# Mojave Desert Ecosystem Program: Central Mojave Vegetation Database

**Final Report**

**Prepared for:**

## Mojave Desert Ecosystem Program

**U.S. DEPARTMENT OF THE INTERIOR**
**U.S. GEOLOGICAL SURVEY**
**Western Ecological Research Center &**
**Southwest Biological Science Center**

# Mojave Desert Ecosystem Program: Central Mojave Vegetation Database

**By Kathryn Thomas[1], Todd Keeler-Wolf[2], Janet Franklin[3], and Peter Stine[4]**

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U.S. GEOLOGICAL SURVEY
WESTERN ECOLOGICAL RESEARCH CENTER &
SOUTHWEST BIOLOGICAL SCIENCE CENTER

## Final Report

Prepared for:

Mojave Desert Ecosystem Program

[1]Colorado Plateau Field Station
USGS Southwest Biological Science Center
2255 N. Gemini Drive
Flagstaff, Arizona 86001

[2]California Department of Game and Fish
Sacramento, California

[3]Department of Geography
San Diego State University
San Diego, California

[4]Pacific Southwest Research Station
U.S. Forest Service
Sacramento, California

Sacramento, California
2004

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, SECRETARY

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director



---

For additional information, contact:

Center Director
Western Ecological Research Center
U.S. Geological Survey
7801 Folsom Blvd., Suite 101
Sacramento, CA 95826

Center Director
Southwest Biological Science Center
U.S. Geological Survey
2255 N. Gemini Drive
Flagstaff, Arizona 86001

2004

## Project Team

## Principal Investigators

Administrative coordination

- Peter Stine, Pacific Southwest Research Station, U.S. Forest Service, Sacramento, California

Photo-interpretation and predictive vegetation modeling

- Janet Franklin, Department of Geography, San Diego State University (SDSU), San Diego, California

Vegetation classification

- Todd Keeler-Wolf, California Department of Game and Fish, Sacramento, California

Fieldwork oversight, data management, product compilation

- Kathryn Thomas, U.S. Geological Survey (USGS), Southwest Biological Science Center, Colorado Plateau Field Station, Flagstaff, Arizona

## Collaborators

Department of Defense oversight

- Clarence Everly, Mojave Desert Ecosystem Program, Barstow, California

Climate modeling

- Joel Michaelsen, University of California Santa Barbara, Santa Barbara, California

Aerial photography

- Aircraft Data Facility, National Aeronautics and Space Administration (NASA) Ames Research Center

## Staff

Field crew: Jim Thorne (crew leader 1997-98), Julie Evens, Sue Weiss, Casey Stewman, Michael Marion, Cristian Singer, Ryan Roberts, Mimi Murov, Fred Sproul, Ryan Stevens, Matthew Gilkey, Matthew Barmann, Nicole Good, Bridget Paule, Keith Pohs

Data management: Jon Helleson, Ryan Stevens, Elena Deshler, Kris Estes, Gina Mullen, J. Judson Wynne, Monica Hansen, Charis Corporation

Photointerpretation and predictive vegetation modeling: David Shaari (SDSU Project Manager); Clint Garrison, Stacie Hathaway, Alexandra Hofmann, Jennifer Miller, Peter Scull, Dena Simons, Richard Sperling, Alexandra Syphard (research assistants)

Vegetation classification: Kari Lewis, Ryelle Bueller, Jennifer Baumbach, Jeanne Wirka, Craig Bailey

Map compilation: Gina Mullen, Shawn Tousley

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Julie Evens, Sequoia and Kings Canyon National Park
Jim Thorne, UC Davis
Dana York, Death Valley National Park
Matt Brooks, USGS, Western Ecological Research Center
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Jim Andre, Sweeney Granite Mountain Reserve
Monica Hansen, USGS, Colorado Plateau Field Station

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# Introduction

The Department of Defense (DOD) and the other desert managers are developing and organizing scientific information needed to better manage the natural resources of the Mojave Desert. Scientific, natural, and cultural resource professionals in the Mojave have agreed upon the importance of developing mechanisms by which land management decisions can be made to maintain the Mojave Desert ecosystem while supporting sustainable economies, communities, and national defense preparedness. The Desert Managers Group (DMG), a federal/state partnership of land and resource managers working in the California portion of the Mojave Desert, contains within their mission (http://mojavedata.gov/partners.html) a charge to develop and integrate databases and scientific studies needed for effective resource management and planning. The Mojave Desert Ecosystem Program (MDEP) Legacy Program, which supports critical DOD installations, collects data needed to support the DMG mission.

Detailed vegetation distribution data, incorporated into a digital map, is a crucial baseline data set needed by the DMG. In 1996, the MDEP requested the U.S. Geological Survey (USGS) Biological Resources Discipline (BRD) to create a vegetation map using current vegetation classification standards in the Mojave Desert in California. The MDEP tasked BRD with detailing the scope of work, identifying the appropriate mix of expertise to accomplish the tasks, and managing the development of the products under the guidance of the MDEP and DMG.

We initiated work in September 1996. The USGS management team spent six months working with the Science and Data Management Team of the DMG and with a large number of field staff from all DMG agencies and other field experts. At the conclusion of this extensive scoping session, we developed a project schedule, the identified the products, and assembled the project core team.

With the level of funding available, we determined that we could map approximately 60%, five million ha of the Mojave in California. The areas selected represent a majority of public lands in the Californian portion of the Mojave (Figure 1), with an emphasis on certain DOD and Department of the Interior lands, referred to as the central Mojave in this report.

## Project Products

The project produced a vegetation map for this area and ancillary maps and coverages to support the development of the vegetation map. Secondly, we reviewed and revised the classification of vegetation types in the Mojave.

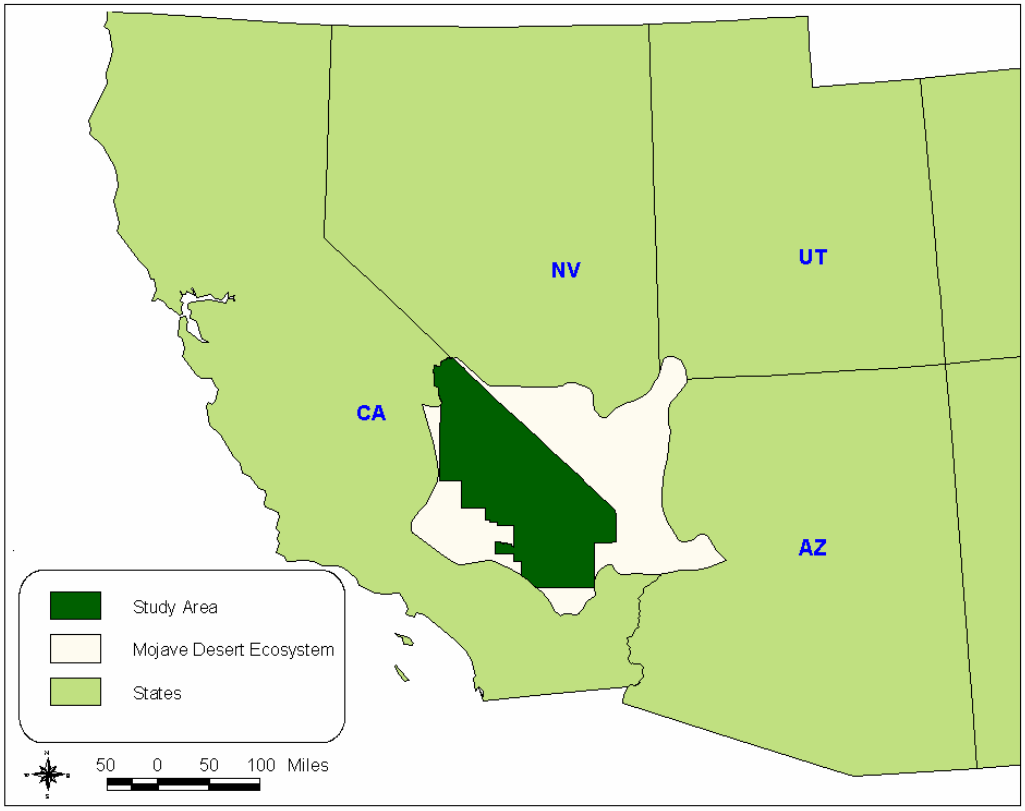


Figure 1. The project study area within the Mojave Ecosystem.

The target specifications for the vegetation map were:

| | |
|---|---|
| Resolution: | Minimum mapping unit (MMU) is 5 ha and certain rare or localized types mapped as points |
| Coverage: | Estimated 60% of California Mojave |
| Thematic detail: | Alliance level for most vegetation types, some types are aggregated and mapped as complexes, and some alliances possibly divided into sub-units and mapped as associations if strong evidence exist for that detail |
| Datum: | Horizontal World Geodetic Systems of 1984 (WGS84), which is equivalent to North American Datum of 1983 (NAD83), Universal Transverse Mercator (UTM) projection<br>Vertical - National Geodetic Vertical Datum of 1929 |
| Accuracy: | 80% thematic accuracy or confidence level |

The resulting map products (four ArcInfo coverages and four grids) and associated metadata for each are compiled into the Central Mojave Vegetation Database. In addition, the compiled database includes the Access records for the classification relevés collected during this project. The Central Mojave Vegetation Database includes:

1. Central Mojave Vegetation Map: Vegetation types for the eastern Mojave Desert in California, at two levels of aggregation,
2. Central Mojave Environmental Type Grid: Environmental classes defined to stratify the study area to allocate the vegetation relevé samples,
3. Mojave Summer Precipitation Grid,
4. Mojave Winter Precipitation Grid,
5. Mojave January Average Minimum Temperature Grid,
6. Mojave July Average Maximum Temperature Grid,
7. Central Mojave Field Data Tables,
8. Central Mojave Plots Map: Locations of relevé locations measured for the project, and
9. Central Mojave Special Features Map: Potential and known locations of special vegetation features, that is rare vegetation or other features with less 5 ha extent

In this report we present a user's guide to the structure of each component of the Central Mojave Vegetation database and discuss the methods used to create it. We describe the production of the quantitatively based classification of Mojave vegetation. In the appendices is a list of currently accepted alliances in the greater Mojave Desert (Appendix A); an identification key based on floristic properties of the alliances (Appendix B) and descriptions of 70 alliances (Appendix C), 20 of which are new to the U.S. National Vegetation Classification.

The Central Mojave Vegetation Database is available on CD-ROM and as individual downloads through the web sites for the Mojave Desert Ecosystem Program or the USGS Colorado Plateau Field Station.

## Vegetation Classification

Selection of the vegetation classification for a map has tremendous influence on the utility of the data for desert land managers. Quantitative, data-driven vegetation classification creates an unbiased source of information for all scientific and management applications, including map labeling. In addition, the vegetation classification is a stand-alone product that can be used with or without reference to the map.

The U.S. National Vegetation Classification, referred to as NVC in the report, (FGDC 1997, Grossman et al. 1998) is the standard classification throughout this project. The FGDC has adopted the National Vegetation Classification Standard (NVCS). It describes a hierarchical vegetation classification framework intended to encompass a uniform method of describing vegetation types across administrative boundaries and at the national level. It is important that as an agency map or inventory land cover, sufficient data are collected to accurately describe vegetation types for national reporting, aggregation, and comparisons. Adoption of the NVCS facilitates the compilation of regional and national vegetation distribution maps. NatureServe, the current managers of the NVC, have reviewed and approved the projects' classification for the Mojave at the alliance level.

The NVCS defines vegetation at several levels (Table 1). The physiognomically-based upper levels of the classification such as the formation or group are often used as a basis of broad regional or national assessments. The mid-resolution floristically based alliance is “a physiognomically uniform group of plant associations sharing one or more dominant or diagnostic species, which as a rule are found in the upper-most stratum of the vegetation" (Grossman et al. 1998). The association is the finest level of the hierarchy and is based upon additional dominant/diagnostic species. It may be used at local scales to address specific projects.

Table 1. Classification hierarchy in the U.S. National Vegetation Classification.

| **Class** | **Sub-class** | **Group** | **Formation** | **Alliance** |
|---|---|---|---|---|
| I. Forest. Trees usually over 5-m tall with their crowns interlocking (generally forming 60-100% cover). | I.A. Evergreen forest. Evergreen species generally contribute > 75% of the total tree cover. | I.A.6. Temperate broad-leaf seasonal evergreen forest | I. A.6.n.b . Lowland or submontane winter-rain evergreen sclerophyllous forest | Ia.6.n.b.2 *Quercus chrysolepis* forest alliance |
| II. Woodland. Open stands Of trees usually over 5-m tall with crowns not usually touching (generally forming 25-60% cover) | II.A. Evergreen woodland. Evergreen species generally contribute >75% of the total tree cover | II.A.4. Temperate or sub-polar needle-leaved evergreen woodland | II.A.4.N.a . Rounded-crowned temperate or subpolar needle-leaved evergreen woodland | II.A.4.N.a.45 *Pinus monophylla* woodland alliance |
| III. Shrubland. Shrubs or trees usually 0.5 To 5-m tall with individuals or clumps not touching to interlocking (generally forming >25% canopy cover). | III.A. Evergreen Shrubland. Evergreen species generally contribute >75% of the total shrub and/or tree cover. | III.A.2 Temperate broad-leaved evergreen shrubland | III.A.2.N.h . Seasonally flooded temperate broad-leaved evergreen shrubland | III.A.2.N.h.2 *Pluchea sericea* seasonally flooded shrubland alliance |
| III. Shrubland. Shrubs or trees usually 0.5 To 5-m tall with individuals or clumps not touching to interlocking (Generally Forming >25% Canopy Cover). | III.B. Deciduous shrubland. Deciduous species generally contribute >75% of the total shrub and/or tree cover | III.A.5. Extremely xeromorphic subdesert shrubland | III.A.5.N.b . Facultatively deciduous extremely xeromorphic subdesert shrubland | III.A.5.N.b.11 *Coleogyne ramosissima* shrubland alliance |
| IV. Dwarf-shrubland. Low-growing shrubs and/or trees usually under 0.5-m tall, individuals or clumps not touching to interlocking (generally forming >25% cover). | IV.A. Evergreen dwarf-shrubland. Evergreen species generally contribute >75% of the total shrub and/or tree cover. | IV.A.2. Evergreen subdesert dwarf shrubland | IV.A.2.N.a . Extremely xeromorphic evergreen subdesert dwarf-shrubland | IV.A.2.N.a.6 *Ambrosia dumosa* dwarf-shrubland alliance |
| V. Herbaceous vegetation. Graminoids and/or forbs (including ferns) generally forming >10% cover with woody cover usually <10%. | V.A. Perennial graminoid vegetation. Graminoids over 1-m tall when inflorescences are fully developed, generally contributing to >50% of total herbaceous cover | V.A.5. Temperate or subpolar grassland | V.A.5.N.d . Medium-tall bunch temperate or subpolar grassland | V.A.5.N.d.3 *Pleuraphis rigida* herbaceous alliance |

The NVC had not been extensively developed for California alliances. *The Manual of California Vegetation* (Sawyer and Keeler-Wolf 1995) was previously developed to address the need for a classification of vegetation in California. To build on the Sawyer and Keeler-Wolf descriptions of series in the Mojave, we collected and analyzed relevé data collected for this project or otherwise available and revised the classification to identify alliances compatible with the NVC, examples of which occur on Table 1.

# The Central Mojave Vegetation Database

## Central Mojave Vegetation Map

A total of 101 alliances have been identified as occurring within the greater Mojave Desert (see Appendix A), but not all of these alliances occurred in the study area. Alliances on the vegetation map are those that consistently occur in patches of at least five ha or more. Other alliances that we identified in the study area were not included in the map because they do not occur in patches as large as the minimum map unit. Where there is a field observation of one of these alliances, we included the observation point in the Special Features Map (see Central Mojave Special Features Map).

In the vegetation spatial database there are 31 primary vegetation type labels (label_1, label_2) consisting of alliances, alliances complexes, and land use type map labels and 12 systems consisting of groups of the primary map labels (Table 2). While the classification we produced defined alliances in the Mojave Desert, we did not find it possible to map most vegetation types directly to the alliance level. Our map labels have two levels of aggregation, fine and coarse. The finest level of mapping, "Label_1" and "Label_2", represents a single alliance or groupings of similar alliances (alliance complex) or a land use type. The coarser level of mapping, the "System", consists of “sets of alliances of mixed composition/physiognomy occurring in tight juxtaposition on the natural/semi-natural landscape” (Perlstine et al. 1998), the ecological complex in NatureServe terminology, and “sets of alliances within the same NVC class that are found in similar environments, and with similar spectral signatures. Component alliances often share species of the same genera, or at least family, in the upper-most vegetation stratum” (Perlstine et al. 1998), the compositional group in NatureServe terminology.

**Structure**

The Central Mojave Vegetation Map is a digital map (ArcInfo vector coverage, MojVeg.e00) with each polygon or map unit labeled with five database items:

| | |
|---|---|
| Label_1: | Vegetation type representing an alliance, alliance complex, or land use type |
| Label_2: | Vegetation type representing an alliance or alliance complex that may also be found in the map unit |
| Source_1: | The source of information used to assign Label_1 (Table 3) |

Source_2: The source of information used to assign Label_2, if present (Table 3)
System: Vegetation type representing groupings of alliances

The Central Mojave Vegetation Map is accompanied by a FGDC compliant metadata text file (MojoVeg_Metadata.txt) and embedded metadata that can be viewed with the ArcCatalog module of ArcGIS8. The citation for the coverage is:

> Thomas, K., J. Franklin, T. Keeler-Wolf and P. Stine. 2002. Central Mojave Vegetation Map. A Digital spatial database (ArcInfo). U.S. Geological Survey.

Table 2. Vegetation types in the Central Mojave Vegetation Map.

| System | **Label_1, Label_2** | **Alliances, alliance complexes or land use represented** |
|---|---|---|
| Barren | Sparse vegetation | Less than 2% perennial vegetation |
| Creosote Bush Mixed Scrub | Creosote | *Larrea tridentata* Shrubland Alliance, *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance, *Larrea tridentata-Encelia farinosa* Shrubland Alliance (occasionally), *Ambrosia dumosa* Dwarf-Shrubland Alliance, *Encelia farinosa* Shrubland Alliance (occasionally) |
| Creosote Bush Mixed Scrub | Creosote-Brittlebush | *Larrea tridentata-Encelia farinosa* Shrubland Alliance, *Encelia farinosa* Shrubland Alliance |
| Creosote Bush Mixed Scrub | White Burrobush | *Ambrosia dumosa* Dwarf-Shrubland Alliance |
| Desert Grassland and Shrub Steppe | Galleta | *Pleuraphis jamesii* or *Pleuraphis rigida* Herbaceous Alliance |
| Desert Sink | Alkali Meadow/Sink | *Distichlis spicata* Intermittently Flooded Herbaceous Alliance |
| Desert Sink | Iodine Bush-Bush Seepweed | *Allenrolfea occidentalis* Shrubland Alliance, *Suaeda moquinii* Intermittently Flooded Shrubland Alliance |
| Desert Sink | Playa | Barren, around edges may find *Atriplex polycarpa*, *Atriplex confertifolia*, or *Atriplex canescens* shrubland alliances; *Allenrolfea occidentalis* Shrubland Alliance, *Suaeda moquinii* Intermittently Flooded Shrubland Alliance, *Pluchea sericea* Seasonally Flooded Shrubland Alliance, *Prosopis glandulosa* Shrubland Alliance, *Sporobolus airoides* Intermittently Flooded Herbaceous Alliance |
| Desert Wash System | Low Elevation Wash System | Barren, *Psorothamnus spinosus* Intermittently Flooded Shrubland Alliance, *Hymenoclea salsola* Shrubland Alliance, *Ephedra californica* Intermittently Flooded Shrubland Alliance, *Acacia greggii* Shrubland Alliance, *Chilopsis linearis* |

| | | |
|---|---|---|
| | | Intermittently Flooded Shrubland Alliance, *Encelia virginensis* Shrubland Alliance, *Ericameria nauseosa* Shrubland Alliance, *Eriogonum fasciculatum* Shrubland Alliance, *Hyptis emoryi* Intermittently Flooded Shrubland Alliance, *Lepidospartum squamatum* Intermittently Flooded Shrubland Alliance, *Prosopis glandulosa* Shrubland Alliance, *Tamarix* spp. Semi-Natural Temporarily Flooded Shrubland Alliance, *Viguiera parishii* Shrubland Alliance and occasionally more typically upland types such as *Atriplex hymenelytra* Shrubland Alliance, *Atriplex canescens* Shrubland Alliance, *Atriplex confertifolia* Shrubland Alliance or *Atriplex polycarpa* Shrubland Alliance |
| Desert Wash System | Mid Elevation Wash System | Barren, *Acacia greggii* Shrubland Alliance, *Prosopis glandulosa* Shrubland Alliance, *Chilopsis linearis* Intermittently Flooded Shrubland Alliance, *Ericameria paniculata* Intermittently Flooded Shrubland Alliance, *Viguiera parishii* Shrubland Alliance, *Baccharis sergiloides* Intermittently Flooded Shrubland Alliance, *Viguiera reticulata* Intermittently Flooded Shrubland Alliance, *Ephedra californica* Intermittently Flooded Shrubland Alliance, *Hymenoclea salsola* Shrubland Alliance, *Salazaria mexicana* Shrubland Alliance, *Encelia virginensis* Shrubland Alliance, *Ericameria nauseosa* Shrubland Alliance, *Eriogonum fasciculatum* Shrubland Alliance, *Lepidospartum squamatum* Intermittently Flooded Shrubland Alliance, occasionally more typically upland types such as *Atriplex hymenelytra* Shrubland Alliance and *Atriplex canescens, A. confertifolia* or *A. polycarpa* shrubland alliances |
| Desert Wash System | High Elevation Wash System | Sparsely Vegetated Wash, Unvegetated, *Prunus fasciculata* Shrubland Alliance, *Salazaria mexicana* Shrubland Alliance, *Hymenoclea salsola* Shrubland Alliance, *Salvia dorrii* Dwarf-Shrubland Alliance, *Viguiera reticulata* Intermittently Flooded Shrubland Alliance (occasionally), *Baccharis sergiloides* Intermittently Flooded Shrubland Alliance, occasionally more typically upland types such as *Artemisia tridentata* Shrubland Alliance |
| Interior Dunes | Dunes | Barren; Herbaceous Dunes Sparse Vegetation Alliance; *Panicum urvilleanum* Sparsely Vegetated Herbaceous Alliance; *Achnatherum speciosum* Herbaceous Alliance; *Pleuraphis rigida* Herbaceous |

| | | |
|---|---|---|
| | | Alliance; *Ambrosia dumosa* Dwarf-Shrubland Alliance; *Atriplex canescens, A. polycarpa* or *A. confertifolia* shrubland alliances; *Larrea tridentata* Shrubland Alliance; *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance; *Prosopis glandulosa* Shrubland Alliance, *Abronia villosa* Sparsely Vegetated Alliance |
| Land Use | Agriculture | Agriculture generally irrigated |
| Land Use | Mining | Mining pits and infrastructure |
| Land Use | Rural Development | Building, structures or surface development other than urban |
| Land Use | Urban | Towns and settlements as designated on the DeLorme Atlas (1998) and with multiple residences within the five ha mapping unit |
| Lava Beds | Lava Beds and Cinder Cones | Barren, *Atriplex hymenelytra* Shrubland Alliance, *Encelia farinosa* Shrubland Alliance, *Larrea tridentata-Encelia farinosa* Shrubland Alliance |
| Limber Pine-Bristlecone Pine Woodland | Limber Pine/Bristlecone Pine | *Pinus flexilis* Woodland Alliance, *Pinus longaeva* Woodland Alliance |
| Mesquite Bosque | Mesquite | *Prosopis glandulosa* Shrubland Alliance |
| Mid Elevation Mixed Desert Scrub | Blackbrush | *Coleogyne ramosissima* Shrubland Alliance |
| Mid Elevation Mixed Desert Scrub | Hopsage | *Grayia spinosa* Shrubland Alliance |
| Mid Elevation Mixed Desert Scrub | Joshua Tree | *Yucca brevifolia* Wooded Shrubland Alliance |
| Mid Elevation Mixed Desert Scrub | Menodora | *Menodora spinescens* Dwarf-Shrubland Alliance |
| Mid Elevation Mixed Desert Scrub | Mojave Yucca | *Yucca schidigera* Shrubland Alliance |
| Mid Elevation Mixed Desert Scrub | Nevada Joint-Fir | *Ephedra nevadensis* Shrubland Alliance |
| Pinyon Juniper Woodland | Big Sagebrush | *Artemisia tridentata* Shrubland Alliance, *Ephedra viridis- Artemisia tridentata* Shrubland Alliance |
| Pinyon Juniper Woodland | Juniper | *Juniperus californica* or *Juniperus osteosperma* Wooded Shrubland Alliance |
| Pinyon Juniper Woodland | Pinyon | *Pinus monophylla* Wooded Shrubland Alliance, *Pinus monophylla* - (*Juniperus osteosperma*) |

| | | |
|---|---|---|
| | | Woodland Alliance |
| Saltbush Scrub | Saltbush | *Atriplex canescens* Shrubland Alliance, *Atriplex polycarpa* Shrubland Alliance, *Atriplex confertifolia* Shrubland Alliance (when around playas) |
| Saltbush Scrub | Shadscale | *Atriplex confertifolia* Shrubland Alliance |
| Saltbush Scrub | Desert Holly | *Atriplex hymenelytra* Shrubland Alliance |

Table 3. Source codes in the Central Mojave Vegetation Map

| **Source Code** | **Source of map label information** |
|---|---|
| EXPERT1 | Expert review workshop |
| EXPERT2 | MDEP mapping team editors |
| FIELD1 | San Diego State University photointerpretation team field observations |
| FIELD2 | Relevé data, retrospective data, validation and editing observations |
| LSU | Landforms from Geomorphic Landform and Surface Composition |
| MOD1 | First iteration predictive modeling |
| MOD2-100 | Predictive modeling, all of polygon is predicted as a primary label |
| MOD2-25 | Predictive modeling, 25-34% of polygon is predicted as a primary label |
| MOD2-35 | Predictive modeling, 35-44% of polygon is predicted as a primary label |
| MOD2-45 | Predictive modeling, 45-54% of polygon is predicted as a primary label |
| MOD2-55 | Predictive modeling, 55-64% of polygon is predicted as a primary label |
| MOD2-65 | Predictive modeling, 65-74% of polygon is predicted as a primary label |
| MOD2-75 | Predictive modeling, 75-84% of polygon is predicted as a primary type |
| MOD2-85 | Predictive modeling, 85-99% of polygon is predicted as a primary type |
| Photo-CPFS | Photointerpretation conducted at Colorado Plateau Field Station |
| Photo-SDSU | Photointerpretation conducted at San Diego State University |

**Methods**

We assumed, based on literature review and personal observation, that floristic variation (at the alliance level) in the Mojave Desert is not strongly related to spectral reflectance as recorded in satellite imagery because vegetation cover is sparse and the substrate dominates the reflectance response. Although more details about vegetation can normally be discerned with aerial photography than with satellite imagery, many vegetation types, particularly desert types, are not identifiable, even with large-scale photography. We decided to use a hybrid approach where aerial photography was used to delineate polygons and each polygon was assigned a map label using information derived from one of five different sources of information on the vegetation types found at that location. Those sources were: 1) field observations; 2) photo-interpretation; 3) expert knowledge; 4) the Geomorphic Landform and Surface Composition GIS (GLSCGIS, http://mojavedata.gov/datasets.php?&qclass=geo), a spatial database developed by R. Dokka of Louisiana State University for the MDEP Legacy Program; or 5) predictive modeling.

We used the following steps, sometimes conducted concurrently, to develop the vegetation map:

- Delineate map polygons
- Develop map label information sources
- Assign labels to map polygons
- 

**Delineating Map Polygons**

For this mapping effort, NASA's High Altitude Airborne Sciences Program obtained color aerial photography at approximately 1:32,000 scale between May 14 and July 24, 1997. Photo frames had a nominal overlap of 60 percent. Color diapositive transparencies were provided to us, some in 9 x 9 inch format (Wild-Heerbrugg RC30 metric mapping camera 6 inch focal length), and some in 9 x 18 inch format (Hycon HR-732 large scale mapping camera 24 inch focal length). Color positive contact prints were also developed for every other photo and provided to the vegetation sampling crew. NASA acquired photos during several missions, and using two different aircraft platforms, due to problems with cloud cover. Photos varied in quality, as a function of format and mission.

We also obtained SPOT panchromatic satellite imagery with 10-m resolution from the California Department of Fish and Game (copyright CNES/SPOT Image Corp. 1994) for the mapping area. This imagery was geocoded and terrain corrected (R. Dokka, personal comm.) and reprojected to UTM projection WGS84 datum. The imagery was provided to us in files corresponding to one half of each USGS 1:100,000 topographic map in the mapping area. As described below, we used the SPOT imagery as a base for delineated map polygons.

The aerial photography was to identify map polygons based on vegetation and land-surface characteristics. Following field reconnaissance, we determined we could delineate polygons based on tone, texture, and terrain features related to landform, soil or surface color, and sometimes plant size, tone, or density. Only large shrubs and trees could be resolved on the photos; even using magnification, small shrubs were not typically visible, especially when contrast with the substrate was poor.

We developed a classification of photo-interpreted preliminary labels with three attributes: vegetation type, landform, and vegetation cover. These preliminary labels indicated what criteria the photo-interpreter used to delineate the polygon. We used these labels to stratify the mapped area to apply the test predictive models separately to non-overlapping areas of the landscape representing subsets of the vegetation types. We included a photo-interpreted landform label because although there was a landform map available, the Geomorphic Landform and Surface Composition GIS (GLSCGIS), it was developed at a coarser scale (10 ha MMU). Our landform classification is simplified from that used in the GLSCGIS, but it was adequate for our vegetation mapping purposes and enabled us to assign landform labels to the finer-scale polygons that we delineated.

Rolls of photo transparencies were cut into frames, and placed in protective polypropylene sleeves. Polygons were drawn onto the sleeve and then visually transferred and digitized on-screen using the georeferenced SPOT image as a base map. Therefore, polygons had to be interpretable or “detectable” (their boundaries visible) in the SPOT image for them to be delineated. Interpreters first delineated landform boundaries, and then added any additional boundaries related to vegetation physiognomy (large shrubs, trees) and cover (as indicated by tone and texture).

The polygon map initially consisted of about 25,000 polygons ranging in area from approximately five ha to over 10,000 ha. While the nominal MMU was five ha and some polygons were slightly smaller, it is typical in a vegetation map for many polygons to range from 10-1000 times larger than the MMU (Franklin and Woodcock 1997). The largest polygons corresponded to undifferentiated bajadas and to dissected highlands with very sparse vegetation. Washes and small inselbergs were the finest-scale features. Washes were especially problematic to delineate because although their vegetation composition may contrast strongly with surrounding uplands, they are narrow linear features, often occurring in braided systems difficult to map at the MMU. We initially mapped a landform class that we called “Wash Systems” – a high density of small washes with the intervening areas of upland included in the polygons. During editing, we tried to separate all washes and upland while maintaining the specified MMU.

Delineated polygons do not necessarily correspond directly to vegetation alliance boundaries in many cases, but rather to those landscape units that we interpreted from the photos. We tended to delineate highlands (mountain ranges) into many small polygons corresponding to topography (slope facets) with no corresponding change in vegetation across boundaries. Conversely, we could not delineate vegetation changes that occur on one landform such as a bajada, or a highly dissected highland area, with no clear vegetation boundary visible in the air photos. A widespread example is a *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance on an upper bajada, which may be replaced by a *Larrea tridentata* Shrubland Alliance (associated with *Atriplex polycarpa* Shrubland Alliance) on finer, more alkaline soils nearer a playa or valley floor. We could not recognize this vegetation boundary in the photos, although we could commonly see it in the field. Delineation of polygons corresponding to these alliances could be achieved in the future through additional field-based mapping.

While we preserved all polygon boundaries in the final vegetation map so that the source and secondary label items are maintained for each polygon, an ArcInfo "dissolve" can be used to eliminate polygon boundaries between adjacent identical primary map labels. Alternately, the map may be viewed in ArcView with polygon boundaries eliminated for a presentation of contiguous vegetation labels without the polygon boundaries.

**Map Label Information Sources**

We used five main sources of information to guide labeling of the map polygons:

- Decision tree predictive modeling
- Photo interpretation
- Field observations
- Geomorphic Landform and Surface Composition GIS
- Expert knowledge

***Map Labels from Modeling***

An increasing number of large-area (regional to continental scale) land cover or vegetation maps are being developed, and many of them are based on satellite imagery and spectral pattern recognition. However, where floristic detail is required, some element of gradient modeling, predictive mapping based on the relationship between vegetation patterns and environmental gradients (Franklin 1995), can be incorporated. This method has been used in cases where the exclusive use of photo-interpretation or field observations of vegetation types is impractical due to the source material available (air photo quality and scale) and size of the area mapped.

Decision tree models (also known as classification or regression trees) were developed as one type of gradient modeling to predict the presence/absence of an alliance or group of alliances. Decision tree modeling is a non-parametric method of iteratively partitioning, or splitting of the data (the observed vegetation types) into increasingly homogeneous subsets or nodes with the use of decision rules based on threshold values of the independent variables (the environmental data). Breiman et al. (1984), Clark and Pregibon (1992), Austin et al. (1994), Franklin (1995, 1998), Quinlan (1993) Michaelsen et al. (1994), and Venables and Ripley (1994) discuss this modeling approach.

Decision tree modeling is essentially a multivariate, divisive, monothetic classification method. The statistical software presents an output that looks much like a dendrogram (hence, decision tree) with branches and nodes. It shows the probability of a dependent variable (in our case the alliances or groups of alliances being predicted) at a "terminal node." A terminal node is not split any further because it has reached maximum homogeneity or the number of observations in it is the minimum acceptable. Each terminal node is associated with a subset of the explanatory environmental variables used to develop the decision tree and an alliance or alliance group that the tree predicted to occur as a response of that particular subset of explanatory environmental variables. Decision tree methods can estimate the “probability” of an alliance or alliance group occurring with each subset based on its proportion of the observations at the terminal node (note that this is not a true probability as would be estimated by a logistic regression or other methods). These decision tree models can be converted into a script encoding the decision rules, which can then be used in a geographic information system (GIS) to produce a probability surface (a map of the probability of a vegetation type occurring) from maps of the environmental variables. Again, these probability maps have N discrete values where N is the number of terminal nodes, because the probability is simply estimated from the proportions of the training observations from an Alliance in a terminal node.

Decision trees can be used with continuous (regression trees) or categorical response variables (classification trees). In this study, we focus on the prediction of a dichotomous variable (vegetation type presence/absence); therefore, we used classification trees. We used the S-Plus software version 2000 for Windows (StatSci 1999) for statistical analysis. Conversion of the decision tree model into a GIS script was done with a customized C++ program.

We developed decision tree models for each of 20 training datasets, one for each alliance/alliance complex to be predicted. A training dataset consisted of a random subset of 75% of all available field observations recoded to presence/absence of each alliance or alliance group, and the value of the environmental variables at the location at which each field observation occurred (extracted from GIS maps). Each decision tree model was "cross-validated" (a S-Plus editing function) to determine a suitable number of terminal nodes that minimized unexplained deviance (remaining heterogeneity in the grouped observations) without over-fitting the model to the training data. The decision trees were "pruned" to the cross-validated size, and then "snipped" to remove nodes that were redundant. We verified the models with the test data (the other 25% of the observations). Then, we used all observations to develop the final decision tree models.

*Explanatory Environmental Variables in the Decision Tree Model*

We tested eight terrain, two landform and four climate variables and decided to use following terrain variables were used (Table 4):

1. Elevation - related to temperature and precipitation.
2. Slope - related to available soil moisture, soil depth.
3. Aspect - related to solar radiation, evaporative demand (water balance). This variable was “scaled” using a cosine transform to differentiate pole facing (moist), neutral, and equator-facing (dry) slope aspects. We used ((*cos*(aspect-225) +1) *100) as an index of "southwestness" (higher values are more xeric exposures).
4. Potential Solar Radiation or Topographic Solar Radiation - modeled incoming (potential) shortwave solar radiation as a function of terrain (elevation, slope, aspect, terrain-reflectance and horizon effect) assuming a clear sky (optical depth ~0.6). We calculated daily radiation for the winter solstice as an index of annual radiation.
5. Upslope Catchment Area - count of grid cells in the Digital Elevation Model (DEM) upslope from (draining into) a given grid cell (based on various flow distribution algorithms).
6. Topographic Moisture Index - Upslope Catchment Area scaled by the tangent of the slope. Related to available soil moisture as a function of drainage basin position and slope angle
7. Hillslope Position Index - surrogate for soil development, texture, moisture holding capacity. By automatically deriving streams and ridges from a DEM, Skidmore (1989) proposed that one could assign cells to hillslope position classes (ridge, upper midslope, midslope, toeslope) based on the relative distance

between the closest ridge and stream. We assigned cells a value from 1-100 based on their relative distance to the nearest stream and ridge.

8. Landscape Position Index - another measure of hillslope position. Average difference between a cell and neighbors (negative upslope, positive downslope) for a chosen search radius, *r* (4, 10 and 16 cells).

Simple (slope, aspect, and elevation) and complex (topographic solar radiation, topographic moisture index) terrain variables are related to vegetation patterns in other predictive mapping studies. Terrain variables were all derived from the pre-processed (seamless) mosaic of 1:24,000 30-m resolution USGS digital elevation models (DEM) provided for the study area by the Bureau of Land Management (BLM). Digital terrain models (30-m resolution, corresponding to 1:24,000 scale topographic quadrangles) were acquired from the USGS (http://rmmcweb.cr.usgs.gov/elevation/). The level 2 (root mean square error < ½ contour interval) quadrangles for the Mojave were made into a mosaic, and seams and other obvious errors were edited (T. Zmudka, BLM, personal comm.). We calculated slope aspect, angle, and flow accumulation (upslope catchments or contributing area) using ArcInfo functions (and the algorithms noted in Table 4).

Other variables were examined for their use. The GLSCGIS is a digital polygon coverage with three attributes: landform, surface composition and age. We used landform and surface composition as explanatory variables in the classification trees. We aggregated the surface composition classes for the decision tree modeling (Table 4) but we used the landform classes from the GLSCGIS without aggregation. We also used the four interpolated climate variables as explanatory variables in the classification trees. See the section of the report on Mojave Climate Grids for further information on the development of the climate grids. We also examined southwestness, upslope catchment area, and hillslope position index, but we did not use these variables in the predictive modeling.

*Developing Labels for Wash Systems*

Wash systems are a habitat characterized by hydrological process. All reference field data points designated *a priori* as alliances characteristic of washes were included in a “washplots” data subset. Upon reviewing our vegetation polygons it was determined that, because the delineated wash system polygons are large (five ha MMU), they will inevitably be composed of mixtures of wash alliances in most cases. Therefore, a set of wash system labels commensurate with the map scale comprises three groups of alliances – those occurring at low-, mid-, and high-elevations within the study area. The elevation boundaries and composition of these mixtures was determined by developing a classification tree using only elevation as a predictor variable. The result was three wash system types: “low elevation” (< 980-m), “mid elevation” (980 - 1482-m), and “high elevation” (> 1482-m).

We applied the wash system labels only to those polygons receiving “wash” photo-interpreted preliminary labels. Therefore, there is never an upland alliance label derived by predictive modeling for a photo-interpreted wash system polygon (and vice versa).

However, upland types do occur within the wash systems, and this is reflected in the definitions of the alliances expected in the map label.

