf-shrubland alliance includes stands that could also be classified as a dwarf-shrub herbaceous vegetation.

Vegetation hierarchy

Formation class	IV - Dwarf-shrubland
Formation subclass	IV.B - Deciduous dwarf-shrubland
Formation group	IV.B.2 - Cold-deciduous dwarf-shrubland
Formation subgroup	IV.B.2.N - Natural/Semi-natural cold-deciduous dwarf-shrubland
Formation name	IV.B.2.N.a - Cespitose cold-deciduous dwarf-shrubland

United States distribution	AZ, TX, UT
Global distribution	United States
Global range	This alliance is reported from Utah and Arizona, but is likely more widespread throughout the semi-arid western U.S.

Vegetation summary: This broadly defined alliance is characterized by an open to moderately dense dwarf-shrub canopy (10-50% cover) dominated by *Gutierrezia sarothrae*, frequently with *Opuntia* spp., and a sparse to moderately dense herbaceous layer. Some stands have a diverse woody layer that includes low cover of *Artemisia nova*, *Atriplex canescens*, *Atriplex confertifolia*, *Atriplex obovata* (broadscale), *Chrysothamnus viscidiflorus*, *Coleogyne ramosissima*, *Ephedra* spp., *Eriogonum* spp., *Grayia spinosa*, *Lycium pallidum*, *Parryella filifolia* (common dunebroom), *Purshia tridentata* (antelope bitterbrush), *Yucca* spp., or occasional *Pinus edulis* or *Juniperus osteosperma* trees. The herbaceous layer is typically dominated by graminoids with several species present to abundant including *Pleuraphis jamesii*, *Achnatherum hymenoides*, *Aristida purpurea*, *Bouteloua gracilis*, *Elymus elymoides*, *Hesperostipa comata*, *Pascopyrum smithii*, or *Sporobolus airoides*. 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.

Wetland indicator: N

Environmental Summary: This alliance is described from Utah and Arizona at elevations ranging from 1,350-2,000 m. Sites include stream terraces, plains, gently sloping hillslopes, ridges, plateaus and bluffs. Stands occur on all aspects. 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 in some areas, as some stands may have been created by chaining of trees and improper grazing of livestock.

Dynamics: *Gutierrezia sarothrae* occurs in many natural grassland and steppe communities in the western U.S. and is known to increase when these communities are disturbed mechanically or by over-grazing (Stubbendieck et al. 1992, USFS 1937). The role of disturbance in this association needs further study to understand its successional nature.

Local Description: This association was not formally documented with a field plot. Instead, the alliance was observed in several locations across the park mapping project area. Most commonly, this association was found to occur on side slopes or toeslopes adjacent to woodland communities. In general, *Gutierrezia sarothrae* was the dominant species (< 20% cover) and was accompanied by a sparse herbaceous understory.

3.3.2. Woodland vegetation

3.3.2.1. *Elaeagnus angustifolia* Semi-natural Woodland Alliance

Translated name	Unique identifier	Classification approach
Russian-olive Semi-natural Woodland Alliance	A.3566	International Vegetation Classification (IVC)

Figure 18. *Elaeagnus angustifolia* Semi-natural Woodland Alliance at HUTR

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

Vegetation hierarchy

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

Global distribution	United States
Global range	This is a broadly defined upland shrubland association currently described from western Colorado and Nevada, but it likely occurs more widely in the western U.S.

Vegetation summary: The vegetation is characterized by a moderately dense to dense (40-70% cover) shrub canopy dominated by *Ericameria nauseosa* shrubs 0.5-3 m tall, with a relatively sparse herbaceous layer. In Colorado, stands have low diversity. Additional associated short and dwarf-shrubs are *Artemisia frigida*, *Artemisia tridentata* ssp. *wyomingensis*, and *Rosa woodsii*. In Nevada, stands are more diverse, and several other shrubs, such as *Atriplex canescens*, *Psorothamnus polydenius*, *Sarcobatus vermiculatus*, and *Tetradymia tetrameres*, may be important. The sparse herbaceous layer is a mixture of grasses and forbs. Native grasses include *Achnatherum hymenoides*, *Distichlis spicata* (saltgrass), and *Elymus elymoides*. Common forbs may include the non-natives *Cirsium arvense* (Canada thistle), *Descurainia incana* ssp. *incise* (mountain tansymustard), *Erodium cicutarium* (redstem stork's bill), *Lepidium campestre* (field pepperweed), *Iva axillaris* (povertyweed), *Salsola tragus*, and *Sisymbrium altissimum* (tall tumblemustard), and the natives *Eriogonum hookeri* (Hooker's buckwheat), *Rumex salicifolius* (willow dock), and *Verbesina encelioides* (golden crownbeard). The introduced annual grass *Bromus tectorum* and native grasses *Pseudoroegneria spicata* and *Sporobolus airoides* are typically absent or have low cover.

Wetland indicator: N

Local description: No formal field plots characterized this association within the park vegetation mapping project area. Instead, this alliance was observed in the immediate floodplain area along the Pueblo Colorado Wash (fig. 18). The majority of polygons mapped as this alliance occurred outside the political boundaries of HUTR (fig. 19). Restoration efforts involving the clearing and burning of woody vegetation have been enacted by HUTR personnel, which may explain the minimal amount of *Elaeagnus angustifolia* present within the HUTR boundary. In HUTR, this alliance was observed as occurring as both a woodland and a forest, with canopy heights ranging from 5-20 m. Areas dominated by *Elaeagnus angustifolia* and areas where it codominates represented this alliance locally. In areas where *Elaeagnus angustifolia* was a codominant, *Populus* sp. and *Tamarix* sp. were the most common codominant species.

Figure 19. Landscape view of *Elaeagnus angustifolia* Semi-natural Woodland Alliance (background) looking southwest from Hubbell Hill (sewage lagoons in foreground)

3.3.2.2. *Juniperus osteosperma* **Woodland Alliance**

Translated name	Unique identifier	Classification approach
Utah Juniper Woodland Alliance	A.536	International Vegetation Classification (IVC)

Summary: This woodland alliance is distributed across the Intermountain West from the eastern Sierra Nevada to the central and southern Rocky Mountains. Stands occur on middle mountain slopes of the many mountain ranges and plateaus of the region above areas of cold-air drainage in high intermountain basins. Vegetation included in this alliance is characterized by an open tree canopy of *Juniperus osteosperma*, quite often in association with *Pinus monophylla* (singleleaf pinyon) or *Pinus edulis*. *Cercocarpus ledifolius* (curl-leaf mountain mahogany) is a common associate in these interior stands. Scattered *Pinus ponderosa* (ponderosa pine), *Pinus flexilis* (limber pine), *Pinus aristata* (bristlecone pine), or *Pseudotsuga menziesii* (Douglas-fir) trees may be present where stands grade into montane coniferous forest. If present, the shrub layer may be composed of *Artemisia tridentata*, *Artemisia arbuscula*, *Artemisia nova* (black sagebrush), *Symphoricarpos oreophilus* (mountain snowberry), *Amelanchier alnifolia* (Saskatoon serviceberry), *Cercocarpus intricatus* (littleleaf mountain mahogany), *Cercocarpus montanus* (mountain mahogany), *Chrysothamnus* spp., *Quercus gambelii* (Gambel oak), *Prunus virginiana* (chokecherry), or *Purshia tridentata* (antelope bitterbrush). The herbaceous layer, if present, is usually sparse and dominated by cespitose perennial grasses, including *Pseudoroegneria spicata*, *Festuca idahoensis* (Idaho fescue), *Pleuraphis jamesii* (= *Hilaria jamesii*), *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Elymus elymoides*, and *Hesperostipa* spp. (= *Stipa* spp.). Characteristic of this alliance is an open tree canopy, with at least 5% and sometimes greater than 25% cover that is dominated by *Juniperus osteosperma*. In some stands of more extreme environments, the tree canopy may have cover as low as 10%.

Classification comments: The low-elevation woody vegetation of the Great Basin has been traditionally lumped into *Pinus monophylla* or pinyon-juniper woodlands, and further classification work is needed to differentiate true woodlands from wooded herbaceous stands. Many stands described as woodlands have less than 20% cover in the tree layer (Blackburn et al. 1968a, 1968b, 1969a, 1969b) and may actually fit better in the *Juniperus osteosperma* Wooded Herbaceous Alliance (A.1502). While the amount of literature available for pinyon-juniper vegetation is large, relatively little classification work has been done for these vegetation types. Further inventory and review of the classification of pinyon-juniper woodlands and wooded herbaceous communities are needed for the entire West.

Vegetation hierarchy

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

United States distribution	AZ, CA, CO, ID, MT, NM, NV, UT, WY
Global distribution	United States
Global range	These woodlands are distributed across the Great Basin and Colorado Plateau from the central Rocky Mountains of central Wyoming and western Colorado, through southern Idaho, Utah, and Nevada to the northern Mojave region of California. A second substantial range occurs along interior slopes of the Transverse Ranges of southern California.

Vegetation summary: These communities are characterized by an open canopy of *Juniperus osteosperma*, quite often in association with *Pinus monophylla* or *Pinus edulis*. The majority of these stands occur in dry ranges or plateaus of the Colorado Plateau or Great Basin. *Cercocarpus ledifolius* is a common associate in these interior stands. Less common tree associates include *Pinus ponderosa*, *Pinus flexilis*, *Pinus aristata*, or *Pseudotsuga menziesii*, where these communities grade into montane coniferous forest, or *Juniperus scopulorum* (Rocky Mountain juniper), and *Juniperus monosperma* in the central and southern Rockies. Widespread shrub associates include *Artemisia tridentata*, *Artemisia arbuscula* (little sagebrush), *Artemisia nova*, *Symphoricarpos oreophilus*, *Amelanchier alnifolia*, *Cercocarpus intricatus*, *Cercocarpus montanus*, *Chrysothamnus* spp., *Quercus gambelii*, *Prunus virginiana*, and *Purshia tridentata*.

The herbaceous layer is usually somewhat sparse and dominated by cespitose perennial grasses, including *Pseudoroegneria spicata*, *Festuca idahoensis*, *Pleuraphis jamesii* (= *Hilaria jamesii*), *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Elymus elymoides*, and *Hesperostipa* spp. Some stands in rocky terrain may lack an understory entirely.

Vegetation structure summary: These are sparse to somewhat dense woodlands (25-70% cover), dominated by scale-leaved evergreen trees of low stature (<20 m in height). Needle-leaved evergreen trees or tall shrubs are often present and may be codominant. Generally, evergreen or cold-deciduous shrubs occupy the interstices between trees, interspersed with cespitose graminoids. In total, the ground layer is usually of low to moderate cover (20-40%).

Wetland indicator: N

Environmental summary: Vegetation within this woodland alliance is distributed across the Intermountain West, from the eastern Sierra Nevada to the central and southern Rocky Mountains. Stands along the Bighorn Range in Wyoming are near the eastern side of the Rockies. The alliance usually occupies semi-arid, lower to middle mountain slopes of the many mountain ranges and plateaus of the region, occurring between 1,000 and 2,650 m in elevation. Average annual precipitation is usually between 25-50 cm, but the seasonal distribution varies across the range of the alliance. Generally, winter precipitation, in the form of westerly storms, is maximal along the northwest edge of the range, and summer moisture increases to the east and south. Distribution of the alliance is also correlated with "thermal belts", which occur above the areas of cold-air drainage in high intermountain basins. Adjacent vegetation is usually *Artemisia* shrub-steppe at the lower elevation margin and montane and subalpine coniferous vegetation at the upper margin. Communities in this alliance are often closely associated with *Pinus edulis* or *Pinus monophylla* woodlands. *Juniperus osteosperma* usually forms monotypic stands on drier or colder sites than where the pines occur.

Dynamics: *Juniperus osteosperma* is a very slow-growing, long-lived tree, and stands appear somewhat static over time, compared to more productive forests. *Juniperus osteosperma* stands have always been widespread, but were formerly restricted to certain habitats (rocky ridges, etc.). These woodlands are expanding into adjacent steppe grasslands in many areas, reportedly in connection with livestock grazing and altered fire regimes (Blackburn 1967). *Juniperus osteosperma* is the first to invade adjacent *Artemisia nova* shrublands, but is eventually succeeded by *Pinus monophylla*. Jameson et al. (1962) inferred a similar relationship between *Juniperus osteosperma* and *Pinus edulis* in the Grand Canyon. They noted that individuals of *Juniperus osteosperma* were older and even-aged, while *Pinus edulis* occupied all age classes. Many of these communities have been severely impacted by past range practices of chaining, tilling, and reseeding with exotic forage grasses. Although the dominant trees appear to regenerate after such disturbances, the effects on understory species are poorly known.

3.3.2.3. *Juniperus osteosperma* / *Artemisia tridentata* **ssp.** *tridentata* **Woodland**

Translated name	Unique identifier	Classification approach
Utah Juniper / Basin Big Sagebrush Woodland	CEGL002360	International Vegetation Classification (IVC)

Summary: This woodland association occurs locally on benches, alluvial terraces, plateaus and draws in northwestern Colorado and southeastern Utah. Elevations range from 1,620 m in Colorado to 1,860 m in Utah. Sites are located on gentle to moderate slopes and tend to occupy relatively cool microsites, either on north aspects or cold-air drainages. Stands of this association tend to develop in *Artemisia tridentata* ssp. *tridentata* shrublands that have escaped disturbance for a long enough time to allow *Juniperus osteosperma* trees from nearby woodlands to invade. Soils are deep and generally derived from alluvium. The best-developed stands occur on canyon floors where terraces are protected from flooding. The tree canopy is generally open, with 10 to 50% cover by *Juniperus osteosperma*. *Artemisia tridentata* ssp. *tridentata* often has equal or greater cover than the tree layer, and shrubs may be 2 m high. If other shrubs are present, they are with low cover; species reported include *Amelanchier utahensis* (Utah serviceberry), *Ericameria nauseosa*, *Atriplex canescens*, *Opuntia* spp., and *Gutierrezia sarothrae*. The herbaceous layer is diverse and well-developed in stands that have been protected from grazing, and may be dominated by grasses, such as *Bouteloua gracilis*, *Hesperostipa comata*, or *Distichlis spicata*. However, most stands have experienced a long history of grazing, and in these cases, the herbaceous layer is generally dominated by *Bromus tectorum*.

Classification confidence: 2 - Moderate

Vegetation hierarchy

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

Ecological systems placement

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

Global status	GNR (22Mar2005)
Rounded global status	GNR - Not Yet Ranked
United States distribution	CO, UT
Global distribution	United States
Global range	This association has been sampled in southeastern Utah and northwestern Colorado. It is likely to be widespread throughout the Colorado Plateau.