Table 4. Explanatory variables examined for predictive modeling.

| Used | **Terrain Variables** | **Source** | **Algorithm** | **Range of Values Used** |
|---|---|---|---|---|
| Yes | Elevation | USGS 7.5' DEM, 30-m grid | | -85 – 3390 m |
| Yes | Slope | " | maximum difference (3x3 window) | 0-78 ° |
| Yes | Aspect | " | Direction of the maximum (eight classes) | 0-300 ° |
| Yes | Potential Solar Insolation | " | Clear sky, winter solstice, horizon effect, terrain reflected, Dubayah and Rich (1995) | 0-383 |
| Yes | Topographic Moisture | " | (Upslope Catchment Area)/tan(Slope), Moore et al. (1991) | 0-22.6 |
| Yes | Landscape Position | " | Average difference between a cell and neighbors (negative upslope, positive downslope), Fels and Matson (1996) | -1732 to 2311 |
| Yes | Landform | GLSCGIS | Disaggregated classes | 29 classes |
| Yes | Surface composition | GLSCGIS | Aggregated classes | 6 classes: calcium carbonate, evaporite, igneous plutonic, igneous volcanic metamorphic, sedimentary |
| Yes | Winter precipitation | Mojave Winter Precipitation Grid | Interpolation using geostatistics and spatial regression | See table 7 |
| Yes | Summer precipitation | Mojave Summer Precipitation Grid | Interpolation using geostatistics and spatial regression | See table 7 |
| Yes | January average minimum temperature | Mojave January Average Minimum Temperature Grid | Interpolation using geostatistics and spatial regression | See table 7 |
| Yes | July average maximum temperature | Mojave July Average Maximum Temperature Grid | Interpolation using geostatistics and spatial regression | See table 7 |

*Developing Probability Maps*

Initially, we used a modeling dataset of 2,008 point observations (relevés collected by fall of 1999 and some data from retrospective plots) to create a preliminary map of predicted alliance and alliance complex distributions. This map was field validated in the fall of 1999 using check maps of vegetation polygons overlain on satellite imagery. Based on the field validation and a review panel of Mojave vegetation experts, additional updating and editing of the map were planned based on collection of new field survey points. In the spring of 2000, we collected over 2,000 additional observation points.

A second modeling dataset with 3,819 point observations of vegetation types and their georeferenced locations (UTM northing and easting) was used for the final modeling effort. These consisted of project relevés, retrospective plots, and 1999-2000 survey observations. We selected twelve environmental variables from all the variables examined for predictive modeling (Table 4). These variables were obtained in digital format (with integer values and 30-m resolution) to cover the study area. The temperature data originally consisted of decimal values, so to reduce file size while retaining a range of variability each of the values was multiplied by 10. The four climate grids were originally one-km resolution, but we resampled them to 30-m resolution for consistency.

We created modeling datasets for training and testing for each of 20 vegetation types (Table 5), by adding a field indicating presence or absence of each type at each field point observation. For example, the dataset for *Atriplex canescens* Shrubland Alliance would contain a field named "p_a" where an entry of "p" indicates observations where this was the observed alliance and "a" indicates its absence.

The value for each environmental variable at each of the field point observations was extracted (ArcInfo "sample"). This resulted in a database containing the observed vegetation type, UTM coordinates at that site, and the value for each of 12 environmental variables at that site. We developed, pruned and snipped decision tree models predicting presence/absence of each of the 20 alliances. The resulting trees ranged in size from 12 to 41 terminal nodes. A C++ program was used to convert the classification tree rules into an AML (Arc Macro Language) script for use in ArcInfo. The AML generated consists of a series of “if-then” statements based on the threshold values of environmental variables, and the terminal node associated with those environmental criteria. We interactively edited each AML so that the terminal node number represented the proportion of observations in which the modeled alliance was present at that node, and this proportion is interpreted as a probability that the Alliance is present in the cell. When combined with grids of the environmental data, the AML generates an output grid where each grid cell meets the environmental criteria of one of the classification tree terminal nodes and has an associated probability of presence based on the observed data used to construct the model.

Table 5. Alliance and alliance complexes used in predictive modeling

| **Alliance** | **NOTES** |
|---|---|
| *Allenrolfea occidentalis* Shrubland Alliance and *Suaeda moquinii* Intermittently Flooded Shrubland Alliance | Combined for predictive modeling and in map labeling. |
| *Artemisia tridentata* Shrubland Alliance and *Ephedra viridis-Artemisia tridentata* Shrubland Alliance | Combined for predictive modeling and in map labeling. |
| *Atriplex canescens* Shrubland Alliance | Combined after predictive modeling with other *Atriplex* alliances for assignment of map label. |
| *Atriplex confertifolia* Shrubland Alliance | Combined after predictive modeling with other *Atriplex* alliances for assignment of map label when located at playa edges |
| *Atriplex hymenelytra* Shrubland Alliance | |
| *Atriplex polycarpa* Shrubland Alliance | Combined after predictive modeling with other *Atriplex* alliances for assignment of map label. |
| *Atriplex* spp. | Combined after predictive modeling with other *Atriplex* alliances for assignment of map label. |
| *Coleogyne ramosissima* Shrubland Alliance | |
| *Ephedra nevadensis* Shrubland Alliance | |
| *Pleuraphis rigida* and *P. jamesii* Herbaceous Alliance | Combined for predictive modeling and in map labeling. |
| *Grayia spinosa* Shrubland Alliance | |
| *Juniperus californica* and *J. osteosperma* Wooded Shrubland Alliance | Combined for predictive modeling and in map labeling. |
| *Larrea tridentata* Shrubland Alliance | Combined with *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance and *Larrea tridentata-Encelia farinosa* Shrubland Alliance (in part) after predictive modeling for map labeling. |
| *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance | Combined with *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance and *Larrea tridentata-Encelia farinosa* Shrubland Alliance (in part) after predictive modeling for map labeling. |
| *Larrea tridentata-Encelia farinosa* Shrubland Alliance | Used as a map label only where predictive modeling resulted in 85% or higher probability. |
| *Menodora spinescens* Dwarf-Shrubland Alliance | |
| *Pinus monophylla* Woodland and *Pinus monophylla* Wooded Shrubland Alliance | Combined for predictive modeling. |
| *Salazaria mexicana* Shrubland Alliance | Not included in map label set because of disturbance nature of alliance |
| *Yucca brevifolia* Wooded Shrubland Alliance | |
| *Yucca schidigera* Shrubland Alliance | |

We used the AML's to generate 20 probability maps, one for each vegetation type modeled. The predicted probabilities for each vegetation type ranged from 0-100 initially and were reclassified (ArcInfo Grid "reclass") to five categories: 1 = <10% probability, 2= 11-49%, 3=50-64%, 4=65-84%, and 5=85-100% probability.

Each probability grid was clipped into "workareas" based on 1:100,000 topographic quads within the study area. In some cases, we further subdivided the probability grids for processing. We combined the 20 probability grids into a master probability grid (ArcInfo Grid "combine") for each workarea where each grid cell contained the 1-5 probability category for the 20 predicted alliances.

We extracted the database tables for the master probability grids (by workarea) into an Access database for further processing. Using these tables, we assigned one alliance to each grid cell by inspecting the probability categories for all 20 alliances for each cell and selecting the best possible prediction(s) for that grid cell. We visually inspected the probabilities in each cell to recode using a set of recoding rules described below. To develop the recoding rules, we examined the omission and commission errors for each alliance in each of the five probability categories. Based on that analysis, we used the following rules:

1. *Larrea tridentata/Ambrosia dumosa* Shrubland Alliance, *Larrea tridentata* Shrubland Alliance, and *Larrea tridentata/Encelia farinosa* Shrubland Alliance were combined into Creosote Bush Shrubland except when *Larrea tridentata/Encelia farinosa* Shrubland Alliance had a probability of five (85-100% prediction probability). The *Larrea* dominated alliances occur across gradients and are difficult to delineate except from ground-based observations.
2. The *Atriplex* alliances: *Atriplex canescens* Shrubland Alliance, *Atriplex polycarpa* Shrubland Alliance, and *Atriplex spinifera* Shrubland Alliance were combined into a Saltbush Complex. The *Atriplex* alliances occur in similar environments, often intermixing, and we generally could not delineate them as separate alliances except from the ground.
3. The recoding assigned the alliance with the highest prediction probability for that location. If a single vegetation type was predicted with a probability category of five or four (greater than 65%), we assigned the grid cell that label.
4. If more than one vegetation type had a probability category of four or five, we assigned the grid cell a combination of all the types with probability four or five.
5. If the highest predicted probability was three, two, or one, we assigned the grid cell the vegetation type with the highest probability.
6. If the Creosote Bush Shrubland was predicted with a probability equal to a non-*Larrea* dominated vegetation type, the we assigned the grid cell the non-*Larrea* dominated vegetation type. This rule was used because model performance (correct prediction of alliance presence/absence) is a function of both the probability threshold used to predict "presence" and the accuracy criteria used (omission or commission errors, or both). In particular, in models predicting a binary outcome, often a low probability threshold must be selected to minimize omission and commission, errors when the class is rare

within the sample. This is the case for most alliances except for the Creosote Bush Shrubland. In other words, if an alliance were rare within the sample, a trivial model that predicts it to be absent everywhere would have a high correct classification rate, but would have 100% omission errors.

The recoded grids were converted from raster to vector format to create check maps with preliminary map labels consisting of the assigned modeled alliance or alliance complex. We printed the check maps with ancillary information (select reference points, 1:24K topographic quad lines and names, road information from Digital Line Graphic data (DLG) to aid in georeferencing. A two-person field crew was given check maps with the directions to provide feedback on the preliminary map label assignments in specific areas. Before going to the field, the check maps were reviewed and questionable predicted map labels identified. Based on review from team members and the feedback of the field crew on the check maps, we decided that we would use the probability maps as only one of several data sources to assign final map labels to the photointerpreted polygons.

***Map Labels from Photointerpretation***

We delineated several land use types from the aerial photography and often cross-checked the delineation against land use in the Southern and Central California Atlas and Gazetteer (DeLorme 1998). These land use types included urban and rural development, mines, and agricultural fields.

Two vegetation alliances were labeled from photointerpretation: *Pinus monophylla* - (*Juniperus osteosperma*) Woodland Alliance could be sometimes identified on the aerial photography, as could *Prosopis glandulosa* Shrubland Alliance. The *Pinus monophylla* - (*Juniperus osteosperma*) Woodland Alliance was included in the map label "Pinyon" with *Pinus monophylla* Wooded Shrubland Alliance. The vegetation map includes Pinyon polygons labeled from the photointerpretation and from the predictive model. We labeled the Mesquite Bosque (*Prosopis glandulosa* Shrubland Alliance) polygons using photointerpretation, field observation, and expert review.

***Map Labels from Field Observations***

In this project, data from field relevés allocated by gradient directed sampling, retrospective data, and field observations collected extensively across the desert were used for three key purposes: 1) to develop a classification of vegetation types, 2) to develop models to predict the occurrence of alliances from environmental variables, and 3) to directly label some map polygons.

Vegetated areas with less than 2% total vegetation cover ("Sparse Vegetation") are difficult to model, and impossible to photointerpret (being virtually indistinguishable from barren). We found that sparse vegetation has some fidelity with certain landforms, occurring on dunes and playas (about 35% of the sparse vegetation relevés), and on eroded highlands (about 40%), but the remainder is divided among a variety of landforms including lava flow and montane talus/scree, and so on. In preliminary modeling, the model always predicted sparse vegetation as a mixture with other vegetation types. We chose to apply the Sparse Vegetation and Barren map label from direct field observations and from known association with landform defined habitats such as sand dunes, playas, and lava fields. The aerial photography and the GLSCGIS did not provide fine enough resolution data to distinguish sparse vegetation from desert pavement. The photointerpreted polygon coverage was updated with specified landform polygons extracted from the GLSCGIS coverage.

### *Map Labels from the Geomorphic Landform and Surface Composition GIS*

In the Mojave, a few geomorphic units are strongly associated with the distribution of certain alliances. We have mapped habitat types that are important vegetation controllers in the Mojave – sand dunes, lava fields and volcanic cones, and playas (Table 2). Delineation of the geomorphic boundaries for these habitats was obtained from the GLSCGIS map.

### *Map Labels from Expert Knowledge*

Nine Mojave Desert vegetation experts attended a project workshop in November 1999. The workshop attendees reviewed the first version of the vegetation map and provided information on the location of certain vegetation types that we had not been able to adequately sample. We used this information and observations made by the team mapping editors to guide polygon labeling in some cases.

#### *Assigning Labels to Map Polygons*

We labeled vegetation within polygons using the best available information for the location. Best available information was determined in the following order of priority:

1. Field observations where the observation was for an area at least the size of the minimum map unit (five ha). We obtained field observations from San Diego State University observations to support photointerpretation, photos of the relevés acquired as part of the project (1997, 1998, and 1999), and the validation assessment (2000).
2. Expert knowledge where a) the expert is known as an area authority, b) the alliance type is known to be discrete in its distribution, and/or c) the assignment could be based on the expert's use of ancillary data sources.
3. Photointerpretation for some alliances in the Pinyon system (*Pinus monophylla* - (*Juniperus osteosperma*) Woodland Alliance), Sparse Vegetation, all land use categories (Development, Mining, Agriculture, and Urban), Mesquite (*Prosopis glandulosa* Shrubland Alliance), and Limber Pine/Bristlecone Pine (*Pinus flexilis* and *Pinus longaeva* Woodland Alliances).
4. Modeling for Low Elevation, Mid Elevation, and High Elevation Wash Systems based on identification of wash alliances that occur within particular elevation

zones. We used elevation modeling of the field-collected relevé data and the descriptions of wash alliances as presented in Appendix B.

5. The GLSCGIS landform labels for Interior Dune, Lava Beds/Cinder Cones, and Playa.
6. Modeling for all other labels. We assigned model-derived map labels to photointerpreted polygons based on the area of predicted vegetation types for all grid cells within polygons (by a vector overlay of the polygon coverage on the raster recoded grids, ArcView "tabulate area"). These areas were exported to Access, and the percentage of each prediction in each polygon was calculated. Model map labels were assigned to each polygon based on the composition of predicted alliances within each polygon. The majority prediction was the first alliance assigned to each polygon. The Source item in the map coverage expresses the percent (100%, 85-99%, 65-84%, 55-64%, 45-55%, and so on) of the polygon that the model predicted as occupied by that alliance (Table 3).

*Assigning Systems to Map Polygons*

We derived the system labels from the map labels. Groupings of systems were designed using the systems developed by The Nature Conservancy (TNC) for their Mojave Ecoregional Planning as a guideline (Pat Comer, pers. Comm.).

## Central Mojave Environmental Types Grid

The distribution of plant species and vegetation types can correlate with various physical environmental variables. We combined four climate variables and geologic substrate to create a Central Mojave Environmental Types Grid, which we also used in part to determine the locations to collect field data for the alliance classification and vegetation map. The main purpose of the Central Mojave Environmental Types Grid was to provide the first stage of stratification in a two-stage, random stratified sample of vegetation in the study area. The Central Mojave Field Data Tables section of this report describe allocating relevé locations, the field sampling methods, and results of sampling. In this section, we describe how the grid was developed. Franklin et al. (2001) also describe the development of the environmental grid and allocation of the sample of field relevé locations

### Structure

The Central Mojave Environmental Types Grid is a digital map (ArcInfo grid, envtypes_grid.e00) that consists of one-square-kilometer grid cells each labeled by a combination of climatic and geologic substrate variables. The grid contains one hundred sixty-seven environmental classes (unique combinations of values of the climate and geology variables). Metadata documenting the Central Mojave Environmental Types Grid is also provided in a text file and embedded in the grid for viewing with the ArcCatalog module of ArcGIS8 (MojoEnvTypes_Metadata.txt). The citation for the coverage is:

Franklin, J. and D. Shaari. 2002. Central Mojave Environmental Types Grid. A digital spatial database (ArcInfo). U.S. Geological Survey.

### Methods

The 1:750,000 scale geologic map of California (Jennings 1985) was the best available digital data on geologic substrate for the study area when the project began. This digitized map (ArcInfo grid, one-$km^2$ resolution) depicted about 22 categories in the study area. We aggregated these categories into eight geologic classes (Table 6) thought to best represent environmental gradients (water availability, nutrients) affecting plant species distributions.

The climate variables were derived from the four climate grids developed for this project. We inspected maps of each climate variable and histograms of their values to aggregate the variables into a small number of categories (Table 7). Regression analysis showed correlation between January average minimum temperature and elevation in the study area ($r=-0.78$), and so January average minimum temperature was finely divided into six categories that also reflect an elevation gradient. July average maximum temperature was divided into two categories using a threshold value of 35 °C. Winter precipitation shows a west-east gradient that was captured in three categories (Table 7). Summer precipitation shows relatively higher values in the eastern Mojave, and we captured this distinction using a threshold value of 40 mm to divide this variable into two categories.

In a GIS, we "overlayed" (intersected) the reclassified climate and geology grids to create the Central Mojave Environmental Type Grid (Franklin et al. 2001). Each one-$km^2$ grid cell in the map was labeled with a category for the climate variables and class from the geologic map. Overlaying the grid maps could potentially have produced 504 unique combinations or “environmental classes” (2 x 6 x 2 x 3 x 7). However, only 167 combinations occurred in the study area.

## Mojave Climate Grids

We created four Mojave Climate Grids. We used them to develop the Central Mojave Environmental Types Grid described in the previous section and to provide climate data in the predictive modeling portion of the Central Mojave Vegetation Map.

### Structure

Four climate grids were developed:

1. Mojave January Average Minimum Temperature (jan_tmp_grid.e00),
2. Mojave July Average Maximum Temperature (july_tmp_grid.e00),
3. Mojave Summer Precipitation (sum_ppt_grid.e00), and
4. Mojave Winter Precipitation (win_ppt_grid.e00).

Table 6. Geologic classes used to create Environmental Types Grid.

| Class[1] | Description (geologic map categories combined to form this class) |
|---|---|
| Alluvium | Unconsolidated bajadas and alluvial fans; Quaternary, mainly Holocene marine and non-marine origin. |
| Older Alluvium | Old bajada and fans surfaces, consolidated into fanglomerates. |
| Aeolian Sand | Extensive sand deposits, sand sheets. |
| Playa | Quaternary playas. |
| Weakly lithified sedimentary rock | "Badlands" -- sedimentary rock of various ages and marine/non-marine origin. |
| Silicic-intermediate rock | Includes igneous plutonic, volcanic/metavolcanic, sedimentary/metasedimentary rock of various ages of silicic-intermediate composition (granite, diorite, rhyolite, andesite, gneiss). |
| Mafic-ultramafic rock | Includes igneous plutonic, volcanic/metavolcanic, sedimentary/metasedimentary rock of various ages of mafic-ultramafic composition (schist, basalt, gabbro). |
| Carbonate rock | Sedimentary/metasedimentary rock of various ages with carbonate composition (limestone, dolomite, marble). |

[1] Based on aggregation of classes in the Geology Map of California, 1:750,000 scale (Jennings 1985).

Table 7. Classification of climate variables used in predictive modeling.

| Climate Variable | Mean and Range | Reclassified Category | Standard Error of Variable |
|---|---|---|---|
| July average maximum temperature | 35.5 °C<br>(16.6 to 44.4 °C) | < 35 °C<br>≥ 35 °C | +/- 1.1 °C |
| January average minimum temperature | -0.0 °C<br>(-11.3 to 4.8 °C) | < –7 °C,<br>-7 to <-4.5 °C<br>-4.5 to <–2 °C<br>-2 to <0.5 °C<br>0.5 to <2 °C<br>≥ 2 °C | +/- 2.2 °C |
| Summer precipitation (May-October) | 30 mm<br>(11-146 mm) | < 40 mm<br>≥ 40 mm | +/- 30% |
| Winter precipitation (November-April) | 124 mm<br>(45-579 mm) | < 100 mm<br>100 to <175 mm<br>≥ 175 mm | +/- 30% |

The grid cell size for each is approximately one-km² and each extends over the entire California Mojave. The temperature grids report monthly average maximum temperature in July and average monthly minimum temperature in January. Temperature values range from 16.6 to 44.4 °C for the July grid and –11.3 to 4.8°C for the January grid.

The precipitation grids report monthly average precipitation between the months of May to October for the summer grid and November to April for the winter grid. The values range from 11 to 146 mm in the summer grid and 45 to 579 mm for the winter grid (see Table 4).

The grid metadata are text files (MojoJanTemp_Metadata.txt, MojoJulyTemp_Metadata.txt, MojoSummerPrecip_Metadata.txt, and MojoWinterPrecip_Metadata.txt) and are embedded in each grid for viewing with the ArcCatalog module of ArcGIS8. The citations for the grids are:

> Michaelsen, J. 2002. Mojave July Average Maximum Temperature. A digital spatial database (ArcInfo). U.S. Geological Survey.
>
> Michaelsen, J. 2002. Mojave January Average Minimum Temperature. A digital spatial database (ArcInfo). U.S. Geological Survey.
>
> Michaelsen, J. 2002. Mojave Summer Precipitation. A digital spatial database (ArcInfo). U.S. Geological Survey.
>
> Michaelsen, J. 2002. Mojave Winter Precipitation. A digital spatial database (ArcInfo). U.S. Geological Survey.

**Methods**

Joel Michaelsen (Geography Department, University of California Santa Barbara, California) developed the climate maps by interpolating 30-year averages for the climatic variables from 104-135 climate stations over a 30 arc-sec (roughly one-km) grid. Averages were collected over a thirty-year period (1961-1990). We based the interpolations on a two-component statistical model similar to universal kriging (Bailey and Gatrell 1998; Venables and Ripley 1994). The first component consisted of multiple regressions between the climate variable of interest and latitude, longitude, and elevation. This component captured the large-scale variation, or trend, in the climatic variable. The residuals from the linear model predictions at the station locations were autocorrelated, and standard geostatistical models were fit to the variograms of the residuals. Since the presence of autocorrelated residuals violates the assumptions for ordinary least squares, the linear regression models were refit using generalized least squares with residual covariance matrices based on the spatial autocorrelation models. In addition to the model predictions, the method produces reasonable estimates of spatially varying prediction standard errors that account for uncertainties in the linear model predictions and spatial variability in the autocorrelation models. We used cross validation to diagnose any problems with misfit of either component of the climate models and flag potentially erroneous station data.

In effect, the climate model predictions were based on large-scale relationships captured by the linear regression models with adjustments made for deviations of nearby stations from the overall linear regression relationships. For much of the California portion of the Mojave, distances greater than the characteristic autocorrelation distances of 50-260 km separated stations. The primary exception was in the Antelope Valley, where stations were relatively numerous and local conditions somewhat different than in areas farther east. The standard errors of the models vary spatially, depending on the distance from the predicted location to the nearest stations.

## Central Mojave Field Data Tables

The Central Mojave Field Data Tables contain the field observations made at 1,242 relevés (those located by random stratified sampling and surveyed in 1997-99). We used these data to help develop the vegetation classification and for developing the predictive modeling map labels used in the Central Mojave Vegetation Map.

### Structure

The Central Mojave Field Data Tables contain five main tables and eight look-up tables (Table 8) organized in an Access file (Plot_Data.mdb). In addition to environmental and location data for the 1,242 relevés, cover, and strata data are presented for the perennial species found in the relevés.

A separate metadata file exists for the Access file. The citation is:

> Thomas, K., T. Keeler-Wolf, and J. Thorne. 2002. Central Mojave Field Data. A digital database (Access). U.S. Geological Survey.

Table 8. Central Mojave Field Data Tables.

| Main Table Name | Items | Information type | Associated look-up table |
|---|---|---|---|
| GeoInfo | FinalPlotCode | Unique relevé identifier (divides the unique code into segments, which is useful for sorting) | xPlotCodes |
| | DSRVY | Date observations made | |
| | LSBoundry | Relevé within study boundary (Yes) or outside (No) | |
| | NPUTMX | UTM easting (NAD 27) | |
| | NPUTMY | UTM northing (NAD 27) | |
| | NPELEV | Elevation in meters | |
| | NSLOPE | Slope in degrees | |
| | NASPECT | Aspect in degrees | |
| Impact | FinalPlotCode | Unique relevé identifier | xPlotCodes |
| | CIMPACT1 | Code for primary disturbance, if present | xImpact_Code |

| | | | |
|---|---|---|---|
| | CINTENS1 | Intensity of primary disturbance | xIntensity |
| | CIMPACT2 | Code for second level disturbance | xImpact_Code |
| | CINTENS2 | Intensity of second level disturbance | xIntensity |
| | CIMPACT3 | Code for third level disturbance | xImpact_Code |
| | CINTENS3 | Intensity of third level disturbance | xIntensity |
| | CIMPACT4 | Code for forth level disturbance | xImpact_Code |
| | CINTENS4 | Intensity of forth level disturbance | xIntensity |
| | CIMPACT5 | Code for fifth level disturbance | xImpact_Code |
| | CINTENS5 | Intensity of fifth level disturbance | xIntensity |
| | CIMPACT6 | Code for sixth level disturbance | xImpact_Code |
| | CINTENS6 | Intensity of sixth level disturbance | xIntensity |
| SurfCvr | FinalPlotCode | Unique relevé identifier | xPlotCodes |
| | CSOILTEXTURE | Soil texture | |
| | CBASAL | Cover class for basal area of living plants | xCover |
| | CFINES | Cover class for exposed fine soil (<3 mm) | xCover |
| | CBEDROCK | Cover class for exposed bedrock | xCover |
| | CGRAVEL | Cover class for exposed gravel (>3 mm, <76mm) | xCover |
| | CCOBBLE | Cover class for exposed cobble (76 mm-25 cm) | xCover |
| | CSTONE | Cover class for exposed stone (>25-61 cm) | xCover |
| | CBOULDER | Cover class for exposed boulders (>61 cm) | xCover |
| | CLITTER | Cover class for organic matter not including living plant stems but including duff and fallen wood covering ground | xCover |
| VegData | FinalPlotCode | Unique relevé identifier | xPlotCodes |
| | Plant_Code | Code for observed plant (species, genus, or lifeform), | xPlantName |
| | CSPECIES | Species name | |
| | NVCR | Code for plant cover class, a few entries are blank because no data provided by field crew | xCover |
| | NPRCNT | % cover (midpoint of cover class if visual estimate not made) | |
| VegDes | FinalPlotCode | Unique relevé identifier | xPlotCodes |
| | CCOMTYPE | W=wetland, U=upland | |
| | CCOWSYS | Cowardin type (Cowardin et al 1979) | |
| | CSUBSYS | Cowardin subsystem (Cowardin et al 1979) | |
| | CCLASS | Cowardin class (Cowardin et al 1979) | |
| | CCHANNEL | Channel type | |
| | CLEAFPHEN | Code for leaf phenology | xLeafphen |
| | CLEAFTYPE | Code for leaf type | xLeaftype |
| | CPHYSCLASS | Code for leaf physiology | xPhysclass |

| | | | |
|---|---|---|---|
| | NS_MOSLICH | Cover class for moss | xCover |
| | NS_0CM25CM | Cover class for 0-25 cm strata | xCover |
| | NS_25CM50M | Cover class 25-50 cm strata | xCover |
| | NS_50CM1M | Cover class .5-1m strata | xCover |
| | NS_1M3M | Cover class 1-3m strata | xCover |
| | NS_3M5M | Cover class 3-5m strata | xCover |
| | NS_5M10M | Cover class 5-10m strata | xCover |
| | NS_10M20M | Cover class 10-20m strata | xCover |
| | NS_20M30M | Cover class 21-30m strata | xCover |
| | NS_30M | Cover class >30m strata | xCover |
| | CTOT_VEG | Total vegetation cover (class) | xCover |
| | CTOT_PRCNT | Total vegetation cover (%) | |
| | CTOT_TREE | Total tree cover (class) | xCover |
| | CPRCNT_TREE | Total tree cover (%) | |
| | CTOT_SHRUB | Total shrub cover (class) | xCover |
| | CPRCNT_SHR | Total shrub cover (%) | |
| | CTOT_GRND | Total ground layer cover (class) | xCover |
| | CPRCNT_GND | Total ground layer cover (%) | |
| | CTOT_EXOTI | Total non-native cover (class) | xCover |
| | CPRCNT_EXO | Total non-native cover (%) | |

**Methods**

**Gradient Directed Sample Allocation**

We adapted the gradient-directed sampling protocol described by Austin and Heyligers (1989) with some minor modifications. Allocation of relevé locations was accomplished with two-stage stratification (see Franklin et al. 2001).

In the first stage stratification we:

1. Identified environmental variables influencing plant distributions in the study area,
2. Choose best available data (digital maps) for environmental stratification, and
3. Stratified the area for sampling by reclassifying the maps of selected environmental variables and combining them.

We identified climate and geologic substrate to represent the broad-scale environmental gradients affecting species distribution. We developed climate grids as part of the project (see Mojave Climate Grids section). Geologic substrate was the best available coarse scale digital data to represent nutrient and water availability gradients as influenced by substrate that was available when the sampling design was developed. We combined the climate grids and an existing geology map to create the Central Mojave Environmental Type Grid to direct the first stage stratification; the development of that grid is described in another section of the report, Central Mojave Environmental Type Grid.

For the second stage of stratification, we:

1. Identified variables to be used, and data depicting them, for a second stage of stratification at the local scale, and
2. Decided on the effort allocated for sampling the rare environmental types versus adding more replicates to common strata.

Topographic position, based on a simple classification of some digital terrain variables (Table 4), was selected for a second stage of stratification at the local scale because terrain (hill slope position, slope angle, slope aspect) exerts a strong influence on plant distributions at a finer spatial scale than bioclimatic gradients. This is important in the Mojave, where vegetation composition can change dramatically over short distances as a function of terrain position.

The terrain was classified into six categories for second stage sampling based on slope aspect and upslope catchment area (Table 9): drainage (areas of high flow accumulation, corresponding to washes and streams); flat terrain; gentle slopes (corresponding to most bajada surfaces); and steeper slopes, divided into three aspect classes corresponding to higher (southwest), lower (northeast) and intermediate values of insolation (southeast, northwest). This simple scheme captured first-order effects of terrain on vegetation, nested within the climate-geology stratification, in this desert landscape. Those effects are the influence of slope angle and drainage basin position on soil texture and moisture and the influence of slope aspect on solar insolation and evapotranspiration.

Table 9. Terrain classification for second-stage sampling.

| **Class** | **Description (hierarchical decision rules)** |
|---|---|
| Drainage | Upslope catchment area greater than threshold value of 100 cells (9 ha) |
| Flat (<1% slope) | Slope less than 1% |
| Gentle Slope (1-10% slope) | Slope less than 10% |
| Northeast Aspect | Slope ≥ 10% and aspect 0 to <90° |
| Southwest Aspect | Slope ≥ 10% and aspect 180 to <270° |
| Neutral Aspect | Slope ≥ 10% and aspect 90 to <180° or 270 to <360° |

**Assignment of Relevé Locations**

Field sampling was restricted to public lands. One hundred and sixty of the environmental classes identified for first-stage sampling occurred on public lands (seven very small classes occurred only on private lands). We estimated that resources were available to survey 1,000-2,000 vegetation relevés. The vegetation relevé locations were allocated among the environmental type classes based on weighting of the total area of the environmental class within the study area. The rarest environmental classes (≤ 7 $km^2$) were not sampled, but those environmental classes with less than 1,000 $km^2$ generally received more relevés per area and the most common environmental classes received fewer relevés per area (Table 10).

Table 10. Allocation of relevés in environmental cells.

| **Total area of environmental class** | **Number of relevés assigned per class** |
|---|---|
| ≤ 7 km² | 0 |
| 8-10 km² | 1 |
| >11 km² | 1 |
| 11-100 km² | 1-2 each |
| 100-1,000 km² | 2-9 |
| 1,000-5,000 km² | 10-15 |

A computer program randomly selected cells from the one-km$^2$ Environmental Types Grid up to at least 15 grid cells per environmental class (establishing both sample and alternate grid cells). Each of the 1,100 (33x33) 30-m terrain grid cells falling within the one-km$^2$ cells selected for sampling was then classified using the decision rules outlined in Table 10. We used the same computer program to allocate the second-stage sample – the actual relevé locations within the environmental cell. At least two locations were selected per terrain class from the terrain grid within each one-km$^2$ cell in the sample (again providing an alternate location). Terrain classes were only allocated a relevé location if they comprised at least 5% of the one-km$^2$ cells.

**Field Collection of Data**

The UTM coordinates of target sample locations were provided to the field crew. They developed travel routes and work plans to minimize travel time and arrange alternate transportation in roadless and wilderness areas. The crew navigated to the sample location using global positioning systems (GPS) with 5-10-m precision. Field crews were able to adjust their location by up to 90-m so that they did not locate a relevé on a boundary between distinctive vegetation stands. Actual coordinates of the field relevé were acquired in the field using UTM zone 11, NAD 27 so that the field crew could better determine their actual location using USGS 1:24,000 topographic maps (also in UTM zone 11, NAD 27).

The field crew identified all perennial plant species and estimated their cover in a 1,000 m$^2$ circular relevé. Cover was estimated to the nearest percent for each species and for each strata class (ground, shrub, and tree). All exotic species were noted. Annual species were also noted, but if the species was unidentifiable, it was noted as an unknown annual. In most cases, the field crew took a picture of the field relevé for later reference. Species data for each relevé were standardized to a common nomenclature using the USDA Plants Database (NRCS 1999).

The field crew assessed disturbance at each relevé site. They used a list of pre-determined stressors to indicate what was the primary disturbance type, if any, and the intensity of the impact. Additional disturbance types up to six levels were noted, if present.

Environmental data collected included elevation, slope, aspect, soil, landform, and geologic substrate. Elevation was determined using a military-grade GPS or, in a few cases, a 1:24,000 topographic map. Aspect was determined by aligning a compass to the direction that water would be expected to flow from the relevé and measured as the degrees from north. Slope was measured in that same direction using a clinometer. Aspects and slope measurements were made over a slope distance of approximately 90 m.

The field crew visually assessed landform and geological substrate categories. A preliminary classification of landforms and geology developed for the GLSCGIS was used in the field. The categories were aggregated into fewer types subsequent to field data collection. The seven aggregated landform categories are 1) rocky highland, 2) arroyo, 3) upland alluvial deposits, 4) wash, 5) fluvial floodplain, 6) playa, and 7) dunes and sand sheets. The five composition categories are 1) igneous 2) metamorphic, 3) calcareous carbonate, 4) evaporite, and 5) sedimentary. The six-person field crew received orientation to recognizing landform and composition categories, but they were not specifically trained in geomorphology or geology. The landform and geological substrate composition determinations by the field crew are not included in the relevé database, because an analysis showed the field determinations were not consistent among the field crew members (Thomas et al. 2002).

A quick characterization of soil texture was made by simply feeling the soil texture. The percentage of surface covered by living plants, litter, fine soil, and different sizes of rock particles was estimated in very broad categories. Finally, the field crew recorded the Cowardin hydrologic class (Cowardin et al 1979) for the site.

Sawyer and Keeler-Wolf (1995) describe additional details on field protocols.

## Central Mojave Plots Map

Field-collected reference data used in this project consisted of relevés collected (described in the previous section), retrospective plots from other field-based projects conducted in the Mojave, and observations made for map development and validation, a total of 4,297 points. The location and alliance assignment for the reference data are included in the Central Mojave Plots Map. Additional relevés that were labeled with an alliance type that typically has localized occurrence (in an area less than five ha) are not included on the Central Mojave Plots Map but are included on the Central Mojave Special Features Map.

**Structure**

The Central Mojave Plots Map is a digital map (ArcInfo point coverage, plots.e00) that shows the occurrence of 4,297 relevés, plots, and observations. The coverage contains four unique items:

Plot_Num: The number assigned to the field observation in this project. The prefix of each plot number indicates the source of the data (Table 11). The last three digits in the plot number do not show on Table 11; each plot prefix ends with a unique sequential number assigned to that particular plot. All plots with the prefix CA-MDEP1 were relevés conducted during the course of the project and have associated field data (see Central Mojave Field Data Tables).

UTM_Y: The UTM northing for the plot location expressed in UTM Zone 11 NAD83 datum.

UTM_X: The UTM easting for the plot location expressed in UTM Zone 11 NAD83.

Label: The alliance, alliance complex, or land use assigned to that plot location (land use, alliance, or alliance group) (Table 2).

Metadata documenting the Central Mojave Plots Map is in a text file (MojoPlots_Metadata.txt) and embedded for viewing with the ArcCatalog module of ArcGIS8. The citation for the coverage is:

Thomas, K. 2002. Central Mojave Plots Map. A digital spatial database (ArcInfo). U.S. Geological Survey.

Table 11. Source of data in Central Mojave Plots Map[1].

| **Prefix** | **Number of plots** | **Data source** |
|---|---|---|
| CA-MDEP1-xxx | 1,242 | 1997, 1998, 1998 relevés obtained by project |
| CA-MDEP3-01-xxx | 41 | Existing data, Novak (1998) |
| CA-MDEP3-04-xxx | 136 | Existing data, Evens (2000) |
| CA-MDEP3-05-xxx | 300 | Existing data, Novak (1996) |
| CA-MDEP3-06-xxx | 108 | Existing data, Watts (1996) |
| CA-MDEP3-07-xxx | 122 | Existing data, Thomas (1997) |
| CA-MDEP3-08-xxx | 152 | Existing data, Root (1978) |
| CA-MDEP3-09-xxx | 40 | Existing data, Silverman (1996) |
| CA-MDEP4-xxx | 2,197[2] | Spring 2000 observation points |
| CA-MDEP5-xxx | | Fall 1999 observation points |
| TOTAL | 4,297 | |

[1] CA-MDEP2, CA-MDEP3-02, and CA-MDEP3-03 were unassigned; [2] Fall 1999 and spring 2000 observation points are combined.

## Methods

### Project Relevé Data

The project team collected relevé data at 1,242 locations (see Central Mojave Field Data Tables) in the fall of 1997, winter and spring of 1998, and spring of 1999. We assigned each relevé an alliance label using an alliance key (Appendix C). The key was based on classification rules developed for this project (see Vegetation Classification section). The data for all 1,242 relevés from this project (the CA-MDEP1 series) are in the Central Mojave Field Data Tables.

### Observation Data

Additional observations were made in the fall of 1999 and spring of 2000 (2,197 observation points) to support the predictive modeling and verification of the vegetation map. Field crews made extensive observations on the occurrence of alliances by driving any accessible road and making an observation every mile or every time the vegetation type changed. They used the alliance key to apply an alliance label at the time of the observation. Based on the field crew's comments, we edited and revised the alliance key.

### Retrospective Field Data

A survey was conducted to identify existing (retrospective) vegetation studies in the Mojave Desert that had included collection of field plot data. We identified thirty-four different retrospective studies. We evaluated each study's methodology for collection of data to determine if the collection met the following criteria for inclusion in the reference dataset:

- A complete survey was made of perennial species including an estimation of cover for each species;
- Plots were taken within homogeneous stands;
- The study had a minimum of 20 samples; and
- Location of the plot was described with an expected 100-m accuracy.

Seven data sets existed that were used to validate the Central Mojave Vegetation Map (Table 12). We also used some of these datasets for vegetation classification. An additional five data sets were not sufficiently georeferenced for use in the reference dataset, but could be used for classification. Permission was obtained from the initial data developers to use plot data that passed inclusion criteria. We used plot data that met all inclusion criteria except for the positional requirement for vegetation classification and description only (Table 12).

Table 12. Summary of retrospective data accepted for reference and for classification.

| **Source** | **Geographic area** | **Purpose** | **Methods** | **N plots** | **Use**[1] |
|---|---|---|---|---|---|
| Evens (2000) | Eastern Mojave Preserve | Thesis study | 1,000-$m^2$ relevés | 136 | C,R |
| Johnson (1978A) | Eastern Mojave Scenic Area | Unit Resources Inventory for Desert Plan | 100-pace toe-point within representative pre-delineated polygons | 751 | C |
| Johnson (1978B) | Saline Valley Area | Unit Resources Inventory for Desert Plan | 100-pace toe-point within representative pre-delineated polygons | 106 | C |
| Long (1997) | Joshua Tree National Park | Preliminary vegetation mapping data | Relevés averaging 2,100 $m^2$ in representative stands | 72 | C |
| Novak (1998) | Marine Corp Air Ground Command Center | Base-wide Soil/Vegetation Survey | 5-10 parallel 100-ft line intercepts per plot | 41 | C,R |
| Novak (1996) | Fort Irwin | Base-wide Soil/Vegetation Survey | 5-10 parallel 100-ft line intercepts per plot | 300 | R |
| Prigge (1995) | Fort Irwin/Goldstone Military Reservation and Training Center | Pilot sampling strategy for proposed vegetation map | Belt transects 6-m wide and 100-200 m long | 113 | C |
| Root (1978) | Death Valley National Park | Ground truthing NASA-NPS Landsat Mapping | 100 ft x 100 ft orthogonal transects from a central point | 152 | C,R |
| Schramm (1977) | Black Mountains, Death Valley National Park | Thesis research | Belt transect 100 yd x 6 yard, Line intercept two parallel 33-m lines | 82 | C |
| Silverman (1996) | China Lake | Ground truthing associated with separate China Lake mapping effort | Unknown | 40 | R |
| Thomas (1997) | Death Valley NP | Relevé for mapping project later included into this project | 1,000-$m^2$ relevés | 122 | R |
| Watts (1996) | Fort Irwin | Preliminary data from vegetation mapping of Malapai Hill quad | 100-$m^2$ plots with average size of all shrubs estimated for cover | 108 | C,R |

[1] C = used in classification, R = used in map reference dataset (modeling, special features, and map validation).

We assigned alliance labels for the Root (1978) and Evens (2000) datasets by analysis of the species composition of each plot followed by correlation with the classification results of all the 1997-1999 project relevé data. The Novak (1996), Watts (1996), Novak (1998), Thomas (1997), and Silverman (1996) datasets were assigned alliance labels using a floristically based alliance key that summarized the rules developed to classify the field data (Appendix C).

## Central Mojave Special Features Map

The Central Mojave Special Features Map shows known or potential point locations of alliances and unique stands that typically occur with less than five-ha extent. The Central Mojave Special Features Map is incomplete in its representation of all special feature vegetation stands. However, it is important to note the known or potential location of these alliances and unique stands where known as a starting place for future mapping at finer resolution. The Central Mojave Special Features Map serves as a template for more comprehensive development of a database describing rare or localized vegetation types, habitats, or plant species.

### Structure

The Central Mojave Special Features Map is a digital map (ArcInfo point coverage, spec_feat.e00) with point locations. We obtained the point locations from existing digital maps, from hard-copy maps or literature descriptions, or from fieldwork conducted by this project or other Mojave field projects. The attribute table documents each point with these items:

| | |
|---|---|
| Feature: | The type of feature at this point. The point can indicate a landform type expected to have co-occurring alliances or it can indicate a known or potential alliance. |
| Map_Label: | The name of vegetation type occurring at that point, if known. Types can be unique stands or defined alliances (Table 13). |
| Label_Type: | The physiognomic type of Map_Label. |
| Data_Source: | The source of information for the point. |
| Georef: | The manner in which the point was identified: 1) digital data where points were extracted from existing maps, 2) literature data sources where points were estimated based on descriptions in literature or hard copy maps, or 3) measured with a GPS in the field. |
| Plot_Num: | The plot number for data collected by this project either as field relevés or from other Mojave field projects. This can be used to access the full relevé data in the Central Mojave Field Data Tables. |

Metadata documenting the Central Mojave Special Features Map is in a text file (MojoSpecFeat_Metadata) and embedded for viewing with the ArcCatalog module of ArcGIS8. The citation of the coverage is:

Mullen, G. and K. Thomas. 2002. Central Mojave Special Features Map. A digital spatial database (ArcInfo). U.S. Geological Survey.

The Central Mojave Special Features Map contains 1,414 point locations for 33 alliances and six unique stands (Table 13). Unique stands are populations of species that the NVC does not recognize as an alliance, yet are botanically and/or ecologically of interest.

Table 13. Central Mojave Special Features Map.

| **Label_Type (Physiognomic type)** | **Map_Label (Alliance or Unique stand)** |
|---|---|
| Unique Stand | *Abies concolor* Unique Stand |
| Shrubland Alliance | *Acacia greggii* Shrubland Alliance |
| Unique Stand | *Amphipappus fremontii* Unique Stand |
| Shrubland Alliance | *Artemisia nova* Dwarf-Shrubland Alliance |
| Shrubland Alliance | *Baccharis sergiloides* Intermittently Flooded Shrubland Alliance |
| Unique Stand | *Bebbia juncea* Unique Stand |
| Unique Stand | Carothers Canyon Unique Stand |
| Unique Stand | *Castela emoryi* Unique Stand |
| Shrubland Alliance | *Chilopsis linearis* Intermittently Flooded Shrubland Alliance |
| Herbaceous Alliance | *Distichlis spicata* Intermittently Flooded Herbaceous Alliance |
| Shrubland Alliance | *Ephedra viridis* Shrubland Alliance |
| Shrubland Alliance | *Ephedra californica* Intermittently Flooded Shrubland Alliance |
| Sparse Vegetation Alliance | *Ephedra funerea* Sparse Vegetation Alliance |
| Shrubland Alliance | *Eriogonum fasciculatum* Shrubland Alliance |
| Shrubland Alliance | *Ericameria nauseosa* Shrubland Alliance |
| Shrubland Alliance | *Ericameria parryi* Intermittently Flooded Shrubland Alliance |
| Shrubland Alliance | *Ericameria teretifolia* Shrubland Alliance |
| Unique Stand | *Hecastocleis shockleyi* Unique Stand |
| Shrubland Alliance | *Hymenoclea salsola* Shrubland Alliance |
| Unique Stand | Keystone Canyon Unique Stand |
| Shrubland Alliance | *Krascheninnikovia lanata* Dwarf-Shrubland Alliance |
| Unique Stand | Live Oak Unique Stand |
| Shrubland Alliance | *Menodora spinescens* Dwarf-Shrubland Alliance |
| Unique Stand | *Mortonia utahensis* Unique Stand |
| Shrubland Alliance | *Nolina parryi* Shrubland Alliance |
| Herbaceous Alliance | *Phragmites australis* Semipermanently Flooded Herbaceous Alliance |
| Woodland Alliance | *Pinus flexilis* Woodland Alliance |

| | |
|---|---|
| Woodland Alliance | *Pinus longaeva* Woodland Alliance |
| Woodland Alliance | *Populus fremonitii* Seasonally Flooded Woodland Alliance |
| Shrubland Alliance | *Pluchea sericea* Seasonally Flooded Shrubland Alliance |
| Shrubland Alliance | *Prunus fasciculata* Shrubland Alliance |
| Shrubland Alliance | *Psorothamnus spinosus* Intermittently Flooded Shrubland Alliance |
| Shrubland Alliance | *Purshia mexicana* Shrubland Alliance |
| Shrubland Alliance | *Purshia tridentata* Shrubland Alliance |
| Forest Alliance | *Quercus chrysolepis* Forest Alliance |
| Shrubland Alliance | *Salix exigua* Temporarily Flooded Shrubland Alliance |
| Shrubland Alliance | *Salazaria mexicana* Shrubland Alliance |
| Unique Stand | *Simmondsia chinensis* Unique Stand |
| Unique Stand | *Swallenia alexandrae* Unique Stand |
| Shrubland Alliance | *Tamarix spp.* Semi-Natural Flooded Shrubland Alliance |
| Shrubland Alliance | *Viguiera parishii* Shrubland Alliance |
| Shrubland Alliance | *Viguiera reticulata* Intermittently Flooded Shrubland Alliance |
| Wetland Habitat | Unknown, no alliance or unique stand known, but identified as a location in the Feature item |

Springs in the Mojave Desert often support vegetation alliances that occur at less than the five ha MMU. Locations of springs were added to the Central Mojave Special Features Map using USGS springs 1:24,000 (7 ½ minute) and 1:100,000 (15 minute) scale DLG's (see Tables 14 and 15). Polygon features were not included in the map. Not all points identified as springs, such as wells or windmills were deleted. We jointed the resulting quads of spring locations to form a single spring location coverage containing 640 spring locations.

The Death Valley National Park Resource Management supplied the National Wetlands Inventory (1986) map of riparian and wetland features for portions of Death Valley. We did not include point features for areas known to be devoid of vascular vegetation; for example, salt flats.

Maps developed by the BLM in association with the North and East Colorado Desert planning effort (BLM 1997 and BLM 1998) provided point locations of crucifixion thorn (*Castela emoryi*).

Point locations of relevés obtained during the 1997-99 project field work (see Central Mojave Field Data Tables) that we identified as alliances with localized distribution were included in the Central Mojave Special Features Map.

Table 14. 7.5-Minute DLG's used to determine spring locations.

| | | |
|---|---|---|
| Alvord Mtn. West | Anvil Spring Canyon West | Avawatz Pass |
| Baker | Ballarat | Bitter Spring |
| Blackwater Well | Cima Dome | Clark Mtn. |
| Copper Queen Canyon | Cow Cove | Coyote Lake |
| Cuddeback Lake | Crescent Peak | Crucero Hill |
| Deadman Pass | Death Valley Junction | Desert |
| Dunn | East of Echo Canyon | East of Ryan |
| Echo Canyon | Emigrant Pass | Epaulet Peak |
| Franklin Well | Gold Valley | Goldstone |
| Greenwater Canyon | Harris Hill | Hart Peak |
| Hopps Well | Ibex Spring | Ivanpah Lake |
| Jackass Canyon | Jail Canyon | Langford Well |
| Leach Lake | Manly Fall | Manly Peak |
| Maturango Peak NE | Mescal Range | Mineral Hill |
| Nelson Range | Old Ibex Pass | Pachalka Spring |
| Panamint | Paradise Range | Quail Spring |
| Red Pass Lake NE | Resting Spring | Saddle Peak Hills |
| Salsberry Peak | Shenandoah Peak | Shore Line Butte |
| Shoshone Soda | Soda Lake North | Soda Lake South |
| Sourdough Spring | Stump Spring | Tecopa |
| Tecopa Pass | Telescope Peak | Valjean Hills |
| Valley Wells | West of Baker | West of Nelson Lake |
| West of Shenandoah Peak | West of Soda Lake | Wildrose Peak |

Table 15. 15-Minute DLG's used to determine spring locations.

| | | |
|---|---|---|
| Amboy East | Amboy West | Beatty West |
| Big Bear Lake East | Cuddeback East | Darwin Hills East |
| Darwin Hills West | Davis Dam West | Death Valley Junction East |
| Death Valley Junction West | Ivanpah East | Ivanpah West |
| Las Vegas West | Last Chance East | Last Chance West |
| Mesquite Lake East | Mesquite Lake West | Needles West |
| Newberry Springs East | Newberry Springs West | Owlshead Mountains East |
| Owlshead Mountains West | Ridgecrest East | Ridgecrest West |
| Saline Valley East | Saline Valley West | Sheep Hole Mts. East |
| Sheep Hole Mts. West | Soda Mountains East | Soda Mountains West |

**Literature data sources**

During the summer of 1998, we undertook an extensive review of published descriptions of vegetation types with localized distribution. We reviewed the Mojave Desert Ecosystem Program Spatially Referenced Bibliography (http://www.mojavedata.gov/Home/Catalog/ Spatialy_referenced_bibligraph/spatialy_referenced_bibligraph.html) and two survey trips were made to agency offices in the Mojave to identify existing literature and database sources that could contribute to the Central Mojave Special Features Map.

The locations of potential special-feature locations come from the literature (Table 16). In most cases, the UTM location of the point for the feature is from written descriptions and only approximates the location of the feature.

Table 16. Literature sources for alliance locations

| **Data source** | **Information** | **Location determination** |
|---|---|---|
| Stone (1983) | Location of calcicolous taxa (potentially *Mortonia utahensis, Artemisia nova, Nolina parryi, Cercocarpus intricatus)* | UTM determined from 7 ½' topographic map based on place name and location description |
| Hendrickson and Prigge (1975) | Location of *Abies concolor* | UTM determined from 7 ½ ' topographic map based on descriptions found in the literature |
| BLM (1986) | Location of a rupicola assemblage (*Quercus chrysolepis*) | UTM determined from 7 ½' topographic map based on descriptions found in the plan |
| Prigge (1979) | Location of *Abies concolor* in the Clark Mountain Range | UTM determined from 7 ½ ' topographic map based on location description |

**Field collected data Sources**

Point locations of alliances recorded in the field but used to develop the Central Mojave Vegetation Map were also included in the Central Mojave Special Features Map. These field efforts include work overseen by Root (1978) in Death Valley, thesis work conducted by Evens (2000) in the Mojave National Preserve, Novak (1996) in Ft. Irwin, Novak (1998) at Marine Corp Air Ground Command Center (29-Palms), and by this project in 1997 through 2000.

Each data source was inspected for its potential use in the predictive modeling phase of the project. We classified these field data into alliances using the alliance key. Alliances that were not part of the predictive modeling data set were included in the Central

Mojave Special Features Map. The locations of the alliances were determined from the raw field data sheets provided by the data developer and converted to UTM zone 11 NAD83 datum, where conversion was needed.

# Mojave Vegetation Classification

Quantitative classification of vegetation for the Mojave Desert has never been previously attempted. Before Sawyer and Keeler-Wolf (1995), all previous classifications (Munz and Keck 1950, Thorne 1976, Cheatham and Haller 1975, Holland 1986, Mayer and Laudenslayer 1988) derived from anecdotal habitat-based descriptions of vegetation types and lacked a systematic and synoptic view of the region. Sawyer and Keeler-Wolf (1995) reviewed all published analyses of desert vegetation. However, their classification was in many cases speculative and without quantitative data for several series they describe. Several major quantitative efforts have been undertaken in the ecoregion but have never been analyzed comparatively or comprehensively (Root 1978; Johnson 1978a, 1978b; Prigge 1995). Most of these have dealt with relatively circumscribed sub-regions of the Mojave.

### Structure

This part of the project resulted in modifications to the NVC for the Mojave. With the contribution of 20 new alliances to the NVC by this project, 101 alliances are recognized in the greater Mojave Desert (Appendix A) with another six proposed. Fifty-one of these alliances are mapped either individually or in alliance complexes in either the Central Mojave Vegetation Map or the Central Mojave Special Features Map. Appendix B provides descirpitons and photographs of 70 of the 101 Mojave alliances. Appendix C provides a key to alliances found in the study area.

### Methods

Developing a standardized, quantitative classification of the vegetation for the Mojave Desert involved several steps. In brief, the steps are as follows:

1. Accumulate existing literature and combine into preliminary classification,
2. Accumulate and analyze all vegetation data available for a preliminary data-driven classification based on retrospective data,
3. Use field sampling conducted during this project to capture all bio-environments in the study area and fill in the gaps in the existing classification,
4. Analyze these new relevés to develop quantitative classification rules,
5. Standardize the classification with the NVC,
6. Combine the retrospective and the new data into a completed classification, and
7. Develop keys and descriptions to all the alliances of the mapping area.

## Existing Literature Review

Beginning in the fall of 1997, we made a literature search for existing information on vegetation classification of the Mojave. Information from Sawyer and Keeler-Wolf (1995), Bourgeron and Engelking (1994), TNC and NatureServe regional ecologists (P. Bourgeron personal com., R. Crawford personal com., P. Comer personal com., M. Reid, personal com., K. Schulz, personal com.) were synthesized to obtain the most current view of the NVC for the mapping area. Much of the information that went into the existing Mojave classification was collected outside of the mapping area in Nevada, Utah, or Arizona. Although some quantitative studies were available, these studies were typically of small subsets of the vegetation and were not necessarily developed directly for the purpose of classification.

This information was synthesized into a preliminary classification for the Mojave at the alliance level. Because the spatial resolution of the alliance units of vegetation classification is highly variable, notes were also made on the "mapability" of each of the alliances thought to occur in the area. Mapability is defined by visual distinctiveness, that is, contrast, tone, texture, and context in photointerpretation, and size of a typical stand relative to some standard (the project's five ha MMU). A preliminary classification of Mojave Desert Alliances nested within associated formations, and a set of notes about how alliances might need to be aggregated for mapping, was produced following initial literature review and was used to direct work at the beginning of the Central Mojave Vegetation Mapping Project.

The literature review described 80 alliances within the mapping area, a geographical subset of the greater Mojave Desert, several of which might need to be aggregated with other adjacent alliances because they did not meet the criteria for mapping in this project. Some of these alliances, such as several California chaparral alliances, were included because of the uncertain boundaries of the project in its initial stages. We eventually eliminated these when the project boundaries became more constrained.

## Retrospective Field Data for Classification

The second phase of the classification involved investigating the various sources of existing vegetation data. We assembled potential data sources into a table with salient characteristics noted. These data sources represented unpublished field data for several studies with various purposes. The team assessed each each of these sources for vegetation classification. Some were deemed inappropriate for various reasons such as sampling methodology, non-systematic approach, or small sample size. There were also datasets that we could make available. Between the summer of 1997 and 1998, we assembled all usable and available data. The majority of these data had never been analyzed or assembled beyond the stored original field data sheets. Table 12 lists the existing data sources used in the classification, their locations, the number of samples, and the methodology for each of the data sets.

The field data in these studies consisted of location, environmental characteristic, species composition, and cover data. The most consistent and important part of these data was species composition and cover information. In our review of these data, we evaluated the dataset's location information to determine if it was specific enough to be usable in the modeling. We also evlauted the nvironmental data provided bu in general it was variable in resolution and not specific enough or systematically complete to provide adequate ecological characterizations for the vegetation. Long (1997), Johnson (1978a, 1978b), Watts (1996), Evens (2000), Thomas (1997), and Schramm (1977) data were entered into a spreadsheet (plots in rows, species abundances in columns) while others such as Root (1978) were entered into Cornell Condensed Format (Gauch 1982).

Due to the various methods and purposes of data collection, we analyzed all data sets individually. The intent was to compare results from each data set and assemble it into a systematic "existing classification."

The most extensive and consistently collected of the existing data sets is the Johnson data (1978a, 1978b). It consisted of a data set from the eastern Mojave area and the Saline data set from the northwestern Mojave. This effort was a unit resource inventory for the BLM's California Desert Plan. For all three sub-sets, initial vegetation polygons were drawn from 1:130,000-scale aerial photography within selected portions of the Mojave. Within each of the polygons, one or more representative 100-pace toe-point transects were taken. The inventory collected data on elevation, slope direction, slope steepness, landforms, soil surface characteristics, cover of perennial plants, and presence of annuals. Thus, the inventory collected from the three focus areas about 870 vegetation samples using the same methodology. Other data sets were less extensive and more localized and consisted of 72 to 152 individual plots.

**Analysis of Retrospective Classification Data**

The analysis of existing data was conducted with the PC-Ord software suite of ordination and classification tools (McCune and Mefford 1997). PC-Ord allows the use of disparate types of data in classification programs such as TWINSPAN (Hill 1979) or Cluster Analysis (McCune and Mefford 1997), whether entered in various spreadsheet, database, or condensed formats.

The classification analysis for all existing data followed a standard process. First, all sample-by-species information was subjected to two basic TWINSPAN runs. The first used presence/absence of species with no additional cover data considered. This provided a general impression of the relationships between all the groups based solely on species membership. The second used a standard default run, where cover values are converted to five different classes including:

| | |
|---|---|
| Class I | merely present to 2% |
| Class II | >2-5% |
| Class III | >5-10% |
| Class IV | >10-20%, and |
| Class V | >20% cover |

These cover values are reasonable for the typically light cover of most desert vegetation. The first three cover classes compose the majority of the species values. This second run demonstrated the modifications of cover values can make on the group memberships. Depending on the size of the data set, the default runs were modified to show from 6 to 12 divisions (the largest data sets were subdivided more than the smaller data sets). A minimum group size of three observations was specified for all runs. The intent was to display the natural divisions at the finest level of classification (the association) rather than the alliance level.

Following each of these runs, we identified and compared consistent groupings. After identifying natural groups in TWINSPAN, Cluster Analysis using Ward's scaling method and Euclidean Distance (McCune and Mefford 1997) measure was employed for an agglomerative view of grouping as opposed to the divisive grouping in the TWINSPAN algorithm. The congruence of groupings between TWINSPAN and Cluster Analysis was generally close. Disparities were resolved by reviewing the species composition of individual samples. Most of these uncertain plots either represented transitional forms of vegetation that are either borderline misclassified plots or outliers with no similar samples in the data set.

For each of the data sets, we developed a list of groupings based on the combination of TWINSPAN and cluster analysis runs. These lists were developed into a preliminary classification of 37 alliances for the existing data.

**Analysis of Project Field Data**

Following the 1997-98 sampling effort (see Central Mojave Field Data Tables), 1,242 vegetation relevés were available for analysis. The process of analysis of the new data was similar to the existing data analysis with some modifications. This was the largest uniform set of data collected throughout the mapping area based on a random stratified sample and was used as the principal means of defining the alliance composition throughout the mapping area. As a result, we employed careful scrutiny of the membership of each defined grouping to establish membership rules for all existing relevé data and to set the standard for the definition of the alliances.

The process of defining vegetation alliances and assigning relevés to alliances generally followed these steps:

1. Identify the most distantly related relevés using PC-ORD outlier analysis. These relevés usually are vegetation types at either ends of an environmental gradient, such as alliances associated with alkali sinks or high-elevation pinyon or bristlecone pine alliances.
2. Determine the general arrangement of species along the first axis of a detrended correspondence analysis (DCA) using TWINSPAN. The general gradient was of *Allenrolfea occidentalis* Shrubland Alliance and *Prosopis glandulosa* Shrubland

Alliance relevés at low end and *Pinus monophylla* Woodland Alliance relevés at other end.

3. Examine the general variation in arrangement of samples by running different permutations of TWINSPAN. Generally the samples held together well throughout the different permutations, and the main gradient did not vary.
4. Determine the final representative TWINSPAN run to use in the preliminary labeling.
5. Assign alliance and association (when possible) labels to each of the relevés.
6. Identify the major break points (main divisions) in TWINSPAN of the full data set and do individual TWINSPAN runs on major subsets of data (upper elevation scrub, *Larrea tridentata-Ambrosia dumosa* relevés, *Encelia farinosa -Atriplex hymenelytra* data, pinyon and juniper relevés).
7. Run cluster analysis (Ward's method) to test congruence with the subsets of TWINSPAN groupings.
8. Determine consistency of alliances (number and indicator values of other species associated with the selected proposed indicator species) using indicator species analysis.
9. Develop decision rules for each alliance, reflecting most conservative group membership possibilities based on review of species cover on a relevé-by-relevé basis.
10. Apply final alliance labels to each relevé and arrange in spreadsheet with location data for use in predictive modeling and map editing.
11. Apply decision rules developed for the field relevé data to assign alliance names to all retrospective data.
12. Review of new alliance designations by NatureServe for inclusion into the NVC.

Classification of the retrospective data included several additional steps:

1. Define membership and fidelity of select relevés to certain alliances using indicator species analysis (as provided in PC-Ord).
2. Reanalyze subsets of TWINSPAN data. Initial TWINSPAN runs subdivided the dataset because of its size. These subsets were re-analyzed using TWINSPAN and cluster analysis. This process is progressive fragmentation (Bridgewater 1989).
3. Reevaluate each relevé within the context of the cluster it had been assigned following cluster and TWINSPAN analysis to quantitatively define the membership rules for each alliance. These membership rules are defined by species constancy and species cover values and are translated into the floristic key.

Indicator species analysis was a useful tool in defining the alliances. This analysis (Dufrene and Legendre 1997) uses Monte Carlo simulation to test the likelihood of certain species as good indicators for groups of relevés. Thus, it provides a quantitative means to confirm or deny the definition of an alliance based on the presence of a given species.

Despite the strong influence of outlier relevés (relevés that did not fit neatly into analysis groupings) on the arrangement of the main body of vegetation data, we chose not to remove them from the data. Because the sampling scheme tended to under-represent the rare types, based on their rare bio-environments, we considered these relatively unique samples important. They were often the only representatives of rare alliances defined from areas beyond the boundary of the study area. In some cases, they represented unusual species groupings here-to-fore undescribed, and therefore provided insights into unusual vegetation types that would deserve further sampling at some future date. To adjust for the skewing effects of outliers, we removed them from subset analysis, but retained them in the final analysis and classification.

**The NVC Classification for the Mojave Classification**

Quantitative floristic data derived from field relevés are the building blocks of the NVC. However, because of the abrupt shift from the floristic units of the association and alliance to the physiognomic units of formation, group, and class in the NVC (Table 1), additional groupings in the classification must be made to accommodate significant physical differences in the vegetation. These may not strictly reflect the floristic affinities of the relevés.

Although the rules of aggregation for associations and alliances use a flexible set of decisions based on a combination of constancy and cover of characteristic species (Grossman et al. 1998), the rules for membership in the physiognomic upper units of the classification are more rigorous. For example, the classification criteria for woodland with a shrub understory of greater than 10% are that trees should compose on average at least 25% total cover and generally not more than 60% cover. For cases where the tree species is less than 25% cover, the placement of the assemblage within a woodland alliance or a shrubland alliance is not as clear, and we developed criteria on a case-by-case basis. Placing an assemblage with the same species composition as a woodland type in a shrubland type based on cover of the species would require applying cover criteria to a range of canopy covers (including trees, shrubs, and grasses as canopy). The NVC recognizes the "modal" representation of cover as important. Therefore, a single *Pinus monophylla* relevé with extremely high cover (>60%) would not constitute a reason to define a *Pinus monophylla* forest alliance, if the preponderance of the relevé data showed that the modal cover for such vegetation in an area was in the woodland range (25-60% cover).

Several such examples exist in the Mojave Desert. As an example, TWINSPAN and Cluster Analysis group any relevés with pinyon pine greater than 2% cover into a discrete unit. However, the cover values suggest that relevés with *Pinus monophylla* (pinyon pine) >25% cover are a *Pinus monophylla* Woodland Alliance, while relevés with pinyon pine <25% cover could be considered a shrubland with a sparse tree cover. What does remain constant is that the pinyon pine is stillthe characteristic unifying tree species. However, where pinyon pine is < 25% cover, shrubs and/or herbaceous species are usually a more significant component of the overall community structure. Thus, in this example, the first is a *Pinus monophylla* Woodland Alliance, while the second is a *Pinus monophylla*

Wooded Shrubland Alliance. This NVC naming convention allows maintenance of information on both the structural and floristic components of the vegetation type.

For purposes of modeling the alliances without distinctive photo signatures, it was typically necessary to aggregate floristically related alliances, for example, *Pinus monophylla* Woodland and *Pinus monophylla* Wooded Shrubland, into compositional groups. However, for the purposes of the classification, we adhered to the NVC naming convention.

## Accuracy Assessment Protocol for Vegetation Map

Any type of mapping effort will unavoidably involve some degree of error. Maps constructed using satellite imagery, aerial photography, or even ground surveys will contain both thematic and positional error. This is not to suggest that all error in maps can or should be eliminated, but rather that map users should be made aware of the nature of errors contained within the map. We must have some means of judging the reliability or the product that others will use. An accuracy assessment is an essential component of any land cover mapping exercise and the product is unverified before a systematic accuracy assessment. Accuracy assessment is important because quantitative estimates of thematic and positional errors in the data will allow users of the data to assess data suitability for any particular application (ESRI, NCGIA, and TNC 1994). Accuracy assessments are usually only conducted after the map developer believes that the map is near the target accuracy. An accuracy assessment should be distinguished from map validation, defined in this report as a process used in map development to refine and update a preliminary map. Validation is a step that map developers use to achieve the target accuracy but it does not confirm the final accuracy – that is the role of the accuracy assessment. The generally accepted goal for a vegetation map is 80% or higher accuracy for each map class (alliance or ecological system). If accuracy assessment determines a map class to have less than 80% accuracy, additional update may be performed before finalizing the map.

An accuracy assessment is a laborious and relatively expensive task. It has been estimated that the cost of an accuracy assessment is 25%-100% the cost of the mapping effort for this type of map. At the initial development of the Central Mojave Vegetation Map, we asked the Desert Manager's Group and their science Committee if we should incorporate such a task into our workplan, recognizing that this would require a significant proportion of the financial resources available to this project. In light of the fact that we knew at the outset there were insufficient resources to complete the vegetation map for the California portion of the Mojave, we agreed that we should devote all the available resources to development of the Mojave Vegetation Database, including a version of the Central Mojave Vegetation Map, that has not been accuracy assessed. This was not to discount the value and importance of an accuracy assessment. Resources and land management agencies could execute an accuracy assessment in a collaborative effort, with direction from a project coordinating team.

As the Central Mojave Vegetation Map is not accuracy assessed, it is unverified until all mapped areas have a statistically valid accuracy assessment. Until then, it will exist in unassessed form.

We recommend that a statistically valid accuracy assessment be conducted on the map using methods described for accuracy assessment of land cover maps in the USGS/NPS Vegetation Mapping Program (http://biology.usgs.gov/npsveg/aa/toc.html), the National Gap Analysis Program (http://www.gap.uidaho.edu/handbook/LandCoverAssessment/default.htm), Congalton (1991) and Edwards et al. (1998).

In addition, we recommend that:

1. The accuracy assessment must be independent from the mapping process itself. Since the Mojave Vegetation Map for the entire ecoregion may be compiled as a series of within-region projects (Central Section, Western Section, Ward Valley Section, Joshua Tree National Park, and the Mojave regions of the Southwest Gap Analysis), a separate accuracy assessment should be conducted either for each sub-project or for the entire map when compiled. We recommend a single accuracy assessment.
2. The accuracy assessment be based on an observational unit equivalent or larger than the MMU.
3. The recommended number of samples per class reflects the abundance of each class within the project area. Rare classes should be sampled based on how certain we are about their accuracy, not based on their rarity alone. In many cases, the rare ones can never have enough samples to statistically satisfy their accuracy, unless you sample all of them. Most scientists suggest a minimum number of samples for even the most rare classes; 30, 50, or 100. However, using the recommended formula, as few as 20 samples could be used.
4. Thematic accuracy be expressed using contingency matrices, and overall accuracy should be reported both as a simple proportion correctly classified and as map accuracy adjusted for chance agreement with a Kappa index. It is recommended to report users' and producers' accuracy for each class. These accuracies should be expressed as a percentage with a 90% confidence interval. The users should be provided with the actual accuracy estimates rather than stating whether or not the product meets a specific accuracy standard.
5. Ideally, accuracy assessment should capture all components of uncertainty associated with vegetation mapping. Recognizing that operationally this may not be feasible, we nevertheless recommend testing of experimental methods measuring, for example, within polygon variation, or the uncertainty in the position of polygon boundaries.
6. Before implementing any of the accuracy assessment procedures, they should be tested operationally during the preliminary phase of the project. We anticipate that the methodology will need to be refined because of this testing.
7. The number of samples per class should reflect, as much as possible, the importance of each class and the relative abundance of each class within the project area. Statistically the number of samples has nothing to do with the area of

the map covered by the specified type. Rather, it addresses the certainty of mapping a particular type and the desired level of significance from the deviation of the actual accuracy from the estimated accuracy. Thus, the more certain one is about the identity of a mapped type, the fewer samples one needs to collect. However, the more certain one wants to be that the estimated accuracy is actually close to the real accuracy, the more samples one would need to gather. For widespread types, a large number of samples may not be needed, but they need to be distributed in a well stratified, random selection.

# Use and Update of the Mojave Vegetation Map

This project is a first step in developing an up-to-date continuous vegetation map for the entire ecoregion. The detail and accuracy of the Mojave Vegetation Map can be developed and improved in subsequent efforts. The goal of the Mojave Desert Ecosystem Program is to have a seamless vegetation map for the entire Mojave Desert. The Central Mojave Vegetation Mapping Project has initiated this project. The MDEP expressed that the completed Mojave Vegetation Database will ultimately contain vegetation coverage and associated relevé database for the entire ecoregion.

The Mojave Vegetation Database consists of several digital maps and their associated relational databases. Because we developed the digital maps in a GIS environment, they can be continually updated as a dynamic product. Before the advent of software to manage map information, maps were restricted to hard copy format. They were static products, published at one time, with one scale of representation. The data displayed were all the data in the map. The GIS environment allows a map to be periodically updated, to be represented at multiple scales of representation (although the resolution of representation does not change), and to contain selected multiple data items in a relational database.

Implementation of a dynamic map database requires that the methods and procedures for development and update of database are explicit. Updates to the database should include the cartographic history of the map. Users of the map need to be aware that the map is not static. Users need to be aware of which version of the map they are using and should review accompanying metadata to understand how the content of the database edition in use is different from previous versions. A dynamic database may be updated at any time, but the updates should not be distributed until the map is published. Publication for the Mojave Vegetation Database could be posted through the Mojave Desert Ecosystem Program website. FGDC compliant metadata should document each publication and a referencing citation that refers to that version of the map and or database.

### Update of the Mojave Vegetation Map

The first phase of the Central Mojave Vegetation Mapping Project encompassed a 5.5-million ha area in the central section of the Mojave Desert. Three other sections must be addressed to complete mapping for the entire Mojave Desert: 1) the west Mojave, 2) the south Mojave, 3) and the east Mojave. Two other currently ongoing mapping projects, the

USGS/NPS Park Mapping Program in Joshua Tree National Park and the Southwest Regional Gap Analysis Program will potentially provide suitable mapping for the southern Mojave and portions of the eastern Mojave (those portions in Arizona, Nevada, and Utah). Additional areas in the eastern Mojave are the sections in the Mojave not included in this project: Ward Valley and portions of the Colorado River Corridor.

The points of consideration for inclusion of additional mapping into the Mojave Vegetation Database are:

- Consistency of classification standards
- Consistency of mapping resolution
- Consistency of polygon delineation

**Consistency of classification standards**

We developed an alliance-level classification and key of the study area for this stage of the Mojave Vegetation Mapping project. Additional alliances, not yet described or with preliminary description, will be found in the western Mojave or eastern California Mojave. Additions to the classification should use the NVC framework and quantitative analysis of relevé data. We described earlier procedures for quantitative analysis earlier in the Vegetation Classification section. Inclusion of any alliance into the key must be verified by a minimum number of observations supporting that alliance (we suggest five). The accepted process, at the time of consideration, for inclusion of an alliance into the NVC Mojave classification should adopted. Currently, inclusion into the NVC relies on review by NatureServe. The Ecological Society of America is developing guidelines for documentation of alliances within the scientific community. Eventually, all alliances need to be documented in peer-reviewed literature using guidelines that are being established.

**Consistency of mapping resolution**

The target MMU for the Mojave Vegetation Database is five ha. It is known that numerous alliances occur in the Mojave typically at a resolution less than five ha, for example, *Salix exigua* Woodland or *Prosopis glandulosa* Woodland Alliances. In addition, alliances that may occur commonly with greater than five ha extent may also occur as inclusions within a more expansive alliance; for example, 1 hectare of *Salazaria mexicana* Shrubland occurring within a larger expanse of *Larrea tridentata* Shrubland. Three strategies exist to deal with these situations: 1) ignore all alliance occurrences less than five ha in size, 2) gather information on these alliances when encountered but maintain the information separately from the Mojave Vegetation Map, or 3) gather information on these alliances and actively incorporate the data into the Mojave Vegetation Map. The first option is the one usually adopted by mapping projects, but it does not fulfill the intention of a dynamic database. We established the framework for the second option with the Special Features Map. The third option would result in a map with mixed minimum mapping units. We do not recommend this option unless pursued in a systematic manner.

**Consistency of polygon delineation**

We based polygon delineation, as described in the Central Section, on photointerpretation of 1:32,000 true color aerial photography. The polygons in most instances represent primarily integrated land units, subjectively determined, rather than discrete vegetation units. Delineation of exact vegetation units cannot be implemented without higher resolution imagery. The development of Digital Ortho Photoquads (DOQQ's) for the Mojave Desert provides an additional affordable image database that may allow further polygon delineation.

The existing polygons in the vegetation map can be further refined using finer resolution imagery, such as the DOQQ's, or from direct field mapping. Whenever polygons are refined, the changes should be made from a georeferenced base map, such as a DOQQ and/or 1:24,000 topographic quad.

Mapping being conducted in Joshua Tree National Park and for the SW Regional Gap Analysis is using different methods to delineate map units. Compilation of these various map sources into a regional database will potentially result in a map with some inconsistencies in map unit representation. The compiler will need to determine if the inconsistencies are too large to allow effective use of a compiled map. Annotation of each map unit with its original and clear documentation of the methods of original will help make such a compilation more users friendly.

The history of edits should be included either in the ArcInfo database or in a linked relational database. This cartographic history should include:

- Type of edit such as polygon edit or map label change
- Date of edit
- Source of information for edit

We recommended that one entity act as the clearinghouse for any edits made to the Mojave Vegetation Map. Periodic edits to the map should include updates of the accompanying metadata.

**Availability and Use of the Mojave Vegetation Map**

All coverages, grids, and the tabular database are documented with Federal Geographic Data Committee (FGDC)/Tri-Services compliant metadata for all digital maps. The spatial products are available through the MDEP (http://www.mojavedata.gov/datasets.php?&qclass=veg) and the USGS Southwest Biological Science Center's Colorado Plateau Field Station website (http://www.usgs.nau.edu/).

Mapping of vegetation alliances with a five-ha MMU will provide the base information for a variety of management and basic research needs. Following is a list of potential uses of a Mojave Vegetation Map:

Inventory

- Baseline of existing vegetation types
- Distribution of vegetation types
- Diversity of vegetation types

Landscape analysis

- Evaluate existing vegetation conditions
- Determine desired vegetation conditions
- Conduct biodiversity analysis
- Baseline for wildlife habitat modeling
- Baseline for threatened and endangered species modeling

Collaboration

- Provides common platform for all agencies
- Planning and implementation of ground level actions done with common baseline

Management

- Facilitates management activities at a variety of scales (monitoring impacts such as fire and weed invasion, development, and so on)
- Facilitates implementation of land use plans

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# Appendix A. Vegetation Alliances in the Mojave Desert

This appendix lists 101 vegetation alliances known to occur in the Mojave Desert (not just the study area) based on the current listing of alliances as maintained by NatureServe, formerly the Association for Biodiversity Information, (Ecology Group ABI 2000). NatureServe uses a hierarchical code to identify each alliance registered in the National Vegetation Classification as of November 2001. Where the alliance hierarchical code is not yet completely assigned, we use 'x' to indicate the incomplete portion.

NatureServe reviewed and accepted 20 alliances proposed by this study into the National Vegetation Classification (NVC); we used bold text to indicate these alliances in the list following. The data for classification of new alliances consisted of the relevé data collected for this project augmented with other data from select Mojave Desert field samples (see Products: Vegetation Classification, this volume). We indicate the sample sizes for newly described alliances in parenthesis. Usually NatureServe requires four or more plot descriptions to propose an alliance for new listing into the NVC.

Some vegetation types appear to have repeatable consistency across the landscape, but lack sufficient samples for inclusion yet into the NVC. We present these vegetation types as probable alliances pending confirmation with additional sampling in the Mojave Desert.

For the most current information on the accepted alliances in the Mojave Desert, view the NatureServe website, http://www.natureserve.org/.

## I. Forest

Trees usually over 5 m tall with their crowns interlocking (generally forming 60-100% cover).

### I.A. Evergreen Forest

I.A.6.N.b.2 *Quercus chrysolepis* Forest Alliance

### I.B. Deciduous Forest

I.B.2.N.d.38 *Populus fremontii* Temporarily Flooded Forest Alliance

## II. Woodland

Open stands of trees usually over 5 m tall with crowns not usually touching (generally forming 25-60% cover).