Vegetation summary: This woodland association is best developed on canyon floors where terraces are protected from flooding. The tree canopy is generally open, with 10 to 50% cover by *Juniperus osteosperma*. *Artemisia tridentata* ssp. *tridentata* often has equal or greater cover than the tree layer, and shrubs may be 2 m high. If other shrubs are present, it is with low cover; species reported include *Amelanchier utahensis*, *Ericameria nauseosa*, *Atriplex canescens*, *Opuntia* spp., and *Gutierrezia sarothrae*. The herbaceous layer is diverse and well-developed in stands that have been protected from grazing, and may be dominated by grasses, such as *Bouteloua gracilis*, *Hesperostipa comata*, or *Distichlis spicata*. However, most stands have experienced a long history of grazing, and in these cases, the herbaceous layer is generally dominated by *Bromus tectorum*.

Wetland indicator: N

Environmental summary: This woodland association occurs locally in small patches, occupying benches, alluvial terraces, plateaus and draws in the Colorado Plateau of western Colorado and southeastern Utah. Elevations range from 1,620 m in Colorado to 1,860 m in Utah. Sites are located on gentle to moderate (3-46%) slopes and tend to occupy relatively cool microsites, either on north aspects or cold-air drainages. Soils are deep and generally are derived from alluvium.

Dynamics: Stands of this association tend to develop in *Artemisia tridentata* ssp. *tridentata* shrublands that have escaped disturbance for a long enough time to allow *Juniperus osteosperma* trees from nearby woodlands to invade.

Local description: One field plot (HUTR-10) described this association. The field plot was located on top of Hubbell Hill and considered all aspects of the steep (~50%) vegetated hillsides. Bedrock, large rocks, small rocks, and bare soil accounted for the majority of the unvegetated ground cover. The canopy consisted solely of short (2-5 m) *Juniperus osteosperma* trees (7%). The shrub stratum was dominated by *Artemisia tridentata* (10%). Other shrubs present included *Lycium pallidum* (pale desert-thorn) (1%), *Atriplex canescens* (3%), *Ephedra torreyana* (Torrey's jointfir) (1%), and *Gutierezzia sarothrae* (1%). Two species of *Opuntia* were also present in small amounts (<1%). The herbaceous stratum was sparse in cover (5%) and primarily consisted of several graminoid species.

The area described by this field plot may also be considered an additional component association of the "*Juniperus osteosperma* Woodland Alliance". The "*Juniperus osteosperma* / Mixed Shrubs Talus Woodland" association should also be considered as a potential classification for this particular field plot. This alternative association has only been described as occurring in Colorado National Monument. Limited information was available for this association at this time of this report. Additional vegetation data should be collected in HUTR in order to better classify this vegetation type into the most appropriate association.

3.3.2.4. *Juniperus osteosperma / Bouteloua gracilis* **Woodland**

Translated name	Unique identifier	Classification approach
Utah Juniper / Blue Grama Woodland	CEGL002361	International Vegetation Classification (IVC)

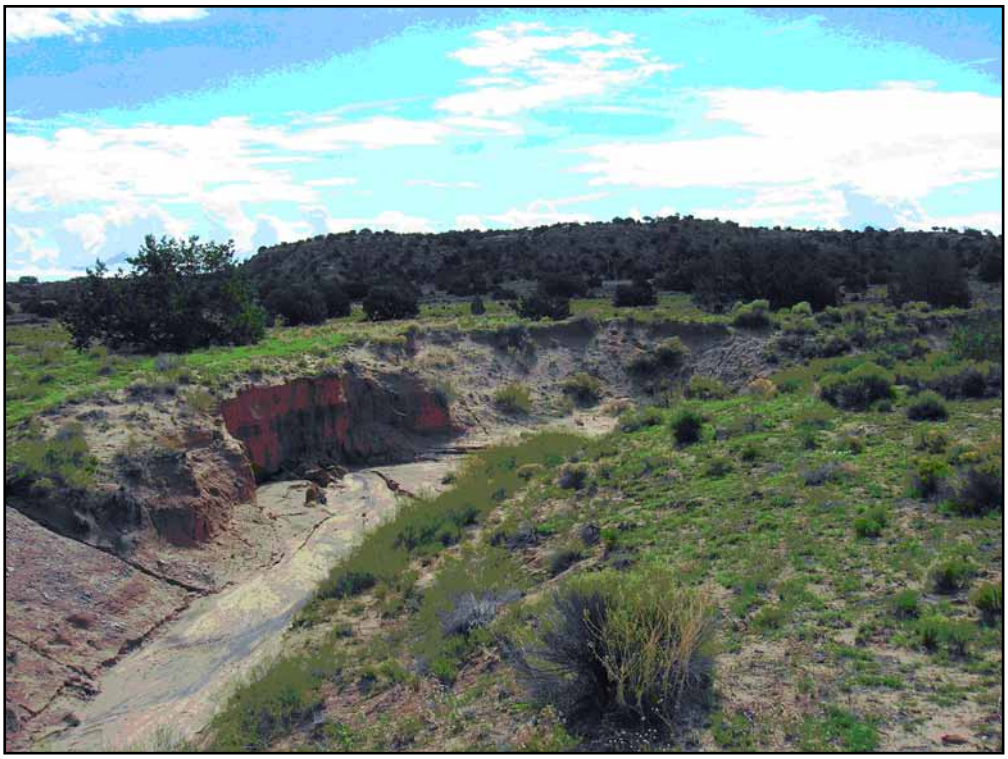

Figure 20. *Juniperus osteosperma / Bouteloua gracilis* Woodland at HUTR

Summary: This woodland association has only been described from Capitol Reef National Park in southern Utah. This summary is derived from plot data collected in the park in 2003. It is documented from the slopes of broad sedimentary valleys. Sites slope gently to the east at 1,561 m elevation. The unvegetated surface has moderate cover of litter and high cover of gravel. There is low to moderate exposure of bare soil. Soils are well-drained and texturally are sandy loam derived from the underlying Morrison Formation. Total vegetation cover does not exceed 35% in this sparsely vegetated stand. The vegetation is characterized by a savanna-like distribution of 2- to 5-m tall *Juniperus osteosperma* that have up to 15% cover and the shortgrass *Bouteloua gracilis* that has up to 5% cover. There is no developed shrub layer, but scattered shrubs may include *Gutierrezia sarothrae*. Young *Juniperus osteosperma* may also be present. The herbaceous layer is low in species diversity and sparse in terms of cover. *Vulpia octoflora* (sixweeks fescue) is the only recorded species.

Classification confidence: 3 - Weak

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

Vegetation hierarchy

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

Ecological Systems Placement

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

Global status	GNR (22Mar2005)
Rounded global status	GNR - Not Yet Ranked
United States distribution	AZ? NM? UT
Global distribution	United States
Global range	This association has only been described from Capitol Reef National Park in southern Utah. It is likely to occur in adjacent northern Arizona and New Mexico.

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

Wetland indicator: N

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

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

Local description: This association was described by one field plot within the HUTR vegetation mapping project area (fig. 20). The canopy tree layer primarily consisted of scattered clumps of *Juniperus osteosperma* that ranged in height from 2 to 5 m. *Juniperus osteosperma* seedlings were also present in low densities (2%). Several shrubs were present in the area, but not with enough cover to form a distinct shrub stratum. Associated shrub species included *Artemisia tridentata*, *Gutierrezia sarothrae*, and *Chrysothamnus greenei* (Greene's rabbitbrush). The herbaceous stratum (30%) was primarily composed of *Bouteloua gracilis*. Other species in the herbaceous stratum included *Malva* sp. and *Portulaca oleracea*.

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

Translated name	Unique identifier	Classification approach
Two-needle Pinyon - (Juniper species) Woodland Alliance	A.516	International Vegetation Classification (IVC)

Figure 21. *Pinus edulis – (Juniperus* spp.) Woodland Alliance (HUTR-11)

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

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

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

Vegetation hierarchy

Formation class	II - Woodland
Formation subclass	II.A - Evergreen woodland
Formation group	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
United States distribution	AZ, CA? CO, NM, NV, OK, TX? UT, WY?
Global distribution	United States
Global range	Stands included in this woodland alliance are common on the Colorado Plateau and extend north into the Uinta Mountains, south in the northern mountains of the Sonoran and Chihuahuan deserts and east to lower montane zone of the southern Rocky Mountains. The alliance is also found on mesas and breaks of the southern Great Plains as far as the Panhandle of Oklahoma and into western Texas.

Vegetation summary: Woodlands included in this alliance occur on dry sites in the lower montane zone in the southern Rocky Mountains; in the mountains, mesas and canyons of the Chihuahuan and Sonoran Deserts, and the Colorado Plateau; and in breaks in the southern Great Plains. Stands have a moderately sparse to moderately dense tree canopy, typically 3-12 m tall. Mature individuals range from 2-3 m tall 'scrub' to large trees up to 21 m tall. Moderately sparse stands have an open canopy with trees distributed in patches, whereas the tree crowns touch in the moderately dense stands. The upper canopy may be solely dominated by the evergreen needle-leaved tree *Pinus edulis*, but more commonly is codominated by one of several species of *Juniperus* or *Quercus* depending on geography. On the Colorado Plateau, *Juniperus osteosperma* may codominate, whereas *Juniperus monosperma* codominates in the eastern part of the woodland's range. At higher elevations, *Juniperus scopulorum* may be present, and in the far southern extent, Madrean evergreen woodland species co-occur. These species include *Juniperus deppeana*, *Juniperus coahuilensis* (= *Juniperus erythrocarpa*), and the encinals, *Quercus arizonica* (Arizona white oak), *Quercus grisea* (gray oak), *Quercus X pauciloba* (*gambelli x turbinella*).

The understory ranges from a relatively rich mixture of evergreen and/or deciduous shrubs, to a sparse to moderately dense herbaceous layer dominated by perennial grasses (with or without shrubs), to no vegetation at all. Most commonly the understory is sparse and has a patchy distribution. Characteristic shrubs and dwarf-shrubs include *Artemisia tridentata*, *Cercocarpus montanus*, *Cercocarpus ledifolius*, *Coleogyne ramosissima*, *Ephedra viridis*, *Gutierrezia sarothrae*, *Lycium pallidum*, *Opuntia* spp., *Purshia mexicana* (Mexican cliffrose), *Purshia tridentata*, *Rhus trilobata* (three-leaf sumac), and *Quercus gambelii*. Shrubs restricted to warmer southern latitudes include *Agave* spp., *Arctostaphylos pungens* (manzanita), *Dasylirion wheeleri* (sotol), *Garrya* (silktassel) spp., *Nolina microcarpa* (*sacahuista*), *Quercus turbinella* Sonoran scrub oak), and *Yucca baccata* (banana yucca). The herbaceous layer is sparse to moderately dense, ranging from 1-30% cover. Perennial graminoids are the most abundant species, particularly *Bouteloua curtipendula*, *Bouteloua gracilis*, *Bouteloua hirsuta*, *Aristida* spp., *Festuca arizonica*, *Koeleria macrantha* (prairie junegrass), *Muhlenbergia* (muhly) spp., *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Piptatherum micranthum* (= *Oryzopsis micrantha*; littleseed ricegrass), *Poa fendleriana* (muttongrass), *Pseudoroegneria spicata*, and *Hesperostipa* spp. *Andropogon hallii* occurs as an understory species in rare, deep sands habitats. Many forb species occur, but few have much cover. Commonly present forbs include species of *Artemisia*, *Eriogonum*, *Heterotheca* (goldenaster), *Mirabilis* (four o'clock), *Penstemon* (beardtongue), *Phlox*, *Senecio* (groundsel), and *Zinnia*. Annual grasses and forbs are seasonally present.

Vegetation structure summary: Vegetation included in this alliance has a moderately sparse to moderately dense tree canopy that is typically 3-10 m tall. Stands are either solely dominated by evergreen needle-leaved trees or may be codominated by broad-leaved or scale-leaved evergreen trees. A sparse to moderately dense shrub layer (0.5-3 m tall) may be present. If present, the shrub layer ranges from a single species to a diverse mixture of broad-leaved and microphyllous deciduous or evergreen shrubs that are usually less than 3 m tall. A sparse to moderate ground layer dominated by perennial graminoids is usually present. Perennial forbs and cacti are often scattered throughout the stands. Annual forbs and grasses may be seasonally present. *Quercus arizonica* (Arizona white oak), *Quercus grisea* (gray oak), *Quercus* X *pauciloba* (*gambelli* X *turbinella*).

Wetland Indicator: N

Environmental summary: Stands included in this woodland alliance occur in the foothills and the lower montane zone in the southern Rocky Mountains; mountains, mesas, piedmonts and canyons in the Chihuahuan and Sonoran deserts and the Colorado Plateau; and breaks and escarpments in the southern Great Plains. Elevations range from 1,500-2,440 m. Climate is semi-arid and droughts are not uncommon. Summers are generally hot, and winters range from mild with cold periods and occasional snows in southern New Mexico and Arizona to the more typical extended periods of freezing temperatures. The seasonality of precipitation varies from east to west with summer rain more common in the southern and eastern portion of the alliance's range and winter precipitation more common in the western portion of the range. Mean annual precipitation ranges from 30-46 cm. Stands typically occur on nearly level to steep (to 80%) rocky slopes on hillsides and ridgetops. Aspect does not seem important except in elevational extremes for a given latitude where low-elevation stands are restricted to the more mesic north slopes, and canyons and high-elevation stands occur on south aspects. Sites are typically dry with shallow, rocky, calcareous and alkaline soils. Other sites include eroded 'badlands', lava flows, scree slopes, and deep sands. Soil textures range from sandy loam to clay and are typically derived from limestone, sandstone or shale. Other parent materials include andesite, basalt, granite, quartzite, monzonite, rhyolite and mixed alluvium. Adjacent vegetation at higher elevations is typically woodland or forest dominated by *Pinus ponderosa*. Adjacent vegetation at lower elevations is often *Juniperus* spp.-dominated woodland and savanna, *Artemisia* spp.-dominated shrubland, or grassland.

Dynamics: *Pinus edulis* is extremely drought-tolerant and slow-growing (Little 1987, Powell 1988, Muldavin et al. 1998). It is also non-sprouting and may be killed by fire (Wright et al. 1979). The effect of a fire on a stand is largely dependent on the tree height and density, fine-fuel load on the ground, weather conditions, and season (Dwyer and Pieper 1967; Wright et al. 1979). Trees are more vulnerable in open stands where fires frequently occur in the spring, the relative humidity is low, wind speeds are over 10-20 mph, and there is adequate fine fuels to carry fire (Wright et al. 1979). Under other conditions, burns tend to be spotty with low tree mortality. Large trees are generally not killed unless fine fuels, such as tumbleweeds, have accumulated beneath the tree to provide ladder fuels for the fire to reach the crown (Jameson et al. 1962). Closed-canopy stands rarely burn because they typically do not have enough understory or wind to carry a fire (Wright et al. 1979).

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

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

Local description: Figure 21 illustrates the characteristics associated with this alliance at HUTR. One field plot, HUTR-11, described the polygons that were mapped as this alliance within the project area. This field plot did not directly correspond to one specific existing NVC association, so only the alliance level was mapped for areas similar to this plot. In this field plot, *Pinus edulis* (7%) and *Juniperus osteosperma* (3%) dominated the canopy layer. In the short shrub/dwarf-shrub stratum (<10%), *Ericameria nauseosa* (3%), *Purshia* sp. (1%), *Gutierrezia sarothrae* (3%), and *Artemisia* sp. (2%) were all present. The herbaceous stratum (10-15%) consisted of various graminoid and forb species. Cryptobiotic crust was also present in the area.

3.3.2.6. *Pinus edulis - Juniperus osteosperma* / **Sparse Understory Woodland**

Translated name	**Unique identifier**	**Classification approach**
Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland	CEGL002148	International Vegetation Classification (IVC)

Figure 22. *Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland (northern extent of mapping area) at HUTR

Summary: This variable woodland association is widespread in parts of western Colorado and southeastern Utah. It is found most commonly on mid- to upper slopes, though other topographic positions are possible. It has been sampled at elevations between 1,580 and 2,389 m and on all aspects. At higher elevations, it tends toward southwestern aspects. Sites range from flat to moderately steep. The ground has variable amounts of litter and often has moderate to high amounts of gravel, rocks, and exposed bedrock. Cryptogamic cover is usually low to moderate, but some sites have up to 55-65% cover. Soils are always rapidly drained to moderately well-drained. Parent materials are also highly variable and can be sandstones, shales, or limestones. The lack of an understory may be due to high rock cover, low soil moisture, or a closed evergreen canopy of pinyon and juniper. This widespread association occurs as relatively sparse to moderately vegetated stands with total vegetation cover ranging from 10-75%. Sparsely vegetated stands (<10% total vegetation cover) composed of only trees are included as a best fit in this woodland association in extremely dry, rocky portions of the Colorado Plateau. The tree canopy is dominated by *Pinus edulis* and *Juniperus osteosperma*. Both typically range from 1-35% cover with some stands having canopy cover by one species up to 50%. The tree canopy is short, usually 2-10 m tall, and open to moderately closed. *Fraxinus anomala* (singleleaf ash) has been observed in the canopy of some stands but always at no more than 5% cover. Several shrub species are commonly found in this association, but they occur as widely scattered individuals or an open shrub stratum. Scattered small *Pinus edulis* and *Juniperus osteosperma* are found along with shrubs such as *Amelanchier utahensis*, *Artemisia tridentata* ssp. *wyomingensis*, *Cercocarpus montanus*, *Ephedra viridis*, *Eriogonum microthecum* (slender wild buckwheat), *Shepherdia rotundifolia* (roundleaf buffaloberry), and *Opuntia* spp. The herbaceous layer is low in cover (<5%) and usually low in diversity. *Achnatherum hymenoides*, *Bouteloua gracilis*, *Bromus tectorum*, *Poa fendleriana*, and *Pleuraphis jamesii* are common graminoids. Forbs are not abundant, but typical species include *Descurainia pinnata* (pinnate tansymustard), *Cryptantha* spp., and *Tetraneuris acaulis* (stemless four-nerve daisy).

Classification confidence: 1 - Strong

Classification comments: Environmental and physiognomic variability within this association is high. There are few consistent understory species across all parks, but that is part of the concept of this type. The general sparseness of the understory is one of the main diagnostic features. Because of the wide range of circumstances that result in a sparse understory, a lot of variability in the floristic components of the understory is allowed. It is possible that this type will be split into several associations based on environmental factors, since floristic factors are not diagnostic. On dry, rocky or slickrock sites on the Colorado Plateau, this pinyon-juniper woodland association may include stands with very open tree canopies (5-10% cover) in cases where the total vegetation cover is less than 15%, and they are considered a variation of the woodland type because of the ecological values of the trees.

Vegetation hierarchy

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

Ecological systems placement

Ecological system unique ID	**Ecological system name**
CES304.767	Colorado Plateau Pinyon-Juniper Woodland
CES304.773	Great Basin Pinyon-Juniper Woodland

Global status	G5 (15Dec2004))
Rounded global status	G5 - Secure
United States distribution	CO, UT
Global distribution	United States
Global range	This association is known to occur in western Colorado and southeastern Utah.

Vegetation summary: This widespread association occurs as relatively sparse to moderately vegetated stands with total vegetation cover ranging from 10-75%. Sparsely vegetated stands (<10% total vegetation cover) composed of only trees are included as a best fit in this woodland association in extremely dry, rocky portions of the Colorado Plateau. The tree canopy is dominated by *Pinus edulis* and *Juniperus osteosperma*. Both typically range from 1-35% cover with some stands having canopy cover by one species up to 50%. The tree canopy is short, usually 2-10 m tall, and open to moderately closed. *Fraxinus anomala* has been observed in the canopy of some stands at Colorado National Monument but always at no more than 5% cover. Several shrub species are commonly found in this association, but they occur as widely scattered individuals or an open shrub stratum. Scattered small *Pinus edulis* and *Juniperus osteosperma* are found along with shrubs such as *Amelanchier utahensis*, *Artemisia tridentata* ssp. *wyomingensis*, *Cercocarpus montanus*, *Ephedra viridis*, *Eriogonum microthecum*, *Shepherdia rotundifolia*, and *Opuntia* spp., usually *Opuntia fragilis* (brittle pricklypear) or *Opuntia polyacantha* (plains pricklypear). The herbaceous layer is low in cover (<5%) and usually low in diversity. *Achnatherum hymenoides*, *Bouteloua gracilis*, *Bromus tectorum*, *Poa fendleriana*, and *Pleuraphis jamesii* are common graminoids. Forbs are not abundant, but typical species include *Descurainia pinnata*, *Cryptantha* spp., and *Tetraneuris acaulis*.

Wetland indicator: N

Environmental summary: This woodland association is found most commonly on mid- to upper slopes, though other topographic positions are possible. It has been sampled at elevations between 1,580 and 2,389 m and on all aspects. At higher elevations, such as in Black Canyon of the Gunnison National Park it tends toward southwestern aspects. Sites range from flat to moderately steep (0-25 degrees). The ground has variable amounts of litter and often has moderate to high amounts of gravel, rocks, and exposed bedrock. Cryptogamic cover is usually low to moderate, but some sites have up to 55-65% cover. Soils vary in texture and can be loamy sand, silts, loams or silty clay but are always rapidly drained to moderately well-drained. Parent materials are also highly variable and can be sandstones, shales, limestones, among others.

Dynamics: The variability of this association is due to the range of circumstances in which it can occur. Some stands have a sparse understory because the substrate has poor water-holding capacity (e.g., shale-derived), or because the surface is nearly completely covered by rock or bedrock. Other stands may have low understory cover because the canopy is nearly closed and herbaceous and shrub species cannot exist in the conditions of low light and available moisture that characterize these stands.

Local description: This association occurred in one field plot (HUTR-12) in the HUTR vegetation mapping project area and was informally observed in other areas (fig. 22 and fig. 23). Six polygons in the entire project mapping area were mapped as this association. The polygons primarily represented the side slopes between the upland and the valley communities of the area. The canopy was dominated by *Pinus edulis* and *Juniperus osteosperma* 2-5 m in height. The shrub stratum (<10%) consisted of *Purshia* sp. (1%), *Ephedra torreyana* (3%), *Atriplex canescens* (1%), and *Artemisia* sp. (1%). Herbaceous vegetation was sparse (<5%) and was characterized by scattered graminoids. Bare soil was abundant.

Figure 23. *Pinus edulis -Juniperus osteosperma* / Sparse Understory Woodland (HUTR-12)

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

Translated Name	Unique Identifier	Classification Approach
Two-needle Pinyon - Juniper species / (Wyoming Big Sagebrush, Mountain Big Sagebrush) Woodland	CEGL000776	International Vegetation Classification (IVC)

Summary: This broadly defined woodland association is common in the Colorado Plateau but also occurs on dry foothills and mesas from north-central New Mexico and southern Colorado west to the eastern Mojave Desert, in extreme northwestern Colorado and adjacent Utah. Elevations range from 1,465 to 2,500 m. Stands occur most often on flat to gentle slopes on all aspects. The soils are generally poorly developed, moderately deep to deep, and well-drained to rapidly drained loams and sands. Ground cover is variable; bare soil is common, but bedrock, litter, and large or small rocks can also be abundant on some sites. Parent material includes sandstone and shale. The vegetation is characterized by a typically open tree canopy (10-30% cover but ranges up to 50% cover) that is codominated by *Pinus edulis* and *Juniperus* spp. The species of *Juniperus* varies with geography and elevation. *Juniperus monosperma* is common in north-central New Mexico and southern Colorado. *Juniperus osteosperma* is common from northwestern New Mexico west and north into Arizona and Utah. *Juniperus scopulorum* is more common in higher elevation stands. *Artemisia tridentata* (either ssp. *vaseyana* or ssp. *wyomingensis,* depending on location) strongly dominates the sparse to moderately dense short-shrub layer (10-35% cover). *Purshia stansburiana* (Stansbury cliffrose) is typically absent or scarce. Other shrubs present may include *Amelanchier utahensis*, *Arctostaphylos patula* (greenleaf manzanita), *Cercocarpus montanus*, *Ephedra viridis*, *Gutierrezia sarothrae*, *Quercus gambelii* (typically <5% cover), or species of *Yucca* and *Opuntia*. Herbaceous cover is variable but generally sparse and dominated by graminoids (<5% cover) with scattered forbs.

Classification confidence: 1 - Strong

Classification comments: On dry, rocky, or slickrock sites on the Colorado Plateau, this pinyon-juniper woodland association may include stands with very open tree canopies (5-10% cover) in cases where the total vegetation cover is less than 15%. These stands may be similar to open *Artemisia tridentata* shrublands with scattered pinyon and juniper trees but is considered to be a variation of the woodland type because of the ecological values of the trees.

Local classification comments: No formal field plot described this association for the HUTR vegetation mapping project area. Also, it is important to note that the subspecies of *Artemisia tridentata* is believed to be different than what was described by this association. At HUTR, it is believed that the subspecies of the sagebrush species *Artemisia tridentata* is *tridentata*; however the association describes two subspecies (i.e., ssp. *wyomingensis*, ssp. *vaseyana*). Other than the specific subspecies of *Artemisia tridentata*, the remainder of the association description fits well with what was observed in the uplands of the HUTR project area.

Vegetation hierarchy

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

Similar associations

Unique identifier	Name
CEGL000730	*Juniperus osteosperma* / *Artemisia tridentata* ssp. *wyomingensis* Woodland
CEGL000782	*Pinus edulis - Juniperus osteosperma* / *Purshia stansburiana* Woodland

Ecological systems placement

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

Global status	G5 (01Feb1996)
Rounded global status	G5 - Secure
United States distribution	AZ, CA?, CO, NM, NV, UT
Global distribution	United States
Global range	This woodland association is common on the Colorado Plateau, occurring from north-central New Mexico and southern Colorado west to the Mogollon Rim of Arizona and the eastern Mojave Desert, and in extreme northwestern Colorado and adjacent Utah.

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

Wetland indicator: N

Environmental summary: This broadly defined woodland association occurs on dry foothills and mesas across much of the Colorado Plateau and adjacent areas. Elevations range from 1,459 to 2,502 m. Stands occur most often on flat to gentle slopes but can be found on moderate to moderately steep slopes on all aspects. The soils are often deep, generally poorly developed, moderately well-drained to rapidly drained loams and sands, and skeletal. Ground cover is variable; bare soil is common, but bedrock, litter, and large or small rocks can also be abundant on some sites. Parent material includes sandstone and shale.

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

Local description: No field plot described this association in the HUTR project area. Also, it is important to note that the subspecies of *Artemisia tridentata* observed at HUTR is believed to be different than what is described by this association. At HUTR, it is believed that the subspecies of the sagebrush species *Artemisia tridentata* is *tridentata*; however the association describes two subspecies (i.e., ssp. *wyomingensis*, ssp. *vaseyana*). The association was observed as occurring in the upland woodland communities in the southern section of the project area. Additional areas were mapped in the project area based on the unique signature of this association from the aerial photographs. The canopy consisted of mature *Pinus edulis* trees with *Juniperus osteosperma* occurring in small amounts. Mortality of the most mature *Pinus edulis* trees was pronounced in the general area, likely caused by the Piñon Ips beetle. The understory was dominated by *Artemisia tridentata* ssp. *tridentata* (15-20%) with scattered graminoids present in the herbaceous stratum (10%).

3.3.3. Forest vegetation

3.3.3.1. *Populus deltoides* Temporarily Flooded Forest Alliance

Translated name	Unique identifier	Classification approach
Eastern Cottonwood Temporarily Flooded Forest Alliance	A.290	International Vegetation Classification (IVC)

Figure 24. *Populus deltoides* Temporarily Flooded Forest Alliance as in HUTR

Summary: This alliance, found throughout the central midwestern and southeastern United States, contains riverfront floodplain forests (fig. 24). The tree canopy is tall (to 30 m) and dominated by *Populus deltoides* and *Salix nigra* (black willow), although *Fraxinus pennsylvanica* (green ash), *Acer negundo* (boxelder), *Acer rubrum* (red maple), *Acer saccharinum* (silver maple), *Platanus occidentalis* (American sycamore), and *Ulmus americana* (American elm) are also commonly encountered in various parts of this alliance's range. Tree diversity is limited due to the dynamics of flooding and deposition/scouring of sediments. The shrub layer is often sparse, but species such as *Salix exigua*, *Carpinus caroliniana* (American hornbeam), *Lindera benzoin* (northern spicebush), *Cornus drummondii* (roughleaf dogwood), and, in the Southeast, ***Ilex vomitoria*** (yaupon), *Ilex opaca* var. *opaca* (American holly), and *Forestiera acuminata* (stretchberry) can be found. Herbaceous growth can be thick and lush but is often patchy and sparse due to frequent inundation. Herbaceous species found throughout the range of this alliance are not well known, but in parts of the range, species can include *Carex* spp., *Leersia oryzoides* (rice cutgrass), *Bidens* (beggarticks) spp., *Asteraceae* (sunflower family) spp., *Eragrostis hypnoides* (teal lovegrass), *Lipocarpha micrantha* (smallflower halfchaff sedge), *Rumex maritimus* (golden dock), *Potentilla paradoxa* (Paradox cinquefoil), and, more commonly in the Southeast, *Leptochloa panicea* ssp. *mucronata* (= *Leptochloa mucronata*) (mucronate sprangletop), and *Mikania scandens* (climbing hempvine).