**II.A. Evergreen Woodland**

| | |
|---|---|
| II.A.2.N.b.1. | *Washingtonia filifera* Seasonally Flooded Woodland Alliance |
| II.A.4.N.a.20 | *Pinus longaeva* Woodland Alliance |
| II.A.4.N.a.27 | *Pinus sabiniana* Woodland Alliance |
| II.A.4.N.a.38 | *Juniperus osteosperma* Woodland Alliance |
| II.a.4.N.a.42 | *Pinus flexilis* Woodland Alliance |
| II.A.4.N.a.45 | *Pinus monophylla* - (*Juniperus osteosperma*) Woodland Alliance |

**II.B. Deciduous woodland**

| | |
|---|---|
| II.B.2.N.b.2 | *Platanus racemosa* Temporarily Flooded Woodland Alliance |
| II.B.2.N.b.12 | *Populus fremontii* Temporarily Flooded Woodland Alliance |
| II.B.2.N.c.7 | *Populus fremontii* Seasonally Flooded Woodland Alliance |
| II.B.3.N.a.2 | *Prosopis (glandulosa, velutina)* Woodland Alliance |

# III. Shrubland

Shrubs or trees usually 0.5 to 5 m tall with individuals or clumps not touching to interlocking (generally forming > 25% canopy cover)

**III.A. Evergreen Shrubland**

| | |
|---|---|
| III.A.2.N.c.13 | *Ceanothus greggii - Fremontodendron californicum* Shrubland Alliance |
| III.A.2.N.c.40 | *Quercus turbinella* Shrubland Alliance |
| III.A.2.N.c.400 | *Quercus cornelius-mulleri* Shrubland Alliance |
| III.A.2.N.h.2 | *Pluchea sericea* Seasonally Flooded Shrubland Alliance |
| III.A.4.N.a.1 | *Artemisia californica - Eriogonum fasciculatum* Shrubland Alliance |
| III.A.4.N.a.6 | *Ericameria parryi* Shrubland Alliance (aka *Chrysothamnus parryi*) |
| III.A.4.N.a.7 | *Cleome isomeris - Ephedra californica - Ericameria linearifolia* Shrubland Alliance |
| III.A.4.N.a.13 | *Purshia tridentata* Shrubland Alliance |
| III.A.4.N.a.16 | *Cercocarpus ledifolius* Shrubland Alliance |
| III.A.4.N.a.17 | *Artemisia tridentata* Shrubland Alliance |
| III.A.4.N.a.21 | *Purshia stansburiana* Shrubland Alliance |
| III.A.4.N.a.23 | *Ericameria nauseosa* Shrubland Alliance |
| **III.A.4.N.b.** | ***Baccharis sergiloides* Intermittently Flooded Shrubland Alliance (n=21)** |
| III.A.4.N.b.1 | *Lepidospartum squamatum* Intermittently Flooded Shrubland Alliance |

| | |
|---|---|
| III.A.4.N.c.1 | *Tamarix* spp. Semi-Natural Temporarily Flooded Shrubland Alliance |
| **III.A.5.N.a.** | ***Larrea tridentata - Ambrosia dumosa* Shrubland Alliance** |
| III.A.5.N.a.5 | *Larrea tridentata* Shrubland Alliance |
| III.A.5.N.a.9 | *Ephedra viridis - Artemisia tridentata* Shrubland Alliance |
| III.A.5.N.a.10 | *Ephedra nevadensis - Ephedra viridis* Shrubland Alliance |
| III.A.5.N.a. 11 | *Ephedra nevadensis* Shrubland Alliance |
| III.A.5.N.a.12 | *Ephedra viridis* Shrubland Alliance |
| III.A.5.N.a.14 | *Encelia virginensis* Shrubland Alliance |
| **III.A.5.N.b.x** | ***Larrea tridentata - Encelia farinosa* Shrubland Alliance (n=87)** |
| III.A.5.N.b.1 | *Atriplex (lentiformis, polycarpa)* Shrubland Alliance |
| III.A.5.N.b.2 | *Atriplex spinifera* Shrubland Alliance |
| III.A.5.N.b.3 | *Allenrolfea occidentalis* Shrubland Alliance |
| III.A.5.N.b.4 | *Encelia farinosa* Shrubland Alliance |
| III.A.5.N.b.5 | *Eriogonum fasciculatum* Shrubland Alliance |
| III.A.5.N.b.6 | *Atriplex canescens* Shrubland Alliance |
| III.A.5.N.b.7 | *Atriplex confertifolia* Shrubland Alliance |
| III.A.5.N.b.9 | *Atriplex hymenelytra* Shrubland Alliance |
| III.A.5.N.b.10 | *Atriplex polycarpa* Shrubland Alliance |
| III.A.5.N.b.11 | *Coleogyne ramosissima* Shrubland Alliance |
| **III.A.5.N.b.x** | ***Viguiera parishii* Shrubland Alliance (n=16)** |
| **III.A.5.N.c.x** | ***Nolina parryi* Shrubland Alliance (n=5)** |
| III.A.5.N.c.3 | *Opuntia bigelovii* Shrubland Alliance |
| III.A.5.N.c.7 | *Yucca schidigera* Shrubland Alliance |
| **III.A.5.N.e.x** | ***Pinus monophylla* Wooded Shrubland Alliance** |
| III.A.5.N.e.1 | *Yucca brevifolia* Wooded Shrubland Alliance |

**III.B. Deciduous Shrubland**

| | |
|---|---|
| III.B.2.N.c.10 | *Suaeda moquinii* Intermittently Flooded Shrubland Alliance |
| III.B.2.N.d.6 | *Salix (exigua, interior)* Temporarily Flooded Shrubland Alliance |
| III.B.2.N.d.28 | *Forestiera pubescens* Temporarily Flooded Shrubland |
| III.B.2.N.d.36 | *Salix lasiolepis* Temporarily Flooded Shrubland Alliance |
| **III.B.3.N.a.x** | ***Salazaria mexicana* Shrubland Alliance (n=14)** |
| III.B.3.N.a.4 | *Prosopis glandulosa* Shrubland Alliance |
| III.B.3.N.a.9 | *Acacia greggii* Shrubland Alliance |
| III.B.3.N.a.11 | *Grayia spinosa* Shrubland Alliance |
| III.B.3.N.a.14 | *Sarcobatus vermiculatus* Shrubland Alliance |
| III.B.3.N.a.15 | *Prosopis pubescens* Shrubland Alliance |
| **III.B.3.N.a.x** | ***Hymenoclea salsola* Shrubland Alliance (n=70)** |
| **III.B.3.N.b.x** | ***Ephedra californica* Intermittently Flooded Shrubland Alliance (n=50)** |
| **III.B.3.N.b.x** | ***Viguiera reticulata* Intermittently Flooded Shrubland Alliance (n=6)** |

**III.B.3.N.b.x** ***Hyptis emoryi*** **Intermittently Flooded Shrubland Alliance (n=1)**
**III.B.3.N.b.x** ***Ericameria paniculata*** **Intermittently Flooded Shrubland Alliance (n=23)**
**III.B.3.N.b.x** ***Prunus fasciculata*** **Intermittently Flooded Shrubland Alliance (n=28)**
**III.B.3.N.b.x** ***Psorothamnus spinosus*** **Intermittently Flooded Shrubland Alliance (n=7)**
III.B.3.N.b.1 *Chilopsis linearis* Intermittently Flooded Shrubland Alliance
III.B.3.N.b.2 *Grayia spinosa* Intermittently Flooded Shrubland Alliance
III.B.3.N.b.3 *Sarcobatus vermiculatus* Intermittently Flooded Shrubland Alliance

**III.C. Mixed evergreen-deciduous shrubland**

**III.C.3.N.c.x** ***Ericameria teretifolia*** **Shrubland Alliance (n=5)**
**III.C**.x.x.x.x ***Juniperus californica*** **Wooded Shrubland Alliance (n=30)**
**III.C.x.x.x.x** ***Juniperus osteosperma*** **Wooded Shrubland Alliance (n=71)**

## IV. Dwarf-shrubland

Low-growing shrubs and/or trees usually under 0.5 m tall, individuals or clumps not touching to interlocking (generally forming > 25% cover).

IV.A.2.N.a.6 *Ambrosia dumosa* Dwarf-shrubland Alliance
IV.A.2.N.a.9 *Artemisia nova* Dwarf-shrubland Alliance
IV.A.2.N.a.8 *Krascheninnikovia lanata* Dwarf-shrubland Alliance
IV.B.3.N.a.4 *Salvia dorrii* Dwarf-shrubland Alliance
**IV.B.3.N.a.x** ***Menodora spinescens*** **Dwarf-shrubland Alliance (n=4)**

## V. Herbaceous Vegetation

Graminoids and/or forbs (including ferns) generally forming > 10% cover with woody cover usually < 10%.

V.A.5.N.d.3 *Pleuraphis rigida* Herbaceous Alliance (aka *Hilaria rigida*)
V.A.5.N.d.19 *Achnatherum hymenoides* Herbaceous Alliance (aka *Oryzopsis hymenoides*)
V.A.5.N.e.14 *Pleuraphis jamesii* Herbaceous Alliance
V.A.5.N.f.2 *Achnatherum speciosum* Herbaceous Alliance (aka *Stipa speciosa*)
V.A.5.N.i.5 *Distichlis spicata* Intermittently Flooded Herbaceous Alliance
V.A.5.N.i.4 *Sporobolus airoides* Intermittently Flooded Herbaceous Alliance
**V.A.5.N.k.x** ***Juncus cooperi*** **Seasonally Flooded Herbaceous Alliance**

| | |
|---|---|
| V.A.5.N.l.4 | *Phragmites australis* Semipermanently Flooded Herbaceous Alliance |
| V.A.5.N.l.5 | *Schoenoplectus americanus* Semipermanently Flooded Herbaceous Alliance |
| V.A.5.N.1.16 | *Schoenoplectus acutus - (Schoenoplectus tabernaemontani)* Semipermanently Flooded Herbaceous Alliance |
| V.A.7.N.e.4 | *Chrysothamnus viscidiflorus* Shrub Herbaceous Alliance |
| V.A.7.N.e.9 | *Pleuraphis rigida/Gutierrezia sarothrae* Shrub Herbaceous Alliance |
| V.A.7.N.h.1 | *Pleuraphis rigida* Shrub Herbaceous Alliance (aka *Hilaria rigida*) |
| V.A.7.N.m.2 | *Achnatherum speciosum* Shrub Herbaceous Alliance |
| **VII.C.1.N.a.x** | ***Panicum urvilleanum* Sparsely Vegetated Herbaceous Alliance (n=3)** |

## VII. Sparse Vegetation

| | |
|---|---|
| VII.A.1.N.a.x | Rock Outcrop Sparse Vegetation Alliance |
| VII.A.1.N.a.x | Rock Outcrop/Butte Sparse Vegetation Alliance |
| VII.A.2.N.a.4 | Open Pavement Sparse Vegetation Alliance |
| VII.B.2.N.b.x | Gravel Wash Sparse Vegetation Alliance |
| VII.C.1.N.a.x | Herbaceous Dunes Sparse Vegetation Alliance |
| VII.C.1.N.a.1 | *Abronia villosa* Sparsely Vegetated Alliance |
| **VII.A.2.N.a.x** | ***Ephedra funerea* Sparse Vegetation Alliance (n=3)** |

## Probable

| | |
|---|---|
| III.A.4.N.a.6. | *Ericameria parryi* Shrubland Alliance |
| III.A.2.N.c.401 | *Quercus john-tuckeri* Shrubland Alliance |
| III.B.3.N.b.x | *Bebbia juncea* Intermittently Flooded Shrubland Alliance |
| V.A.5.N.k.10 | *Eleocharis (montevidensis, palustris, quinqueflora)* Seasonally Flooded Herbaceous Alliance |
| V.A.5.N.k.13 | *Juncus balticus* Seasonally Flooded Herbaceous Alliance |
| V.A.5.N.l.9 | *Typha (angustifolia, latifolia) – (Schoenoplectus* spp.) Semipermanently Flooded Herbaceous Alliance |

# Appendix B. Alliance Key

We developed this key to aid in field identification of alliances and unique stands in the study area. It does not include all alliances in the Mojave Desert. It was field-tested during extensive collection of reference data in the spring of 2000 by six observers.

IA Total perennial plant cover ≤ 2% or no perennial species with ≥ 1% cover. Go to 100A.

IB Go to IIA.

IIA Tree species are present. Trees are defined as woody perennials that are regularly > 3 m in height; including shrub species often taller than 3 m such as *Chilopsis linearis*, *Cercocarpus ledifolius*, *Yucca brevifolia, Tamarix spp.* and *Juniperus osteosperma* or *californica*. The tree layer is visibly uniform in the stand although it may be low in cover. Go to II.1.

- II.1 Tree species generally ≥ 25% cover. If total cover < 25%, tree species cover is greater than either herbaceous or shrub cover. Go to 200A.
- II.2 *Yucca brevifolia, Pinus monophylla, Juniperus californica*, and/or *Juniperus osteosperma* ≥ 1% cover. Go to 250A.
- II.3 Go to IIIA.

IIB Tree species not present. Go to IIIA.

IIIA Perennial herbaceous vegetation present (≥ 2% cover), and woody shrubs generally < 2% cover. Go to 300A.

IIIB Go to IVA.

IVA Shrubs present (≥ 2%); go to 400A.

IVB Perennial vegetation less than 2% or absent; go to 100A.

SPARSE AND UNVEGETATED ALLIANCES

---

100A Perennial plants present but less than 2%; depending upon substrate alliance may be: Rock Outcrop Sparse Vegetation Alliance, Rock Outcrop/Butte Sparse Vegetation Alliance, Open Pavement Sparse Vegetation Alliance, Gravel Wash Sparse Vegetation Alliance, Herbaceous Dunes Sparse Vegetation Alliance

100B Go to 101A.

101A Perennial vegetation absent. May be dominated seasonally by annual herbs and grasses. ***Unvegetated.***

TREE DOMINATED ALLIANCES

---

200A *Pinus monophylla* ≥ 25% cover or total cover greater than either shrubs or herbaceous cover. No other tree species approaches or exceeds it in cover. *Juniperus osteosperma* may be present. Restricted to cooler, moister sites than

*Pinus monophylla* Wooded Shrubland alliance, ***Pinus monophylla* - (*Juniperus osteosperma*) Woodland Alliance**.

200B Go to 201A.

201A *Pinus longaeva* ≥ 25% cover or total cover greater than either shrubs or herbaceous. Found only in the highest portions of the Inyo and Panamint Mountains. When occurring with *Pinus flexilis,* as on the upper east facing slopes of Waucoba Mtn. (Inyo Mountains.) the latter species may equal *Pinus longaeva* in cover, ***Pinus longaeva* Woodland Alliance.**

201B Go to 202A.

202A *Pinus* flexilis is the major tree species (> 55% relative cover and > 25% absolute cover). Typically occurs on more gently sloping, northerly exposures than *Pinus longaeva*, only on highest portion of Inyo and Panamint Mountains, ***Pinus flexilis* Woodland Alliance.**

202B Go to 203A.

203A *Abies concolor* co-dominates with *Pinus monophylla*. Stands are restricted to ravines and north-facing slopes in three mountain ranges in the eastern part of the study area (Clark Mtn., Kingston Range, and New York Mountains.), ***Abies concolor* Unique Stand.**

203B Go to 204A.

204A *Prosopis glandulosa* ≥ 2% cover. No other species with greater or equal cover. Trees and/or large shrubs of washes, dunes or riparian stands, ***Prosopis (glandulosa/velutina)* Woodland Alliance or *Prosopis glandulosa* Shrubland Alliance**.

204B Go to 205A.

205A *Populus fremontii* dominates stands (> 50% relative cover in tree layer), ***Populus fremontii* Seasonally Flooded Woodland Alliance or *Populus fremontii* Temporarily Flooded Woodland Alliance** (depending upon hydrology).

205B Go to 206A.

206A *Salix exigua* dominates stands (> 50% relative cover in tree layer), ***Salix exigua* Temporarily Flooded Shrubland Alliance.**

206B Go to 207A.

207A *Salix lasiolepis* dominates stands dominated (> 50% relative cover in tree layer), *Salix lasiolepis* **Woodland Alliance**.

207B Go to 208A.

208A Vegetation characterized by the relative dominance of *Quercus chrysolepis* (Canyon Live Oak) in the tree layer. Represented in the study area only by the rare canyon bottom stands of in the higher eastern Mojave Desert (Caruthers Canyon and other similar areas of eastern Mojave mountains), *Quercus* ***chrysolepis*** **Woodland Alliance**.

208B Go to 209A.

209A Vegetation characterized by the relative dominance of the shrubby tree *Cercocarpus ledifolius*. Stands occur in dry, rocky, and usually very well drained exposures in the highest portions of the Inyo, Panamint, and other tall ranges of the northern Mojave Desert, ***Cercocarpus ledifolius*** **Shrubland Alliance.**

209B Not treated in key.

250A *Yucca brevifolia* ≥ 1% cover, *Juniperus spp.* and/or *Pinus spp.* absent. Dominant understory species are shrub species such as *Coleogyne ramosissima, Opuntia ramosissima* or the perennial grass *Pleuraphis rigida*. Common in shallow upland soils throughout the Mojave Desert, ***Yucca brevifolia*** **Wooded Shrubland Alliance**.

250B Go to 251A.

251A *Juniperus californica, Juniperus osteosperma* and/or *Pinus monophylla* ≥ 1% cover. *Yucca brevifolia* absent. Go to 251.1.

251.1 *Juniperus californica* or *Juniperus osteosperma* ≥ 1%, *Pinus monophylla* not present (< 1% cover), and dominant understory species is a shrub. Due to taxonomic uncertainty of *Juniperus*, both species are lumped in this classification. However, in general *Juniperus californica* is largely found in the southwestern portion of the study area and *Juniperus osteosperma* in the northern and eastern portion, *Juniperus spp*. **Wooded Shrubland Alliance.**

251.2 *Pinus monophylla* ≥ 1% but less than 25% cover. *Juniperus osteosperma or californica* may be present. *Pinus monophylla* occurs over a sparse to relatively dense cover of shrubs, widespread in all of the higher mountains of mapping area. ***Pinus monophylla*** **Wooded Shrubland Alliance.**

251B Go to 252A.

252A Stands characterized (1% or higher cover) by *Chilopsis linearis* (desert willow) no other tree-size or tall shrub species equals or exceeds *Chilopsis linearis* cover, ***Chilopsis linearis*** **Intermittently Flooded Shrubland Alliance.**

252B Go to 254A.

254A Vegetation dominated by tall shrubby invasive *Tamarix* spp. (either *T. ramosissima, T. chinensis*, or other similar species, not including the less invasive, taller T. *aphylla*). *Tamarix* spp. should strongly dominate (> 60% relative cover) over native tall shrubs and/or low trees to be considered as alliance, ***Tamarix*** **spp. Semi-Natural Flooded Shrubland Alliance.**

254B Not considered in key.

## HERBACEOUS DOMINATED ALLIANCES

300A *Pleuraphis jamesii* ≥ 2%. This species occurs in upper-elevation mid-Mojave Desert, often associated with *Yucca brevifolia*, *Opuntia acanthocarpa* and

*Gutierrezia spp.* May be easily confused with *Pleuraphis rigida*. ***Pleuraphis jamesii* Herbaceous Alliance.**

300B Go to 301A.

301A *Pleuraphis rigida* ≥ 2%. This species occur in low sandy areas and occasionally uplands at mid elevations, often with emergent shrubs such as *Yucca schidigera* and *Ephedra nevadensis*. As an alliance in the Mojave Desert, it is generally uncommon in upland areas and more common in low sandy areas. ***Pleuraphis rigida* Herbaceous Alliance.**

301B Go to 302A.

302A *Distichlis spicata* ≥ 2%. Usually associated with alkali basin wetlands, but small stands may occur along stream margins. ***Distichlis spicata* Intermittently Flooded Herbaceous Alliance.**

302B Go to 303A.

303A *Phragmites australis* ≥ 2%. Usually associated with alkali wetlands adjacent to playas, alkali springs, and meadows; may also occur in freshwater wetlands. ***Phragmites australis* Semipermanently Flooded Herbaceous Alliance.**

303B Go to 304A.

304A Vegetation characterized by the medium height bunch grass *Achnatherum hymenoides* (Indian Rice grass). Rare in the Mojave Desert. Usually a sparsely vegetated alliance with the grass as the major native perennial species. Sandy areas such as dune apron east of Eureka Dunes. ***Achnatherum hymenoides* Herbaceous Alliance.**

304B Go to 305A.

305A Vegetation characterized by the dominance of the bunch grass *Achnatherum speciosum* (desert needlegrass). Rare in mapping area, usually in small enclaves surrounded by more extensive upland vegetation of mid-to-upper Mojave Desert such as *Coleogyne ramosissima* Shrubland. ***Achnatherum speciosum* Herbaceous Alliance.**

305B Go to 306A.

306A Vegetation characterized by the presence of *Panicum urvilleanum* (dune panic grass). Usually a sparse rhizomatous grassland of open dune areas typically < 10% cover. Rare in Mojave Desert, associated with deep dune deposits at Kelso Dunes and Devils Playground. ***Panicum urvilleanum* Sparsely Vegetated Herbaceous Alliance**.

306B Go to 307A.

307A Vegetation characterized by the presence of *Swallenia alexandrae* (Eureka Dune Grass). Occurs only on sand dunes and sand sheets of the Eureka Valley, ***Swallenia Alexandrae* Unique Stands.**

307B Go to 308A.

308A Vegetation characterized by the canopy dominance of the bunchgrass *Sporobolus airoides*. Usually of margins of alkali springs and in alkali meadows as at Tecopa, Shoshone, and other sites along the Amargosa River. Most stands well below 5 ha in extent. ***Sporobolus airoides*** **Intermittently Flooded Herbaceous Alliance.**
308B Go to 309A.

309A Vegetation characterized by the relative dominance of *Schoenoplectus americanus* (three-square or American bulrush). Generally in permanently moist alkali springs, meadows, or streamsides. Most stands less than 5 ha in extent. ***Schoenoplectus americanus*** **Semipermanently Flooded Herbaceous Alliance.**
309B Go to 310A.

310A Vegetation characterized by the relative dominance of *Juncus cooperi*. Usually small stands associated with other species of low-lying alkali seeps or meadows in such areas as Zzyzx, Tecopa, Shoshone, and Death Valley. ***Juncus cooperi*** **Intermittently Flooded Herbaceous Alliance.**
310B Not treated in key.

## SHRUB CHARACTERIZED ALLIANCES

400A Either *Hymenoclea salsola*, *Bebbia juncea, Eriogonum fasciculatum, Salazaria mexicana,* or *Senna armata*, are > 1%. Other shrubs, if present, are each less than half of the above species with the exceptions of *Hyptis emoryi* or *Salvia dorrii*, which may have higher cover. Go 400.1.

400.1 *Bebbia juncea* > 1% other shrubs. May be present in small stands in the Mojave Desert. ***Bebbia juncea*** **Intermittently Flooded Shrubland Alliance.**

400.2 *Hymenoclea salsola* > 1% other shrubs. Found in wash environments or disturbed environments. ***Hymenoclea salsola*** **Shrubland Alliance.**

400.3 *Eriogonum fasciculatum* ≥ 2%. Usually in disturbed shallow soils on slopes and pediments at mid and upper elevation. ***Eriogonum fasciculatum*** **Shrubland Alliance.**

400.4 *Salazaria mexicana* ≥ 2% cover**.** Usually of washes, but may occur on burns or in other disturbed uplands. ***Salazaria mexicana*** **Shrubland Alliance.**

400.5 *Senna armata* > 1% other shrubs. ***Senna armata*** **Unique Stand.**

400B Go to 401A.

401A *Yucca schidigera* ≥ 2% cover. Understory dominant species is a shrub. ***Yucca schidigera*** **Shrubland Alliance.**
401B Go to 402A.

402A Creosote Bush < 1% cover; go to 410A.
402B Go to 403A.

403A No shrub with cover greater than *Larrea tridentata,* with the following exceptions: *Ambrosia dumosa*, *Encelia farinosa, Krameria spp. Bebbia juncea, Ericameria teretifolia* or *Acamptopappus spherocephalus*. *Ephedra nevadensis* or *Opuntia acanthocarpa* may have higher cover, but no more than three times. Go to 401.1.

401.1 *Ambrosia dumosa* present (≥ 1% cover) may have higher cover than *Larrea tridentata*. If *Encelia farinosa is* present, go to 401.2. Widespread on all but the hottest and most rocky, sandy or most alkaline areas of the low Mojave Desert. ***Larrea tridentata-Ambrosia dumosa*** **Shrubland Alliance.**

401.2 *Encelia farinosa* present (≥ 1% cover), may have higher cover than *Larrea tridentata. Ambrosia dumosa* may be present. Widespread on hot (southerly exposure) mountain slopes and upper bajadas. ***Larrea tridentata-Encelia farinosa*** **Shrubland Alliance.**

401.3 Associate shrubs other than *Ambrosia dumosa* or *Encelia farinosa* may be present or absent. Except for shrubs listed above, associate shrub cover is less than Larrea tridentata. ***Larrea tridentata*** **Shrubland Alliance**.

403B Go to 420A.

410A *Ambrosia dumosa* > 1% cover and no other species with equal or higher cover. ***Ambrosia dumosa*** **Dwarf Shrubland Alliance**.

410B Go to 411A.

411A *Encelia farinosa* > 1% and no other species with equal or higher cover. ***Encelia farinosa*** **Shrubland Alliance.**

411B Go to 420A.

420A *Atriplex* spp. with ≥ half of all cover. Go to 420.1.

420.1 *Atriplex confertifolia* with highest shrub cover. May occur in alkaline valleys or playas and in upper mid-elevation Mojave Desert on rolling hills and slopes, particularly common in the northern portion of the mapping area, ***Atriplex confertifolia*** **Shrubland Alliance.**

420.2 *Atriplex canescens* with highest shrub cover. Typically of low-lying playa edges, dune aprons, or edges of alkaline wetlands from low- to mid-elevation. ***Atriplex canescens*** **Shrubland Alliance.**

420.3 *Atriplex polycarpa* with highest shrub cover. May occur on playa edges, in washes through alkaline areas, or occasionally uplands with alkaline substrate, ***Atriplex polycarpa*** **Shrubland Alliance.**

400.4 *Atriplex hymenelytra* > 1% cover and no other species with equal or higher cover. May occur on hot rocky slopes, dry bajadas, or alkaline badlands and playa edges. ***Atriplex hymenelytra*** **Shrubland Alliance.**

400.5 *Atriplex spinifera* with highest shrub cover. Largely restricted to the Western portion of the mapping area around edges of playas and other alkaline situations. ***Atriplex spinifera*** **Shrubland Alliance.**

400.6 Vegetation characterized by the relative dominance of *Atriplex lentiformis* (quailbush). Localized in study area along upper Amargosa River and east shore of Owens Lake. ***Atriplex lentiformis* Shrubland Alliance.**

420B Go to 421A.

421A *Acacia greggii* ≥ 2% cover. No other single tall shrub species with greater cover but *Prunus fasciculata* or *Hyptis emoryi* may be equal or slightly greater cover than *Acacia.* Smaller shrubs such as *Ericameria paniculata* or *Hymenoclea salsola* can have higher cover but no more than twice the cover of *Acacia greggii.* Occurs in washes, arroyos, as well as upland valleys and bouldery slopes**. *Acacia greggii* Shrubland Alliance.**

421B Go to 422A.

422A *Amphipappus fremontii* ≥ 2% cover. No other species with greater or equal cover. Occurs in washes and on slopes in limestone. ***Amphipappus fremontii* Unique Stand.**

422B Go to 423A.

423A *Allenrolfea occidentalis* ≥ 2% cover, no other single species with greater cover. Vegetation typically occupying strongly alkaline playas usually with distinct salt deposits in soil surface. ***Allenrolfea occidentalis* Shrubland Alliance.**

423B Go to 424A.

424A *Artemisia nova* ≥ 2% cover. No other single species with greater cover. This is typically an alliance of the limestone mountains and may occur at mid-elevation Mojave Desert or well up into the higher mountains. Other limestone shrubs such as *Mortonia utahensis* may be common. May also mix with lesser amounts of widespread species such as *Atriplex confertifolia*. ***Artemisia nova* Dwarf-Shrubland Alliance.**

424B Go to 425A.

425A *Atriplex confertifolia* ≥ 2% cover. No other single species with greater cover with the exception of woody subshrubs such as *Krameria spp*. ***Atriplex confertifolia* Shrubland Alliance.**

425B Go to 426A.

426A *Artemisia tridentata* ≥ 2% cover, no other single species with greater cover. Go to 426.1.

426.1 *Ephedra viridis* < 1% cover. ***Artemisia tridentata* Shrubland Alliance.**

426.2 *Ephedra viridis* ≥ 1% cover. Upper elevation scrubs on well drained rocky to gravelly soil usually adjacent to stands of *Pinus monophylla* and or *Juniperus osteosperma*. Other seral shrub species e.g. *Ericameria* spp. may equal these two in cover. ***Ephedra viridis-Artemisia tridentata* Shrubland Alliance.**

426B Go to 427A.

427A *Baccharis sergiloides* dominant. Typically of intermittent springs and washes in mid-elevation Mojave Desert. ***Baccharis sergiloides*** **Intermittently Flooded Shrubland Alliance**.
427B Go to 428A.

428A *Cercocarpus intricatus* the clear dominant (> 55% relative cover in tall shrub layer) on limestone outcrops in northern portion of Mojave Desert as at Last Chance Range, northern Inyo Mountains, Panamint Mountains. (Aguerreberry Point), ***Cercocarpus intricatus*** **Shrubland Alliance.**
428B Go to 429A.

429A *Coleogyne ramosissima* ≥ 2% cover. *Ephedra nevadensis*, and or *Krameria grayi* can have up to twice the cover of *Coleogyne ramosissima*. Typically dominates stands, but may be exceeded by species of disturbance (*Hymenoclea salsola, Salazaria mexicana, Ericameria* spp*., Eriogonum fasciculatum*), A widespread type of shallow rocky soils on upper bajadas, pediments and hill slopes. ***Coleogyne ramosissima*** **Shrubland Alliance.**
429B Go to 430A.

430A *Encelia virginensis* (including the subspecies *Encelia virginensis actonii*) ≥ 2% cover. No other species with greater or equal cover. Typically of washes or other disturbed areas in the eastern Mojave Desert. ***Encelia virginensis*** **Shrubland Alliance.**
430B Go to 431A.

431A Vegetation either dominated or co-dominated by *Ephedra californica,* typically of broad, active washes of mid to upper bajadas and fans. Ranging somewhat locally throughout the southwestern, central and eastern portions of the area. ***Ephedra californica*** **Intermittently Flooded Shrubland Alliance.**
431B Go to 432A.

432A Vegetation strongly dominated by *Ephedra funerea* with no other indicator species present. An uncertain alliance of limestone mountains in the northeastern Mojave Desert, represented by little data. ***Ephedra funerea*** **Sparse Vegetation Alliance**.
432B Go to 433A.

433A *Ephedra nevadensis* ≥ 2% cover. No other species with greater cover with the exceptions of *Acamptopappus sphaerocephalus* or *Chrysothamnus viscidiflorus*. ***Ephedra nevadensis*** **Shrubland Alliance.**
433B Go to 434A.

434A *Ericameria nauseosa* ≥ 2%. *Ericameria nauseosa* must have 25% or greater relative cover. Mid- and upper-elevation elevations, usually in areas with fire, flood or grazing history. ***Ericameria nauseosa*** **Shrubland Alliance.**
434B Go to 435A.

435A *Chrysothamnus viscidiflorus* ≥ 2%. *Chrysothamnus viscidiflorus* must have 25% or greater of all cover. ***Chrysothamnus viscidiflorus* Shrubland Alliance.**
435B Go to 436A.

436A *Ericameria paniculata* ≥ 2%. *Ericameria paniculata* must be ≥ 25% of all cover. Widespread throughout broad elevation range in much of the mapping area in relatively large, recently active washes. ***Ericameria paniculata* Intermittently Flooded Shrubland Alliance.**
436B Go to 437A.

437A *Ericameria teretifolia* ≥ 2% cover. No other species with greater or equal cover. Usually of disturbed uplands**,** mid elevation**. *Ericameria teretifolia* Shrubland Alliance.**
437B Go to 438A.

438A *Grayia spinosa* ≥ 2% cover; no other species with greater cover except *Ericameria cooperi* or *Lycium andersonii. Lycium andersonii* must dominate in some circumstances. ***Grayia spinosa* Shrubland Alliance.**
438B Go to 439A.

439A Vegetation characterized by the tall aromatic shrub *Hyptis emoryi* (desert lavender). Local in rocky washes of upper bajadas and canyons in the southern portion of the Mojave Desert. ***Hyptis emoryi* Intermittently Flooded Shrubland Alliance.**
439B Go to 440A.

440A Vegetation usually of mid- to upper- elevation flats and small basins dominated strongly by the low shrub *Krascheninnikovia lanata* (winter-fat), without any other species in higher cover. Uncommon in mapping area. ***Krascheninnikovia lanata* Shrubland Alliance.**
440B Go to 441A.

441A Vegetation characterized by the broom-like *Lepidospartum squamatum* (scale-broom). Stands concentrated along washes on eastern base of the San Bernardino Mountains in the extreme southwest portion of the mapping area. Other smaller stands occur at mid-elevations throughout the desert. ***Lepidospartum squamatum* Shrubland Alliance.**
441B Go to 442A.

442A *Menodora spinescens* ≥ 2% cover, no other single species with greater cover although many other species may be present. Represented by a few localized stands in well-defined, shallow rocky soils characteristically just above *Larrea tridentata-Ambrosia dumosa.* ***Menodora spinescens* Shrubland Alliance.**
442B Go to 443A.

443A *Mortonia utahensis* ≥ 2% cover. No other species with greater or equal cover. An open scrub of limestone slopes at mid-elevation in the east Mojave Desert mid-elevation. ***Mortonia utahensis*** **Unique Stand.**

443B Go to 444A.

445A *Nolina parryi* > 3% cover. Uncommon, scattered in extreme southwest of study area and in Kingston Range. ***Nolina parryi*** **Shrubland Alliance.**

445B Go to 446A.

446A *Pluchea sericea* ≥ 2% cover. No other species with greater or equal cover. Occurs as narrow stringers at alkaline springs and seeps and as rare extensive stands on alkaline flats such as Devil's Golfcourse and Saline Valley. ***Pluchea sericea*** **Seasonally Flooded Shrubland Alliance.**

446B Go to 447A.

447A *Prunus fasciculata* ≥ 2% cover. Must be 25% or more of total cover. *Gutierrezia sarothrae* may have higher cover. If *Prunus fasciculata* co-occurs with other tall shrubs such as *Acacia greggii*, it must have 2x the cover of other species to make alliance definition. Typically of washes, but may occur on wash terraces and valleys, ***Prunus fasciculata*** **Shrubland Alliance.**

447B Go to 448A.

448A *Psorothamnus spinosus* ≥ 2% cover. No other species with greater or equal cover. Of low elevation washes in southern and central portion of mapping area ***Psorothamnus spinosus*** **Intermittently Flooded Shrubland Alliance.**

448B Go to 449A.

449A *Purshia stansburiana* ≥ 2% cover, no other single species with greater cover. Tends to occur in eastern Mojave Desert limestone mountains in washes in the pinyon and juniper belt. ***Purshia stansburiana*** **Shrubland Alliance.**

449B Go to 450A.

450A *Purshia tridentata* ≥ 2% cover, If *Artemisia tridentata* or *Ephedra viridis* are present they have less than 1% cover. A local type in high eastern and northern portions of mapping area. ***Purshia tridentata*** **Shrubland Alliance**.

450B Go to 451A.

451A Vegetation characterized by the scrub oak *Quercus turbinella*. Occurs in New York Mountains and perhaps Clark Mtn. ***Quercus turbinella*** **Shrubland Alliance**

451B Go to 452A.

452A *Sarcobatus vermiculatus* (Greasewood) ≥ 2%. *Sarcobatus* is the relative dominant and may have *Suaeda moquinii* and *Atriplex* spp. associated in lesser cover. Only known in study area from the alkali dunes and flats above the east shore of Owens Lake. ***Sarcobatus vermiculatus*** **Shrubland Alliance.**

452B Go to 453A.

453A *Suaeda moquinii* ≥ 2% cover. No other species with greater or equal cover. Typically occupying strongly alkaline playas usually with distinct salt deposits in soil surface, but may occur in upland areas adjacent to playas (Owens Lake) where wind-blown salts are deposited. ***Suaeda moquinii*** **Intermittently Flooded Shrubland Alliance.**

453B Go to 454A.

454A *Viguiera parishii* ≥ 2% cover. No other species with greater or equal cover. On northerly slopes of the Mojave Desert characteristically just above *Larrea tridentata-Ambrosia dumosa* , or in washes in east Mojave Desert. ***Viguiera parishii*** **Shrubland Alliance.**

454B Go to 455A.

455A *Viguiera reticulata* ≥ 2% cover. No other species with greater or equal cover. Of calcareous (mostly limestone) washes and arroyos in mountains in the mid- or upper-elevation in the eastern Mojave Desert. ***Viguiera reticulata*** **Intermittently Flooded Shrubland Alliance.**

455B Not Treated in the Key.

# Appendix C. Alliance Descriptions

This appendix provides descriptions for 70 alliances occurring within the map project study area as identified on the vegetation map or special features map. Todd Keller-Wolf and Julie Evens provided photographs.

The descriptions follow a standard format:

- National Vegetation Classification alliance name,
- Habitat: Common upland landforms in which alliance occurs. Common hydrologic regimes in which alliance occurs. Common soil types in which alliance occurs,
- Distribution: Distribution of alliance by ecological section within California (see below) and by state and country for areas outside of California,
- Elevation: Elevation range for the alliance,
- NDDB Rank: The California Natural Diversity Database (http://www.dfg.ca.gov/endangered/ranks.html) ranking of an alliance or the closest alliance synonym. The system consists of global ranks and state ranks. Global Ranks are the worldwide statues of a full species and are indicated with these ratings:
    1. G1 = extremely endangered: < 6 viable occurrences (EO's) or < 1,000 individuals, or < 2,000 acres of occupied habitat
    2. G2 = endangered: about 6-20 EO's, or 1,000 - 3,000 individuals, or 2,000 to 10,000 acres of occupied habitat
    3. G3 = restricted range, rare: about 21-100 EO's, or 3,000-10,000 individuals, or 10,000-50,000 acres of occupied habitat
    4. G4 = apparently secure: some factors exist to cause some concern such as narrow habitat or continuing threats
    5. G5 = demonstrably secure: commonly found throughout its historic range

  State Ranks are the statewide status of a *full species or a subspecies* and are indicated by S1 to S5. S1 to S5 have the same general definitions as global ranks, but just for the range of the taxa within California,
- Synonyms: Labels applied to the alliance in existing classification systems, including: Barry (1989a,b), CALVEG (Matyas and Parker 1980), Cheatam and Haller (1975), Holland (1986), Munz and Keck (1950), PSW-45 (Paysen et al 1980), Thorne (1976) and WHR (Mayer & Laudenslayer 1988), Stone and Sumida (1983), Sawyer and Keeler-Wolf (1995), Rangeland (Shiflet 1994), and Brown, Lowe and Pase (1979),
- References: Additional information on alliance including references to plot-based descriptions that describe and classifies the alliance other than in the Mojave Desert,
- Membership Rules: Criteria to recognize and define the alliance,
- Comments: Notes on the classification of the alliance, vegetation dynamics of the alliance, biology of the dominant species and effects of disturbance,

- Regional Status: Status of the alliance within the Mojave Desert and Southeast Great Basin, the two ecological sections in which parts of the mapping area occur, and
- Management Considerations: Notes on issues of management concern regarding the alliance.

Miles and Goudy (1997) describe one standard for geographic classification of ecological regions. This is a hierarchical system used by several federal agencies to provide a uniform framework of ecosystem classification and mapping throughout the United States. The portion of the hierarchy referred to in this report includes the Ecological Sections and Subsections. Nineteen ecological sections are found in California (Table A1).

Table A1. Ecological Sections in California

| **Ecological Section Name** |
| --- |
| Central California Coast |
| Southern California Coast |
| Great Valley |
| Northern California Coast |
| Klamath Mountains |
| Northern California Coast Range |
| Northern California Interior Coast Ranges |
| Southern Cascades |
| Sierra Nevada |
| Sierra Nevada Foothills |
| Modoc Plateau |
| Central California Coast Ranges |
| Southern California Mountains and Valleys |
| Mojave Desert |
| Sonoran Desert |
| Colorado Desert |
| Mono |
| Southeastern Great Basin |
| Northwestern Basin and Range |

## *Acacia greggii* Shrubland Alliance

Figure A1. *Acacia greggii* Shrubland Alliance, Granite Cove, Granite Mountains

*Acacia greggii* is the sole, dominant, or important tall shrub or small tree in canopy. *Chilopsis linearis, Parkinsonia florida, Juniperus californica, Juniperus osteosperma, Olneya tesota,* or *Psorothamnus spinosus* may be present as emergent trees over the shrub canopy. *Bebbia juncea, Ephedra californica, Encelia virginensis, Ericameria teretifolia, Eriogonum fasciculatum, Hymenoclea salsola, Hyptis emoryi, Larrea tridentata, Opuntia acanthocarpa, Phoradendron californicum, Prunus fasciculata, Rhus ovata, Salazaria mexicana, Senna armata, Viguiera parishii,* or *Yucca schidigera* may be present. Trees < 5 m, scattered; shrubs < 3 m, intermittent or open. Ground layer sparse, annual herbs or grasses seasonally present.

**Habitat:** Rocky slopes, valleys, and bajadas. Washes, intermittent channels, arroyos intermittently flooded riverine or palustrine. Soils coarse, well drained and moderately acidic to slightly saline.

**Distribution**: Mojave Desert, Sonoran Desert, Colorado Desert, and Southern California Mountains and Valleys, south Nevada, west Arizona, Baja California.

**Elevation:** 10 to 1500 m

**NDDB Rank:** G5 S4

**Synonyms**:
Holland: Mojave wash scrub (34250), Mojave desert wash scrub (63700)
Barry: G7411124
Cheatham and Haller: Desert dry wash woodland
PSW-45: Catclaw series
CALVEG: Catclaw series
Thorne: Desert microphyll woodland
WHR: Desert wash
Munz: Creosote bush, Shadscale scrubs, Joshua tree woodland

**References:** Johnson (1976), MacMahon (1988), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Thorne (1982), Turner and Brown (1982), Vasek and Barbour (1977); plot-based descriptions include Vasek and Barbour (1977), Barbour and Wirka (1997), Keeler-Wolf et al.1998.

**Membership Rules**: *Acacia greggii* ≥ 2% cover up to 25% cover. No other single tall shrub species with greater cover but *Prunus fasciculata* or *Hyptis emoryi* may be equal or slightly greater cover than *Acacia.* Smaller shrubs such as *Ericameria paniculata* or *Hymenoclea salsola* can have higher cover but no more than twice the cover of *Acacia greggii.* Occurs in washes, arroyos, as well as upland valleys and bouldery slopes. Evens (2000) states variable cover (1-< 6%) of *Acacia greggii*, but mentions it is always the dominant canopy shrub.

**Comments**: In washes**,** *Acacia greggii* Shrubland Alliance occupies habitat similar to other leguminous microphyll alliances in the Colorado and Sonoran deserts. The *Acacia greggii* Shrubland Alliance extends farther north into the Mojave Desert than these microphyll alliances. Because it is relatively frost-tolerant, it also ascends into the desert mountains and the adjacent desert transition of the Peninsular Ranges. It is a warm-season rain species and does not occur in the western Mojave Desert (T. Keeler-Wolf personal communication, Desert Workshop 2000). Although commonly of washes, arroyos, and lower canyons, *Acacia greggii* Shrubland Alliance may also occupy rocky slopes and valleys away from fluvial disturbance (Reid et al.1999). In Anza-Borrego Desert State Park, it occurs in upland valleys up to 1,200 m and on south-facing rocky granite slopes up to 1,400 m (Keeler-Wolf et al.1998). Evens (2000) sampled 55 plots in the eastern Mojave Desert and described six associations. She indicates that of the six associations she describes as occurring in washes and arroyos only one occurs in lower elevation canyons.

*Acacia greggii* is a large shrub or small tree of the southwest deserts. It is tied to fluvial disturbance in much of its range, lining small to relatively large active washes and arroyos. It is a vigorous sprouter, following flood damage, heavy browsing, or fire, and may be long-lived (FEIS 2001). It is cold-deciduous and requires greater concentrations of water than available in the modal desert landscape. It thus occupies washes, valley bottoms and in some cases, slopes where outcrops and boulders channel surface water to roots. Stands are typically uneven in age. *Acacia* seeds are nutritious and often cached and dispersed by small mammals. Seeds require scarification for germination either by passing through herbivore digestive systems or by abrasion of the seed coat (Young and Young 1986). Recruitment is sporadic. Little information exists on variation in flood frequencies in the wash associations. Fire was not likely to be an important disturbance before the advent of Eurasian annual grasses in portions of its upland distribution. However, in stands with *Pleuraphis rigida* understory, fire may have played a natural disturbance role. *Acacia greggii* individuals are notoriously difficult to kill once they are established (T. Keeler-Wolf personal communication, Desert Workshop 2000).

Flooding intensities along washes are highly variable; however, relatively low discharges (< 20 cu ft./second) are sufficient in small concentrated channels to initiate seed germination and dispersal. *Acacia greggii* may be tolerant of grazing and may be an increaser (Granite Cove, Sweeney Granite Mountains Reserve, Cima Dome area). Fire may enhance the stands due to resprouting following fires spread by fine fuels such as *Bromus madritensis*. Upland stands occur on south-facing slopes as high as 1,300-1,400 m (as in the Granite Mountains and Mid Hills in eastern Mojave Desert). As a result of the resprouting response, *Acacia greggii* stands tend to replace *Larrea tridentata-Ambrosia dumosa, Yucca schidigera, Coleogyne ramosissima* and other related upland alliances following prolonged browsing pressure and/or fire in upland settings. Wash and arroyo stands are relatively persistent, though patchy, and are interspersed with other wash alliances (see *Ericameria paniculata, Hymenoclea salsola, Psorothamnus spinosus, Salazaria mexicana, Eriogonum fasciculatum, Encelia virginensis, Prunus fasciculata, Hyptis emoryi* dominated shrublands). The five Mojave Desert associations defined reflect the range in elevation distribution from the lower and hotter elevations (with *Psorothamnus spinosus* and *Hyptis emoryi* dominated shrublands) through the mid elevations (with *Viguiera parishii* and *Encelia virginensis* dominated alliances) to the cooler, upper elevations (with *Prunus fasciculata* and *Salvia dorrii* dominated shrublands). We expect additional associations to exist in the upland environments.

**Regional Status:**
**Mojave Desert**: Stands occur in the southern and eastern Mojave Desert north to the southern end of Death Valley National Park.
**Sonoran Desert:** Stands occur throughout the Sonoran Desert in California. Flooding intensities have similar effects as in the Mojave Desert portion of its range. *Acacia greggii* alliance appears more restricted to washes in the region due to the excessively dry and relatively low elevations compared to other portions of its California range. Fire and grazing are not as significant an influence as in the Mojave Desert or Peninsular Ranges.

**Management Considerations:** Natural flooding regimes in most wash and riparian settings are adequate for perpetuating the alliance range-wide. Some evidence points to an increase relative to less disturbance-resistant desert alliances in upland stands. It is likely that continued high fire frequency in the upper desert stands with non-native grasses will benefit *Acacia greggii* Shrubland Alliance to the detriment of stands of other non-fire tolerant alliances.

## *Achnatherum speciosum* Herbaceous Alliance

Figure A2. *Achnatherum speciosum* Herbaceous Alliance, Aguerreberry Point, Panamint Mountains

*Achnatherum speciosum* is the sole, dominant, or important grass in ground layer. *Achnatherum hymenoides, Elymus elymoides, Nassella cernua*, and/or *Poa secunda* may be present. Emergent shrubs such as *Coleogyne ramosissima, Ericameria cooperi, Grayia spinosa, Hymenoclea salsola*, and *Krascheninnikovia lanata* may be present. Emergent *Yucca brevifolia* may be present (< 1% cover). Grass < 1 m; cover open to intermittent. Annual herbs may be seasonally present.

**Habitat:** Flat ridges, lower slopes, hills, and swales. Soils sandy, rocky, alluvial

**Distribution:** Mojave Desert, Southeastern Great Basin.

**Elevation:** 600 to 1,800 m

**NDDB Rank:** G1 S1.2

**Synonyms**
Holland: Valley needlegrass grassland (42110 *in part*)
Cheatham and Haller: Creosote bush scrub
Thorne: Creosote bush scrub
WHR: Desert Scrub
Munz: Creosote bush scrub

**References**: Holland (1986), Reid et al. (1999), Sawyer and Keeler-Wolf (1995); plot descriptions occur in the California NDDB.

**Membership Rules:** Vegetation is characterized by the dominance of the bunch grass *Achnatherum speciosum* (desert needlegrass). Rare in mapping area, usually in small enclaves surrounded by more extensive upland vegetation of mid-to-upper elevation Mojave Desert such as *Coleogyne ramosissima* Shrubland.

**Comments:** The species *Achnatherum speciosum* occurs throughout much of the Mojave Desert and Southern Great Basin. However, the *Achnatherum speciosum* Herbaceous Alliance is rare, only known from a few stands in the Mojave Desert and the adjacent Southeastern Great Basin. Its rarity is likely a function of the natural disturbance regimes necessary for its development (see below). However, it is also likely to be a function of the invasion of non-native annual grasses and altered fire frequencies in the California deserts.

*Achnatherum speciosum* will resprout after relatively cool, rapidly spreading fire (Humphrey 1974). Stands of *Achnatherum speciosum* are likely to be associated with past fires. Fires probably occurred most often in late summer or fall. Stands of *Achnatherum speciosum* occupy portions of the desert where fire frequencies are relatively high, such as the borderland between the chaparral and the desert shrublands (Tehachapi Mountains and Antelope Valley). This alliance is likely to be the natural post-fire state of many stands of *Coleogyne ramosissima, Grayia spinosa,* and other fire-susceptible desert shrublands. However, because of the invasion of *Bromus madritensis, Schismus* spp. and other non-native herbaceous species, the increased fire frequencies and rapid invasive qualities of these species have imposed a decline on the importance of native grasses in these desert ecosystems. The successful re-establishment of stands following fire relies on the relatively high stocking of individuals within the pre-fire shrubland. *Achnatherum speciosum* individuals that survive the fire re-sprout rapidly, set seed, and colonize the burned shrubland more rapidly than the formerly dominant woody species. However, shrubland will likely re-invade with the low fire frequencies in most parts of the desert. Fire intervals of 50 years or less are probably necessary to maintain *Achnatherum speciosum* stands. *Achnatherum speciosum* has been seen to invade old cleared agricultural lands in the Antelope Valley of the Mojave Desert (T. Keeler-Wolf personal communication, Desert Workshop 2000).

**Regional Status:**
**Mojave Desert**: Currently stands occur only in the western Mojave Desert, the adjacent Tehachapi Mountains, the eastern Mojave Desert, and Panamint Mountains. These stands are in the upper desert adjacent to stands of *Coleogyne ramosissima, Ericameria teretifolia* or *Grayia Spinosa* Shrublands and *Juniperus californica* or *Yucca* Wooded Shrublands. The Antelope Valley stands are generally small (< 30 ha) and are interspersed among larger stands of *Juniperus californicus, Yucca brevifolia,* and *Ericameria linearifolia*. Stands are generally open and, in good years, may have well developed annual native wildflowers carpeting the bare ground between clumps. The surrounding vegetation is generally well stocked with individuals of *Achnatherum speciosum*, suggesting that with appropriate fire intensity and frequency the stands could increase.

**Southeastern Great Basin:** The only known stands occur in the Panamint Mountains adjacent to stands of *Coleogyne ramosissima* and *Artemisia tridentata*. The irregular shapes of the stands suggest the burn caused the current extent of the stand. Stands are generally < 50 ha.

**Management Considerations:** This rare alliance may have been more common before the invasion of non-native grasses in the deserts of California. In its natural state, it probably represented a relatively short-lived, but important seral community associated with small irregularly occurring fires in the mid-to-upper elevation desert scrubs of the Mojave Desert and the Southeastern Great Basin. All stands should be considered natural resources and should be monitored. Stands of associated shrublands with a significant component of *Achnatherum speciosum* should be identified and post-fire response should be monitored for a better understanding of the shrub/grassland seral relationships and perpetuation of this phase of the natural desert temporal systems. Intensive sheep grazing in the late 1800s and early 1900s may have reduced the range of this alliance. Old rangeland records in the western Mojave Desert on *Achnatherum speciosum* suggest that this species was once more common and widespread (T. Keeler-Wolf personal communication, Desert Workshop 2000).

## *Achnatherum hymenoides* Herbaceous Alliance

Figure A3. *Achnatherum hymenoides* Herbaceous Alliance, Eureka Dunes

*Achnatherum hymenoides* (aka *Oryzopsis hymenoides*) is the sole or dominant grass in ground layer. *Bromus tectorum*, *Elymus elymoides*, *Pascopyrum smithii*, *Koeleria* *macrantha, Poa secunda,* or *Stipa comata* may be present. Emergent shrubs may be present. Grass < 1.5 m tall; cover open.

**Habitat:** All topographic locations. Soils sandy.

**Distribution:** Sierra Nevada, Mojave Desert, Mono, Southeastern Great Basin, Northwestern Basin and Range, western and central U.S.

**Elevation:** 0 to 3,400 m

**NDDB Rank:** G4 S1.2

**Synonyms**
Holland: Mojave mixed steppe
Barry: G7411331 BORHY00
Brown, Lowe and Pase: 142.231
Cheatham and Haller: Great Basin native grassland
PSW-45: Ricegrass series
Thorne: Great Basin sagebrush scrub
WHR: Perennial grass
Munz: Sagebrush scrub

**References:** Heady (1977), Paysen et al. (1980), Stoddart et al. (1975), Turner and Brown (1982); plot descriptions include California NDDB, Major and Taylor (1977).

**Membership Rules:** Vegetation characterized by the medium height bunch grass *Achnatherum hymenoides* (Indian Rice grass). Rare in the Mojave Desert. Usually a sparsely vegetated alliance, with the grass as the major native perennial species. Sandy areas such as dune apron east of Eureka Dunes.

**Comments:** The dominant species, *Achnatherum hymenoides,* is a component of many transmontane California alliances but it rarely dominates stands. In California, most stands where it dominates are small and form fine mosaics with alliances (see *Artemisia tridentata, Abronia villosa, Purshia tridentata* dominated alliances). The ecological literature may refer to *Achnatherum hymenoides* also as *Oryzopsis hymenoides*. *The Jepson Manual* (Hickman 1993) places it in the genus *Achnatherum*; other manuals place it in the genus *Stipa.*

*Achnatherum hymenoides* is a perennial bunchgrass that tolerances low nutrient and water levels. It is commonly found in sandy soils, but individuals may also occur on rocky substrates (including limestone). Seedling establishment is high under moist conditions. Culms are green in the fall and begin growing when spring temperatures become favorable. Plants continue growing into early summer, with more carbohydrates becoming stored in the crowns than in the roots at the end of the growing season. *Achnatherum hymenoides* is good forage for livestock, but heavy early spring grazing easily depletes it. Plants tolerate fire well. Their open crowns burn with little damage to the basal buds. Seedlings establish after fire from off-site seed sources. *Achnatherum hymenoides* may dominate the site within 4 years (Erdman 1970). In some cases, *Achnatherum hymenoides* may locally dominate degraded *Atriplex confertifolia* Shrubland. Such stands are more likely a brief transitional stage between growth cycles of *Atriplex confertifolia* stands. Such a stand occurs along the Death Valley Highway at the junction with Darwin Road. All stands of this alliance in California are known from sandy substrates.

**Regional Status:**
**Southeastern Great Basin:** The alliance occurs at the Eureka Dunes.

**Management Considerations:** This alliance is very rare in California. All stands should be inventoried and monitored.

## *Allenrolfea occidentalis* Shrubland Alliance

Figure A4. *Allenrolfea occidentalis* Shrubland Alliance, Salt Creek

*Allenrolfea occidentalis* is the sole or dominant shrub in canopy. *Suaeda moquinii, Sarcobatus vermiculatus, Atriplex canescens, Distichlis spicata*, *Sporobolus airoides, Frankenia salina* or *Kochia californica* may be present. Shrubs < 2 m tall; canopy continuous to open. Ground layer variable.

**Habitat:** Wetlands intermittently flooded, saturated. Water chemistry: hypersaline. Dry lakebed margins, hummocks, lagoon bars, old lakebeds perched above current drainages, and seeps. Cowardin class: palustrine shrub-scrub wetland. The national list of wetland plants (Reed 1988) lists *Allenrolfea occidentalis* as a Facultative Wetland species.

**Distribution:** Mojave Desert, Sonoran Desert, Colorado Desert, Mono, Southeastern Great Basin, Northwestern Basin and Range, Great Valley, Central California Coast Ranges, southwest U.S., Mexico.

**Elevation:** -80 to 1,800 m

**NDDB Rank:** G3 S2.2 (Great Valley associations are very rare)

**Synonyms**:
Holland: Desert sink scrub (36120 *in part*), Desert greasewood scrub (36130 *in part*), Valley sink scrub (36210 *in part*)
Barry: G7412321
Brown, Lowe and Pase: 153.171
Cheatham and Haller: Alkali sink scrub, saltbush scrub
PSW-45: Iodine bush series
Thorne: Alkali sink scrub
WHR: Alkali sink
Munz: Alkali sink scrub
CALVEG: Iodine bush series

**References:** Bittman (1985), Burk (1977), Griggs (1980), MacMahon (1988), McMahon and Wagner (1985), Payson et al. (1980), Sawyer and Keeler-Wolf (1995), Thorne (1982), Vasek and Barbour (1977), Werschskull et al. (1984), Young et al. (1977): plot descriptions include Odion et al. (1992), McHargue (1973), Keeler-Wolf et al. (1998).

**Membership Rules**: *Allenrolfea occidentalis* ≥ 2% cover, no other single species with greater cover. Occupies strongly alkaline playas usually with distinct salt deposits in soil surface.

**Comments:** This is one of several alliances (see *Atriplex canescens, Suaeda moquinii,* and *Sarcobatus vermiculatus* dominated shrubland alliances) included in alkali sink or scrub vegetation. These alliances commonly occur on and around margins of dry and wet alkaline lakebeds or other bottomlands. Whether a given stand is classed as a member of these alliances or not depends on which species dominates. *Allenrolfea occidentalis* tolerates high salt concentrations. It is typically found in distinctly saline or alkaline situations, often as the only species growing on salt-laden evaporite deposits. Compared to the *Suaeda moquinii* Shrubland Alliance it is more restricted to intermittently saturated substrates and is not found on uplands. Compared to several *Atriplex* dominated shrubland alliances it is more tolerant of high concentrations of salinity and inundation. Stands of these alliances can form a fine mosaic in response to microtopography. *Allenrolfea occidentalis* is less common than these other alliances because of its highly stressful and localized environment. *Allenrolfea occidentalis* occurs at seasonally moist or flooded sites where evaporation concentrates transported salts, leaving visible mineral crusts at the soil surface. *Allenrolfea occidentalis* is tolerant of extreme salinities and heavy soils, which tend to exclude other species, and usually forms the lowest ring of perennial vegetation around desert salt flats. The species tends to tap permanent moisture from relatively long roots and is thus found on playas and other settings where the water table is accessible to the plant's root system.

The *Allenrolfea occidentalis* Shrubland Alliance is restricted to alkaline/saline substrates in desert or semi-desert. Little is known about dispersal and seed viability. Birds are presumably the principal agents of dispersal. These communities are maintained by intra- or inter-annual cycles of flooding followed by extended drought, which favor accumulation of transported salts. The moisture supporting these intermittently flooded wetlands is usually derived off-site, and they are dependent upon natural watershed function for persistence (Reid et al. 1999). *Allenrolfea occidentalis* has a varied morphology depending on the conditions of moisture, salinity, and age of the stand. In general, many Mojave and Colorado desert stands are made up of small, low, and widely spaced shrubs or sub-shrubs, while San Joaquin Valley stands may be composed of shrubs that are up to 2 m in height and width. Based on the substantial woody base of older shrubs, maximum ages of *Allenrolfea occidentalis* may be greater than other shrubs of similar environments such as *Suaeda moquinii*, though little is known about growth rate. Stand density is variable (2-80%). Due to the harsh environment and succulent nature of the plants, fire is unlikely in all but the densest and driest conditions. Disturbance in some areas comes from shifts in the water table beneath the playas.

**Regional Status:**
**Mojave Desert**: *Allenrolfea occidentalis* occurs in all of the Mojave Desert, but is restricted to low-lying alkaline playas and basins. Disturbance patterns are as described generally above. Groundwater pumping seems to have affected some stands in Mesquite Valley dry lake. Bradley (1970) defines two associations in Death Valley National Park (Mojave Desert).
**Sonoran Desert:** *Allenrolfea occidentalis* occurs around some playas.
**Colorado Desert:** *Allenrolfea occidentalis* occurs around playas and in basins. In Anza-Borrego, it occupies playa borders and adjacent lower bajadas as well as alkaline terraces above washes. It mixes with *Suaeda moquinii*-, *Atriplex polycarpa*- and *Atriplex canescens*-dominated shrubland alliances in these locations.

**Management Considerations:** *Allenrolfea occidentalis* Shrubland Alliance is simple floristically and structurally. Management concerns include direct alteration and disturbance such as evaporite mining and scraping and blading for road construction. Groundwater pumping also appears to reduce vigor of the plants. In the stands with high cover, response to fire needs to be researched.

## *Ambrosia dumosa* Dwarf-shrubland Alliance

Figure A5. *Ambrosia dumosa* Dwarf-shrubland Alliance, Panamint Mountain

*Ambrosia dumosa* is the sole or dominant shrub in canopy. *Acamptopappus spherocephalus, Atriplex canescens, Atriplex confertifolia, Atriplex hymenelytra, Echinocactus polycephalus, Ephedra funerea, Encelia farinosa, Larrea tridentata, Opuntia acanthocarpa*, *O. basilaris, O. bigelovii. O. ramosissima,* or *Pleuraphis rigida* may be present. Shrubs in dominant layer < 1 m tall. Emergent *Larrea tridentata* and *Fouquieria splendens* may be present. Tall emergent shrubs < 3 m tall. Emergent trees < 5 m tall. Ground layer is open. Annuals seasonally present.

**Habitat:** Alluvial fans, bajadas, rocky hills, partially stabilized, stabilized sand fields, upland slopes, older wash and river terraces. Soils well drained, may have pavement surface, may be sandy, clay rich, and/or calcareous.
**Distribution:** Mojave Desert, Sonoran Desert, Colorado Desert, and Southeastern Great Basin.

**Elevation:** 0 to 1,700 m

**NDDB Rank:** G5 S4

**Synonyms:**
Sawyer and Keeler-Wolf: Brittlebush-white bursage (*in part*)
Holland: Sonoran creosote bush scrub (33100 *in part*), Mojave creosote bush scrub (34100 *in part*)
Brown, Lowe and Pase: 154.113

Cheatham and Haller: Mojave creosote bush scrub, Sonoran creosote bush scrub
Thorne: Desert dune sand plant community
WHR: Desert scrub
Munz: Creosote bush scrub
CALVEG: White bur-sage series

**References:** Burk (1977), Hunt (1966), MacMahon (1988), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Thorne (1982), Turner (1982b), Turner and Brown (1982), Vasek and Barbour (1977); plot-based descriptions are Keeler-Wolf et al. (1998).

**Membership Rules**: *Larrea tridentata* < 1% cover; *Ambrosia dumosa* > 1% cover and no other species with equal or higher cover. In Keeler-Wolf et al. (1998) described as *Ambrosia dumosa* the major shrub or subshrub with only scattered emergent shrubs (no species > 1%), at least twice greater cover *than Larrea tridentata*, and exceeds cover of any other subshrubs such as *Encelia farinosa.*

**Comments:** This is part of creosote bush scrub. In this alliance *Ambrosia dumosa* dominates or shares dominance with other low shrubs (see *Larrea tridentata-Ambrosia dumosa, Larrea tridentata-Encelia farinosa, Encelia farinosa,* and *Larrea tridentata* alliance descriptions). Shrub density varies, as does diversity. Further sampling throughout much of the California desert over the past several years has refined the description. It is now considered partly disturbance-related, ecologically close to *Larrea tridentata-Ambrosia dumosa, Larrea tridentata-Encelia farinosa, Encelia farinosa,* and *Atriplex hymenelytra* Shrublands and extending from low elevations to over 1,700 m, where it is related to *Atriplex confertifolia* Shrubland and *Juniperus osteosperma* Wooded Shrubland Alliances. The brittlebush-white bursage series of Sawyer and Keeler-Wolf (1995) has been subsumed partially by this alliance, which now includes all stands where *Ambrosia dumosa* dominates or shares dominance with *Encelia farinosa* (≥ 50% relative cover).

*Ambrosia dumosa* is a short-lived shrub living generally < 50 years, although it does have limited cloning abilities. It has relatively shallow and restricted roots. It colonizes sites that have had vegetation removed mechanically more quickly than *Larrea tridentata* (Vasek 1980). *Ambrosia dumosa*, with its high recruitment and mortality rates, dominates in the colonizing stage in many locally disturbed *Larrea tridentata-Ambrosia* stands in the Mojave and Sonoran deserts. *Ambrosia dumosa* is poorly adapted to fire because of its limited sprouting ability (FEIS 2001). Despite its adaptation to early seral transition states, *Ambrosia dumosa* stands often seem to be more defined by substrate than by a higher disturbance frequency than the modal *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance. As a dominant indicator, *Ambrosia dumosa* occurs on sandy substrates (dune aprons, shallow blow sand, wash terraces), rocky hills (of calcareous, igneous, or sedimentary rock), or alluvial fans, particularly older ones with a developed caliche or clay layer. It tends to replace *Larrea tridentata* on soils with high clay content. *Ambrosia dumosa* is a species tolerant of harsh substrates (limestone) and of local site disturbance (excellent recolonizing abilities from seed in adjacent seed sources). It is also removed from areas subjected to long-term, moderate-to-intense grazing, where the palatable foliage is selected over less palatable and more browse-resistant *Larrea tridentata* and other large species.

**Regional Status:**
**Mojave Desert:** *Ambrosia dumosa* Dwarf-shrubland Alliance is scattered throughout the Mojave Desert, found in various settings throughout the region. Its sandy substrate forms such as the *Ambrosia dumosa-Pleuraphis rigida* association occur on linear dunes and sand sheets. Its calcareous rock forms occur in limestone ranges (*Ambrosia dumosa-Ephedra funerea* association), and it may occur as low-diversity, often monospecific stands, in recently disturbed areas adjacent to roads, powerlines, off-highway-vehicle (OHV) areas.
**Southeastern Great Basin:** The Southeastern Great Basin marks the northernmost occurrences of the alliance in California. Here it may co-occur as local disturbance-related stands within larger stands of *Atriplex confertifolia* Shrubland and *Juniperus osteosperma* Wooded Shrubland Alliances at elevations up to 1,500 m. It also occupies limestone outcrops.

**Management Considerations:** Sensitivity to fire carried by non-native annual grasses and to over-grazing, makes the absence of *Ambrosia dumosa* a good indicator of these types of unnatural disturbances. Fire and long-term intensive grazing should be excluded from *Ambrosia dumosa* stands. Typical small-scale disturbance patterns that initiate small stands of *Ambrosia dumosa* (blading, excavation, spot fires) are not a normal part of the processes in the hot deserts of California. Natural stands of *Ambrosia dumosa* Dwarf-shrubland Alliance are more related to particular substrate preferences.

## *Artemisia nova* Dwarf-shrubland Alliance
No photograph is available.

*Artemisia nova* is the sole dominant or important shrub in canopy. *Arenaria macradenia, Atriplex confertifolia, Chrysothamnus viscidiflorus, Echinocactus polycephalus, Ephedra funerea, Ephedra viridis, Eriogonum heermannii, Lycium andersonii, Menodora spinescens, Mortonia utahensis*, or *Krascheninnikovia lanata* may be present. Emergent *Pinus jeffreyi, Pinus monophylla,* or *Juniperus osteosperma* may be present. Shrub < 0.5 m tall; canopy continuous to open. Ground layer sparse or grassy.

**Habitat:** The alliance occurs on flats, depressions, slopes, and ridges. Parent material limestone or other calcareous substrates. Soils are poorly drained to rocky.

**Distribution:** Mojave Desert, Southeastern Great Basin, Southern California Mountains and Valleys, Utah, Nevada, Arizona.

**Elevation:** 1,000 to 2,300 m

**NDDB Rank:** G4 S3.2

**Synonyms:**
Holland: Subalpine sagebrush scrub (in part), Pebble plain scrub (in part).
Barry: G7411211 CARNO00
Brown, Lowe and Pase: 152.113
PSW-45: Sagebrush series
Rangeland: SRM 405
Stone and Sumida: Calcareous community
Thorne: Great Basin sagebrush scrub
WHR: Low sagebrush

**References:** Derby and Wilson (1978, 1979), Krantz (1983, 1988), Paysen et al. (1980), Tisdale (1994), Turner (1982a), Young et al. (1977), West (1988), Reid et al. (1999); plot-based descriptions are found in California NDDB

**Membership Rules:** *Artemisia nova* ≥2% cover. No other single species with greater cover. This is typically an alliance of the limestone mountains and may occur at mid-elevation Mojave Desert or well up into the higher mountains. Other limestone shrubs such as *Mortonia utahensis* may be common. May also mix with lesser amounts of widespread species such as *Atriplex confertifolia*.

**Comments:** In California, *Artemisia nova* is generally restricted to substrates with some calcareous component. This includes harsh rocky desert mountain slopes and canyons, as well as flats with clay-rich soil derived from surrounding calcareous rock. The pebble plain community of the Big Bear Lake area of the San Bernardino Mountains (Krantz 1988; Holland 1986) has *Artemisia nova* alliance stands in deep alluvial soils in small basins adjacent to intermittent lakes and vernally moist valley bottoms. These stands often contain *Thelypodium stenopetalum* or other rare species. They may occur adjacent to stands of *Artemisia tridentata* and *Chrysothamnus viscidiflorus* shrubland alliance or to the true pebble plains stands that are dominated by several rare, low mat-forming perennial herbs such as *Eriogonum kennedyi* var. *austromontanum*. In the mountains of the Mojave Desert and Southeastern Great Basin, stands of *Artemisia nova* are often associated with other calcophile alliances dominated by *Ephedra funerea*, *Purshia stansburiana*, or *Viguiera reticulata*. .

*Artemisia nova* is a fire-sensitive species (FEIS 2001) and does not resprout. However, fire is not a regular component of the disturbance regime of this alliance. Some stands in the San Bernardino Mountains may receive sufficient moisture in some springs to be flooded and thus disturbed. Most desert stands are open and are in rocky or otherwise open stands.

**Regional Status:**
**Mojave Desert:** Stands are known from calcareous alluvium in the Clark Mountains.
**Southeastern Great Basin**: Stands are known from the Last Chance Range, the Cottonwood Mountains, the Funeral Range, and the Panamint Mountains; all drain into Death Valley. Stands are also known from the White and Inyo Mountains**.** Seven stands were sampled in the Southeastern Great Basin as part of this project.

**Management Considerations:** In the San Bernardino Mountains, stands containing rare species are protected from trampling and grazing by the U.S. Forest Service.

## *Artemisia tridentata* Shrubland Alliance

Figure A6. *Artemisia tridentata* Shrubland Alliance, Mid Hills

*Artemisia tridentata* is the sole or dominant shrub in canopy. *Ericameria nauseosa, Chrysothamnus viscidiflorus, Ephedra viridis, Purshia tridentata*, *Ribes velutinum*, or *Tetradymia canescens* may be present. Emergent trees may be present. Shrubs < 3 m tall; cover continuous, intermittent, or open. Ground layer sparse or grassy.

**Habitat:** Bajadas, pediments, alluvium, valleys, dry washes. Soils well-drained, gravelly.

**Distribution:** Southern Cascades, Sierra Nevada, Sierra Nevada Foothills, Modoc Plateau, Great Valley, Southern California Mountains and Valleys, Mojave Desert, Mono, Southeastern Great Basin, Northwestern Basin and Range, Intermountain West, Baja California.
**Elevation:** 300 to 3,000 m

**NDDB Rank:** unknown

**Synonyms**:
Holland: Big sagebrush, Great Basin mixed scrub, Sagebrush steppe
Barry: G7411211 CARTR20

Brown, Lowe and Pase: 142.213, 142.222, 152.111, and 152.112
Cheatham and Haller: Great Basin sagebrush
PSW-45: Sagebrush series
Rangeland: SRM 401, SRM 403
Thorne: Great Basin sagebrush scrub
WHR: Sagebrush
Munz: Sagebrush scrub

**References:** Paysen et al. (1980), Taylor (1976), Tisdale (1994), Vale (1975), West (1988), Wolfram and Martin (1965), Young et al. (1977); plot-based descriptions include Taylor (1980), Keeler-Wolf (1990b), Ferren and Davis (1991), Franklin and Dyrness (1973), Gordon and White (1994), Spolsky (1979), and Keeler-Wolf et al. (1998)

**Membership Rules:** *Artemisia tridentata* ≥ 2% cover, no other single species with greater cover, and *Ephedra viridis* < 1% cover.

**Comments:** Stands of the *Artemisia tridentata* Shrubland Alliance are extensive and varied in the Great Plains, Pacific Northwest, Great Basin, and Southwest. Some stands of this alliance have scattered juniper, pine, or *Yucca brevifolia* trees. *Artemisia tridentata* occurs as an important understory shrub in stands of woodland and forest alliances (see *Pinus monophylla-Juniperus osteosperma*, *Pinus washoensis, Pinus jeffreyi* Woodlands and *Juniperus occidentalis* and *Yucca brevifolia* Wooded Shrublands). Where *Artemisia tridentata* shrubs are infrequent, the stand is placed within an herbaceous alliance.

In California *Artemisia tridentata* includes four subspecies. In Intermountain West vegetation classifications, subspecies define different alliances. In California, the subspecies have overlapping ranges, and two subspecies are uncommon (*Artemisia tridentata* ssp. *parishii,* and *Artemisia tridentata* ssp. *wyomingensis*). *Artemisia tridentata* ssp. *vaseyana,* with narrow inflorescences, tends to grow on slopes at higher elevations than *Artemisia tridentata* ssp. *tridentata,* which inhabits valley bottoms.

Young et al. (1977) list 11 species as important grasses in describing regional variation in the alliance. Keeler-Wolf (1990b) qualitatively describes a ridgetop stand at Mud Lake Resource Natural Area in Plumas Co., at Cahuilla Mountain RNA in Riverside Co.; at Whippoorwill Flat RNA in Inyo Co.; Hanes (1976) describes vegetation types in the San Gabriel Mountains including the *Artemisia tridentata* Shrubland Alliance.

*Artemisia tridentata* ecology varies among subspecies, and their differences are mainly known for areas outside the state. *Artemisia tridentata* ssp. *tridentata* grows in deep, fertile soils, so much of its habitat has been claimed for pasture and agriculture. It is less palatable to livestock and wildlife than *Artemisia tridentata* ssp. *vaseyana* and grows on the foothills and mountain slopes in shallow, well-drained, rocky soils. It is an important browse for livestock and wildlife, especially in the winter. Much of the lands dominated by big sagebrush are over-grazed.

Big sagebrush plants are easily killed by fire. Seeds from this shrub are prolific and have high germination rate, which allows for rapid establishment of seedlings following fire. Seed are available from surviving plants and from a bank of seeds that are viable up to 5 years. Seed dispersal is less than 4 m. It takes about a decade for seedlings to grow to dominate the site. Shrubs live to 50 years. Severe fires that burn the banked seeds and mycorrhizal spores are slow to regenerate.

**Regional Status:**
**Mojave Desert:** Locally present stands had higher elevations in the northeastern part
**Southeastern Great Basin:** Common.

**Management Considerations**: No additional information is available.

## *Atriplex hymenelytra* Shrubland Alliance

Figure A7. *Atriplex hymenelytra* Shrubland Alliance, Death Valley

*Atriplex hymenelytra* is the sole or conspicuous shrub in canopy. *Encelia farinosa, Ambrosia dumosa, Atriplex confertifolia, Suaeda moquinii, Larrea tridentata, Tidestromia oblongifolia, Dalea mollossima,* or *Peucephyllum schottii* may be present. Shrubs < 1 m tall; canopy open. Ground layer sparse; annuals seasonally present.

**Habitat:** Alluvial fans, along washes, steep colluvium, recent lava flows, cinder cones. Soils are derived from alluvium, colluvium, and residuum from metamorphic, igneous, and other sedimentary rocks and may be carbonate, alkaline, or salt-rich. Also, wetland habitats such as intermittently flooded wash bottoms. Cowardin Class: riverine.

**Distribution:** Mojave Desert, Sonoran Desert, Colorado Desert, and Southeastern Great Basin.

**Elevation:** -75 to 1,400 m

**NDDB Rank:** G5 S4

**Synonyms**:
Holland: Desert saltbush scrub (36110 *in part*)
Barry: G7411221
Cheatham and Haller: Creosote bush scrub
PSW-45: Saltbush series
Thorne: Creosote bush scrub
WHR: Desert scrub
Munz: Creosote bush scrub
CALVEG: Desert holly series

**References:** Brown (1982), Hunt (1966), Johnson (1976), MacMahon (1988), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Thorne (1982); plot-based descriptions include Annable (1985) and Schramm (1982)

**Membership Rules**: *Atriplex hymenelytra* > 1% cover and no other species with equal or higher cover. May occur on hot rocky slopes, dry bajadas, or alkaline badlands and playa edges.

**Comments:** This alliance is part of either creosote bush scrub or saltbush scrubs ecological system, which is a collection of alliances. This alliance shares species with the *Larrea tridentata, Larrea tridentata-Ambrosia dumosa,* and *Larrea tridentata-Encelia farinosa* Shrublands. It commonly occurs along drainages that dissect the west-facing bajadas and on western and southern slopes of very dry mountains. It also occurs on desert pavement with very sparse vegetation. It may occupy rough lava and limestone deposits with skeletal soil and heavy alkaline sea floor and lake sediments (mud hills). The density of shrubs is usually very low. This is the most xeric shrub alliance in the Mojave Desert. It persists in extremely hot, dry locations where almost no other perennial shrub is able to flourish.

In its rarified environment, *Atriplex hymenelytra* alliance has relatively simple seral relationships. *Atriplex hymenelytra* can be both an invader and a long-lived stable component of the landscape. Studies at the Zzyzx Desert Studies Center (A. Romspert, personal communication) indicate individuals are long-lived and may undergo sex change based on age and environmental conditions. Recruitment at Trona Pinnacles is episodic; the last major event was 21 years ago, suggesting long-viable seeds in soil (G. Harris, personal communication). Natural disturbance in the harsh upland environments comes mostly as shifts in moisture availability. A series of wetter years will shift the *Atriplex hymenelytra* toward other desert alliances such as *Larrea tridentata, Larrea tridentata-Ambrosia dumosa* or *Larrea tridentata-Encelia farinosa* Shrublands. A series of drier years will eliminate individual *Atriplex hymenelytra* and other component species and leave only annual ephemeral herb species, such *Geraea canescens* and *Chorizanthe rigida*, in the seed bank. Where *Atriplex hymenelytra* occurs in washes it generally occupies the rocky, gravelly bottoms that have little or no organic build up in the substrate. These washes may not receive water for several successive years. Surrounding upland vegetation may include *Larrea tridentata-Ambrosia dumosa* or *Larrea tridentata-Encelia farinosa* Shrublands or desert annuals. Tolerance of bare mineral substrate with low nutritional value, and no apparent mycorrhizal associations confer an advantage for *Atriplex hymenelytra* in colonizing low-elevation washes as well as roadcuts and other unnatural disturbances. *Tidestromia oblongifolia*, one of the most common associates of this alliance, is commonly found in disturbed sites (OHV areas, roadsides). It is possible that severe degradation of upland *Atriplex hymenelytra* stands can result in *Tidestromia oblongifolia* alliance, but this has not yet been described.

**Regional Status:**
**Mojave Desert:** *Atriplex hymenelytra* occurs in all parts of the Mojave Desert, but is more common in the northern Mojave Desert. There it may form large stands hundreds of hectares in size, on lower bajadas, rocky slopes, and alkaline mud hills. Disturbance patterns are as described generally above.
**Southeastern Great Basin:** This alliance occurs in large stands on lava, cinder fields and other volcanic substrate in the Cottonwood Mountains. It also occurs in smaller stands in the Inyo, Grapevine, Coso/Argus and Panamint Ranges. At Owens Lake it may intermingle with *Suaeda moquinii* and *Atriplex confertifolia* dominated alliances on wind-blown alkaline deposits on the lower bajadas of the Inyo Mountains.

**Management Considerations:** *Atriplex hymenelytra* Shrubland Alliance is simple floristically and structurally. It occurs in such harsh environments that it is rarely impacted by human-mediated disturbance, except by OHV activity in some areas (e.g., Trona Pinnacles). As with other shrubby *Atriplex* species, *Atriplex hymenelytra* is likely to be palatable to livestock. Management concerns are minimal except where mining, OHV, and grazing activity are present.

## *Atriplex polycarpa* Shrubland Alliance

Figure A8. *Atriplex polycarpa* Shrubland Alliance, Emigrant Canyon

*Atriplex polycarpa* is the sole or dominant shrub in canopy. *Ambrosia dumosa, Atriplex canescens, Bromus madritensis, Chamaesyce polycarpa, Distichlis spicata, Hymenoclea salsola, Isocoma acradenia, Larrea tridentata* or *Schismus barbatus* may be present. Emergent *Prosopis glandulosa* may be present. Shrubs < 3 m tall; canopy continuous to open. Ground layer variable, including native annuals.

**Habitat:** Soil of old beach, lake deposits; dissected alluvial fans, alluvial terraces, rolling hills. Soils may be carbonate-rich, alkaline, sandy, sandy clay loams. Washes, playa lakebeds and shores. Water chemistry: mixohaline. Cowardin class: palustrine shrub-scrub wetland. The national list of wetland plants (Reed 1988) lists *Atriplex polycarpa* as a Facultative Upland species.

**Distribution:** Mojave Desert, Colorado Desert, Sonoran Desert, Great Valley, Central California Coast Ranges, Southern California Mountains and Valleys, Sierra Nevada Foothills, Southeastern Great Basin, Nevada, Arizona, New Mexico, Mexico

**Elevation:** -75 to 1,500 m

**NDDB Rank:** G5 S4 some associations are rare in Great Valley (S2, S1)

Synonyms:
Holland: Relictual interior dunes (23200), Desert saltbush scrub (36110 *in part*), Valley saltbush scrub, (36220 *in part*), Sierra-Tehachapi saltbush scrub (36310), Interior coast range saltbush scrub (36320)
Barry: G7411221 CATPO00
Cheatham and Haller: Saltbush scrub
PSW-45: Saltbush series
Thorne: Shadscale scrub
WHR: Alkali sink
Munz: Creosote bush scrub, shadscale scrub
CALVEG: Allscale series

**References:** Bittman (1985), Burk (1977), Griggs (1980), Griggs and Zanovitch (1984), Johnson (1976), MacMahon (1988), MacMahon and Wagner (1985), McHargue (1973), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995).
Vasek and Barbour (1977), Werschkull et al. (1984); plot-based descriptions include Keeler-Wolf et al. (1998).