Stands are found primarily along riverfronts, where they develop on bare, moist soil on newly made sand bars, front-land ridges, and well-drained flats. Soils are formed in alluvium, are deep, medium-textured, and with adequate or excessive moisture available for vegetation during the growing season. This alliance can also be found on abandoned fields and well-drained ridges in the first bottoms.

Classification comments: In the Midwest, this alliance can overlap floristically with the *Acer saccharinum* Temporarily Flooded Forest Alliance (A.279), particularly where historic flooding regimes have been altered, leading to stabilized substrates and suitable conditions for *Acer saccharinum* and other species less tolerant of floods. Where *Acer saccharinum* is either codominant with *Populus deltoides* or has become the dominant subcanopy species and the understory composition reflects the new hydrologic regime, the stand should be placed in that alliance. This alliance is known from Kentucky's Mississippi River Alluvial Plain, where it provides nesting habitat for the Mississippi Kite.

Vegetation hierarchy

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

United States distribution	AL, AR, AZ?, CO, FL, GA, IA, IL, IN, KS, KY, LA, MN, MO, MS, MT, NC?, ND, NE, NJ, NM, OH, OK, SC, SD, TN, TX, UT?, VA?, WI
Canadian Province distribution	AB, SK
Global distribution	Canada, Mexico , United States
Global range	This alliance is found in the southeastern U.S. in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Oklahoma, South Carolina, Tennessee, Texas, and possibly North Carolina and Virginia; in the midwestern U.S. in Indiana, Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, Ohio, North Dakota, South Dakota, and Wisconsin; in the western U.S. in Montana, Colorado, New Mexico, and possibly Arizona and Utah; and in Canada, in Alberta and Saskatchewan. It is likely to occur elsewhere, including Mexico.

Vegetation summary: The tree layer is dominated by tall (20-35 m in height) single-stemmed deciduous species. The canopy is overlapping, generally forming 60-100% cover. The shrub layer is also dense with up to 60% cover and often multi-tiered, with both tall and short shrubs. The herbaceous layer is dominated by forbs with up to 20% cover. In parts of this alliance's range, graminoid cover is primarily from introduced grass species.

Wetland indicator: Y

Environmental summary: Stands of this alliance are found primarily along riverfronts, where they develop on bare, moist soil on newly formed sand bars, front-land ridges, low streambanks, overflow areas, and well-drained flats along major streams, rivers, and lake margins. Stands can also be found on abandoned fields and well-drained ridges in the first bottoms. These sites tend to be further from the main channel. Elevations range from 600 m in Montana to 1300 m in Colorado. Soils are formed in alluvium, and are deep, medium-textured, and with adequate or excessive moisture available for vegetation during the growing season. Typically, the soil profile is highly stratified but with distinct soil development (B) layers. Textures are predominately loose, friable sands interspersed with narrow bands of clay loams and sandy clays.

Dynamics: Cottonwood forests grow within an alluvial environment that is continually changing due to the ebb and flow of the river. Riparian vegetation is constantly being 're-set' by flooding disturbance. Cottonwood communities are early, mid- or late-seral, depending on the age class of the trees and the associated species of the stand. Mature cottonwood stands do not regenerate in place but regenerate by 'moving' up and down a river reach. Over time, a healthy riparian area supports all stages of cottonwood communities. The process of cottonwood regeneration is well documented. Periodic flooding events can leave sandbars of bare mineral substrate. Cottonwood seedlings germinate and become established on newly-deposited, moist sandbars. In the absence of large floods in subsequent years, seedlings begin to trap sediment. In time, the sediment accumulates and the sandbar rises. The young forest community is then above the annual flood zone of the river channel.

In this newly elevated position, with an absence of excessive browsing, fire, or agricultural conversion, this cottonwood community can grow into a mature riparian forest. At the same time, the river channel continually erodes streambanks and creates fresh, new surfaces for cottonwood establishment. This results in a dynamic patchwork of different age classes,

plant associations, and habitats.

As cottonwoods mature, other tree species may become established. If the land surface is subject to reworking by the river, the successional processes will start over with erosion and subsequent flooding deposition. If the land surface is not subject to alluvial processes, for example on a high terrace, the cottonwoods will be replaced by upland shrub or tree species from adjacent areas.

Local description: This type occurred primarily outside the boundary of the site, along Pueblo Colorado Wash.

3.3.3.2. *Populus deltoides* / *Ericameria nauseosa* **Forest**

Translated name	Unique identifier	Classification approach
Eastern Cottonwood / Rubber Rabbitbrush Forest	CEGL005969	International Vegetation Classification (IVC)

Figure 25. *Populus deltoides* / *Ericameria nauseosa* Forest at HUTR

Summary: This association is found in the San Juan River basin in northwestern New Mexico. The type is found in wide lowland valleys at elevations ranging from 1410 to 1840 m. It usually occurs on high, elevated, dry terraces situated well above the active channel (discharge ratios >5.0) that are rarely flooded (every 25-100 years). Occasionally it occurs on lower alluvial terraces that are more frequently flooded. Soils are dry with no evidence of aquic conditions within 1 m and are either sandy Inceptisols (Fluventic Ustochrepts), reflecting some soil development on the higher terraces, or less undeveloped sandy or sandy and rocky Entisols (Typic Ustifluvent). This type is characterized by open to moderately closed canopies of mature *Populus deltoides* ssp. *monilifera* (plains cottonwood) or *Populus deltoides* ssp. *wislizeni* (Rio Grande cottonwood), with a shrubby understory dominated by *Ericameria nauseosa* (= *Chrysothamnus nauseosus*) and other facultative upland shrub species (one obligate wetland species, *Salix exigua*, has been recorded for the type). Preliminary data suggest that the herbaceous layer is relatively low in diversity (17 species) and is represented by scattered bunch grasses including *Sporobolus cryptandrus*, *Sporobolus airoides*, and *Aristida purpurea*. Seven out of 30 species recorded for the type are exotic.

Classification comments: This type, although it lacks significant wetland indicators other than cottonwood, is found in a mosaic with wetter forested and shrub wetland types than occur lower in the floodplain. It is similar to *Populus deltoides* ssp. *monilifera* / *Artemisia tridentata* CT (New Mexico state type) but lacks significant amounts of *Artemisia tridentata*. Dick-Peddie (1993) refers to a *Populus fremontii* / *Chrysothamnus nauseosus* / Mesic Grass - Forb type as part of his Floodplain-Plains Riparian group, which may be equivalent to the *Populus deltoides* / *Ericameria nauseosa* Forest.

Wetland indicator: Y

Vegetation hierarchy

Formation class	I - Forest
Formation subclass	I.B - Deciduous forest
Formation group	I.B.2 - Cold-deciduous forest
Formation subgroup	I.B.2.N - Natural/Semi-natural cold-deciduous forest
Formation Name	I.B.2.N.d - Temporarily flooded cold-deciduous forest
Alliance Name	*Populus deltoides* Temporarily Flooded Forest Alliance

Global status	G4? (21Jul2004)
Rounded global status	G4 - Apparently Secure
United States distribution	NM
Global distribution	United States
Global range	This association is found in the San Juan River basin in northwestern New Mexico.

Local description: This association occurred in the lower level alluvial terraces that seasonally flood at HUTR. One field plot (HUTR-6) described this association at HUTR, which was located along the Pueblo Colorado Wash (fig. 25). The canopy was dominated by *Populus deltoides* up to 15 m in height. Other associated tree species that may have been present, but were not dominating species, include *Tamarix* sp. and *Elaeagnus angustifolia*. *Ericameria nauseosa* was the dominant shrub species ranging in height from 1-2 m. The herbaceous stratum (10%) was composed of various graminoids and exotic forbs.

3.3.4. Non-NVC Types (Proposed Local Alliances or Associations)

During field reconnaissance of the HUTR mapping area, several vegetation alliance or association types were observed as repeatedly occurring across the landscape (i.e., mapping area). These vegetation communities are not currently described by the NVC. In order to represent the existing vegetation, we are proposing several local vegetation alliances or associations that are included in the vegetation map. Each local vegetation type is described in the following section. Additional association level vegetation plot work would be needed to fully describe and classify these local vegetation types.

3.3.4.1. *Artemisia* sp. Dwarf-shrubland Alliance

Figure 26. *Artemisia* sp. Dwarf-shrubland Alliance looking west from HUTR-8

Local description: This proposed local alliance was documented at one field plot (HUTR-8) in the HUTR project area (fig. 26 and fig. 27). The plot was dominated by an unknown dwarf sagebrush (17%) and represented a large area surrounding the plot. Only one polygon in the project area represented the proposed alliance, and it was located outside the HUTR boundary. *Gutierrezia sarothrae* was the second most abundant shrub species with an estimated cover of 5%. The herbaceous stratum was sparse (<5%) and consisted primarily of *Portulaca oleracea*.

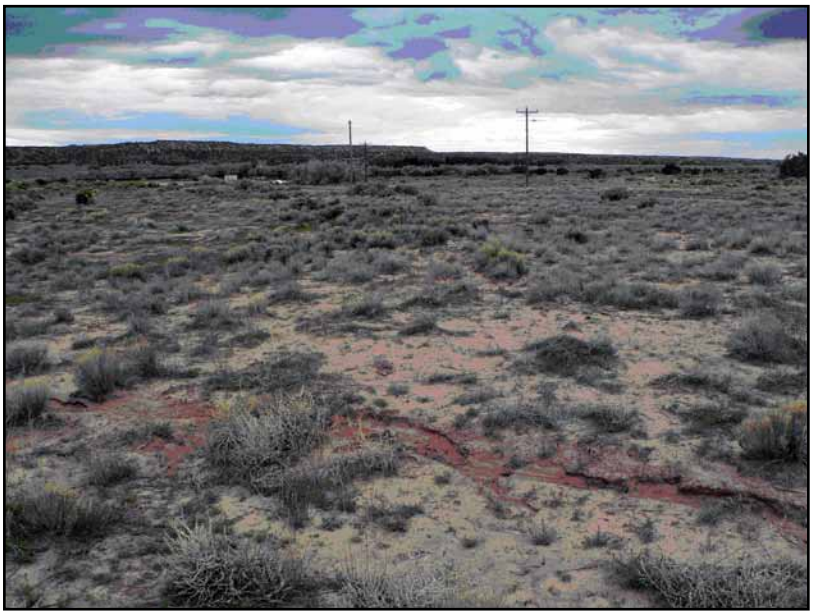

Figure 27. *Artemisia* sp. Dwarf-shrubland Alliance looking south from HUTR-8

3.3.4.2. *Lycium pallidum* **Shrubland Alliance**

a)

b)

Figure 28a & b
Lycium pallidum Shrubland Alliance (Proposed local alliance) at HUTR

Local description: This shrubland type does not represent an existing NVC association, but it was observed several times across the project area (fig. 28). The presence of this shrub in a dominant form is often thought to indicate some type of anthropogenic disturbance. In the Southwest, the anthropogenic disturbance often dates back to ancient Native American cultures and may mark the site of significant archeological remains. The shrub is often located in areas of the Southwest with aeolian sand deposits. In HUTR, this is not necessarily the case. Two field plots (HUTR-7, HUTR-9) represented this vegetation association. In both instances, *Lycium pallidum* was the dominant shrub, ranging in cover from 25-30%. Associated shrubs observed in the two field plots included *Atriplex canescens*, *Gutierrezia sarothrae*, and *Artemisia* sp. The herbaceous understory strata varied greatly between the two field plots. Field plot HUTR-7 was located on a terrace above the main Pueblo Colorado Wash. The understory was dominated by *Portulaca oleracea* and other exotic species with an estimated strata cover of 80%. Field plot HUTR-9 was located near Hubbell Hill, where bare soil represented a great amount of cover. The estimated herbaceous stratum cover for this plot was only 5%.

3.3.4.3. Restoration Site (Planted Shrubs and/or Trees)

a)

b)

Figure 29a & b. Cottonwood restoration site at HUTR (8/2006)

Local description: This vegetation classification locally represented areas that were undergoing restoration (fig. 29). For the HUTR vegetation mapping project area, two polygons were mapped as this vegetation type. Both polygons were located northwest of the administrative buildings at HUTR and on each side of Pueblo Colorado Wash. The polygon located on the south side of the wash was primarily composed of planted cottonwood trees ranging in height from 1-2 m. The perimeter of the cottonwood saplings was mapped in the field using a GPS unit and later converted to a feature in GIS. On the north side of the wash, a larger restoration area existed and was composed of a variety of planted tree and shrub species. The primary restoration goals of these two areas were to eradicate both *Tamarix* sp. and *Elaeagnus angustifolia,* and to restore native riparian woody species.

3.3.4.4. *Ulmus pumila* **Woodland Alliance**

Local vegetation summary: This proposed alliance represents groves of *Ulmus pumila* (Siberian elm), which were planted during European settlement. Only three polygons were mapped as this proposed local cultivar vegetation alliance. Two of three polygons were located on privately owned agricultural land southwest of HUTR. The third polygon represented the elm trees that surround the HUTR visitor center and trading post buildings. Canopy heights of these small areas commonly ranged from 10-15 m.

3.3.4.5. **Weedy Forbs / Abandoned Agriculture Field**

Local vegetation summary: The proposed alliance occurred throughout the mapped project area of HUTR. This vegetation alliance is intended to represent all herbaceous areas dominated by exotic species—areas difficult to classify. Disturbance is the primary mechanism for the vast majority of exotic species. While past cultivation is not the only cause for disturbance, it is the most commonly observed cause for disturbance in these areas. Areas mapped as this vegetation type were also observed at past and present machine/supplies/gravel staging areas and other areas disturbed by humans. Exotic species commonly present during the field visit of August 2006 included *Portulaca oleracea*, *Salsola tragus*, *Convolvulus arvensis*, and *Amaranthus retroflexus* (redroot amaranth). Additional species that may have been present and that were reported as common in 2001 by Roth (2004) included *Chorispora tenella* and *Descurainia sophia*. The annual species distribution and abundance of annual exotic species at HUTR is believed to be directly related to season and weather and thus may vary from year to year (Roth 2004).

3.4. Local Anderson's Land Use Code Descriptions

Anderson et al. (1976) Level II land-use codes were used to represent areas that were developed or non-vegetated. Some areas of continuous vegetation existed in the developed areas, but they were often below the minimum mapping unit (0.5 ha), and were difficult to delineate from the developed surroundings. Brief descriptions of HUTR areas classified as Level II are included below.-

Urban

- **Residential**. This map class represented residential areas within the mapping project area. Density of residential structures ranged from low to high. In general, all residential areas that were geographically clustered and above the minimum mapping unit were mapped as this map class.
- **Commercial and Services**. Areas that are predominately used for the sale of services and products were represented by this map class; for example, the rodeo facilities and hospital grounds were classified as Commercial and Services.
- **Transportation, Communications, and Utilities**. This class represented major transportation routes, as well as facilities that were used for communications or utilities. For example, highways, railroads, seaports, airports, water treatment facilities, dams, and any type of communications tower were considered in this class.
- **Mixed Urban or Built-up Land.** This map class represented areas that have a mixture of urban and built-up land, and areas where land use was difficult to discern. In the vegetation mapping project area, this map class represented low density residential areas with mixed land uses, such as ranching or agriculture. This class is most closely related to the residential map class.
- **Other Urban or Built-up Land**. At HUTR, this map class represented all the buildings (i.e., visitor center, trading post, administrative building etc.) and a small cemetery located in Ganado near the entrance to the hospital grounds.

Agriculture

- **Cropland and Pasture**. This class represented areas of active agricultural use in the project area (fig. 30).

Barren Land

- **Bare Exposed Rock**. This map class represented one polygon in the mapping project area and is located immediately north of Hubbell Hill. The ground surface was dominated by rocks and several small knolls. Vegetation cover was less than 5% and consisted of scattered forbs (fig. 31).

Water

- **Streams and Canals**. This map class is represented by Pueblo Colorado Wash and a few neighboring arroyos that flow into the main wash following precipitation events.

Figure 30. Active agricultural land (Cropland and Pasture class) in HUTR project area

Figure 31. Region in HUTR project area mapped as "Bare Exposed Rock"

3.5. Photographic Database

Four digital photographs were taken from the center of each field plot facing each of the four cardinal directions when possible. The field plot photographs were labeled with the plot number and the direction of the photo (e.g., 2-East). Many other digital photographs representing various topics were taken and were organized by directory folders.

3.6. Photointerpretation and Map Units

Map units for the HUTR vegetation mapping project may have either a one-to-one relationship of vegetated associations to map unit or a many-to-one relationship. Whenever possible, polygons were mapped to the association level. Most commonly, the association level mapping was the result of a field plot being located within a polygon representing a delineated area with a unique signature. The remainder of the polygons that either did not have an associated field point, or for which the photo interpreter could not identify a signature that corresponded with field plot data, were then mapped to the alliance level. Polygons mapped to the alliance level represented several vegetation associations that were combined into one map unit because of the difficulty in distinguishing similar associations on an aerial photograph. A total of 24 map units were established for the HUTR project as described in earlier sections.

3.7. Vegetation Map

The vegetation and land-cover map created for AZRU is shown in Figure 32. A total of 663 ha (1,639 acres) were mapped, encompassing the entire political boundary of HUTR (64.7 ha (159.9 acres)) and the designated environs (1.0 km buffer). A total of 152 unique polygons were delineated to represent the vegetation within the project area. After sampling the plots and analyzing the data, polygons were adjusted and then classified into map units. Twenty-four map units were used to describe the vegetation of the project area. These map units represented

- 11 existing NVC types
- 5 locally proposed vegetation types
- 8 Level II Anderson land-use types (Anderson et al. 1976)

The most commonly occurring map unit across the project area was *Ericameria nauseosa* Shrubland, which was represented by 29 distinct polygons ranging in size from 0.3 ha (0.8 acre) to 27.9 ha (69.0 acres), with an average polygon size of 5.9 ha (14.5 acres). The *Ericameria nauseosa* Shrubland map unit was also the most extensive, covering 170.4 ha (421.0 acres), or approximately 26% of the total project area.

The individual map unit statistics are important in that they reveal much more than the mean size. Often the mean area, considered alone, for each map unit may be misleading. For example, the mean area of a given map unit may be small, yet the frequency of the many small polygons of the map unit may be high, indicating that the map unit is well-distributed across the landscape. Alternatively, a few large polygons classified as a different map unit

Figure 32. Vegetation Map for Hubbell Trading Post National Historic Site

may represent the greatest area. Summary statistics, in addition to the mean, should be considered in any analysis of map-unit distributions.

The customized vegetation map units that were developed to describe each polygon are a particularly useful attribute of the vegetation map. We have proposed five project-specific vegetation types that have considerable local detail for this mapping effort. We have also cross-walked the project specific vegetation types to several other landcover classification systems, which will enable analysis at various other scales and perspectives. These include two Anderson-type landcover codes (levels I and II) and the ecological system codes. Using these items, one can link to external databases that may supplement the information provided here.

This map (fig. 32) can be used at several different levels of complexity. A very basic application of the vegetation map is to determine potential habitat of a particular species of concern by examining how large an area of potential habitat is represented by a specific map unit under certain topographical constraints . The answer could easily and quickly be found through a combination of queries. In a more complex application, the vegetation map could be used as an input into landscape models of fuel loadings or spread of invasive species. These more advanced investigations may require the services of a GIS analyst.

3.8. Map Verification

The HUTR vegetation mapping project area encompassed 152 polygons. The majority of these were visited in the field for both formal and informal observations. Augmenting the polygon designation derived from aerial imagery with field plots and notes provided a non-statistical assumption of close to 100% accuracy for the vegetation map. It is important to note that some polygons were only mapped to the NVC alliance level. Several component NVC associations are thought to occur in these classified polygons. Likewise, in the many polygons classified as one of the Anderson's land-use map units, vegetation assemblages were often present, but were difficult to discern from the aerial photography, as well as in the field, due to the anthropogenic impacts.-

4. Discussion

4.1. NVC Classification

Past and current land uses have significantly altered the vegetation within the Hubbell Trading Post National Historic Site (HUTR) project area. This is largely because about 90% of the project area was located outside the HUTR boundary and included

- the town of Ganado and the associated infrastructure
- the major Highway 264, which borders the park to the north
- residential properties of varying size and density throughout the buffer area
- commercial and service buildings
- active agricultural land.

As a result, it was difficult to place a large proportion of the vegetation and landcover types within an existing NVC alliance or association. Approximately 32% (209 ha; 516 acres) of the project area was represented by either a proposed local vegetation association, as described in the "Results" section of the report, or an existing level II land-use map unit, defined by Anderson et al. (1976).

The spread of noxious, woody, riparian species is of great concern at HUTR and throughout the southwestern U.S. The encroachment of *Tamarix* spp. and *Elaeagnus angustifolia* is altering the composition and structure of vegetative riparian systems at HUTR, as is illustrated in Figure 12, which shows the increase and spread of *Elaeagnus angustifolia* in

Pueblo Colorado Wash. All areas that were composed of any mixture of *Tamarix* spp., *Elaeagnus angustifolia* (dominant) and *Populus deltoides* were mapped as the NVC alliance "*Elaeagnus angustifolia* Semi-natural Woodland Alliance." This alliance represents approximately 6% (~ 38 ha; 94 acres) of the total project area and occurs primarily outside the HUTR boundary along the Pueblo Colorado Wash. It is important to note that all delineations for the vegetation map were made based on 2003 aerial photography. Thus, the total amount of each specific map unit that is on the ground today may differ from what was found on the ground at that time. It is likely that the geographic extent has changed since 2003 due to the continued encroachment of exotics, and to restoration efforts (i.e., eradication of *Tamarisk* spp. and/or *Elaeagnus angustifolia)* within the park boundary.

The field plots and informal field notes collected represent a large portion of the entire project area. A small percentage of polygons were not visited in the field due to their location (i.e., distance and/or private ownership boundaries) and/or their perceived similarity to previously visited polygons in the project area. Photointerpretation techniques and the ancillary field data were used to assign map units for the polygons that were not visited in the field. These polygons were most often mapped to the alliance level and will remain tentative until further field inquiries are made.

Ten of the thirteen field plots sampled in HUTR corresponded directly to an existing NVC alliance or association. Of the three field plots that did not represent an existing NVC type, two represented vegetation communities dominated by the shrub *Lycium pallidum*. The third field plot represented an area composed of an unknown *Artemisia* sp. dwarf-shrub. Corresponding NVC alliances/associations that were not always described as occurring in the state of Arizona, were still chosen as the "best fitting" existing NVC vegetation type. As additional vegetation surveys are expanded geographically, we expect that existing association extents will expand as well.

Certainly, not all investigators will agree with all of the designations and we invite all to submit their comments to NatureServe, which will ultimately decide upon inclusion, exclusion, or modification to the NVC.

4.2. Global Rarity

Only associations have been matched to their global rarity. Of these, all but one were either G5 (Secure) or GNR (Not yet ranked). One association, "*Populus deltoides* / *Ericameria nauseosa* Forest" was identified with a global status of G4 (Apparently Secure). One association described for HUTR was not yet ranked—"*Juniperus osteosperma* / *Artemisia tridentata* ssp. *tridentata"*. Roth (2004) reports that no special status plants exist in the physical boundary of HUTR. Also, only one sensitive habitat is believed to occur at HUTR—the riparian habitat of Pueblo Colorado Wash (Roth 2004).

4,3. Non-Native Species

Non-native species are abundant at HUTR. The park's close proximity to major roads, high annual tourist visitation rates, and the high level of past land disturbance (e.g., grazing, irrigation, agriculture, settlement) all affect the abundance of weedy species (Roth 2004). Both the diversity and abundance of exotic species at HUTR are believed to be increasing. Roth (2004) estimated that 30-33% of the total flora and 43% of the new species found at HUTR were exotic. Fifteen percent of the currently documented species of HUTR are listed in SWEMP (Roth 2004). Alteration of the native vegetation composition in the riparian floodplain along the Pueblo Colorado Wash continues to be a major ecological and social concern. The primary species of concern include *Tamarix* sp., *Ulmus pumila*, and *Elaeagnus angustifolia*. We documented the occurrences of non-

native species within plots on the field plot form and in the database for future management consideration.

4.4. Photointerpretation and Map Units

Ordinarily, when mapping small parks, it is possible to visit every polygon during the field sampling operation. The HUTR vegetation mapping project area was unique in that it extended into the western portion of the town of Ganado, Arizona. Because access was restricted in some areas (due to private property issues), not every polygon was visited in the field.

The HUTR map units have a one-to-one correspondence with either NVC alliances or associations, and a one-to-many correspondence with NVC associations. Several map codes were not represented by the NVCS, but instead were based on Anderson's land-use units and proposed local vegetation alliances.

Polygons were classified as a single NVC association, Anderson's land-use map unit, or proposed local vegetation type. These classifications were derived by sampling a field plot located within the polygon, or because of their correspondence to a signature from an existing field plot at another location. Large polygons may have contained several plots corresponding to more than one association. In these cases, the polygon was mapped to the alliance level if the representative signatures could not be delineated from the aerial photograph. This was most often the case in forested or woodland areas dominated by *Pinus edulis* and/or *Juniperus osteosperma*. In the event that only one field plot was located within a large polygon, the decision to map to the alliance level was due to the photo interpreter's belief that the entire polygon was not represented by the one association sampled. Instead, the polygon was likely to have more than one association present, but it was not easy to delineate them from the aerial photographs.

In the HUTR project area, the *Juniperus osteosperma* woodland alliance and component associations were limited to the lower elevations of the project area (e.g. HUTR-13). One polygon, representing a large portion of Hubbell Hill, was mapped as the NVC association "*Juniperus osteosperma* / *Artemisia tridentata* (ssp. *wyomingensis*, spp. *vaseyana*) Woodland," which is represented by HUTR field plot 10. We believed that the subspecies of *Artemisia tridentata* present in the HUTR project area was ssp. *tridentata,* which is not described within the NVC association. Instead of creating a new local vegetation association, we chose to fold the vegetation association into the existing NVC association.

Pinus edulis woodland alliances and associations represent upland associations and are found along the northern, southern, and southeastern extent of the project area. The increased elevation and unique geologic substrate are believed to be important factors in constraining *Pinus edulis* to these areas within the project. In general, three vegetation patterns were observed to occur in the *Pinus edulis – Juniperus osteosperma* dominated woodlands:

(1) sparse vegetated cover with high amounts of bare soil, bedrock and small rocks (e.g., HUTR-12). This type was found on the side slopes of the uplands and mapped as "*Pinus edulis – Juniperus osteosperma* / Sparse Understory Woodland."

(2) a mixture of shrubs and grasses. This pattern, found on an undulating woodland plateau above the side slopes of the uplands (HUTR-11), did not directly correspond to any existing NVC associations, and was mapped to the "*Pinus edulis – Juniperus* spp. Alliance."

(3) small woodland areas dominated by the shrub *Artemisia tridentata*. This pattern was represented by a unique signature on the aerial photographs and several polygons were mapped as this association,

based on their geographic location and unique signatures.

Finally, we think that not all of the plant associations present at HUTR are represented in the HUTR vegetation map. Several factors may have contributed to this: limited vegetation association field data, MMU, aerial photo limitations, and lack of NVC descriptions. Additional associations that may occur within the HUTR project area, but were not specifically represented by a map unit are as follows:

- *Juniperus osteosperma* / Sparse Understory Woodland (Area mapped as 'Barren Rock Knoll' just north of Hubbell Hill)
- *Juniperus osteosperma* / Mixed Shrubs Talus Woodland (Alternative association for Hubbell Hill; HUTR-10)
- *Juniperus osteosperma* / *Bouteloua gracilis* Woodland (Observed with HUTR-13, but not mapped due to large extent of polygon and lack of defining signature)
- *Pinus edulis* Rockland Woodland (May represent some areas in project area, but no NVC description is available at this time)
- *Pinus edulis – Juniperus osteosperma* / Mixed Shrubs Talus Woodland (May be considered as an alternative for all side slopes of the uplands in the project area; HUTR-12)

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Appendix A

Aerial Photography of Hubbell Trading Post National Historic Site

USDA/NPS-acquired aerial photos of Hubbell Trading Post National Historic Site and surrounding areas, including the community of Ganado, Arizona, east of the historic site. The photos, which are in natural color, were taken on September 14, 2003, along a flight path in which the plane first flew along a south to north trajectory and then turned around and flew slightly east in a north to south trajectory. The first number in the figure label refers to the flight path and the second number refers to the photo number in the series.