**Membership Rules**: *Atriplex* > 2% absolute and > 50% relative canopy cover. *Atriplex polycarpa* with highest shrub cover. May occur on playa edges, in washes through alkaline areas, or occasionally uplands with alkaline substrate.

**Comments:** This alliance is part of the saltbush scrub ecological system. One or more perennial species of *Atriplex* spp. dominate most alliances within the saltbush scrub collection of alliances (see also *Atriplex canescens, Atriplex spinifera, Atriplex hymenelytra, Atriplex confertifolia* Shrublands). *Atriplex polycarpa* Shrubland is the most widespread and common of the saltbush scrub in the Mojave Desert and the foothills surrounding the southern San Joaquin Valley. It occupies large areas of the central and western Mojave Desert, either adjacent to playas or in large spreading basins. It also covers many of the low hills of the Inner Coast Ranges, the southern Sierra and Tehachapi foothills. It is more narrowly distributed, mostly in alkaline basins and along washes and stream channels, in portions of the Sonoran and Colorado deserts and the Southeastern Great Basin. *Atriplex polycarpa* is a facultative phreatophyte and occurs in moderately saline (< 2%) conditions, just above the water table or xeric non-saline upland sites (Vasek and Barbour 1977). It has limited salt tolerance and is very drought-tolerant (Vasek and Barbour1977). These two factors interact to control water stress in plants and define habitat boundaries. In California, *Atriplex spinifera* and *Atriplex canescens* are more tolerant of finer textured soils and higher alkalinity (T. Keeler-Wolf personal communication, Desert Workshop 2000).

*Atriplex polycarpa* produces abundant seed, which is banked in the soil. Following some disturbance events, such as heavy grazing, and with sufficient winter rain, *Atriplex polycarpa* produces abundant seedlings (T. Keeler-Wolf personal communication, Desert Workshop 2000). Many North American species of *Atriplex* are highly tolerant of fire. If top-killed, they sprout prolifically (FEIS 2001). However, *Atriplex polycarpa* is only a weak root-sprouter (T. Keeler-Wolf personal communication, Desert Workshop 2000).

Managers in some parts of its range are concerned about the alliance, because human caused fires have burned the matrix of annual grassland and *Atriplex polycarpa*, diminishing its extent. Due to the arid climate and typically low elevation of stands in much of its range, fire was not likely to have been a significant natural disturbance agent. *Atriplex polycarpa* as with other *Atriplex* spp. may be more sensitive to fire, depending on the time of year, with late spring and summer fires more destructive. However, in some areas of upper elevations, fire is a natural component of disturbance. Most natural fires were relatively small and had long intervals (T. Keeler-Wolf personal communication, Desert Workshop 2000). Because it produces abundant, wind-dispersed seed, *Atriplex polycarpa* probably also establishes on burned sites from off-site seed. The natural disturbance cycle in much of its range also includes flooding events. In deserts, this alliance commonly occupies the terraces and edges of large, low gradient washes. Flood frequencies are not as high as in adjacent wash bottom alliances such as *Ericameria paniculata, Hymenoclea salsola, Psorothamnus spinosus,* or *Bebbia juncea* dominated shrublands, but are higher in frequency than in *Larrea tridentata-Ambrosia dumosa* Shrubland and other surrounding upland alliances.

**Regional Status:**
**Mojave Desert**: *Atriplex polycarpa* occurs throughout all of the Mojave Desert, but is more common in the western Mojave Desert. There it may form large stands thousands of hectares in size (as between Red Mountain and Kramer Junction), in slightly alkaline plains and basins. In these areas *Atriplex polycarpa* gives way to *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance on rocky hills. Some of these stands have colorful and diverse annual flower displays on years with high rain (*Coreopsis bigelovii, Lasthenia californica, Phacelia distans,* etc.) Other stands have very high cover of non-native grasses (*Bromus madritensis* and *Schismus* sp.). Disturbance patterns are generally as described above. *Atriplex spinifera* Shrubland Alliance stands tend to be on finer-textured soils compared to *Atriplex polycarpa*. At Red Rock Canyon State Park, some resprouting has been noted after light blading of shrubs by bulldozers.

**Management Considerations:** *Atriplex polycarpa,* as with other shrubby *Atriplex* species, is palatable to livestock. Reduction in extent due to grazing and fire needs to be investigated. Losses due to intensive agriculture and development have occurred in the Great Valley and surrounding foothills. Fire has increased greatly since the spread of non-native annual grasses in the understory of many stands. Protection of stands from fire may become necessary in the western Mojave Desert and the San Joaquin Valley and surrounding foothills.

## *Atriplex spinifera* Shrubland Alliance

No photograph is available.

*Atriplex spinifera* is the sole or dominant shrub in canopy. *Atriplex polycarpa*, *Frankenia salina, Ephedra californica, Hymenoclea salsola,* and/or *Distichlis spicata* may be present. Shrubs < 2 m tall; canopy open. Ground layer variable. Annuals seasonally present.

**Habitat:** Alluvial fans; old lakebeds perched above current drainages. Soils may be carbonate-rich. Wetland habitats intermittently flooded, saturated. Water chemistry: mixosaline. Dry lakebeds, plains. Cowardin class: palustrine shrub-scrub wetland. The national list of wetland plants lists *Atriplex spinifera* as a Facultative species.

**Distribution**: Central California Coast Ranges, Great Valley, and Mojave Desert

**Elevation**: 50 to 800 m

**NDDB Rank**: G2 S2.2 stands in the southern Great Valley may be very rare (S1.1)

**Synonyms:**
Holland: Desert saltbush scrub (36110 *in part*), Valley saltbush scrub, (36220 *in part*), Sierra-Tehachapi saltbush scrub (36310), Interior coast range saltbush scrub (36320)
Barry: G7411221 CATPO00
Cheatham and Haller: Saltbush scrub
PSW-45: Saltbush series
Thorne: Shadscale scrub
WHR: Alkali sink
Munz: Creosote bush scrub, shadscale scrub
CALVEG: Allscale series

**References:** Bittman (1985), Burk (1977), Griggs (1980), Griggs and Zanovitch (1984), Johnson (1976), MacMahon (1988), MacMahon and Wagner (1985), McHargue (1973), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Vasek and Barbour (1977), Werschkull et al. (1984); plot-based descriptions include Phillips and MacMahon (1981) in MacMahon (1988).

**Membership Rules**: *Atriplex spinifera* with highest shrub cover. Largely restricted to the Western portion of the mapping area around edges of playas and other alkaline situations.

**Comments:** This alliance is part of saltbush scrub ecological system, which is a collection of alliances dominated by saltbush species as *Atriplex canescens, Atriplex hymenelytra,* and/or *Atriplex confertifolia*. *Atriplex spinifera* Shrubland is the most restricted of the *Atriplex*-dominated alliances in the Mojave Desert and the foothills surrounding the southern San Joaquin Valley. It occupies small areas of the central and western Mojave Desert, either adjacent to playas or in large spreading basins. It is frequently associated with *Atriplex polycarpa* alliance stands, but often occurs more immediately adjacent to playas, while *Atriplex polycarpa* may occur farther away from the lakebeds. Similarly, in the southern San Joaquin Valley, *Atriplex spinifera* stands are often associated with alkaline soils of basins and occur adjacent to stands of *Allenrolfea occidentalis,* while *Atriplex polycarpa* stands are more commonly found on uplands.

*Atriplex spinifera,* as with the related *Atriplex polycarpa* and *Atriplex confertifolia* Shrublands, probably produces abundant seed, which is banked in the soil. However, little specific information is available. Fire is not likely to be a strong natural impact to the stands of this alliance but it may be a negative impact in areas where annual grass cover is high.

**Regional Status:**
**Mojave Desert:** Stands of *Atriplex spinifera* are largely restricted to the western Mojave Desert, where they occur adjacent to alkaline playas usually in combination with *Atriplex polycarpa* or *Atriplex canescens*.

**Management Considerations:** Stands in the San Joaquin Valley are considered rare and threatened due to the fragmented habitat and threats from fire carried by non-native annual grasses.

## *Atriplex canescens* Shrubland Alliance

Figure A9. *Atriplex canescens* Shrubland Alliance, Stovepipe Wells

*Atriplex canescens* is the sole or dominant shrub in canopy. *Ambrosia dumosa, Atriplex confertifolia, Atriplex polycarpa, Chrysothamnus viscidiflorus, Ephedra viridis, Grayia spinosa, Hymenoclea salsola, Isomeris acradenia, Larrea tridentata,* or *Suaeda moquinii,* may be present. Emergent *Prosopis glandulosa* may be present. Shrubs < 3 m tall, canopy open or intermittent. Trees < 5 m tall, scattered distribution. Ground layer variable, seasonally present including annual herbs and non-native grasses.

**Habitat:** Soil of old beach, lake deposits; dissected alluvial fans, rolling hills. Soils may be carbonate-rich, alkaline, sandy, sandy clay loams. Wetland habitats such as washes, playa lakebeds and shores. Water chemistry: mixohaline. Cowardin class: palustrine shrub-scrub wetland. The national list of wetland plants (Reed 1988) lists *Atriplex canescens* as a Facultative Upland species.

**Distribution:** Mojave Desert, Colorado Desert, Sonoran Desert, Great Valley, Central California Coast Ranges, Southern California Mountains and Valleys, Southeastern Great Basin, Intermountain West.

**Elevation:** -75 to 1,500 m

**NDDB Rank:** G5 S4, some associations are rare in Central California Coast Ranges

**Synonyms:**
Holland: Relictual interior dunes (23200), Desert saltbush scrub (36110 *in part*), Valley saltbush scrub, (36220 *in part*), Sierra-Tehachapi saltbush scrub (36310), Interior coast range saltbush scrub (36320)
Barry: G7411221 CATPO00
Cheatham and Haller: Saltbush scrub
Rangeland: SRM 414
PSW-45: Saltbush series
Thorne: Alkali sink scrub
WHR: Alkali sink
Munz: Creosote bush scrub, shadscale scrub, alkali sink
CALVEG: Allscale series

**References:** Bittman (1985), Burk (1977), Griggs (1980), Griggs and Zanovitch (1984), Johnson (1976), MacMahon (1988), MacMahon and Wagner (1985), McHargue (1973), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Vasek and Barbour (1977), Werschkull et al. (1984); plot-based descriptions include Keeler-Wolf et al. (1998).

**Membership Rules**: *Atriplex canescens* with highest shrub cover. Typically of low-lying playa edges, dune aprons, or edges of alkaline wetlands from low- to mid- elevation Mojave Desert.

**Comments:** This alliance is part of the saltbush scrub ecological system, which is a collection of alliances dominated by *Atriplex polycarpa, Atriplex spinescens, Atriplex lentiformis, Atriplex hymenelytra,* or *Atriplex confertifolia* species. In California, *Atriplex canescens* Shrubland occurs in the low hills of the Inner South Coast Range.

In California, ecological settings for the alliance are variable. They include sandy dune aprons and low dunes, as in Death Valley and Saline Valley, and moderately alkaline playas such as Silver Dry Lake and Superior Dry Lake. In the hot deserts of California, *Atriplex canescens* appears to have more of an affinity for windblown sand than other *Atriplex* shrubs and frequently forms part of the dune margin matrix with stands of *Prosopis glandulosa, Pleuraphis rigida,* and *Larrea tridentata-Ambrosia* Shrublands. *Atriplex canescens* also mixes regularly with other species of *Atriplex* to form mixed stands in washes (*Atriplex canescens*-*Atriplex polycarpa*), and on playa and playa edges (*Atriplex canescens*-*Atriplex confertifolia*). Associated alliances range from wetland types such as *Schoenoplectus americanus, Distichlis spicata, Pluchea sericea,* and *Juncus balticus*- dominated alliances to playa types dominated by *Suaeda moquinii, Allenrolfea occidentalis,* and *Atriplex polycarpa* to upland types dominated by *Atriplex confertifolia, Grayia spinosa,* and *Coleogyne ramosissima.* Chromosomal differences in populations explain, at least partially, the wide variety of ecological settings in which the alliance occurs.

Different ploidy levels of *Atriplex canescens* appear to occupy different ecoregions. These include hot desert and cold desert ecotypes (FEIS 2001). The species is one of the most rapidly evolving shrubs in North America (FEIS 2001). In California, *Atriplex canescens* occurs in 34 counties (CalFlora 2000), including ssp. *linearis* and ssp. *canescens* as treated in *The Jepson Manual* (Hickman 1993), but the alliance is largely restricted to the deserts and the San Joaquin Valley and surrounding foothills.

*Atriplex canescens* is a very widespread species throughout the western United States. The species has been used extensively for rehabilitation of mine excavations in Wyoming and Montana. It colonizes readily from seed and does not appear to require mycorrhizal associations to grow vigorously. Tolerant of grazing, the species is also resistant to fire because of moist and non-volatile leaf composition. If top-killed, it sprouts prolifically (FEIS 2001). Natural disturbance processes probably did not involve fire to any great degree in most California stands except in the cismontane region. Fire may be more important currently because of invasion of *Bromus* spp. in understory and increased ignitions caused by people.

**Regional Status:**
**Mojave Desert:** *Atriplex canescens* occurs throughout the Mojave Desert. It occurs less commonly in large stands than *Atriplex polycarpa,* and small stands may occur within a matrix of *Prosopis glandulosa* Shrubland along streams and washes or at edges of dunes. It is more restricted to alkaline areas than *Atriplex polycarpa* Shrubland and does not occur on rocky uplands, as does *Atriplex confertifolia* or *Atriplex hymenelytra* Shrubland Alliances. It commonly associates with *Suaeda moquinii* Intermittently Flooded Shrubland Alliance at edges of playas.
**Southeastern Great Basin:** Occupies edges of playas, valleys, and flats with clay soil (northern Panamint Range). Stands at higher elevations than elsewhere in the state (up to 1,600 m) may indicate different ecotype and ploidy levels than in hot deserts of California.

**Management Considerations:** In general, this alliance is in good shape throughout its range. Its ability to tolerate alkaline soils, grazing, fire, and other disturbance bodes well for its persistence. Investigations are needed on the alliance's sensitivity to high levels of grazing and fire at certain times of the year (FEIS 2001). This may be particularly important in the cismontane distribution of the species.

## *Atriplex confertifolia* Shrubland Alliance

Figure A10. *Atriplex confertifolia* Shrubland Alliance, Amargosa Desert

*Atriplex confertifolia* is the sole or dominant shrub in canopy. *Ambrosia dumosa, Artemisia spinescens, Atriplex polycarpa, Atriplex spinescens, Chrysothamnus viscidiflorus, Encelia actonii, Coleogyne ramosissima, Ephedra nevadensis, Eriogonum heermannii, Grayia spinosa, Gutierrezia microcephala, Krascheninnikovia lanata, Larrea tridentata, Lycium andersonii, Sarcobatus vermiculatus,* or *Tetradymia axillaris* may be present. Shrubs < 1 m tall; canopy continuous, intermittent, or open. Emergent taller shrubs may be present. Ground layer sparse.

**Habitat:** Bajadas, flats, edges of playas, lower slopes, rocky hills, valleys, and minor rills and washes. Soils variable; may be carbonate-rich, clay-rich, may have high sand content, may have desert pavement. Wetland habitats such as ashes, playa lakebeds and shores. Water chemistry: mixohaline. Cowardin class: palustrine shrub-scrub wetland. The national list of wetland plants (Reed 1988) lists *Atriplex confertifolia* as a Facultative Upland species.

**Distribution:** Northwestern Basin and Range, Mono, Southeastern Great Basin, Mojave Desert, Modoc Plateau, Intermountain West

**Elevation:** 450 to 2,500 m

**NDDB Rank:** G4 S3.2

**Synonyms:**
Holland: Shadscale scrub (36140)

Cheatham and Haller: Shadscale scrub
PSW-45: Saltbush series
Rangeland: SRM 414, SRM 501
Thorne: Shadscale scrub
WHR: Alkali sink
Munz: Shadscale scrub
CALVEG: Shadscale series

**References:** Beatley (1976), Burk (1977), MacMahon (1988), MacMahon and Wagner (1985), McHargue (1973), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Thorne (1982), Turner (1982b), Vasek and Barbour (1977), Young et al. (1977).

**Membership Rules**: *Atriplex confertifolia* ≥ 2% cover. No other single species with greater cover with the exception of woody subshrubs such as *Krameria* spp. May occur in alkaline valleys or playas and in upper mid-elevation Mojave Desert on rolling hills and slopes, particularly common in the northern portion of the mapping area.

**Comments:** *Atriplex confertifolia* Shrubland is one of the major regional vegetation types of the Great Basin Province. It exists in many associations from low alkali basins across extensive intermountain flats and on rocky upland soils. It ranges widely south and west into the Mojave Desert. The species continues westward across the Tehachapi Mountains into the southern San Joaquin Valley and to the Carrizo Plain of San Luis Obispo Co. Chromosomal variation enables, at least in part, the variety of ecological settings occupied by *Atriplex confertifolia*. Diploid individuals typically occur in rocky uplands. Tetraploids typically occur in basins at lower elevations in extensive, nearly pure stands. Octaploid and decaploid races also grow in extensive, pure stands in lower elevation basins, or with *Artemisia tridentata* or *Sarcobatus vermiculatus* (FEIS 2001). Male *Atriplex confertifolia* plants are much more common on harsher sites than are female plants (FEIS 2001). *Atriplex confertifolia* Shrubland occurs adjacent to *Larrea tridentata-Ambrosia* Shrubland in the Mojave Desert and ranges up into the *Artemisia tridentata* Shrubland and the edge of the *Juniperus osteosperma* and *Pinus monophylla* Woodland.

*Atriplex confertifolia* Shrubland is disturbance-related at least in part. In many parts of its range, it tolerates moderate or even heavy grazing (FEIS 2001). It also has increased its range relative to other alliances such as *Artemisia tridentata*, *Artemisia nova*, and *Krascheninnikovia lanata* Shrublands because of grazing and mechanical disturbance. *Atriplex confertifolia* reestablishes readily following mechanical treatments. For example, it can replace cleared stands of *Artemisia tridentata* and dominate sites in less than 10 years (FEIS 2001). *Atriplex confertifolia* is sensitive to certain types of disturbance. Grazing in the fall tends to decrease stands (FEIS 2001). Prolonged drought tends to kill most mature shrubs in a stand, and shrubs are not typically long lived. Thus, stands tend to increase and diminish due to the irregular, desert precipitation patterns.

The effects of fire on *Atriplex confertifolia* Shrubland are not well understood. Fire does not typically affect the open stands of most *Atriplex confertifolia. Bromus tectorum* and other non-native annual exotics are likely to carry fire readily through many stands. It is likely that *Atriplex confertifolia* is resistant to fire because of its low volatilization rates. However, resistance may be related to timing and intensity of the fire. Also, in most stands fire is not a factor due to the relative openness of the stand. The species apparently does not resprout. Although most stands tend to consist of relatively short-lived shrubs, individuals of *Atriplex confertifolia* have been estimated to live over 100 years, as seen from historical photography matching (Robert Webb, personal communication).

**Regional Status:**
**Mojave Desert:** Stands include both upland and basin types. In Owens Valley, the Funeral Mountains, Greenwater Valley, the Owlshead Mountains, Searles Valley, and Granite Mountains upland stands occur on rocky hills mixed with stands of *Ephedra nevadensis, Menodora spinescens, Larrea tridentata-Ambrosia dumosa, Yucca schidigera,* and *Yucca brevifolia*-dominated alliances. In the Owens Valley, Pahrump Valley, and central Mojave Desert valleys, stands also occur in valleys and flats surrounding and within playas and alkali basins. Most stands in the southern portion of the range of the alliance are in valleys surrounding *Atriplex polycarpa* Shrubland and below upland stands of *Larrea tridentata-Ambrosia* Shrubland (e.g., Superior Dry Lake, Coolgardie Mesa).
**Southeastern Great Basin:** Upland stands are extensive in the Cottonwood Mountains and Coso, Argus and Panamint ranges, where they may intermix with *Yucca brevifolia, Grayia spinosa, Artemisia tridentata* and *Larrea tridentata-Ambrosia dumosa* Shrublands. Several upland stands in the Cottonwood Mountains show recent demise of many shrubs and are currently occupied by species of sandy substrates including *Achnatherum hymenoides.*

**Management Considerations:** *Atriplex confertifolia* Shrublands occupy a broad spectrum of environmental situations in the Southeastern Great Basin and Mojave Desert. It may occur as a seral and invasive alliance; it may be short-lived or site-persistent. We need further information in California to understand the natural and disturbance-related contexts for this alliance. Since the species increases under browsing, its presence in certain areas may be due to response to grazing. However, some stands in all ecological settings may be natural. Response to fire and invasion of *Bromus* and *Schismus* spp. needs to be investigated.

## *Baccharis sergiloides* Intermittently Flooded Shrubland Alliance

Figure A11. *Baccharis sergiloides* Intermittently Flooded Shrubland Alliance

*Baccharis sergiloides* is the sole or dominant shrub in canopy. *Eriogonum fasciculatum Gutierrezia microcephala, Lotus rigidus, Yucca schidigera, Ericameria linearifolia, Sphaeralcea ambigua, Acacia greggii, Opuntia acanthocarpa Artemisia ludoviciana, Prunus fasciculata,* or *Rhus trilobata* may be present. Emergent *Populus fremontii* and *Salix* species may be present. Shrubs < 5 m tall; canopy open to continuous. Understory is sparse to intermittent.

**Habitat:** Washes, arroyos and canyon bottoms. Streams and seeps, intermittently flooded. Soils seasonally saturated, gravelly to sandy to medium fine sandy loam. Cowardin class: intermittently flooded riverine or palustrine.

**Distribution:** Mojave Desert, Southern California Mountains and Valleys, Nevada, Arizona, north Mexico.

**Elevation:** 1,000 to 1,800 m

**NDDB Rank:** G4 S3.2

**Synonyms:**
Holland: Mojave wash scrub (34250), Mojave desert wash Scrub (63700)
Barry: G7411124
Cheatham and Haller: Desert dry wash woodland

WHR: Desert wash
Munz: Pinyon-juniper woodland, Joshua Tree woodland

**References**: Beatley (1976), Evens (2000); plot-based descriptions found in Evens (2000)

**Membership Rules:** *Baccharis sergiloides* dominant. Typically of intermittent springs and washes in mid-elevation Mojave Desert**.**

**Comments:** *Baccharis sergiloides* is a common shrub of moist canyon bottoms, seeps, and springs in the mountains of the Mojave Desert. It occurs in similar habitats in the desert-facing Peninsular and Transverse ranges of California. Stands are typically small and occur in relatively moist, intermittently flooded stretches of canyon bottoms, or borders and tails of springs and seeps. Boulders and bedrock typically break up the stands, although rooting substrate is typically relatively fine sand. Evens (2000) found this alliance only on granitic substrates in the narrower canyons of the eastern Mojave Desert mountains. She describes variation in this association based on associated species and microtopography ranging from flat sandy stretches, bouldery ravines > 10% slope, to vertical waterfalls on bedrock. In comparison to other canyon alliances in the eastern Mojave Desert, *Baccharis sergiloides* Intermittently Flooded Shrubland has an ecological overlap with the *Salix exigua* Temporarily Flooded Shrubland, suggesting relatively high subsurface moisture requirements.

As with other members of the genus, *Baccharis sergiloides* produces abundant seed that is easily dispersed on the wind with the assistance of substantial pappus bristles. Little specific information exists on the autecology of the species. Its longevity and relationship to fire and mechanical disturbance are not treated in FEIS (2001). However, as with other similar species (e.g., *Baccharis sarothroides* and *Baccharis pilularis*), it probably does resprout following disturbance and does not attain great age.

**Regional Status:**
**Mojave Desert:** Stands are known from most of the eastern Mojave Desert mountains on granite.
**Southeastern Great Basin:** Stands occur in the Panamint, Inyo, and Coso Mountains in similar settings to other parts of its range.

**Management Considerations:** No additional information is available.

## *Cercocarpus ledifolius* Shrubland Alliance

No photograph is available.

*Cercocarpus ledifolius* or *Cercocarpus intricatus* is the sole or dominant in shrub or tree canopy. Emergent trees such *Juniperus occidentalis* ssp. *australis, Juniperus occidentalis* ssp. *occidentalis, Pinus albicaulis, P. balfouriana, P. contorta* ssp. *murrayana, P. jeffreyi* and *P. monophylla* may occur or emergent shrubs such as *Amelanchier alnifolia, Arctostaphylos patula, Artemisia tridentata, Prunus virginiana,* or *Purshia tridentata* may occur. Trees < 10 m tall; canopy continuous or scattered. Shrubs are common or infrequent. Ground layer sparse or grassy.

**Habitat:** Ridges, upper slopes. Soils sedimentary, ultramafic, volcanic-derived and shallow.

**Distribution:** Klamath Mountains (subalpine), montane Northern California Coast Ranges (montane), Southern Cascades (montane and subalpine), Modoc Plateau, Southern California Mountains and Valleys, Mojave Desert (ranges), Mono, Southeastern Great Basin, Northwestern Basin and Range, western U.S., Mexico.

**Elevation:** 1,200 to 3,000 m

**NDDB Rank:** unknown

**Synonyms**:
Holland: Broadleaved upland forests.
Barry: G74 G7411214.
Cheatham and Haller: High desert scrub.
PSW-45: Mountain mahogany series.
Rangeland: SRM 415, SRM 417.
Thorne: Desert rupicolous scrub, Mountain juniper woodland.
WHR: Sagebrush.
Munz: Sagebrush scrub.

**References:** Davis (1994a, 1994b), Paysen et al. (1980), West (1988), Young et al. (1977); plot-based descriptions are found in Keeler-Wolf (1987), Keeler-Wolf (1990b), Jensen and Schierenbeck (1990), Keeler-Wolf et al. (1998), and Young et al. (1977)

**Membership Rules:** Vegetation characterized by the relative dominance of the shrubby tree *Cercocarpus ledifolius*. Stands occur in dry, rocky and usually very well drained exposures in the highest portions of the Inyo, Panamint, and other tall ranges of the northern Mojave Desert.

**Comments:** *The Jepson Manual* (Hickman 1993) recognizes two varieties of *Cercocarpus ledifolius*. *Cercocarpus ledifolius* var. *ledifolius* is uncommon in comparison to *Cercocarpus ledifolius* var. *intermontanus*. *Cercocarpus intricatus* may dominate on rock outcrops in Mojave Desert and Southeastern Great Basin. *Cercocarpus intricatus* stands are included in the *Cercocarpus ledifolius* Shrubland Alliance at this time.

*Cercocarpus ledifolius* has a wide range in California. On rocky ridges and steep slopes with thin soil, this plant can be the sole tall shrub or small tree. Other trees may be present in these areas as well. Trees, if present, also occur in other alliances of the region. The degree of canopy development varies as *Cercocarpus ledifolius* can occur in other alliances as a secondary component.

*Cercocarpus ledifolius* is a long-lived, small tree or shrub characteristic of nutrient and water-deficient environments, especially on ridges, rock outcrops, and steep slopes. It mainly reproduces by seed, and it is a sporadic producer. The wind-dispersed seeds germinate best on well-lighted, mineral soil, but seedling mortality is high as they are readily browsed. Higher survivorship is afforded seedlings under the protection of older plants. Mature plants are important browse for livestock and wildlife. It is easily killed by fire, after which it is a feeble respouter.

Stands of *Cercocarpus ledifolius* alliance are typically on sites that inhibit conifer establishment. *Cercocarpus ledifolius* also occurs in woodland and forest alliances, where it plays a seral role, and may be maintained within them by fire.

**Regional Status:**
**Mojave Desert:** Found in the northern ranges.
**Southeastern Great Basin:** Found in the ranges.

**Management Considerations**: No additional information is available.

## *Chilopsis linearis* Intermittently Flooded Shrubland Alliance

Figure A12. *Chilopsis linearis* Intermittently Flooded Shrubland Alliance

*Chilopsis linearis* is the sole, dominant, or important tall shrub or small tree in canopy; *Acacia greggii, Olneya tesota, Prosopis glandulosa, Psorothamnus spinosus*, or *Yucca brevifolia* may be present. Emergent trees may be present over a shrub canopy. *Atriplex polycarpa, Bebbia juncea, Ephedra californica, Encelia virginensis, Ericameria paniculata, Eriogonum fasciculatum, Hymenoclea salsola, Hyptis emoryi, Larrea tridentata, Lepidospartum squamatum, Opuntia acanthocarpa, Petalonyx thurberi, Prunus fasciculata, Senecio flaccidus, Viguiera parishii,* or *Yucca schidigera,* may be present. Trees < 6 m tall; canopy intermittent or open. Shrubs < 3 m tall; intermittent or open. Ground layer sparse, annual herbs or grasses seasonally present.

**Habitat:** Washes, intermittent channels, arroyos, lower canyons; intermittently flooded riverine or palustrine. Soils coarse, well drained, moderately acidic to slightly alkaline, including granitic and calcareous substrates.

**Distribution:** Mojave Desert, Sonoran Desert, Colorado Desert, and Southern California Mountains and Valleys, south Nevada, west Arizona, New Mexico, Texas, Baja California, Mexico.

**Elevation:** 100 to 1,500 m

**NDDB Rank:** G4 S3.2

**Synonyms:**
Holland: Mojave wash scrub (34250), Mojave Desert Wash Scrub (63700)
Barry: G7411124
Cheatham and Haller: Desert dry wash woodland
PSW-45: Desert willow series
CALVEG: Desert wash woodland
Thorne: Desert microphyll woodland
WHR: Desert wash
Munz: Creosote bush scrub

**References:** Johnson (1976), MacMahon (1988), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Thorne (1982), Turner and Brown (1982), Vasek and Barbour (1977); plot-based descriptions are found in Keeler-Wolf et al. (1998) and Evens (2000)

**Membership Rules**: Keeler-Wolf et al. 1998 suggest trees and/or large shrubs of *Chilopsis linearis* at least 2% cover, with no other large shrubs equaling or exceeding it in cover. Other smaller shrubs (e.g., *Hymenoclea salsola, Hyptis emoryi, Ericameria paniculata, Atriplex* spp.) may be higher in cover in understory than emergent trees. Evens (2000) reports similar limits of 1-2% minimum cover over a variable short- to tall-shrub understory for her six associations.

**Comments:** *Chilopsis linearis* Intermittently Flooded Shrubland Alliance occurs strictly in washes and arroyos in the southern Mojave, Colorado, and sporadically in the Sonoran deserts of California. Arid climate restricts stands to washes, riparian arroyos, and adjacent flood plains. Although the alliance is widely distributed, stands are local and do not occur in many of the washes that would seem suitable. It tends to occupy sandy or gravelly washes where wash energy is dissipated across a relatively wide flood path. It does not range up into mountain valleys and narrow arroyos as much as the *Acacia greggii* or *Prunus fasciculata* Shrublands, and does not tend to occupy the most active wash centers such as do *Psorothamnus spinosus, Ericameria paniculata,* or *Hymenoclea salsola* Shrublands. Evens (2000) reports five out of the six associations she describes as occurring in washes and arroyos surrounded by alluvial deposits and only one in lower canyons.

*Chilopsis linearis* can become a large (5-6 m), relatively long-lived tree, and some of the best mature stands of this alliance occur along wash terraces where flooding has been infrequent, but where subterranean water is available. Many stands occur where runoff is forced to near surface as in washes across pediments, and in natural “narrows” in valleys. This alliance often occurs as a matrix with other wash alliances such as *Ericameria paniculata, Acacia greggii, Psorothamnus spinosus, Ephedra californica, Lepidospartum squamatum, Prunus fasciculata* and *Hymenoclea salsola* dominated alliances. Sawyer and Keeler-Wolf (1995) include this alliance within *Acacia greggii* Shrubland Alliance. Reid et al. (1999) recognizes it from other parts of the southwest United States. It is a “warm season” rain species and thus does not occur in the western Mojave Desert. It is reported to be sensitive to salinity and alkalinity (T. Keeler-Wolf personal communication, Desert Workshop 2000). *Chilopsis linearis* is a partially facultative, winter-deciduous species that may opportunistically delay its leaf output until water is available. This alliance is dependent on the intermittent flows/flooding of the channel to supplement soil moisture. The plants become large, and are likely to become fairly old (> 100 yrs) if established in relatively sheltered locations. Seeds are shed in the winter. Seedling establishment is sporadic, with occasional good recruitment, but many stands show none to few seedlings even after good flooding events. Seeds are not dormant, but inundation in wet sand will speed germination (Young and Young 1986). Most stands tend to be represented by multiple age classes. However, they are often strongly dominated by individuals of a single size class. It is likely that moderate flooding in combination with abnormally wet years provide the most favorable conditions to establish seedlings.

Flood frequencies and intensity levels are highly variable (Waananen and Crippen 1977); but compared to *Ericameria paniculata* and *Hymenoclea salsola* Shrublands, flooding frequencies are probably lower. Most large-stature stands are on small terraces above the most active wash channels. The understory of many of the Mojave Desert stands for this alliance is composed of the shrubs that are dominates in other alliances. Thus, flooding frequencies are probably within the low range of these shorter structured shrub alliances. Most stands probably receive sheet flooding at least every 10-20 years. No information on stand replacement and persistence is available.

Other disturbance effects include some competition from exotic *Tamarix* spp. Although most *Chilopsis* stands are not prone to invasion by *Tamarix* due to less than optimum moisture availability for *Tamarix* spp. establishment. Resprouting is well developed (FEIS 2001) although response to fire is not documented.

**Regional Status:**
**Mojave Desert:** Stands occur in the southern and eastern Mojave Desert north to the vicinity of Alvord, Avawatz and Clark Mountains, and west to Daggett Wash. Stands are widely scattered with more in the south and the eastern portions of the ecoregion.

**Management Considerations:** Because *Chilopsis linearis* is likely to be an alliance of longer disturbance intervals, it is less likely to be capable of frequent regeneration. Stands are relatively uncommon and typically small. They may be thought of as distinct resources requiring relatively low frequency flooding events, coupled with an abnormally wet seedling establishment period for stand maintenance. Some stands show partial senescence. The die-off is usually of individual trees that have likely reached their maximum age. Conservation planning for long-range maintenance of this alliance should include large drainages with several stands of different age classes.

## *Coleogyne ramosissima* Shrubland Alliance

Figure A13. *Coleogyne ramosissima* Shrubland Alliance, Homewood Canyon

*Coleogyne ramosissima* is the sole or dominant shrub in canopy. *Artemisia spinescens, Atriplex confertifolia, Eriogonum fasciculatum, Ephedra nevadensis, Grayia spinosa, Krascheninnikovia lanata, Menodora spinescens, Salazaria mexicana,* or *Thamnosma montana* may be present. Emergent trees such as *Juniperus californica, Juniperus osteosperma, Pinus monophylla, Yucca schidigera,* or *Yucca brevifolia* may be present. Shrubs < 1 m tall; canopy intermittent to continuous. Ground layer sparse.

**Habitat:** Alluvial slopes, bajadas, and rocky highlands. Soil shallow, may have calcareous cemented duripans.

**Distribution:** Mojave Desert, Southeastern Great Basin, Sierra Nevada, Southern California Mountains and Valleys, south Nevada, north Arizona, south Utah, southwest Colorado.

**Elevation:** 1,200 to 1,800 m

**NDDB Rank**: G4 S4

**Synonyms:**
Holland: Black bush scrub (34300)
Barry: G7411222 BCORA00

Brown, Lowe and Pase: 153.121
PSW-45: Black bush series
Rangeland: SRM 212
Stone and Sumida: Black bush scrub
Thorne: Black bush scrub
WHR: Sagebrush
CALVEG: Black bush
Munz: Sagebrush Scrub

**References:** Bates (1984), FEIS (2001), Bown and West (1976), McMahon (1988), Martin (1994), Paysen et al. (1980), Reid et al. (1999), Stebbins et al. (1965), Thorne (1982), Turner (1982b), Vasek and Barbour (1977), Webb et al. (1988); plot-based descriptions are found in Keeler-Wolf et al. (1998).

**Membership Rules:** *Coleogyne ramosissima* ≥ 2% cover. *Ephedra nevadensis*, and or *Krameria grayi* can have up to twice the cover of *Coleogyne ramosissima*. Typically dominates stands, but may be exceeded by species of disturbance (*Hymenoclea salsola, Salazaria mexicana, Ericameria* spp.*, Eriogonum fasciculatum*). A widespread type of shallow rocky soils on upper bajadas, pediments and hill slopes.

**Comments:** *Coleogyne ramosissima,* or Blackbrush, is in a monotypic genus restricted to the arid southwestern U.S. Stebbins and Major (1965) considers it a paleoendemic. This alliance occurs at transitional elevations between the Mojave Desert and the Southeastern Great Basin. Over the past few years plot data have confirmed the intermediate relationship between the two deserts. Elements of the lower, hotter Mojavean flora may be mixed with *Coleogyne ramosissima* Shrubland including *Larrea tridentata-Ambrosia dumosa, Yucca schidigera*, and *Yucca brevifolia* Shrublands. Upper elevation stands may mix with alliances dominated by *Artemisia tridentata, Atriplex confertifolia, Ephedra nevadensis, Juniperus californica, Juniperus osteosperma,* and/or *Pinus monophylla*. Blackbrush is also found in the peninsular ranges as far south as Anza-Borrego Desert State Park, where it forms intermittent stands between *Yucca schidigera* Shrubland Alliance stands and stands dominated by *Juniperus californica* or *Pinus monophylla*.

*Coleogyne ramosissima* is a long-lived shrub, up to 400 years (Webb et al. 1988) that is quite susceptible to fire. It is typically killed outright by fire, and as most stands are relatively dense and strongly dominated by *Coleogyne ramosissima,* even low frequency fire can destroy significant portions of stands for long periods. Recovery from fire is slow. Growth rates for the species are very slow (Webb et al. 1988). According to Bowns and West (1976), *Coleogyne ramosissima* is a relict species that may be on its way to extinction.

Individual plants produce relatively few seeds, which are relatively large and less mobile than other shorter-lived species in genera such as *Ericameria, Atriplex*, and *Artemisia*. Brown and West (1976) report that while some *Coleogyne ramosissima* seeds germinate on the surface, seedlings often emerge from rodent caches. Seedling survival is poor, with most not surviving beyond cotyledon stage. *Coleogyne* stands are notably depauperate in seedlings and young plants, suggesting that pulse establishment after favorable weather conditions are rare. Sinuous sharp transitions between remnant stands of *Coleogyne ramosissima* and adjacent stands that may have been burned over 50 years ago are frequently obvious. For a fire to carry through a *Coleogyne ramosissima* stand, not only does the stand need to be relatively dense but climatic conditions also need to be favorable (strong winds and dry conditions). Fire frequency is not high in these stands, as they occur in relatively low-lightning-frequency areas. In much of its range, the blackbrush-dominated alliance may be succeeded post-fire by several phases of vegetation, including an *Achnatherum speciosum* dominated phase, an *Eriogonum fasciculatum* dominated phase, an *Ericameria teretifolia* dominated phase, or a *Salazaria mexicana* dominated phase.

**Regional Status:**
**Mojave Desert:** Common above 1,000 m in mountains and on pediments. Fire has negatively affected its distribution and recruitment (M. Brooks, personal communication 2000).
**Southeastern Great Basin:** Stands are common in the Panamint, Last Chance, Grapevine, and Coso-Argus ranges, where they are adjacent to *Grayia spinosa, Larrea tridentata-Ambrosia dumosa, Yucca brevifolia, Menodora spinescens,* and *Artemisia tridentata* Shrublands.

**Management Considerations:** Increased fire frequency in the California deserts is an adverse impact on this alliance. The presence of non-native annual grasses such as *Bromus madritensis* and *Bromus tectorum* can contribute to carrying fire into and through blackbrush stands. Although relatively widespread in California, the alliance is sporadically distributed particularly towards the south of its range. Some parts of the desert (e.g., Anza Borrego) have very spotty distributions of this alliance. Extralimital and isolated stands should be protected from fire.

## *Encelia farinosa* Shrubland Alliance

Figure A14. *Encelia farinosa* Shrubland Alliance

*Encelia farinosa* is the sole or dominant shrub in canopy. *Ambrosia dumosa, Artemisia californica, Eriodictyon crassifolium, Eriogonum fasciculatum, Agave deserti, Ferocactus cylindraceus, Opuntia bigelovii, Echinocactus engelmannii, Salvia apiana,* or *Yucca whipplei* may be present. Emergent *Fouquieria splendens* may be present. Shrubs <2 m tall; open to intermittent single-layered. Trees < 5 m tall scattered. Ground layer open; annuals seasonally present.