Figure A-1: 303-178

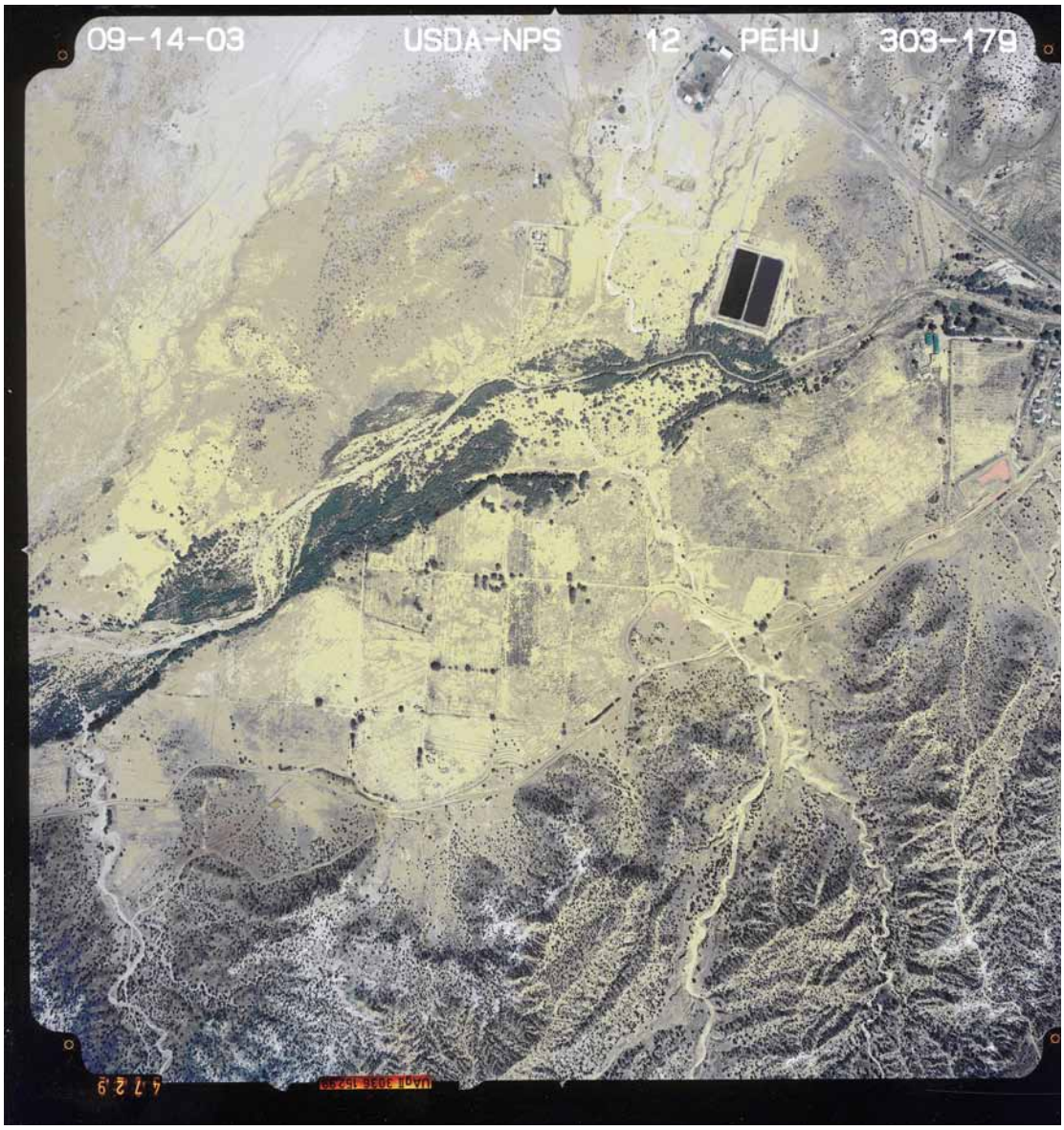

Figure A-2: 303-179

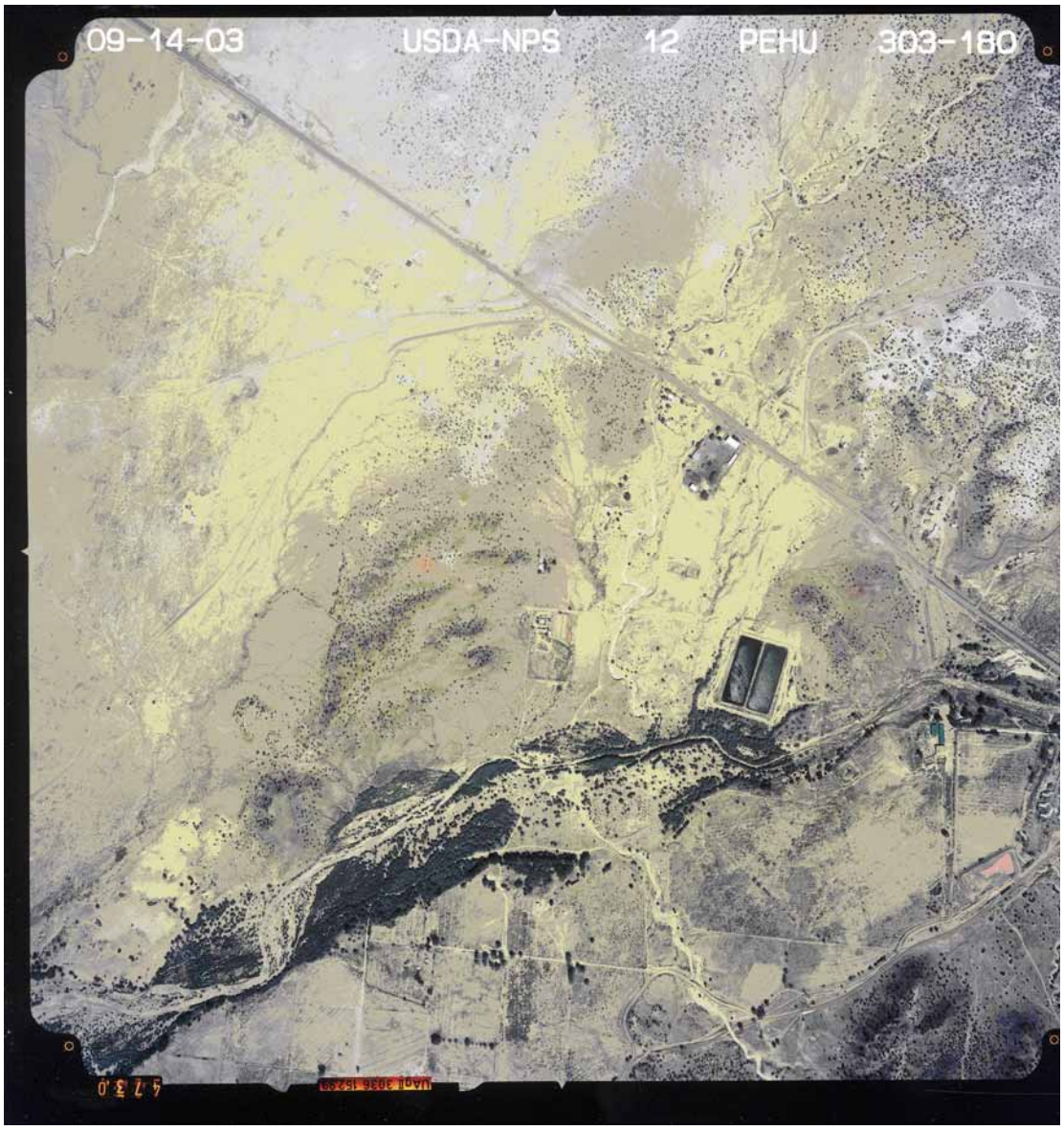

Figure A-3: 303-180

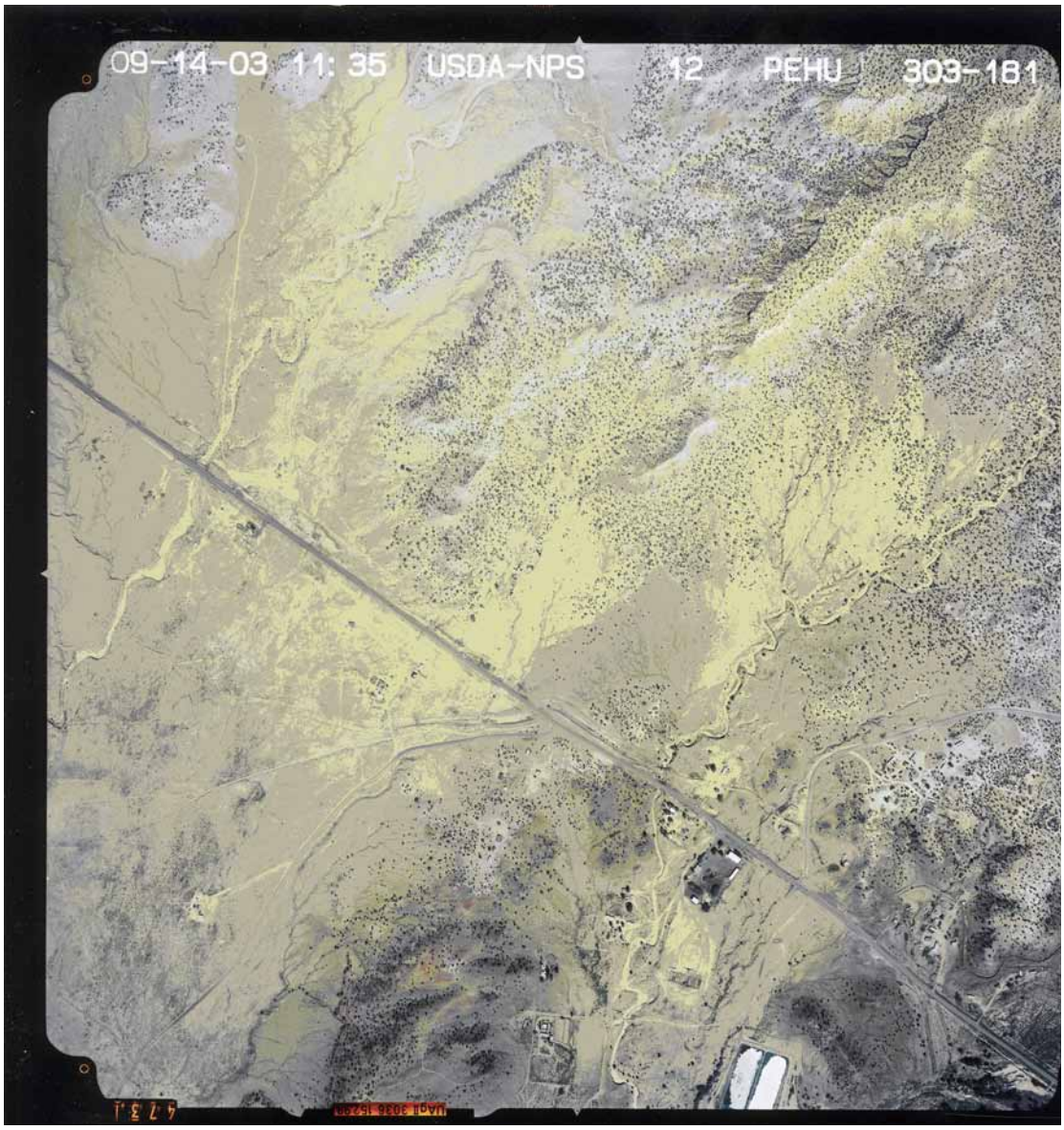

Figure A-4: 303-181

Figure A-5: 303-182

Figure A-6: 303-183

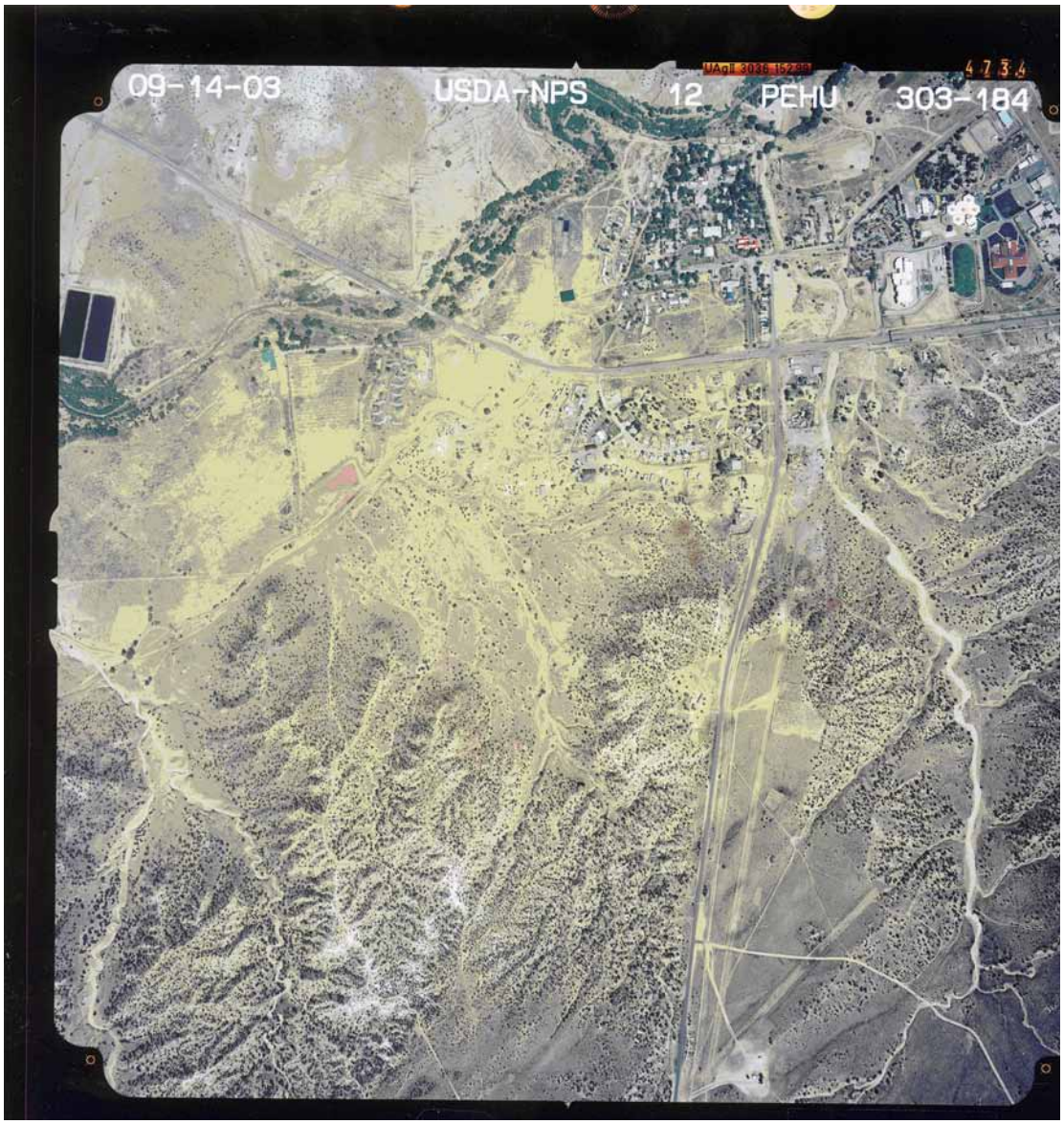

Figure A-7: 303-184

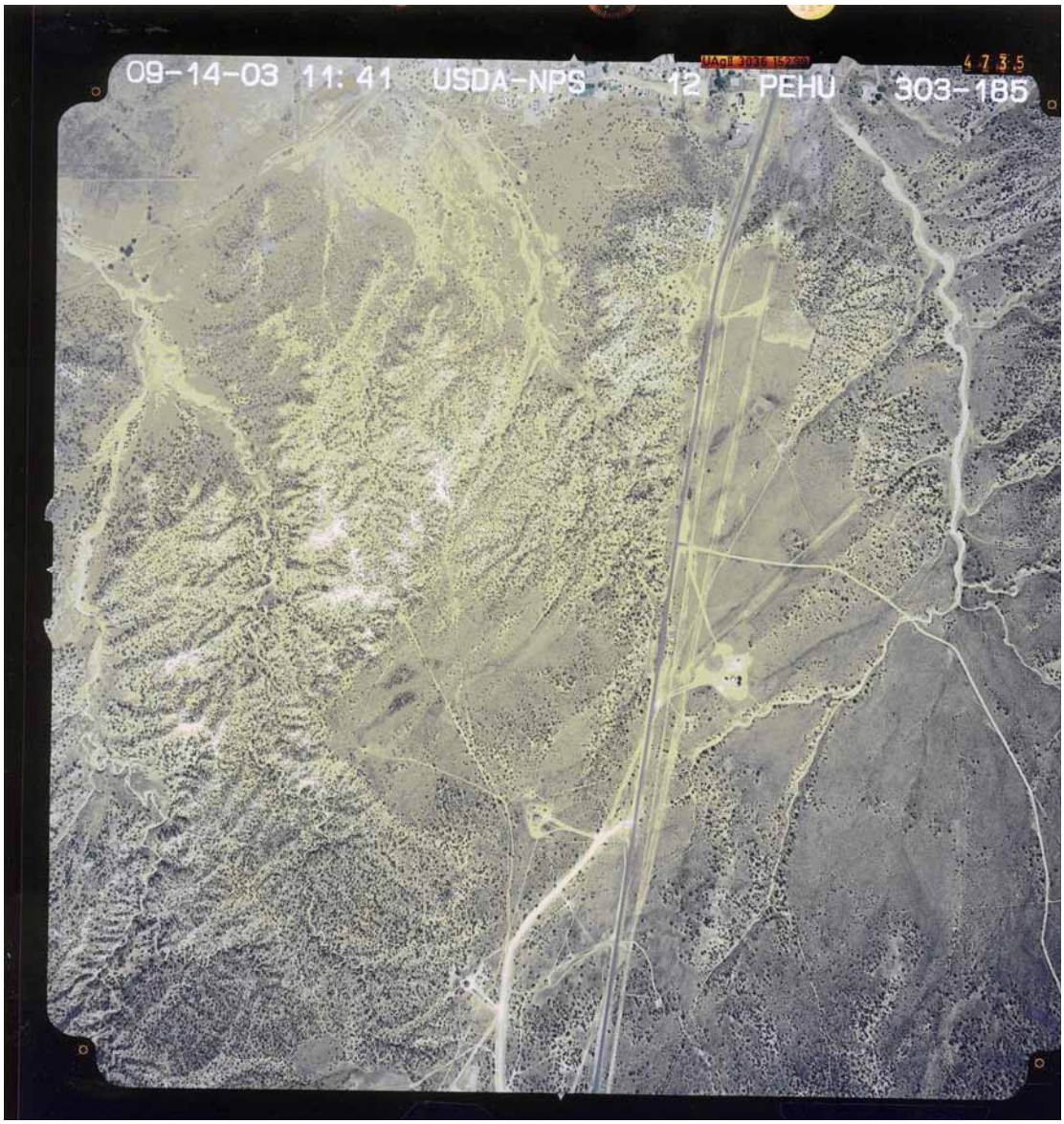

Figure A-8: 303-185

Appendix B

Lookup Table

The lookup table provides information on the vegetation types, map units, and codes used in the map. It also provides a crosswalk from one type of designation to another (e.g. from the map unit names to the Anderson Land Use Classification, or from the vegetation type/map unit name to the ecological system class).

1. The Map_unit column provides the numbers assigned to the map units.

2. Vegetation_name indicates the vegetation type/map unit names.

3. The NVCS (National Vegetation Classification System) column indicates the code for that type assigned by NatureServe; if none has been assigned by NatureServe, n/a indicates that it is not applicable for that vegetation type/map unit.

4. FM_class, FM_subclass, FM_group, FM_subgroup, and FM_formation are designations of the physiognomic levels of the NVCS hierarchical classification structure (Grossman et al. 1998).

5. Alliance is also part of the NVCS hierarchical system, but indicates groupings based on floristic characteristics;

6. Association is the finest level of the NVCS, and is also based on floristic characteristics.

7. Ecosys1_ID and Ecosys2_ID refer to the identification numbers of types of ecological systems in NatureServe's Ecological Systems Classification.

8. Ecosys1 and Ecosys2 are the ecological systems in which the vegetation type/map unit occurs (some types may occur in more than one ecological system) (http://www.natureserve.org/explorer).

9. Anderson_l1, Anderson_l2, Anderson_l3, and Anderson_l4 refer to levels of the Anderson land use classification (Anderson et al. 1976).

10. Global_status and Rounded_global_status refer to the conservation rankings of the vegetation types/map units (http://www.natureserve.org/explorer).

Map_ unit	Veg_name	NVCS	FM_class	FM_subclass	FM_group
1	*Artemisia sp.* Dwarf-shrubland Alliance	n/a	n/a	n/a	n/a
2	*Atriplex canescens* Shrubland	CEGL001281	III - Shrubland	III.A - Evergreen shrubland	III.A.5 - Extremely xeromorphic evergreen shrubland
3	Bare Exposed Rock	n/a	n/a	n/a	n/a
4	Commercial and Services	n/a	n/a	n/a	n/a
5	Cropland and Pasture	n/a	n/a	n/a	n/a
6	*Elaeagnus angustifolia* Semi-natural Woodland Alliance	A.3566	II - Woodland	II.B - Deciduous woodland	II.B.2 - Cold-deciduous woodland
7	*Ericameria nauseosa* Shrubland	CEGL002713	III - Shrubland	III.A - Evergreen shrubland	III.A.4 - Microphyllous evergreen shrubland
8	*Gutierrezia sarothrae* Dwarf-shrubland Alliance	A.2528	IV - Dwarf-shrubland	IV.B - Deciduous dwarf-shrubland	IV.B.2 - Cold-deciduous dwarf-shrubland
9	*Juniperus osteosperma / Artemisia tridentata ssp*. tridentata Woodland	CEGL002360	II - Woodland	II.A - Evergreen woodland	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland
10	*Juniperus osteosperma* Woodland Alliance	A.536	II - Woodland	II.A - Evergreen woodland	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland
11	*Lycium pallidum* Shrubland Alliance	n/a	n/a	n/a	n/a
12	Mixed Urban or Built-up Land	n/a	n/a	n/a	n/a
13	Other Urban or Built-up Land	n/a	n/a	n/a	n/a
14	*Pinus edulis - Juniperus osteosperma /* Sparse Understory Woodland	CEGL002148	II - Woodland	II.A - Evergreen woodland	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland
15	*Pinus edulis - Juniperus* spp./*Artemisia tridentata* Woodland	CEGL000776	II - Woodland	II.A - Evergreen woodland	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland
16	*Pinus edulis - (Juniperus* spp.) Woodland Alliance	A.516	II - Woodland	II.A - Evergreen woodland	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland
17	*Populus deltoides / Ericameria nauseosa* Forest	CEGL005969	I - Forest	I.B - Deciduous forest	I.B.2 - Cold-deciduous forest
18	*Populus deltoides* Temporarily Flooded Forest Alliance	A.290	I - Forest	I.B - Deciduous forest	I.B.2 - Cold-deciduous forest
19	Residential	n/a	n/a	n/a	n/a
20	Restoration Area (Planted Native Riparian Trees and/or Shrubs)	n/a	n/a	n/a	n/a
21	Streams and Canals	n/a	n/a	n/a	n/a
22	Transportation, Communications, and Utilities	n/a	n/a	n/a	n/a
23	*Ulmus pumila* Woodland Alliance	n/a	n/a	n/a	n/a
24	Weedy Forbs - Abandoned Agriculture Field (Disturbed Area)	n/a	n/a	n/a	n/a

Map_ unit	FM_subgroup	Formation
1	n/a	n/a
2	III.A.5.N - Natural/Semi-natural extremely xeromorphic evergreen shrubland	III.A.5.N.b - Facultatively deciduous extremely xeromorphic subdesert shrubland
3	n/a	n/a
4	n/a	n/a
5	n/a	n/a
6	II.B.2.N - Natural/Semi-natural cold-deciduous woodland	II.B.2.N.a - Cold-deciduous woodland
7	III.A.4.N - Natural/Semi-natural microphyllous evergreen shrubland	III.A.4.N.a - Lowland microphyllous evergreen shrubland
8	IV.B.2.N - Natural/Semi-natural cold-deciduous dwarf-shrubland	IV.B.2.N.a - Cespitose cold-deciduous dwarf-shrubland
9	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
10	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
11	n/a	n/a
12	n/a	n/a
13	n/a	n/a
14	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
15	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
16	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
17	I.B.2.N - Natural/Semi-natural cold-deciduous forest	I.B.2.N.d - Temporarily flooded cold-deciduous forest
18	I.B.2.N - Natural/Semi-natural cold-deciduous forest	I.B.2.N.d - Temporarily flooded cold-deciduous forest
19	n/a	n/a
20	n/a	n/a
21	n/a	n/a
22	n/a	n/a
23	n/a	n/a
24	n/a	n/a

Map_ unit	Alliance	Association	Ecosys1_ID	Ecosys1
1	n/a	n/a	n/a	n/a
2	*Atriplex canescens* Shrubland Alliance	*Atriplex canescens* Shrubland	CES302.749	Sonora-Mojave Mixed Salt Desert Scrub
3	n/a	n/a	n/a	n/a
4	n/a	n/a	n/a	n/a
5	n/a	n/a	n/a	n/a
6	*Elaeagnus angustifolia* Semi-natural Woodland Alliance	n/a	n/a	n/a
7	*Ericameria nauseosa* Shrubland Alliance	*Ericameria nauseosa* Shrubland	CES304.777	Inter-Mountain Basins Big Sagebrush Shrubland
8	*Gutierrezia sarothrae* Dwarf-shrubland Alliance	n/a	n/a	n/a
9	*Juniperus osteosperma* Woodland Alliance	J***uniperus osteosperma***/*Artemisia tridentata ssp.* tridentata Woodland	CES304.767	Colorado Plateau Pinyon-Juniper Woodland
10	*Juniperus osteosperma* Woodland Alliance	n/a	n/a	n/a
11	n/a	n/a	n/a	n/a
12	n/a	n/a	n/a	n/a
13	n/a	n/a	n/a	n/a
14	*Pinus edulis - (Juniperus spp*.) Woodland Alliance	*Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland	CES304.767	Colorado Plateau Pinyon-Juniper Woodland
15	*Pinus edulis - (Juniperus spp*.) Woodland Alliance	*Pinus edulis - Juniperus spp./Artemisia tridentata*	CES304.767	Colorado Plateau Pinyon-Juniper Woodland
16	*Pinus edulis - (Juniperus spp*.) Woodland Alliance	n/a	n/a	n/a
17	*Populus deltoides* Temporarily Flooded Forest Alliance	*Populus deltoides / Ericameria nauseosa* Forest	n/a	n/a
18	*Populus deltoides* Temporarily Flooded Forest Alliance	n/a	n/a	n/a
19	n/a	n/a	n/a	n/a
20	n/a	n/a	n/a	n/a
21	n/a	n/a	n/a	n/a
22	n/a	n/a	n/a	n/a
23	n/a	n/a	n/a	n/a
24	n/a	n/a	n/a	n/a

Map_ unit	Ecosys2_ID	Ecosys2	Anderson_L1	Anderson_L2	Anderson_L3	Anderson_L4
1	n/a	n/a	3	Rangeland	32	Shrub and Brush Rangeland
2	CES304.784	Inter-Mountain Basins Mixed Salt Desert Scrub	3	Rangeland	32	Shrub and Brush Rangeland
3	n/a	n/a	7	Barren Land	74	Bare Exposed Rock
4	n/a	n/a	1	Urban or Built-up Land	12	Commercial and Services
5	n/a	n/a	2	Agricultural Land	21	Cropland and Pasture
6	n/a	n/a	4	Forest Land	41	Decidious Forest Land
7	n/a	n/a	3	Rangeland	32	Shrub and Brush Rangeland
8	n/a	n/a	3	Rangeland	32	Shrub and Brush Rangeland
9	n/a	n/a	4	Forest Land	42	Evergreen Forest Land
10	n/a	n/a	4	Forest Land	42	Evergreen Forest Land
11	n/a	n/a	3	Rangeland	32	Shrub and Brush Rangeland
12	n/a	n/a	1	Urban or Built-up Land	16	Mixed Urban or Built-up Land
13	n/a	n/a	1	Urban or Built-up Land	17	Other Urban or Built-up Land
14	CES304.773	Great Basin Pinyon-Juniper Woodland	4	Forest Land	42	Evergreen Forest Land
15	CES306.835	Southern Rocky Mountain Pinyon-Juniper Woodland	4	Forest Land	42	Evergreen Forest Land
16	n/a	n/a	4	Forest Land	42	Evergreen Forest Land
17	n/a	n/a	4	Forest Land	41	Decidious Forest Land
18	n/a	n/a	4	Forest Land	41	Decidious Forest Land
19	n/a	n/a	1	Urban or Built-up Land	11	Residential
20	n/a	n/a	4	Forest Land	41	Decidious Forest Land
21	n/a	n/a	5	Water	51	Streams and Canals
22	n/a	n/a	1	Urban or Built-up Land	14	Transportation, Communications, and Utilities
23	n/a	n/a	4	Forest Land	41	Decidious Forest Land
24	n/a	n/a	3	Rangeland	31	Herbaceous Rangeland

Map_unit	Global_sta	Rounded_gl
1	n/a	n/a
2	G5 (23Feb1994)	G5 - Secure
3	n/a	n/a
4	n/a	n/a
5	n/a	n/a
6	n/a	n/a
7	G5 (26Jun2001)	G5 - Secure
8	n/a	n/a
9	GNR (22Mar2005)	GNR - Not Yet Ranked
10	n/a	n/a
11	n/a	n/a
12	n/a	n/a
13	n/a	n/a
14	G5 (15Dec2004)	G5 - Secure
15	G5 (01Feb1996)	G5 - Secure
16	n/a	n/a
17	G4? (21Jul2004)	G4 - Apparently Secure
18	n/a	n/a
19	n/a	n/a
20	n/a	n/a
21	n/a	n/a
22	n/a	n/a
23	n/a	n/a
24	n/a	n/a

Appendix C

Plant Species List:

Hubbell Trading Post National Historic Site

A species list of vouchered plant specimens collected by Roth (2004) and others, included in NPSpecies, the National Park Service Biodiversity Database (secure online version: https://science1.nature.nps.gov/npspecies/web/main/start, accessed 11/3/2008).