**Habitat**: Alluvial fans, bajadas, colluvium, upland slopes, small washes, and rills. Soils well-drained, rocky, may have desert pavement surface, often derived from granitic or volcanic rock.

**Distribution**: Mojave Desert, Sonoran Desert, Colorado Desert, Southern California Mountains and Valleys, Arizona, Nevada, Utah, Mexico.

**Elevation**: -75 to 1,400 m
**NDDB Rank**: G5 S4

**Synonyms:**
Sawyer and Keeler-Wolf (1995): Brittlebush series (in part),
Holland: Mojave creosote bush scrub *in part* (34100), Sonoran creosote bush scrub *in part* (33100), Riversidean Desert Scrub (32730 *in part*), Riversidean sage scrub (32700 *in part*)
Barry: G7411221

Brown, Lowe and Pase: 154.126
Cheatham and Haller: Creosote bush scrub, Coastal sage scrub
PSW-45: Encelia series
CALVEG: Encelia series
WHR: Desert scrub, Coastal scrub
Munz: Creosote bush scrub, Coastal sage scrub

**References:** Barbour (1994), Burk (1977), Hunt (1966), MacMahon (1988), Pase and Brown (1982), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Vasek and Barbour (1977); plot-based descriptions are found in Kirkpatrick and Hutchinson (1977), White (1994) and Keeler-Wolf et al. (1998).

**Membership Rules**: *Encelia farinosa* > 1% and no other species with equal or higher cover.

**Comments:** Many of the stands formerly considered part of the *Encelia farinosa* series and *Larrea tridentata* series (Sawyer and Keeler-Wolf 1995) are actually composed of a mixture of both species (see *Larrea tridentata-Encelia farinosa* alliance). However, this alliance lacks the overstory of taller *Larrea*. It is related to the *Larrea tridentata-Encelia farinosa, Ambrosia dumosa,* and *Larrea tridentata-Ambrosia dumosa* Shrublands. The *Encelia farinosa* Shrubland represents a drought-tolerant extension of the *Larrea tridentata* Shrubland, which is less cold-hearty and more heat-tolerant extension of the *Larrea tridentata-Ambrosia dumosa* Shrubland. The alliance also does not tolerate sandy or clay-rich soils as well as *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance. The virtual absence of creosote bush in the overstory may be due to the disturbance history of the stand (see below). It may also be due to the steep, rocky nature of the stand. Cover is variable with many steep rocky stands averaging less than 10% total vegetation cover, while disturbance-related stands may approach 50% cover.

*Encelia farinosa* is, like *Ambrosia dumosa*, a short-lived sub-shrub that forms an open to intermittent sub-shrub canopy. However, it is even more tolerant of hot, dry conditions and is more of an aggressive colonizer than *Ambrosia dumosa.* Leafing and flowering is opportunistic whenever moisture is available. *Encelia farinosa* rapidly colonizes burns and other disturbance; both in the south coastal scrub and desert vegetation (FEIS 2001). *Encelia farinosa* is short lived with maximum reported age 32 yrs (FEIS 2001). It reproduces entirely by seed and resprouts weakly from damaged stems. It is frost sensitive, limiting the elevation it extends to and geographic range. It grows poorly on clay soils, but survives on coarse, steep, and very rocky soils better than *Ambrosia dumosa*. It may replace longer-lived perennials after fire and, once established, may persist for decades. It is alleopathic to several winter annuals (FEIS 2001), suggesting that biodiversity is reduced if it replaces other vegetation. *Encelia farinosa* is fire sensitive and intolerant of heat from fire, as resprouting is weak or non-existent. However, it recolonizes from off-site seed readily. Recurrent desert fire selects for *Encelia farinosa* over longer-lived shrubs. Despite the colonizing properties of *Encelia farinosa*, some stands of the *Encelia farinosa* Shrubland Alliance are generally stable and occupy rocky sites too harsh for the *Larrea tridentata-Encelia farinosa* Shrubland

Alliance. Seral stages following fire or other unnatural disturbance are likely to involve a state dominated by *Encelia farinosa* for several years before *Larrea tridentata* and other long-lived shrubs re-establish. If *Larrea tridentata* reestablishes, then the stands convert to *Larrea tridentata-Encelia farinosa*-dominated alliance. Stands in the Southern California Mountains and Valleys may replace more diverse stands of *Artemisia californica, Salvia apiana* and *Eriogonum fasciculatum* Shrubland alliances following high-frequency fires.

**Regional Status:**
**Mojave Desert:** This alliance is much less common than the *Larrea tridentata-Encelia farinosa* Shrubland Alliance. However, it likely occurs in all the Mojave Desert except the northernmost and westernmost. In most parts of the Mojave Desert it is a disturbance related alliance of rocky substrates including roadsides, wash margins, and recently burned slopes. It may occupy limestone and other calcareous, as well as granitic and volcanic substrates. The northernmost stands occur on volcanic substrate on roadsides near Panamint on the boundary of the Southeastern Great Basin.

**Management Considerations:** This is another alliance where coincidence of non-native annual grass invasion and human-related fires have conspired to threaten the structure and diversity of the vegetation. In the deserts, fires should be excluded at all times of the year, and core areas should be identified where grass cover is low and thus stands are defensible. Unlike the *Larrea tridentata-Ambrosia dumosa* alliance, the rocky, extremely xeric nature of many of the stands preclude the establishment of dense cover of *Bromus madritensis,* and thus the resistance of this alliance to non-natural fire and weed invasion is relatively high. It is likely that this alliance is increasing relative to *Larrea tridentata-Encelia farinosa* or *Larrea tridentata-Ambrosia dumosa* in less rocky/steep parts of the desert where fires are relatively frequent. Similarly, in the inner coastal scrub, the *Encelia farinosa* alliance is often a degraded scrub resulting from high fire frequency. Fire frequencies in this area may be as high as once every 10 years.

## *Encelia virginensis* Shrubland Alliance

Figure A15. *Encelia virginensis* Shrubland Alliance, Last Chance Range

*Encelia virginensis* is the important or dominant canopy shrub. *Ericameria nauseosa, Ephedra nevadensis, Gutierrezia microcephala, Hymenoclea salsola, Psorothamnus arborescens, Salvia dorrii, Salazaria mexicana, Stephanomeria pauciflora, Viguiera reticulata, Yucca baccata* or *Aristida purpurea* may be present. Emergent *Acacia greggii* may occur. Canopy intermittent short shrubs < 2 m tall. Ground layer is intermittent.

**Habitat:** Intermittently flooded arroyos, canyons and washes in desert mountains and on adjacent alluvial fans. Soils alluvial, gravel, or cobble, derived from calcareous, other metamorphic, or volcanic substrates; texture medium sand.

**Distribution:** Mojave Desert, Southeastern Great Basin, Nevada, Arizona
**Elevation:** 300 to 1,900 m

**NDDB Rank:** G4 S3.2

**Synonyms:**
Holland: Mojave wash scrub (34250), Mojave creosote bush scrub (34100), Sonoran creosote bush scrub (33100)
Munz: Creosote bush scrub, Shadscale scrub, Pinyon-Juniper woodland

**References:** Reid et al. (1999), Peterson (1984), Evens (2000); plot-based descriptions are found in Evens (2000)

**Membership Rules:** *Encelia virginensis* (including the subspecies *Encelia virginensis actonii*) ≥ 2% cover. No other species with greater or equal cover. Typically of washes or other disturbed areas in the eastern Mojave Desert (Evens 2000) *Encelia virginensis* over 2% cover may have *Salvia dorrii* at greater cover (> 5%).

**Comments:** *Encelia virginensis* and its subspecies *Encelia virginensis* spp. *actonii* occur commonly throughout the middle and upper elevations of the Mojave Desert and adjacent Colorado Desert and Southeast Great Basin. The species occurs commonly on slopes and in several vegetation alliances including those dominated by *Coleogyne ramosissima, Menodora spinescens, Larrea tridentata-Ambrosia dumosa, Larrea tridentata, Eriogonum fasciculatum,* and *Grayia spinosa*. However, *Encelia virginensis* only forms its own alliance in washes. Such stands are particularly well developed in the northeastern Mojave Desert and adjacent Southeastern Great Basin in such areas as the Cottonwood, Saline, Panamint, and Last Chance ranges of Death Valley National Park. In late spring in a good year these stands show spectacularly in full golden flower, lining the washes emanate from these mountains. Evens (2000) notes that *Encelia virginensis* Shrubland Alliance occupies washes with slopes of 4-5% with banks > 3 m high, settings which equate to her definition of upper washes and arroyos.

The *Encelia virginensis* Shrubland Alliance is locally common in washes where irregular flooding occurs. Not a great deal is known about the species' life history. It is likely not a prolific resprouter and probably does not live for long periods. It seeds well after wet years and occupies recently on disturbed ground whether in washes, roadcuts, or other recently disturbed substrate.

**Regional Status:**
**Mojave Desert** Stands occurs in calcareous alluvium in the Clark Mountains.
**Southeastern Great Basin**: Stands are common on the east side of the Last Chance Range, the Cottonwood Mountains, the Funeral Range, and the Panamint Mountains, all of which drain into Death Valley.

**Management Considerations:** No additional information is available.

## *Ephedra californica* Intermittently Flooded Shrubland Alliance

No photograph is available.

*Ephedra californica* and *Hymenoclea salsola* are important canopy shrubs. *Adenophyllum cooperi, Ambrosia dumosa, Larrea tridentata, Lycium andersonii, Isomeris arborea, Opuntia ramosissima,* and *Senecio flaccidus* may be present. Perennial grasses *Pleuraphis rigida, Achnatherum hymenoides,* and *Achnatherum speciosum* may be present. Shrubs < 2 m tall; intermittent canopy over sparse ground layer with annual or perennial herbs and grasses.

**Habitat:** Intermittently flooded arroyos, and washes in desert mountains and on adjacent alluvial fans. Soils alluvial, derived from granitic substrates; texture is coarse to medium, sand.

**Distribution:** Mojave Desert, Colorado Desert

**Elevation:** 200 to 1,200 m

**NDDB Rank:** G3 S2.3. The coast range association defined as Monvero residual dunes is rare and threatened (G1 S1.2). Other coast range associations yet undefined may also be rare.

**Synonyms:**
Sawyer and Keeler-Wolf (1995): Bladderpod-California Ephedra-Narrowleaf goldenbush (in part)
Holland: Mojave wash scrub (34250), Mojave creosote bush scrub (34100), Monvero residual Dunes (23300), Sonoran creosote bush scrub (33100),
Munz: Creosote bush scrub, Shadscale scrub

**References:** Evens (2000), McHargue (1973), Sawyer and Keeler-Wolf (1995); plot-based descriptions are found in Evens (2000)

**Membership Rules:** Vegetation either dominated or co-dominated by *Ephedra californica,* typically of broad, active washes of mid to upper bajadas and fans. Ranging somewhat locally throughout the southwestern, central, and eastern portions of the area.

**Comments:** *Ephedra californica* is a widespread shrub of the Mojave and Sonoran deserts of California, ranging up the Central Coast ranges to Merced County (CalFlora 2000). It is a component of several alliances including those dominated by: *Psorothamnus spinosus, Larrea tridentata-Ambrosia dumosa, Atriplex canescens, Atriplex polycarpa, Fouquieria splendens,* and *Yucca schidigera.* Stands of *Ephedra californica* Shrubland Alliance are scattered throughout the Mojave, Sonoran, and Colorado deserts of California. Such stands are most commonly associated with washes. These stands are usually of low diversity, associated with the active portions of washes. In washes, the *Ephedra californica* Shrubland Alliance occupies a similar habitat to *Hymenoclea salsola* Shrubland Alliance, but is often found in slightly less disturbed micro sites as along low terraces and banks of washes (Evens 2000 and personal observation). Some stands are associated with sand sheets, dunes, and other sandy substrates. On these non-alluvial substrates, the stands often associate with perennial grasses such as *Pleuraphis rigida, Achnatherum hymenoides,* and *Achnatherum speciosum*. The isolated stands of *Ephedra californica-Isomeris arborea-Ericameria linearifolia* found in the inner coast range called Monvero Dunes community by Holland (1986) are found on ancient stabilized diatomaceous dunes. It is interesting to note that *Isomeris arborea* is often a characteristic species with this alliance, from the isolated coast range stands to the eastern Mojave Desert wash stands (Sawyer and Keeler-Wolf 1995, Evens 2000).

The *Ephedra californica* Shrubland Alliance is indicative of low gradient wash sites within the mid and lower elevations of the Mojave Desert. It occurs along washes ranging from 10 to 100 m in width and with variable slope aspect. Large, continuous stands are found along some washes in the eastern Mojave Desert, but many are small stands less than 100 square meters. Stands on sand sheets tend to stabilize and form mounds. *Ephedra californica* is a clonal species and may spread by underground rhizomes, making it well adapted to shifting sand and alluvial substrates.

**Regional Status:**
**Mojave Desert:** This alliance occurs throughout the Mojave Desert. In all parts of the Mojave Desert it is a disturbance related alliance of washes and is restricted to alluvial fans derived from non-calcareous substrate.

**Management Considerations:** No additional information is available.

## *Ephedra funerea* Sparse Vegetation Alliance

Figure A16. *Ephedra funerea* Sparse Vegetation Alliance

*Ephedra funerea* is the dominant or important shrub in the canopy. *Amphipappus fremontii, Achnatherum speciosum, Encelia farinosa, Encelia virginensis, Ferocactus cylindraceus, Echinocactus polycephalus, Eucnide urens, Gutierrezia microcephala, Larrea tridentata, Salazaria mexicana,* or *Yucca schidigera* may be present. Shrubs < 1 m tall; canopy open. Ground layer sparse.

**Habitat:** Rocky highlands. Soils shallow, skeletal and calcareous.

**Distribution:** Mojave Desert, Southeastern Great Basin, and perhaps Nevada

**Elevation:** 800 to 1,600 m

**NDDB Rank**: G3 S2.3 (locally distributed on limestone and other carbonates, mostly in Death Valley NP and BLM wilderness areas)

**Synonyms:**
Holland: Black bush scrub (34300)
Barry: G7411222 BCORA00
Brown, Lowe and Pase: 153.121
PSW-45: Black bush series
Rangeland: SRM 212
Stone and Sumida: Black bush scrub
Thorne: Black bush scrub
WHR: Sagebrush
CALVEG: Black bush
Munz: Sagebrush Scrub

**References:** Beatley (1976)

**Membership Rules**: Vegetation strongly dominated by *Ephedra funerea* with no other indicator species present. An uncertain alliance of limestone mountains in the northeastern Mojave Desert, represented by little data.

**Comments:** *Ephedra funereal,* as a species, is endemic to the northern Mojave Desert and southern Great Basin of western Nevada and adjacent eastern California. It is a regular component of *Coleogyne ramosissima, Larrea tridentata-Ambrosia dumosa* and *Larrea tridentata-Encelia farinosa* dominated shrubland alliance stands on calcareous mountains. On relatively steep, rocky slopes, *Ephedra funerea* Sparse Vegetation occasionally forms open stands of low cover (usually 5-10% total vegetation) where the soil is too rocky for *Larrea tridentata, Encelia farinosa* or *Coleogyne ramosissima* to attain high cover. Slopes may be east or west/southwest facing.

The *Ephedra funerea* Sparse Vegetation Alliance occupies very open and rugged slopes and ridges where vegetation cover is usually no greater than 10%. Thus, fire is not a disturbance factor. As with other *Ephedra* species *Ephedra funerea* is probably relatively long-lived and can persist through long droughts. It may be able to resprout, and thus damage from rockfalls and other mechanical disturbance may initiate resprouting. Most shrubs are small in this alliance.

**Regional Status:**
**Mojave Desert:** The alliance appears to be relatively common in parts of the Nopah, Mesquite and Kingston Ranges.
**Southeastern Great Basin:** Stands occur in the Panamint Mountains.

**Management Considerations:** Little is known about this alliance. More sampling is needed to clarify relationships with other alliances and to its understand seral trends. Because the species is endemic to a relatively small area the alliance's ecological relationships and range should be further assessed.

## *Ephedra nevadensis* Shrubland Alliance

Figure A17. *Ephedra nevadensis* Shrubland Alliance

*Ephedra nevadensis* is the sole, dominant or important shrub in canopy. *Artemisia tridentata, Atriplex confertifolia, Coleogyne ramosissima, Ericameria cooperi, Eriogonum fasciculatum, Grayia spinosa*, *Lycium andersonii, Menodora spinescens, Salazaria mexicana* or *Yucca schidigera* may be present. Shrubs < 2 m; open to intermittent cover. Ground layer open may include the bunchgrass *Achnatherum speciosum, Oryzopsis hymenoides, Elymus elymoides*, *Poa secunda* or *Pleuraphis jamesii. A*nnuals seasonally present. Emergent *Yucca brevifolia* may be present.

**Habitat:** Dry, open slopes, ridges, breaks with southern exposures, canyons, floodplains, Arroyos, and washes. Soils well drained, with gravel or rock, may be alkaline or saline**.**

**Distribution:** Mojave Desert, Southeastern Great Basin, Mono, Nevada, Utah

**Elevation:** 1,000 to 1,800 m

**NDDB Rank:** G3 S3.3

**Synonyms:**

Holland: Mojave mixed woody scrub (34210 *in part*), Sagebrush scrub (35200 *in part*), Blackbrush scrub (34300 *in part*)
Cheatham and Haller: Blackbrush scrub
Munz: Shadscale scrub, Creosote bush scrub
WHR: Desert scrub

**References:** FEIS (2001)**,** Reid et al. (1999) Yoder (1983); plot-based descriptions are found in Yoder (1983)

**Membership Rules:** *Ephedra nevadensis* ≥ 2% cover; no other species with greater cover with the following exceptions: *Acamptopappus spherocephalus* or *Chrysothamnus viscidiflorus*. Examine other alliance assignment if another species has equal cover. Note*:* *Ephedra nevadensis* may have high cover in *Coleogyne ramosissima, Larrea tridentata-Ambrosia dumosa* and *Larrea tridentata* Shrublands. For a stand to be a member of *Ephedra nevadensis* Shrubland, *Ephedra nevadensis* must have greater than twice the cover of the nominate species in these alliances.

**Comments:** *Ephedra nevadensis* is a common and widespread shrub of the transition between the Mojave Desert and Southeastern Great Basin (FEIS 2001). It is a component of many alliances including those dominated by: *Atriplex confertifolia*, *Coleogyne ramosissima*, *Larrea tridentata-Ambrosia dumosa, Juniperus osteosperma, Grayia spinosa, Lycium andersonii, Menodora spinescens, Pleuraphis jamesii, Yucca brevifolia,* and *Yucca schidigera.* Stands of *Ephedra nevadensis* Shrubland Alliance are common but generally widely scattered throughout the Mojave Desert and Southeastern Great Basin of California. Such stands may be in part related to fire, grazing, or other mechanical disturbance (see below). These stands are often composed of a diversity of perennial species and may include up to 35 species of shrubs (Reid et al. 1999). It occupies a similar climatic zone to *Grayia spinosa* Shrubland Alliance, but appears to segregate from it primarily based on soil depth, as *Grayia spinosa* Shrubland Alliance tends to prefer deeper alluvial soils than *Ephedra nevadensis* Shrubland Alliance.

The *Ephedra nevadensis* Shrubland Alliance is indicative of relatively disturbed sites within the mid-to-upper Mojave Desert and the lower-mid elevation Southeastern Great Basin. Yoder (1983) suggests it is the result of heavy use by livestock in the *Coleogyne ramosissima* and *Artemisia tridentata* Shrubland Alliances. *Ephedra nevadensis* is the most palatable and sought out by livestock of all the *Ephedra* species (FEIS 2001). Unlike most other dominant indicators of alliances within the same climatic zone (with the exception of *Grayia spinosa), Ephedra nevadensis* resprouts readily following browsing and light to moderate fire. Its seed set is variable, prolific in some years but low in others, probably due to precipitation (FEIS 2001). Despite its tolerance of fire and grazing, it is a relatively slow-growing shrub. It may slowly spread and replicate itself clonally. Seed viability is short (most < 5 years), although seeds do germinate from rodent caches with favorable moisture (FEIS 2001). Observations in Nevada, Utah, and Arizona (R. Webb personal communication) suggest that the species flowers infrequently, survives for long periods (15% of shrubs monitored are > 100 years old), and tend to establish in disturbed sites, such as ghost towns, after the first wave of colonizers represented by the *Hymenoclea salsola* Shrubland Alliance (Webb et al. 1988). New plants commonly develop from the roots or "stolons" of older clones in the absence of disturbance. Seedlings are very tolerant of drought and generally establish well following fall or winter plantings. *Ephedra nevadensis* generally sprouts from the root or crown after fire; however, under certain circumstances (e.g., severe June fire) hot fires may eliminate regenerative structures (FEIS 2001). *Ephedra nevadensis* may also reoccupy disturbed sites through seed. Periods of above-normal precipitation can contribute to increased stand flammability by promoting the growth of annuals such as *Bromus tectorum* and *Bromus madritensis.*

**Regional Status:**
**Mojave Desert:** Stands are widespread but local throughout most of the region except in the western Mojave Desert. It is commonly associated with *Coleogyne ramosissima, Atriplex confertifolia* and *Eriogonum fasciculatum* Shrublands.
**Southeastern Great Basin:** Upland stands probably occur throughout this region. These generally occur adjacent to stands dominated by *Artemisia tridentata, Coleogyne ramosissima* or *Atriplex confertifolia*.

**Management Considerations:** The current extent of this alliance is not well known. However, stands should be monitored and disturbance effects quantified throughout its range. It is not likely to have been an extensive type and may have increased as a result of more frequent and extensive fires and livestock use over the last 100 years or so. The high diversity of shrub species in some stands should be investigated more closely. Diversity may be related to the disturbance regime and if so it brings into focus the role of disturbance for maintaining floristic diversity in the desert.

## *Ephedra viridis - Artemisia tridentata* Shrubland Alliance
No photograph is available.

*Ephedra viridis* and *Artemisia tridentata* are co-dominant, dominant, or important shrubs in canopy. *Pinus monophylla, Juniperus osteosperma, Juniperus californica* may be present. Emergent trees may be present over a shrub canopy. *Eriogonum heermannii, Opuntia erinacea, Ericameria nauseosa, Chrysothamnus viscidiflorus, Gutierrezia microcephala, Purshia mexicana* or *Purshia glandulosa* may be present. In the herbaceous layer *Elymus elymoides* and *Poa secunda* and herbs may be present. Trees < 6 m tall; scattered cover. Shrubs 1-3m tall; open to continuous cover. Ground layer < 1.5 m tall; canopy sparse to continuous.

**Habitat:** Ridges, slopes, Soils bedrock, colluvium, or alluvium derived.

**Distribution:** Mono, Southeastern Great Basin, Mojave Desert, Nevada, northern Arizona

**Elevation:** 1,500 to 2,300 m

**NDDB Rank:** G4 S4

**Synonyms:**
Holland: Great Basin mixed scrub (35100), big sagebrush (35210), Sagebrush steppe (35300)
Barry: G7411211 CARTR20
Brown, Lowe and Pase: 142.213, 142.222, 152.111
Cheatham and Haller: Great Basin sagebrush
PSW-45: Sagebrush series
Thorne: Great Basin sagebrush scrub
WHR: Sagebrush
CALVEG: Great Basin sagebrush
Munz: Sagebrush scrub

**References:** Reid et al. (1999), Peterson (1984); plot-based descriptions are found in Peterson (1984)

**Membership Rules**: *Ephedra viridis* ≥ 1% cover. Upper elevation scrubs on well drained rocky to gravelly soil usually adjacent to stands of *Pinus monophylla* and or *Juniperus osteosperma*. Other seral shrub species (e.g., *Ericameria* spp.) may equal these two in cover.

**Comments:** This alliance is considered part of the Great Basin sagebrush scrubs, or big sage scrubs by other authors. It typically occurs on shallow soils and relatively steep sites in the upper elevations of the north and east Mojave Desert. Variation in cover of both species is great. In some cases *Artemisia tridentata* dominates and in others *Ephedra viridis* dominates. The presence of both species in a stand at notable levels (see below) is sufficient for definition. Compared to the *Artemisia tridentata* Shrubland Alliance in the same regions, it is usually found on shallow, rocky, and not-deep residual or alluvial soils. *Ephedra viridis* tends to become more abundant on steeper rocky soils.

*Ephedra viridis* and *Artemisia tridentata* are both widespread shrubs of the Great Basin. They mix in stands in the high mountains of the northern and eastern Mojave Desert and the mid-elevations of the Great Basin. *Ephedra viridis* will resprout after fire or mechanical disturbance. *Ephedra viridis* also may germinate from seed following fire. *Artemisia tridentata* does not resprout (FEIS 2001); however, *Artemisia tridentata* seeds germinate in soil after moderate fire. Thus, a stand of *Ephedra viridis-Artemisia tridentata* may recover to previous composition and structure 15-20 years following a moderate fire event and up to 30 years after more severe burns (FEIS 2001). Fire is the principal natural disturbance affecting this alliance. Due to typically steep and rocky-slope exposures, rock falls and avalanche may occasionally impact stands. Heavy grazing is likely to affect some stands of the alliance. Grazing reduces understory grasses and herbaceous cover and creates understories susceptible to weed invasion. Natural fire frequency is related to lightning strikes from infrequent summer thunderstorms. Stand cover is generally lower than the *Artemisia tridentata* Shrubland Alliance (mean=17%, n=10). Thus, fires were likely to have been infrequent and small prior to the occurrence of invasive non-native grasses.

**Regional Status:**
**Mojave Desert:** This alliance occurs above 1,300 m in Providence, Kingston, and Funeral mountains. Little specific information on disturbance effects exists in the Mojave Desert**.**
**Southeastern Great Basin:** This alliance occurs above 1,200 m in the Inyo, Cottonwood, Grapevine, Coso and Argus mountains. It may occur as large stands on open slopes, but more typically occurs as smaller stands interspersed with *Pinus monophylla* Wooded Shrubland (cooler, less-exposed sites), and *Artemisia tridentata* Shrubland (deeper soil, less-steep sites).

**Management Considerations:** Although fire is a natural component of this alliance, large, high-frequency fires are detrimental.

## *Ericameria nauseosa* Shrubland Alliance

Figure A18. *Ericameria nauseosa* Shrubland Alliance, Wildrose Canyon

*Ericameria nauseosa* is the sole or dominant shrub in canopy. *Artemisia tridentata, Chrysothamnus viscidiflorus, Ephedra* species or *Purshia tridentata* may be present. Emergent junipers or pines may be present, or emergent shrubs may occur over a ground layer of grass. Trees scattered, if present. Shrubs < 3 m tall; canopy continuous, intermittent, or open. Ground layer sparse or grassy.

**Habitat:** All topographic settings. Soils well-drained, sandy, gravelly.

**Distribution:** Central California Coast Ranges, Northern California Interior Coast Ranges, Southern Cascades, Sierra Nevada, Modoc Plateau, Southern California

Mountains and Valleys, Mojave Desert, Mono, Southeastern Great Basin, Northwestern Basin and Range, Intermountain West.

**Elevation:** 50 to 3,300 m

**NDDB Rank**: G5 S4

**Synonyms**:
Holland: Rabbitbrush scrub
Barry: G7411221 BCHNA20
Brown, Lowe and Pase: 142.141
Cheatham and Haller: Great Basin sagebrush
PSW-45: Rabbitbrush series
Thorne: Great Basin sagebrush scrub
WHR: Sagebrush

**References:** Paysen et al. (1980), West (1988), Young et al. (1977); plot-based descriptions are found in Ferren and Davis (1991).

**Membership Rules:** *Ericameria nauseosa* ≥ 2%. *Ericameria nauseosa* must have 25% or greater relative cover. Mid- and upper-elevation Mojave Desert, usually in areas with fire, flood or grazing history.

**Comments:** California stands are dominated by any of eight subspecies of *Ericameria nauseosa*. Some subspecies are local, while others have extensive ranges. It is not known which subspecies are sufficiently common to characterize California vegetation, since few ecologists make determinations of them. The species was previously in the genus *Chrysothamnus. Jepson* (Hickman 1993) redesignated it to be in the genus *Ericameria;* however, it often is still cited as *Chrysothamnus.*

*Ericameria nauseosa* is a fast growing shrub in the composite family that characteristically dominates in areas after disturbance. It blooms in the late summer and fruits in the fall. The wind-dispersed seeds do not require stratification and seeds germinate in the early spring. Plants grow about 10 years. In the Southeastern Great Basin *Ericameria nauseosa* is replaced over time by *Artemisia tridentata* if the stand is not disturbed.

*Ericameria nauseosa* is variable browse for livestock and wildlife, depending on subspecies and ecotype. Its resinous foliage burns readily even with high moisture content. It may resprout after fire, and wind-dispersed seeds readily colonize areas after fire from neighboring plants.

**Regional Status:**
**Mojave Desert:** Along watercourses in the eastern Mojave Desert**.** In the western Mojave Desert, stands occupy fallow agricultural fields

**Management Considerations:** This alliance is indicative of recent disturbance including fire, flood, and mechanical clearing. The existence of large areas of this alliance in an area suggests a level of disturbance greater than the norm.

## *Ericameria paniculata* Intermittently Flooded Shrubland Alliance

Figure A19. *Ericameria paniculata* Intermittently Flooded Shrubland Alliance; Emigrant Canyon, Panmint Mountains

*Ericameria paniculata* is the sole or dominant shrub in canopy. *Ambrosia eriocentra, Brickellia incana, Encelia farinosa, Encelia virginensis, Ephedra nevadensis, Ephedra californica, Eriogonum fasciculatum, Hymenoclea salsola, Salvia dorrii* or *Stephanomeria pauciflora* may be present. Emergent *Acacia greggii* and *Chilopsis linearis* may be present. Trees < 5 m tall; scattered cover. Shrubs < 3 m tall; intermittent or open cover. Ground layer sparse. Annual herbs or grasses seasonally present.

**Habitat:** Washes, intermittent channels, arroyos intermittently flooded riverine or palustrine. Soils coarse, well-drained moderately acidic to slightly saline. The national list of wetland plants (Reed 1988) lists *Ericameria paniculata* as a Facultative Upland species.

**Distribution**: Mojave Desert, Sonoran Desert, Colorado Desert, Southeastern Great Basin.

**Elevation:** 100 to 1,100 m

**NDDB Rank:** unknown

**Synonyms:**
Holland: Mojave wash scrub (34250), Mojave Desert wash scrub (63700)
Barry: G7411221
Cheatham and Haller: Desert dry wash woodland
WHR: Desert wash
Munz: Creosote bush scrub, Shadscale scrub, Joshua tree woodland

**References:** FEIS (2001), Johnson (1976), Vasek and Barbour (1977),

**Membership Rules:** *Ericameria paniculata* ≥ 2%. *Ericameria paniculata* must be ≥ 25% of all cover. Widespread throughout broad elevation range in much of the mapping area in relatively large, recently active washes. Evens (2000) indicates *Ericameria paniculata* as the dominant canopy shrub with cover > 5%.

**Comments:** *Ericameria paniculata* Intermittently Flooded Shrubland Alliance is widespread, though localized, in washes and other fluvial channels throughout the hot deserts of California and adjacent Arizona, Nevada and Utah. Its center of distribution is in the Mojave Desert, where it occupies active washes and adjacent terraces on gently sloping bajadas and alluvial fans. It is commonly known as black-stemmed rabbitbrush, from fungal rust that causes distinct black bands around the young stems. As with other "rabbitbrush" species, it is relatively short-lived and well adapted to disturbance. However, it is not typically found in upland stands, as is *Ericameria nauseosa*, or *Chrysothamnus viscidiflorus*; *Ericameria paniculata* Intermittently Flooded Shrubland Alliance is largely limited to fluvial disturbance.

Many stands are monospecific and may be relatively dense with little or no understory. Most stands are found in medium-to-large washes where flooding events are regular (at least some water flows every few years). Stands typically occupy wash bottoms in broad, braided-channel washes and terraces in narrower, higher-energy washes, suggesting high rates of scour and flooding intensities are not conducive to high-density establishment. Seeding is prolific in the fall (September-November). The wind-blown seed will lodge in gravel and irregularities in the wash bottoms, and are further dispersed and germination activated when flooding comes. *Ericameria paniculata* grows quickly in favorable sites and may reach 4 m in height. However, shrub life span is relatively short.

Some resprouting may occur following minor damages from flood or fire, but moderate to severe fire likely kills shrubs (FEIS 2001). Fire is not likely to be an important agent of disturbance in this alliance due to its characteristic habitat. Large flooding events may destroy and eliminate all shrubs in the main watercourse, but seedling recruitment from adjacent individuals in protected microsites may be rapid. *Ericameria paniculata* does not occur at high elevations or further north in the Great Basin as do several other *Ericameria* spp. It may be relatively frost-sensitive.

**Regional Status:**
**Mojave Desert:** Stands occur in washes throughout the Californian Mojave Desert. In the west Mojave Desert, it occupies a similar niche to *Lepidospartum squamatum* Intermittently Flooded Shrubland Alliance (as at Red Rock Canyon State Park). It may also overlap with *Atriplex polycarpa, Atriplex hymenelytra, Hymenoclea salsola, Psorothamnus spinosus,* and *Larrea tridentata* or *Larrea tridentata-Ambrosia dumosa* Shrublands. In the Black Mountains and other mountains of Death Valley, it may occur with *Encelia virginensis* Shrubland Alliance. It mixes with these alliances and with open wash woodlands of *Chilopsis linearis* and *Acacia greggii*-dominated alliances. On terraces where such trees occur, *Ericameria paniculata* may succeed to the tree-dominated alliances, following long periods of no disturbance.
**Southeastern Great Basin** *Ericameria paniculata* Intermittently Flooded Shrubland occurs along washes in the Saline Valley and Cottonwood, Grapevine, Coso, Argus, and Panamint Ranges. Occupies washes with *Hymenoclea salsola* and *Encelia virginensis* Shrublands.

**Management Considerations:** Short-lived communities such as these are relatively unscathed by human interactions except for off-highway vehicle impacts and gravel mining within the wash environment.

## *Ericameria teretifolia* Shrubland Alliance

No photograph is available.

*Ericameria teretifolia* is the dominant or important plant in the shrub layer. *Artemisia ludoviciana, Ephedra viridis, Eriogonum fasciculatum, Grayia spinosa, Gutierrezia microcephala, Opuntia acanthocarpa, Prunus fasciculata, Salazaria mexicana, Salvia dorrii, Sphaeralcea ambigua,* or *Stephanomeria pauciflora* along with other shrubs may be present in the overstory. *Muhlenbergia porteri, Poa secunda, Pleuraphis rigida, Pleuraphis jamesii,* or *Achnatherum speciosum* may form a scattered grass understory. Shrubs 0.5-2 m tall; intermittent to open cover. Grasses 0.5-1.5m tall; intermittent to open cover.

**Habitat:** Ridges, slopes, valleys. Soils bedrock or alluvium-derived.

**Distribution:** Mojave Desert, Southern California Mountains and Valleys, Southeastern Great Basin.

**Elevation:** 800 to 1,700 m

**NDDB Rank:** G4 S4

**Synonyms**:
Holland: Mojavean juniper woodland and scrub (72220), Peninsular juniper woodland and scrub (72320), Mojave mixed woody scrub (34210), Mojave mixed woody and succulent scrub (34240), Blackbrush scrub (34300)
Barry: G74G7411112BJUCA00

Cheatham and Haller: Mojavean pinyon juniper woodland
PSW-45: Juniper series
Thorne: Pinyon juniper woodland
WHR: Juniper
CALVEG: Pinyon-Juniper
Munz: Pinyon-juniper woodland, Shadscale scrub

**References:** Thorne (1982), Vasek and Thorne (1977), Keeler-Wolf et al.1998; plot-based descriptions are found in Keeler-Wolf et al.1998.

**Membership Rules:** *Ericameria teretifolia* ≥ 2% cover. No other species with greater cover but can share dominance with *Eriogonum fasciculatum, Gutierrezia sarothrae,* or O*puntia chlorotica.* Usually of disturbed uplands**,** mid-elevation Mojave Desert.

**Comments:** In the Mojave Desert and Peninsular Range/Colorado Desert borderland, the *Ericameria teretifolia* Shrubland Alliance is one of several mid-elevation xeromorphic upland scrub alliances above the broad belt of *Larrea tridentata-Ambrosia dumosa,* but below the high-elevation shrublands with *Artemisia tridentata* and the *Pinus monophylla*. It occurs in disturbed areas, including burns, washes, and heavily grazed sites. *Ericameria teretifolia* nearly always shares the short-shrub canopy with other shrub species. As with other members of its genus, *Ericameria teretifolia* is a relatively short-lived shrub, which may seed and germinate abundantly after disturbance. In Anza-Borrego Desert State Park, there is evidence that this alliance replaces *Juniperus californica* Wooded Shrubland Alliance following fire.

*Ericameria teretifolia* is a common shrub of the mid-elevation of the Mojave Desert and the Southeastern Great Basin. In the Mojave Desert, this alliance occupies similar environments to *Grayia spinosa, Eriogonum fasciculatum, Salazaria mexicana, Pleuraphis* spp. and *Juniperus osteosperma*-dominated alliances. Stands of this alliance share several other species with other relatively high-frequency disturbance alliances. In the Peninsular Ranges, the alliance occupies former stands of *Juniperus californica* following fire events as old as 25 years. This alliance is a seral type that replaces other long-persistent alliances following fire or perhaps other disturbance such as intensive grazing or mechanical soil disturbance. It occurs adjacent to *Juniperus osteosperma*, *Juniperus californica*, *Atriplex confertifolia*, *Coleogyne ramosissima,* and *Grayia spinosa*-dominated alliances. It likely replaces those types for undetermined periods following disturbance.

**Regional Status:**
**Mojave Desert:** This is a disturbance-following type with relatively few large stands. It generally occurs below the pinyon belt and is frequently found in the shadscale and juniper zones in the eastern and northern parts of the Mojave Desert. No specific disturbance information is available.
**Southeastern Great Basin:** It occurs in habitats similar to the Mojave Desert (see above) and has colonized road cuts in upper elevation portions of Death Valley National Park.

**Management Considerations:** This alliance is a seral type and should be considered part of the natural matrix of mid-to-upper desert vegetation. Large stands are indicative of some more-extensive, often anthropogenic, disturbance processes.

## *Eriogonum fasciculatum* Shrubland Alliance

No photograph is available.

*Eriogonum fasciculatum* is the sole, dominant, or important shrub. In the Mojave Desert, emergent shrubs such as *Ambrosia dumosa, Coleogyne ramosissima, Ephedra nevadensis, Ericameria teretifolia, Hymenoclea salsola, Larrea tridentata, Pleuraphis jamesii, Salazaria mexicana, or Viguiera parishii* and emergent trees of *Juniperus californica, Juniperus osteosperma,* or *Yucca schidigera* may be present. Shrubs < 1 m tall; canopy continuous or intermittent. Ground layer variable, may be grassy.

**Habitat:** Slopes, rarely flooded low-gradient deposits. Soils shallow and rocky. Also in wetland habitats such as washes, intermittent channels, arroyos intermittently flooded riverine or palustrine. Soils are coarse, well drained, and moderately acidic to slightly saline.

**Distribution:** Southern California Coast, Southern Central California Coast Ranges, Southern California Mountains and Valleys, Mojave Desert, western Colorado Desert, Baja California.

**Elevation:** 0 to 1,200 m

**NDDB Rank: unknown**

**Synonyms**:
Holland: Alluvial fan chaparral; Central Lucian coastal, Diablan sage, Diegan coastal sage scrub, Riversidean sage scrub, Southern coastal bluff, Venturan coastal sages
Barry: G7411211 CERFA00
Cheatham and Haller: Central coastal, Coastal sage scrubs
PSW-45: California buckwheat series
Rangeland: SRM 205
Thorne: Southern coastal scrub
WHR: Coastal scrub
Munz: Coastal sage scrub

**References:** Axelrod (1978), Barbour (1994), DeSimone and Burk (1992), Keeley and Keeley (1988), Kirkpatrick and Hutchinson (1977), Malanson (1984), Mooney (1977), O'Leary (1989), Paysen et al. (1980), Pase and Brown (1982), Vasek and Barbour (1977), Westman (1983); plot-based descriptions are found in Hanes et al. (1989), Kirkpatrick and Hutchinson (1977), Gordon and White (1994), White (1994), and Keeler-Wolf et al. (1998)

**Membership Rules:** *Eriogonum fasciculatum* ≥ 2%. Usually in disturbed shallow soils on slopes and pediments near interface with mid- and upper-elevation Mojave Desert. Other shrubs, if present, are each less than half cover, with the exceptions of *Hyptis emoryi* or *Salvia dorrii*, which may have higher cover.