Species	Common Name	Family	Nativity*
Achillea millefolium	common yarrow	Asteraceae	N
Achnatherum hymenoides	Indian ricegrass	Poaceae	N
Achnatherum nelsonii ssp. dorei	Dore's needlegrass	Poaceae	N
Aegilops cylindrica	jointed goatgrass	Poaceae	N
Agropyron desertorum	desert wheatgrass	Poaceae	N
Agrostis stolonifera	creeping bentgrass	Poaceae	N
Alyssum minus	alyssum	Brassicaceae	E
Amaranthus albus	prostrate pigweed	Amaranthaceae	N
Amaranthus blitoides	mat amaranth	Amaranthaceae	E
Amaranthus powellii	Powell's amaranth	Amaranthaceae	N
Amaranthus wrightii	Wright's amaranth	Amaranthaceae	N
Ambrosia acanthicarpa	flatspine burr ragweed	Asteraceae	N
Ambrosia psilostachya	Cuman ragweed	Asteraceae	N
Argemone munita	flatbud pricklypoppy	Papaveraceae	N
Aristida purpurea	Fendler's threeawn	Poaceae	N
Aristida purpurea var. longiseta	purple threeawn	Poaceae	N
Artemisia bigelovii	Bigelow sage	Asteraceae	N
Artemisia carruthii	Carruth's sagewort	Asteraceae	N
Artemisia tridentata	basin big sagebrush	Asteraceae	N
Asclepias subverticillata	horsetail milkweed	Asclepiadaceae	N
Astragalus amphioxys	crescent milkvetch	Fabaceae	N
Atriplex canescens	fourwing saltbush	Chenopodiaceae	N
Bassia hyssopifolia	fivehorn smotherweed	Chenopodiaceae	E
Bouteloua curtipendula	sideoats grama	Poaceae	N
Bouteloua gracilis	blue grama	Poaceae	N
Bromus inermis	smooth brome	Poaceae	E
Bromus japonicus	Japanese brome	Poaceae	E
Bromus tectorum	cheatgrass	Poaceae	E
Calochortus nuttallii	sego lily	Liliaceae	N
Camelina microcarpa	littlepod false flax	Brassicaceae	N
Capsella bursa-pastoris	shepherd's purse	Brassicaceae	E
Cardaria chalapensis	lenspod whitetop	Brassicaceae	E
Carduus nutans	nodding plumeless thistle	Asteraceae	E
Castilleja linariifolia	Wyoming Indian paintbrush	Scrophulariaceae	N
Centaurea repens	hardheads	Asteraceae	E
Chaetopappa ericoides	rose heath	Asteraceae	N
Chamaesaracha coronopus	greenleaf five eyes	Solanaceae	N
Chamaesyce fendleri	Fendler's sandmat	Euphorbiaceae	N
Chamaesyce glyptosperma	ribseed sandmat	Euphorbiaceae	N
Chamaesyce nutans	eyebane	Euphorbiaceae	N
Chenopodium album	lambsquarters	Chenopodiaceae	E
Chenopodium graveolens	fetid goosefoot	Chenopodiaceae	N
Chloris virgata	feather fingergrass	Poaceae	N
Chorispora tenella	crossflower	Brassicaceae	E
Chrysothamnus greenei	Greene's rabbitbrush	Asteraceae	N

Species	Common Name	Family	Nativity*
Cichorium intybus	chicory	Asteraceae	E
Cirsium arizonicum	Arizona thistle	Asteraceae	N
Cirsium ochrocentrum	yellowspine thistle	Asteraceae	N
Cirsium vulgare	bull thistle	Asteraceae	E
Cleome serrulata	Rocky Mountain beeplant	Capparaceae	N
Convolvulus arvensis	field bindweed	Convolvulaceae	E
Conyza canadensis	Canadian horseweed	Asteraceae	N
Croton texensis	Texas croton	Euphorbiaceae	N
Cryptantha barbigera	bearded cryptantha	Boraginaceae	N
Cryptantha cinerea var. jamesii	James' cryptantha	Boraginaceae	N
Cuscuta umbellata	flatglobe dodder	Cuscutaceae	N
Cymopterus purpureus	purple springparsley	Apiaceae	N
Cyperus esculentus	yellow nutsedge	Cyperaceae	N
Dactylis glomerata	orchardgrass	Poaceae	E
Dalea candida	white prairie clover	Fabaceae	N
Descurainia sophia	flixweed	Brassicaceae	E
Dimorphocarpa wislizeni	spectacle pod	Brassicaceae	N
Dracocephalum parviflorum	American dragonhead	Lamiaceae	N
Echinochloa crus-galli	barnyardgrass	Poaceae	E
Elaeagnus angustifolia	Russian olive	Elaeagnaceae	E
Elymus canadensis	Canada wildrye	Poaceae	N
Elymus elymoides ssp. elymoides	bottlebrush squirreltail	Poaceae	N
Elymus trachycaulus	slender wheatgrass	Poaceae	N
Ephedra torreyana	Torrey's jointfir	Ephedraceae	N
Equisetum arvense	field horsetail	Equisetaceae	N
Eremopyrum triticeum	annual wheatgrass	Poaceae	E
Ericameria nauseosa	rubber rabbitbrush	Asteraceae	N
Erigeron divergens	spreading fleabane	Asteraceae	N
Eriogonum cernuum	nodding buckwheat	Polygonaceae	N
Erodium cicutarium	redstem stork's bill	Geraniaceae	E
Erysimum repandum	spreading wallflower	Brassicaceae	N
Gaura mollis	velvetweed	Onagraceae	N
Gilia subnuda	coral gilia	Polemoniaceae	N
Grindelia nuda var. aphanactis	curlytop gumweed	Asteraceae	N
Gutierrezia sarothrae	broom snakeweed	Asteraceae	N
Helianthus ciliaris	Texas blueweed	Asteraceae	N
Helianthus petiolaris	prairie sunflower	Asteraceae	N
Heterotheca villosa	hairy false goldenaster	Asteraceae	N
Hordeum jubatum	foxtail barley	Poaceae	N
Hordeum murinum ssp. glaucum	smooth barley	Poaceae	E
Hordeum murinum ssp. leporinum	smooth barley	Poaceae	E
Hymenopappus filifolius	fineleaf hymenopappus	Asteraceae	N
Hymenoxys richardsonii	Colorado rubberweed	Asteraceae	N
Iris germanica	German iris	Iridaceae	E

Species	Common Name	Family	Nativity*
Iva axillaris	povertyweed	Asteraceae	N
Juglans cinerea	butternut	Juglandaceae	N
Juncus xiphioides	irisleaf rush	Juncaceae	N
Juniperus monosperma	oneseed juniper	Cupressaceae	N
Juniperus osteosperma	Utah juniper	Cupressaceae	N
Kochia scoparia	kochia	Chenopodiaceae	E
Krascheninnikovia lanata	winterfat	Chenopodiaceae	N
Lactuca serriola	prickly lettuce	Asteraceae	E
Lappula occidentalis var. cupulata	flatspine stickseed	Boraginaceae	N
Lappula occidentalis var. occidentalis	flatspine stickseed	Boraginaceae	N
Lepidium perfoliatum	clasping pepperweed	Brassicaceae	E
Lesquerella intermedia	mid bladderpod	Brassicaceae	N
Linum aristatum	bristle flax	Linaceae	N
Lupinus kingii	King's lupine	Fabaceae	N
Lycium pallidum	pale desert-thorn	Solanaceae	N
Machaeranthera canescens var. canescens	hoary tansyaster	Asteraceae	N
Malacothrix fendleri	Fendler's desertdandelion	Asteraceae	N
Malus baccata	paradise apple	Rosaceae	E
Malus sylvestris	European crabapple	Rosaceae	E
Malus X soulardii		Rosaceae	E
Malva neglecta	common mallow	Malvaceae	E
Marrubium vulgare	horehound	Lamiaceae	E
Medicago lupulina	black medick	Fabaceae	E
Medicago sativa	alfalfa	Fabaceae	E
Melilotus officinalis	yellow sweetclover	Fabaceae	E
Menodora scabra	rough menodora	Oleaceae	N
Mentha arvensis	wild mint	Lamiaceae	N
Mentzelia pumila	dwarf mentzelia	Loasaceae	N
Mirabilis linearis	narrowleaf four o'clock	Nyctaginaceae	N
Mirabilis multiflora	Colorado four o'clock	Nyctaginaceae	N
Monroa squarrosa	false buffalograss	Poaceae	N
Morus alba	white mulberry	Moraceae	E
Muhlenbergia asperifolia	scratchgrass	Poaceae	N
Muhlenbergia wrightii	spike muhly	Poaceae	N
Nama retrorsum	Betatakin fiddleleaf	Hydrophyllaceae	N
Oenothera albicaulis	whitestem evening-primrose	Onagraceae	N
Oenothera flava	yellow evening-primrose	Onagraceae	N
Oenothera pallida ssp. runcinata	pale evening-primrose	Onagraceae	N
Opuntia polyacantha	plains pricklypear	Cactaceae	N
Opuntia whipplei	Whipple's cholla	Cactaceae	N
Oxytropis lambertii	purple locoweed	Fabaceae	N
Panicum capillare	witchgrass	Poaceae	N
Parryella filifolia	common dunebroom	Fabaceae	N

Species	Common Name	Family	Nativity
Parthenocissus quinquefolia	virginia creeper	Vitaceae	N
Pascopyrum smithii	western wheatgrass	Poaceae	N
Physalis longifolia var. longifolia	longleaf groundcherry	Solanaceae	N
Physalis virginiana	Virginia groundcherry	Solanaceae	N
Physaria chambersii	Chamber's twinpod	Brassicaceae	N
Physaria newberryi	Newberry's twinpod	Brassicaceae	N
Pinus edulis	twoneedle pinyon	Pinaceae	N
Plantago major	common plantain	Plantaginaceae	N
Plantago patagonica	woolly plantain	Plantaginaceae	N
Pleuraphis jamesii	James' galleta	Poaceae	N
Poa fendleriana	muttongrass	Poaceae	N
Poa pratensis	Kentucky bluegrass	Poaceae	E
Polygonum aviculare	prostrate knotweed	Polygonaceae	E
Polygonum lapathifolium	curlytop knotweed	Polygonaceae	N
Polygonum ramosissimum	bushy knotweed	Polygonaceae	N
Polypogon monspeliensis	annual rabbitsfoot grass	Poaceae	E
Populus alba	white poplar	Salicaceae	E
Populus deltoides	plains cottonwood	Salicaceae	N
Portulaca oleracea	purslane	Portulacaceae	N
Prunus gracilis	Oklahoma plum	Rosaceae	N
Prunus rivularis	creek plum	Rosaceae	N
Puccinellia distans	weeping alkaligrass	Poaceae	N
Ranunculus cymbalaria	alkali buttercup	Ranunculaceae	N
Ratibida columnifera	upright prairie coneflower	Asteraceae	N
Ribes aureum	golden currant	Grossulariaceae	N
Rosa woodsii var. woodsii	Wood's rose	Rosaceae	N
Rumex salicifolius var. mexicanus	Mexican dock	Polygonaceae	N
Rumex stenophyllus	narrowleaf dock	Polygonaceae	N
Salix exigua	narrowleaf willow	Salicaceae	N
Salix irrorata	dewystem willow	Salicaceae	N
Salsola collina	slender Russian thistle	Chenopodiaceae	E
Salsola tragus	prickly Russian thistle	Chenopodiaceae	E
Salvia reflexa	lanceleaf sage	Lamiaceae	N
Schoenoplectus americanus	chairmaker's bulrush	Cyperaceae	N
Sclerocactus parviflorus	intermediate fishhook cactus	Cactaceae	N
Senecio flaccidus var. flaccidus	threadleaf ragwort	Asteraceae	N
Setaria viridis	green bristlegrass	Poaceae	E
Sisymbrium altissimum	tall tumblemustard	Brassicaceae	E
Solanum rostratum	buffalobur nightshade	Solanaceae	N
Solanum triflorum	cutleaf nightshade	Solanaceae	N
Sphaeralcea ambigua	apricot globemallow	Malvaceae	N
Sphaeralcea coccinea	scarlet globemallow	Malvaceae	N
Sphaeralcea fendleri	thicket globemallow	Malvaceae	N
Sphaeralcea parvifolia	smallflower globemallow	Malvaceae	N
Sporobolus airoides	alkali sacaton	Poaceae	N

Species	Common Name	Family	Nativity*
Stanleya pinnata	desert princesplume	Brassicaceae	N
Streptanthus cordatus	heartleaf twistflower	Brassicaceae	N
Syringa vulgaris	lilac	Oleaceae	E
Tamarix chinensis	five-stamen tamarisk	Tamaricaceae	E
Tamarix ramosissima	saltcedar	Tamaricaceae	E
Taraxacum officinale	common dandelion	Asteraceae	E
Thelesperma megapotamicum	Hopi tea greenthread	Asteraceae	N
Thelesperma subnudum	Navajo tea	Asteraceae	N
Tragopogon dubius	yellow salsify	Asteraceae	E
Tribulus terrestris	puncturevine	Zygophyllaceae	E
Trifolium repens	white clover	Fabaceae	E
Tripterocalyx carnea	winged sandpuffs	Nyctaginaceae	N
Tripterocalyx carnea var. wootonii	Wooton's sandpuffs	Nyctaginaceae	N
Ulmus pumila	Siberian elm	Ulmaceae	E
Verbena bracteata	bigbract verbena	Verbenaceae	N
Verbesina encelioides	golden crownbeard	Asteraceae	N
Veronica americana	American speedwell	Scrophulariaceae	N
Xanthium strumarium	Canada cockleburr	Asteraceae	N
Yucca angustissima	narrowleaf yucca	Agavaceae	N
Yucca baccata	banana yucca	Agavaceae	N

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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