**Comments:** *Eriogonum fasciculatum* is a semi-woody, many-branching shrub often occurring on coarse-textured soils that may be moderately saline. It produces conspicuous flowers over much of the year with low seed set. Seed germination requires stratification and does not require a fire-related stimulus. In coastal areas, this alliance is part of the coastal scrub ecological system. Associated species vary depending upon the geographic section in which the alliance occurs (see below).

It establishes after disturbance by fire, flood, or livestock. It rarely resprouts after disturbance and can be replaced by longer-living species in areas with long periods between disturbances.

**Regional Status:**
**Mojave Desert**: Local at mid and upper elevations in areas in the eastern Mojave Desert disturbed by fire, grazing, and water (in washes).

**Management Considerations:** No additional information is available.

## *Forestiera pubescens* Temporarily Flooded Shrubland Alliance

Figure A20. *Forestiera pubescens* Temporarily Flooded Shrubland Alliance, Willow Spring

*Forestiera pubescens* is the dominant or important shrub in the canopy. *Salix exigua, Salix laevigata, Atriplex canescens, Vitis girdiana, Baccharis sergiloides, Baccharis emoryi, Phragmites australis,* or *Rhus trilobata* may be present. Canopy intermittent to continuous. Shrubs < 5 m tall.

**Habitat:** Soils intermittently flooded, saturated. Water chemistry: fresh. Floodplains, stream banks, springs, river terraces or washes. Soils gravelly to fine sandy. The national list of wetland plants (Reed 1988) lists *Forestiera pubescens* as a NI (not enough information) for California.

**Distribution:** Mojave Desert, Southeastern Basin and Range, Colorado

**Elevation:** 800 to 1,800m

**NDDB Rank:** G3 S2.2 Multiple associations may be represented; some may be very rare.

**Synonyms:**
Cheatham and Haller: Desert dry wash woodland, Southern alluvial woodland
Thorne: Desert riparian woodland
WHR: Desert riparian

**References:** Reid et al. (1999)

**Membership Rules:** None developed.

**Comments:** The *Forestiera pubescens* Temporarily Flooded Shrubland Alliance occurs in widely scattered, small stands throughout the mountains of the Mojave Desert and adjacent Southeastern Great Basin. Stands are never common and usually occur locally around permanent water or subsurface moisture. Typical settings are springs in hilly or mountainous terrain, or narrows in canyon bottoms where moisture is forced to the surface. These stands are often associated with other wetland alliance stands dominated by *Salix exigua, Tamarix* spp., *Populus fremontii* and *Baccharis sergiloides*. The highest density of stands apparently occurs in the Argus and Coso Mountains area of the Southeastern Great Basin. There, many of the springs in the canyons on the east side of the Argus Range support stands, some of which are foraging habitat for the endemic Inyo race of the California towhee (M. Bagley, personal communication). Compared to the *Salix exigua* and *Populus fremontii*-dominated alliance, *Forestiera pubescens* Intermittently Flooded Shrubland appears to prefer slightly drier conditions as upslope from flowing water. Stands are usually dense with sparse understory.

*Forestiera pubescens* is a desert wetland species**.** Its fruits are drupes and are probably bird dispersed. It appears to form clonal thickets perhaps because of stem damage. No information is available from FEIS (2001) on disturbance ecology.

**Regional Status:**
**Mojave Desert:** Stands occur in the eastern Mojave Desert mountains around springs and in canyons.
**Southeastern Great Basin:** Stands occur in Inyo, Argus, and Coso Mountains.

**Management Considerations:** This wetland alliance could be very sensitive to invasion by *Tamarix* spp. It is rare and localized throughout its known range in California.

## *Grayia spinosa* Shrubland Alliance

Figure A21. *Grayia spinosa* Shrubland Alliance, Inyo Mountains

*Grayia spinosa* is the dominant or important shrub in canopy. *Acamptopappus spherocephalus, Achnatherum speciosum, Ambrosia dumosa, Artemisia spinescens, Atriplex confertifolia, Chrysothamnus viscidiflorus, Larrea tridentata, Krascheninnikovia lanata, Lycium andersonii,* or *Tetradymia spp.* may be present. Emergent *Yucca brevifolia* may be present. Shrubs < 1 m tall; canopy continuous, intermittent, or open. *Bromus tectorum, Eriogonum ovalifolium*, or *Poa secunda* may be present. Ground layer sparse to intermittent.

**Habitat:** Basins, valleys, lower mountain slopes. Soils alluvial-derived, ranging from gravelly, sandy loams to dry heavy clays, but is typically found on highly calcareous, alkaline soils. It prefers sandy soils that are free of salt and hardpans (FEIS 2001).

**Distribution:** Northwestern Basin and Range, Mono, Southeastern Great Basin, Mojave Desert, Modoc Plateau, Intermountain West

**Elevation:** 500 to 1,900 m

**NDDB Rank:** G5 S3.3 (some associations may be rarer)

**Synonyms:**
Holland: Shadscale scrub (36140)
Cheatham and Haller: Shadscale scrub
PSW-45: Saltbush series
Rangeland: SRM 414, SRM 501

Thorne: Shadscale scrub
WHR: Alkali sink
Munz: Shadscale scrub
CALVEG: Shadscale series

**References:** Beatley (1976), Webb et al 1988, FEIS (2001)

**Membership Rules:** *Grayia spinosa* ≥ 2% cover; no other species with greater cover except *Ericameria cooperi* or *Lycium andersonii. Lycium andersonii* must dominate in some circumstances.

**Comments:** *Grayia spinosa* Shrubland is widespread in the Mojave Desert and Southeast Great Basin. It occupies a distinct and relatively narrow portion of the environmental gradient above the *Larrea tridentata-Ambrosia* Shrubland and below stands of *Artemisia tridentata* Shrubland and upland stands of *Atriplex confertifolia* Shrubland. According to Beatley (1976), it is the most characteristic plant community of the transition between the Mojave Desert and the Southeastern Great Basin in south-central Nevada. It often occupies deep, well-drained soils in valleys and bajadas. It typically occurs adjacent to *Coleogyne ramosissima* (shallower, rocky soils), *Atriplex confertifolia* (more alkaline or shallow calcareous soils), or upper-elevation stands of *Larrea tridentata* and *Larrea tridentata-Ambrosia dumosa* Shrublands. It grows well on limey soils, but is not as well adapted to salty soils as *Atriplex confertifolia, Atriplex polycarpa, Atriplex canescens,* or *Sarcobatus vermiculatus*. *Grayia spinosa* commonly occurs in nearly pure stands and is most commonly associated with *Lycium andersonii* in the Southeastern Great Basin and the Mojave Desert. The NVC differentiates stands with an intermittent flooding regime as *Grayia spinosa* Intermittently Flooded Shrubland Alliance and stands mixed with the evergreen shrub *Ephedra viridis* as members of another alliance, *Grayia spinosa-Ephedra viridis* Shrubland Alliance. Although suspected in California, these alliances have not been identified yet.

*Grayia spinosa* is considered to be intermediately-lived (mostly < 100 years), and can colonize soon after, but not immediately following mechanical disturbance (Webb et al. 1988). It is reported to sprout readily after mechanical disturbance such as trampling and/or light burning. However, deep plowing easily kills *Grayia spinosa* (FEIS 2001). It tolerates browsing and may be an important range feed for livestock in the Great Basin (FEIS 2001), but because of its spines, *Grayia spinosa* is not considered of high forage value (FEIS 2001). Response to fire is not well quantified. Plants are known to re-sprout from the base following fire (FEIS 2001). However, participants in the Desert Workshop (T. Keeler-Wolf personal communication, Desert Workshop 2000) considered it to generally be a weak sprouter. As it is an intermediately-lived shrub, it is indicative of stable conditions in many areas. Living shrubs of *Grayia spinosa* have been successfully transplanted in roadside re-vegetation projects in eastern California (FEIS 2001). Little is known about the seral stages and natural disturbance patterns of this alliance. Reproduction by seed is periodic and relatively uncommon (T. Keeler-Wolf personal communication, Desert Workshop 2000).

**Regional Status:**
**Mojave Desert:** Stands occur in Owens, Greenwater, Searles, and Mojave valleys. Upland stands occur on rocky hills mixed with stands of *Ephedra nevadensis, Atriplex confertifolia, Menodora spinescens, Larrea tridentata-Ambrosia dumosa, Yucca schidigera,* and *Yucca brevifolia* Shrublands. Stands are known as far south as Lucerne and Johnson valleys. It ranges west into the western Mojave Desert where it commonly co-occurs in stands with *Krascheninnikovia lanata* Dwarf-shrubland. Most stands in the southern portion of the range of the alliance are in valleys surrounding *Atriplex polycarpa* Shrubland and below other upland stands of *Larrea tridentata-Ambrosia dumosa.* Stands with a high level of cattle browsing in the Ord Mountains are mixed with *Hymenoclea salsola* and *Acamptopappus spherocephalus.*
**Southeastern Great Basin**: Upland stands are extensive in the Cottonwood and Grapevine Mountains and Coso, Argus and Panamint Ranges. These may form a mosaic with *Coleogyne ramosissima, Yucca brevifolia, Atriplex confertifolia, Artemisia tridentata, Ephedra nevadensis,* and *Larrea tridentata-Ambrosia dumosa* Shrublands. Stands occur in alluvial valley bottoms and on gradual slopes. In the Panamint Mountains this alliance transitions gradually at lower elevations into the *Larrea tridentata-Ambrosia* Shrubland and upwards into the *Coleogyne ramosissima* Shrubland.

**Management Considerations:** A further understanding of fire history and other disturbance response is needed. In some areas, the alliance seems compatible with a high level of livestock browsing. It also characterizes the preferred habitat of the endangered Mojave ground squirrel (M. Bagley, personal communication).

## Herbaceous Dunes Sparse Vegetation Alliance
No photograph is available.

This alliance is characterized by its occurrence on stabilized sand sheets and dunes rather than by any one dominant species. Scattered forbs and grasses in the ground canopy. *Abronia villosa, Cleome sparsifolia, Croton californicus, Dicoria canescens, Geraea canescens, Oenothera deltoides, Oryzopsis hymenoides, Panicum urvilleanum, Pleuraphis rigida, Rumex hymenosepalus,* or *Swallenia alexandrae* may be present. Individual emergent shrubs may be present such as *Ambrosia dumosa, Atriplex canescens, Eriogonum deserticola*, or *Larrea tridentata.* Shrubs < 3 m tall. Ground layer open. Annuals seasonally present.

**Habitat:** Sand bodies. Active, partially stabilized, and stabilized dunes; or partially stabilized and stabilized sand fields.

**Distribution:** Southern California Mountains and Valleys, Mojave Desert, Sonoran Desert, Colorado Desert, Mono Co. and Southeastern Great Basin.

**Elevation:** -10 to 1,200 m

**NDDB Rank**: G3 S2.2

**Synonyms**:
Sawyer and Keeler-Wolf (1995): *Abronia villosa* series (in part)
Holland: Active desert dunes, stabilized and partially stabilized dunes, stabilized and partially stabilized desert sand fields
Barry: G7411323
Cheatham and Haller: Partially stabilized desert dunes, stabilized desert dunes.
PSW-45: Croton series
Stone and Sumida: Sand plant community.
Thorne: Desert dune sand plant
WHR: Desert scrub

**References:** Henry (1979), Thorne (1982), Paysen et al. (1980), Vasek and Barbour (1977); plot-based descriptions include Bagley (1986), DeDecker (1979), Spolsky (1979); plot-based descriptions are available for individual dunes: Algodones dunes (Beauchamp 1977), Ballarat dunes (Pavlik 1985), Borrego dunes (Beauchamp 1986), Cadiz dunes, Chuckwalla Valley dunes, Death Valley dunes (DeDecker 1979, 1984), Deep Springs dunes (Pavlik 1985), Dumont dunes, Eureka dunes (DeDecker 1984), Mono dunes (Pavlik 1985), Olancha dunes (Pavlik 1985), Panamint Valley dunes, Rice Valley dunes, Saline Valley dunes (DeDecker 1984), Saratoga dunes (Pavlik 1985).

**Membership Rules:** Perennial plants present but less than 2%; characteristized by sand dunes and sand flats. Perennial species can include scattered grasses such as *Achnatherum hymenoides, Panicum urvilleanum, Pleuraphis jamesii, Pleuraphis rigida* and *Swallenia alexandrae*; shrubs such as *Atriplex canescens, Larrea tridentata,* and *Ambrosia dumosa*; and forbs such as *Dicoria canescens, Abronia villosa,* and *Oenothera deltoids.*

**Comments:** Eighteen dune areas are scattered throughout the deserts of transmontane California, each with its own set of plant species (Pavlik 1985). Dunes that have been studied floristically are Algodones, Ballarat, Borrego, Cadiz, Chuckwalla Valley, Death Valley, Deep Springs, Dumont, Eureka, Kelso, Mono, Olancha, Panamint Valley, Rice Valley, Saline Valley, and Saratoga. Sawyer and Keeler-Wolf (1995) considered all desert dunes to be included within *Abronia villosa* series; however, much seasonal and within-dune system variation occurs, some of which requires further research to clarify. Currently there is sufficient information to break out some components of dune vegetation into separate alliances (see *Panicum urvilleanum* and *Achnatherum hymenoides* Herbaceous Alliances).

Other alliances on sand dunes and flats include *Achnatherum hymenoides, Atriplex canescens, Larrea tridentata-Ambrosia dumosa, Panicum urvilleanum, Pleuraphis jamesii,* and *Pleuraphis rigida*-dominated alliances and unique stands of *Swallenia alexandrae.*

Sand dunes are used for many uses other than passive recreation. Algodones (Imperial) and Dumont dunes are open to motorized recreation. Eureka Dunes have been used for sand-boarding. Various plant species each have their peculiar adaptations to growing on sand. Psammophitic grasses such as *Swallenia alexandrae, Achnatherum hymenoides, Panicum urvilleanum,* and *Pleuraphis rigida* each have different tolerances and tend to arrange themselves accordingly within dune systems. Annual psammophytes tend to rearrange themselves based on varying annual rainfall and temperature conditions. Some have adapted seasonally, like *Dicoria canescens* and grow in summer-fall; others such as *Abronia villosa* and *Oenothera deltoides* are early spring species.

**Regional Status:**
**Mojave Desert**: Ballarat Dunes, Death Valley Dunes, Dumont Dunes, Kelso Dunes Olancha Dunes, Panamint Valley Dunes
**Southern California Mountains and Valleys:** Colton Dunes
**Southeastern Great Basin**: Deep Springs Dunes, Eureka Dunes, Saline Valley Dunes

**Management Considerations:** Sand sheets and dunes are relatively rare. OHV use and disruption of sand sources have degraded many. Protection from impacts has been implemented on a portion of California dunes, but many, such as Dumont, Algodones, and Rice Valley dunes, have had long-term quantifiable negative impacts.

## *Hymenoclea salsola* Shrubland Alliance

Figure A22. *Hymenoclea salsola* Shrubland Alliance, Jubilee Pass, Death Valley

*Hymenoclea salsola* is the sole or dominant shrub in overstory. *Ephedra californica, Encelia farinosa, Ericameria paniculata, Eriogonum fasciculatum, Larrea tridentata, Opuntia echinocarpa, O. basilaris, Psorothamnus schottii,* or *Salazaria mexicana* may be present. Emergent *Acacia greggii, Parkinsonia florida, Chilopsis linearis, Olneya tesota* or *Psorothamnus spinosus* may be present. *Bromus madritensis* and other weedy annuals may be in ground layer. Shrubs open to intermittent cover; < 2 m tall. Emergent tall shrubs or low trees < 6 m tall. Ground layer sparse or seasonally present.

**Habitat:** Valleys, flats, rarely flooded low-gradient deposits. Soils are shallow; sandy, gravelly, or disturbed desert pavement. Wetland habitats such as washes, intermittent channels, arroyos, intermittently flooded riverine or palustrine. Soils are coarse, well drained, and moderately acidic to slightly saline.

**Distribution:** Mojave Desert, Sonoran Desert, Colorado Desert, Southeastern Great Basin, Great Valley, Central California Coast Ranges, Arizona, Nevada, and perhaps Utah

**Elevation:** 0 to 1,600 m

**NDDB Rank:** G4 S4

**Synonyms:**
Holland: Mojave wash scrub (34250), Mojave creosote bush scrub (34100), Sonoran creosote bush scrub (33100)
Munz: Creosote bush scrub, Shadscale scrub

**References:** FEIS (2001), Johnson (1976), Vasek and Barbour (1977); plot-based descriptions are found in Keeler-Wolf et al. (1998).

**Membership Rules:** *Hymenoclea salsola* > 1%. Other shrubs, if present, are each less than half the cover of *Hymenoclea Salsola,* with the exceptions of *Hyptis emoryi* or *Salvia dorrii*, which may have higher cover.

**Comments:** *Hymenoclea salsola* is widespread in many alliances in the hot deserts of California. However, canopy dominance by *Hymenoclea salsola* is necessary to define the alliance. *Hymenoclea salsola* Shrubland is the ubiquitous native indicator of recent disturbance throughout the hot deserts of California. It occurs commonly in washes, but also in burned and heavily grazed areas from below sea level to at least 1,600 m. Flooding is the most frequent natural disturbance associated with this alliance. However, it has benefited from increased fire frequencies resulting from the fuels built up from non-native annual *Bromus* spp. It has also benefited from over-grazing by livestock in certain parts of the desert. Thus, it currently occupies upland sites as well as wash and bottomland sites throughout its distribution. It has varied relationships to other vegetation types, given its geographic and ecological range. In many lower elevation washes, it occurs adjacent *to Psorothamnus spinosus, Olneya tesota, Parkinsonia florida*, *Atriplex polycarpa, Ephedra californica*, and *Bebbia juncea*-dominated alliances. At mid-elevations, it is commonly associated with *Ericameria paniculata, Salazaria mexicana, Chilopsis linearis, Eriogonum fasciculatum, Ephedra californica, Larrea tridentata, Larrea tridentata-Ambrosia dumosa,* and *Yucca brevifolia*-dominated alliances. On calcareous substrates, it may occur with *Encelia virginensis* and *Viguiera reticulata*-dominated alliances in washes and on slopes having *Artemisia nova* Shrubland. It occurs adjacent to *Acacia greggii* Shrubland in both washes and upland settings. In some upland, settings it may occur with non-native *Bromus madritensis* stands. It may coexist with *Atriplex confertifolia, Prunus fasciculata* and *Ericameria nauseosa* Shrublands at high elevations.

The *Hymenoclea salsola* Shrubland Alliance is indicative of disturbed sites. In wash and arroyo settings, flooding regimes for the alliance are generally of high frequency and have variable intensity. The seeds have high viability and high germination rates compared to other desert shrubs. Seeding is prolific; and flowering, leaf-flush, and seed set are opportunistic whenever water is available (FEIS 2001). The species is short-lived and has a shallow root system consisting of a relatively short taproot with prominent laterals. It not only seeds from adjacent sites and colonizes bare mineral soil, but it also re-sprouts following mechanical above-ground damage from flood and from fire (FEIS 2001). *Hymenoclea salsola* Shrublands recover quickly after fire via off-site seeds and sprouting. Five years after the Snow Creek fire, *Hymenoclea salsola* frequency and cover were greater on burned than unburned sites (O'Leary and Minnich 1981). Following a fire in the San Ysidro Mountains, more than 90% of *Hymenoclea salsola* plants survived by sprouting. Some *Hymenoclea salsola* started sprouting within 2 months after the fire (Tratz 1978).

**Regional Status:**
**Mojave Desert:** This alliance occurs throughout the Mojave Desert. In all parts of the Mojave Desert, it is a disturbance-related alliance of washes, roadsides, OHV, military camps, heavily grazed land, and recently burned slopes. It may occupy limestone and other calcareous substrates and granitic- and volcanic-derived soils. Its elevation range is up to 1,500 m, as in the mid-hills**.**

**Management Considerations:** *Hymenoclea salsola* with its natural colonizing ability is well suited for being the primary early-seral wash alliance through most of the hot deserts of California. However, its current distribution is more abundant than its historic distribution in much of the desert because of recent human-mediated disturbance patterns. This is another alliance where coincidence of non-native annual grass invasion and human-related fires has threatened the structure and diversity of the vegetation. In the deserts, fires should be excluded at all times of the year, and core areas should be identified where grass cover is low and thus stands are defensible.

## *Hyptis emoryi* Intermittently Flooded Shrubland Alliance
No photograph is available.

*Hyptis emoryi* is the emergent or important tall shrub over a lower-shrub canopy. Emergent *Acacia greggii, Parkinsonia florida, Chilopsis linearis, Olneya tesota* or

*Psorothamnus spinosa* may be present. Tall shrubs or emergent trees < 6 m tall; intermittent to open cover. Small shrubs < 3 m tall; canopy intermittent to open. *Bebbia juncea, Encelia farinosa, Eriogonum inflatum, Hymenoclea salsola, Justicia californica, Larrea tridentata, Psorothamnus schottii, Opuntia basilaris,* or *Trixis californica* may be present. Ground layer open; annuals seasonally present.

**Habitat:** Steep, very rocky colluvium on lower portion of canyon slopes. Soils are azonal and very rocky. It also occurs in wetland habitats such as bouldery or rocky arroyo margins, seasonal watercourses, and washes. Soils intermittently flooded, saturated. Water chemistry: fresh. Cowardin class: temporarily flooded, palustrine shrub-scrub wetland.

**Distribution:** Colorado Desert, Sonoran Desert and southern Mojave Desert in California, Baja California, and perhaps Sonoran Desert in Arizona.

**Elevation:** 10 to 800 m

**NDDB Rank:** G3 S3

**Synonyms:**
Holland: Desert dry wash woodland (62200 *in part*), Mojave desert wash scrub (63700 *in part*), Mojave wash scrub (34250 *in part*)
Thorne: Desert microphyll woodland (in part)
WHR: Desert wash
Munz: Creosote bush scrub

**References:** Plot-based descriptions are based on Keeler-Wolf et al. (1998)

**Membership Rules:** Vegetation characterized by the tall, aromatic shrub *Hyptis emoryi* (desert lavender). It is local in rocky washes of upper bajadas and canyons in the southern portion of the Mojave Desert.

**Comments:** *Hyptis emoryi* forms scraggly stands along many of the minor washes in the low, hot, and very dry Colorado and Sonoran deserts of California. They tend to occupy narrow washes with moderate-to-steep gradients and along washes that are not big enough to support stands of the microphyllous legume trees of the desert. The *Hyptis emoryi* Shrublands appear to prefer the rocky and bouldery stretches of washes, rather than the broad and sandier portions. Stands are often only narrow strips that ascend drainages in old-dissected alluvial fans or badlands. This alliance seems to be limited by temperature, as it does not ascend > 700 m in the desert mountains and it does not occur very far north into the Mojave Desert.

*Hyptis emoryi* appears to tolerate a high degree of flood disturbance. It is a long-lived species that resprouts following flood or severe damage. Shrubs are often positioned in the center of small washes and sustain repeated damage from flooding. Stems appear to ramify following damage. Flooding in the smaller washes probably occurs at least every

10 years. The relationship between this alliance and other similar ones such as *Acacia greggii* Shrubland needs to be determined. Seeds are probably dispersed in water. Flowering and seed set are opportunistic following rain and flooding (T. Keeler-Wolf personal communication, Desert Workshop 2000).

**Regional Status:**
**Mojave Desert:** Stands occur on the north side of Joshua Tree National Park and at least as far north as the southern bajadas of the Marble Mountains.

**Management Considerations:** Burro and OHV use affects many small washes in the Sonoran and Colorado deserts**.** Their impacts to this alliance have not been quantified.

## *Juncus cooperi* Seasonally Flooded Herbaceous Alliance

Figure A23. *Juncus cooperi* Seasonally Flooded Herbaceous Alliance, Death Valley

*Juncus cooperi* is the sole dominant or important species in this herbaceous alliance. *Atriplex spp., Juncus mexicanus, Distichlis spicata, Schoenoplectus americanus, Phragmites australis, Anemopsis californica, Iva acerosa,* or *Heliotropium curassavicum* may be present. Grasses and herbs < 1 m tall. Canopy intermittent to continuous.

**Habitat:** Habitat intermittently saturated with shallow water table. Water chemistry: fresh, mixohaline, mixosaline. Cowardin class: palustrine persistent emergent wetland. The national list of wetland plants (Reed 1988) lists *Juncus cooperi* as a Facultative Wetland species.

**Distribution:** Mojave Desert, Southeastern Basin and Range, Nevada

**Elevation:** -75 to 950 m

**NDDB Rank:** G3 S3.2

**Synonyms:**
Holland: Transmontane alkali marsh (52320)
Barry: G7412331
Cheatham and Haller: Great Basin alkali marsh
Thorne: Alkali meadow, freshwater marsh
WHR: Fresh emergent wetland
Munz: Freshwater marsh

**References:** None

**Membership Rules**: Vegetation characterized by the relative dominance of *Juncus cooperi*. Usually, small stands are associated with other species of low-lying alkali seeps or meadows in such areas as Zzyzx, Tecopa, Shoshone, and Death valleys.

**Comments:** *Juncus cooperi* Herbaceous Alliance is apparently restricted to the Mojave Desert and the adjacent Southeastern Great Basin. It occurs in typically small stands around the margins of alkaline springs associated with *Distichlis spicata* Intermittently Flooded Herbaceous Alliance, and frequently surrounds other more hydrophilic alliances that are dominated by *Schoenoplectus americanus* and *Phragmites australis*. There is often a salt crust on the surface, suggesting that the distribution of the alliance is related to alkaline/saline soils. Many of the stands are associated with springs adjacent to desert basins containing Pleistocene lake playas. These stands are located in relatively low, hot portions of the Mojave Desert and Southeastern Great Basin where temperatures commonly rise above 40º C for many consecutive days in the summer. Plot data are limited, but observation of this alliance in many stands throughout the Mojave Desert supports defining it as an alliance.

*Juncus cooperi* occupies relatively dry margins of springs and seeps with access to subterranean moisture for at least part of the growing season. The species forms dense, monospecific stands in relatively moist areas, and tends to form more open stands in drier areas, with an understory of *Distichlis spicata* and other salt-tolerant species. Stands typically form rings around more moisture-loving alliances dominated by *Phragmites australis* or *Schoenoplectus americanus*. These alliances are in turn surrounded by *Distichlis spicata*, *Atriplex* spp., *Suaeda moquinii*, or *Allenrolfea occidentalis*-dominated alliances.

**Regional Status:**
**Mojave Desert:** Stands are found at springs and seeps in low-lying valleys and playa edges.

**Southeastern Basin and Range:** Stands have been observed in Saline Valley.

**Management Considerations:** Poor management of the wetlands in which it exists can easily threaten this relatively rare and little-known alliance.

## *Juniperus osteosperma* Wooded Shrubland Alliance

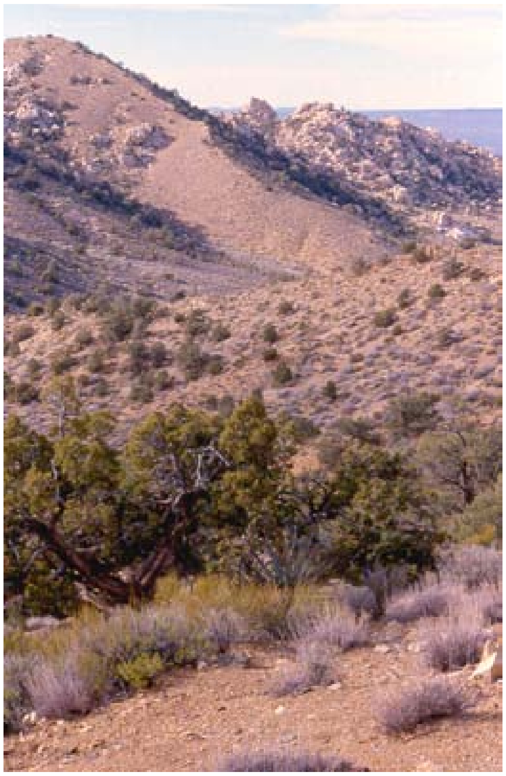

Figure A24. *Juniperus osteosperma* Wooded Shrubland Alliance

*Juniperus osteosperma* is the sole or dominant tree or large shrub occurring over a shorter-shrub canopy. *Pinus monophylla* may be present. *Ambrosia dumosa*, *Artemisia tridentata, Atriplex confertifolia*, *Ericameria* spp., *Coleogyne ramosissima*, *Ephedra nevadensis, Ephedra viridis, Eriogonum fasciculatum, Grayia spinosa, Gutierrezia microcephala, Purshia tridentata, Salvia dorrii,* or *Yucca baccata* may be present. Trees < 15 m tall; canopy intermittent or open. Shrubs < 2 m tall; continuous or intermittent. Ground layer sparse or grassy.

**Habitat:** Pediments, slopes, ridges, ravines. Soils rocky or alluvial, commonly well-drained.

**Distribution:** Mojave Desert, Sierra Nevada, Southeastern Great Basin, Southern California Mountains and Valleys, Mono, Nevada, Utah, Arizona.
**Elevation:** 1100 to 2100 m

**NDDB Rank:** G5 S3.2 (some associations may be S2.2)

**Synonyms:**
Holland: Great Basin juniper woodland and scrub (72123 *in part*), Mojavean juniper woodland and scrub (72220 *in part*)
Cheatham and Haller: Nevadan pinyon-juniper woodland
Rangeland: SRM 414
Thorne: Pinyon-juniper woodland
WHR: Pine-juniper
CALVEG: Utah Juniper series
Munz: Pinyon-juniper woodland

**References:** *Juniperus osteosperma* range in California (Griffin and Critchfield 1972), Meeuwig and Bassett (1983), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Tueller et al. (1979), Vasek and Thorne (1977)

**Membership Rules:** *Juniperus osteosperma* ≥ 1%, *Pinus monophylla* not present (< 1% cover), and dominant understory species is a shrub.

**Comments:** In the Mojave Desert *Juniperus osteosperma* Wooded Shrubland Alliance usually forms a band between the *Pinus monophylla, Artemisia tridentata, Purshia tridentata,* or other high-elevation shrubland alliances above, and various desert scrubs such as *Grayia spinosa, Coleogyne ramosissima, Ephedra nevadensis, Eriogonum fasciculatum, Ericameria teretifolia,* and *Yucca schidigera* Shrublands or *Yucca brevifolia* Wooded Shrubland below. Species diversity is often high, with commonly > 30 woody species per stand.

The alliance occurs in a band that is generally narrow and is only extensive in a few areas where topography levels out at the appropriate climatic zone. As currently treated, the species characteristic species of the alliance, *Juniperus osteosperma*, also can be characteristic of *Pinus monophylla* - (*Juniperus osteosperma*) Woodland Alliance (see that description). Thus, only the lower-elevation, warmer, and drier portion of the species' range, where tree cover is typically more open than in a woodland, supports the *Juniperus osteosperma* Wooded Shrubland Alliance. The alliance is typically composed of savanna-like canopy (< 25% cover) of *Juniperus osteosperma* with a shrubby understory. All plots analyzed in California have been under 25% cover, and most range between 2 and 21% *Juniperus osteosperma* (mean = 5% n = 77). In other parts of its range outside California *Juniperus osteosperma* may have an herbaceous understory, hence *Juniperus osteosperma* Wooded Herbaceous Alliance. The similar *Juniperus californica* Wooded Shrubland Alliance occupies the area west of the main distribution of the *Juniperus osteosperma* Wooded Shrubland. Overlap may occur in several places in the Mojave Desert and in the Southern California Mountains and Valleys. However, *Juniperus californica* stands tend to range lower in elevation than does *Juniperus osteosperma.*

Lightning frequency is higher in the Mojave Desert than in the lower-elevation desert shrublands and woody fuels are also more abundant. Thus, fire is naturally a more important disturbance element than in many lower-elevation alliances; however, *Juniperus osteosperma* does not resprout after fire. Even light to moderate fires can kill or seriously damage individuals (FEIS 2001). Lightly grazed ecotonal areas with a dense understory most readily burn and fire does not carry in some more-open-wooded shrublands. Recolonization by seed takes a long time for this slow-growing, long-lived tree. Some older trees can survive low-intensity fires and function as a seed source. Reoccupation of a site is generally through water or animal-dispersed seed. Most *Juniperus osteosperma* seedlings become established within one to two years after a fire. However, the rate at which *Juniperus osteosperma* spreads into an area depends on the size of burn, maturity (seed-producing capabilities) of the nearest stands, and on the presence of dispersal agents. Islands of unburned juniper are generally present and speed the rate of reestablishment. Trees generally become reestablished on a site 20 to 30 years after the burn, with well-developed woodland present from 85 to 90 years following fire (FEIS 2001). In a west-central Utah study, the crown cover of juniper was found to increase slowly during the first 46 years after a burn, and then to increase more rapidly. Utah juniper began to dominate these sites from 46 to 71 years after the burn (FEIS 2001). In many cases, the effects of the fire can still be seen more than 100 years later (FEIS 2001). Narrow linear stands of *Juniperus osteosperma* may also occur along washes, particularly at the lower limits of the *Juniperus osteosperma* Wooded Shrubland elevation range. Such stands are subject to flooding disturbance. Animals and water disperse the seeds (FEIS 2001).

**Regional Status:**
**Mojave Desert:** The alliance occupies narrow bands below the pinyon zone in many of the eastern mountains. In the Kingston Range, it occurs adjacent to stands of *Nolina parryi* Shrubland. Stands form the highest elevation vegetation in the Avawatz Mountains.
**Southeastern Great Basin:** Stands of *Juniperus osteosperma* are common adjacent to *Artemisia tridentata* and *Pinus monophylla* dominated alliances. Stands may occur at lower elevations where they may form open stands with *Cercocarpus intricatus* (unsampled in California).

**Management Considerations:** A likely result of long-term grazing of livestock in the *Juniperus osteosperma* alliance has been the introduction and spread of non-native annual *Bromus* spp. The impact of *Bromus madritensis* and *Bromus tectorum* in *Juniperus osteosperma* Wooded Shrubland has been substantial in certain parts of its range. A flammable thatch of annual grass stems, which carry fire through many stands, now augments the open-scrub understory. Many of these stands would not have carried fire previously. The result is that there are more *Juniperus osteosperma* Wooded Shrublands being burned at a higher frequency, causing a net reduction in the acreage of stands in certain parts of the alliance's range. It is not clear how much California *Juniperus osteosperma* Wooded Shrubland has been damaged from fire. Stands should be mapped and monitored throughout their range.

## *Krascheninnikovia lanata* Dwarf-shrubland Alliance

Figure A25. *Krascheninnikovia lanata* Dwarf-Shrubland Alliance, Panamint Mountains

*Krascheninnikovia lanata* is the sole or dominant shrub in canopy. *Artemisia nova, Coleogyne ramosissima, Atriplex confertifolia,* or *Chrysothamnus viscidiflorus* may be present. Shrubs < 1 m tall; canopy continuous, intermittent, or open. Ground layer sparse, grassy.

**Habitat:** Flats and lower slopes. Soils may be rocky to silty clay loams. Plains, old lakebeds, and perched wetlands above current drainages. Intermittently flooded, saturated. Water chemistry: mixosaline. Cowardin class: palustrine shrub-scrub wetland.

**Distribution:** Southeastern Great Basin, Mojave Desert, Mono, Northwestern Basin and Range, Nevada, Idaho, Oregon, Washington, Utah, Colorado, Montana, Canada.

**Elevation:** 100 to 2,700 m

**NDDB Rank:** G4 S1

**Synonyms:**
Holland: Shadscale Scrub (36140 *In Part*)
Barry: G7411221
Brown, Lowe and Pase: 153.152, 152.152.
Cheatham and Haller: Shadscale Scrub
Rangeland: Srm 414

Thorne: Alkali Sink Scrub
WHR: Alkali Sink

**References:** Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Turner (1982a), Young et al. (1977), West (1988).

**Membership Rules**: *Krascheninnikovia lanata* is strongly dominant (> 60% relative cover) with no other species equaling or exceeding it in cover. If *Atriplex confertifolia, Grayia spinosa, Salazaria mexicana,* or *Coleogyne ramosissima* equal or only exceed *Krascheninnikovia lanata* by 1-2%, then the stands are named after those species. This vegetation is usually of mid-to upper elevation flats and small basins and is uncommon in mapping area.

**Comments:** *Krascheninnikovia lanata* is a widespread species ranging from the northern Great Plains of southern Canada to New Mexico and west to Santa Barbara, Kern, and San Luis Obispo counties, California. Its main distribution is in the Great Basin. In California, it ranges south into the Mojave Desert and the adjacent Southeastern Great Basin. The species does not usually form single species-dominant stands throughout most of its California range but is a component of several alliances including annual grasslands, *Bromus tectorum, Artemisia nova, Atriplex confertifolia, Atriplex polycarpa, Atriplex canescens, Grayia spinosa, Coleogyne ramosissima, Salazaria mexicana, Eriogonum fasciculatum,* and *Yucca brevifolia*. The only stands of the alliance that have been defined in California occur in the Southeastern Great Basin. Here they occupy small montane basins in the Chalfant Valley, Inyo, Cottonwood, and White mountains. Similar stands probably occur in the Mono Basin and surrounding terrain and in the northwestern Basin and Range. In these settings, they occur as small stands in seasonally flooded or saturated shallow basins or flats surrounded by other more extensive upland alliances.

*Krascheninnikovia lanata* is a long-lived shrub, up to 136 years (FEIS 2001), that is relatively sensitive to disturbance including grazing and fire. Fire can kill *Krascheninnikovia lanata,* but the response is apparently dependent on fire severity. *Krascheninnikovia lanata* is able to sprout from buds near the base of the plant; however, if fire destroys these buds, *Krascheninnikovia lanata* will not sprout. *Krascheninnikovia lanata* can sprout vigorously after low-severity fires in spring or summer (FEIS 2001), but subsequent populations may be reduced. The native disturbance-related grass *Elymus elymoides* and non-native *Bromus tectorum* have been implicated as the major fuels in carrying fire in this naturally open alliance (FEIS 2001). Regeneration from seed is rare after fire. Heavy grazing practices have reduced or eliminated *Krascheninnikovia lanata* on some areas, even though it is somewhat resistant to browsing. Effects depend on severity and season of grazing; *Krascheninnikovia lanata* decreases on moderately-to-heavily grazed native grasslands in much of its range (FEIS 2001).

**Regional Status:**
**Mojave Desert:** A few stands of *Krascheninnikovia lanata* occur in the Mojave Desert; however, these are marginally dominated by *Krascheninnikovia lanata* and are ecologically similar to *Atriplex confertifolia* or *Grayia spinosa* Shrublands.

**Southeastern Great Basin:** Small, closed basins and intermontane flats and valleys in the Inyo Mountains (Cowhorn and Little Cowhorn Valleys) are the only known locations for *Krascheninnikovia lanata* stands in California. These stands are generally of small to moderate size (< 100 ha), *Krascheninnikovia lanata* strongly dominates, and few other species occurr. More information is needed about these stands, which occur on U.S. Forest Service, BLM, and National Park Service lands.

**Management Considerations:** Fire should be excluded from stands of *Krascheninnikovia lanata*. To protect salt-desert shrub communities from fire, greenstrip vegetative fuel breaks have been created in some areas (FEIS 2001). FEIS (2001) recommends that burned sites be seeded before *Bromus tectorum* or other non-native annual grasses are able to establish or gain dominance. Light grazing is not detrimental, but moderate to heavy grazing is. Grazing season has more influence on *Krascheninnikovia lanata* than grazing intensity. Late winter or early spring grazing is detrimental (FEIS 2001). Because this alliance is naturally rare in California and is sensitive to fire and moderate to heavy grazing, stands should be inventoried and actively managed in California.

## *Larrea tridentata - Ambrosia dumosa* Shrubland Alliance

Figure A26. *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance, Lanfair Valley

*Larrea tridentata* and *Ambrosia dumosa* are the important or conspicuous shrubs in the canopy. Other species that can be present are *Achnatherum speciosum, Amphipappus fremontii, Atriplex confertifolia, Atriplex hymenelytra, Atriplex polycarpa, Bebbia* *juncea, Croton californica, Dalea mollossima, Echinocactus polycephalus, Encelia farinosa, Encelia virginensis, Ephedra californica, Ephedra funerea, Ephedra nevadensis, Eriogonum fasciculatum*, *Eriogonum inflatum*, *Hymenoclea salsola, Krameria erecta, Krameria grayi, Lepidium fremontii, Lycium andersonii, Opuntia ramosissima*, *Pleuraphis rigida, Psorothamnus arborescens, Psorothamnus fremontii*, *Salazaria mexicana, Senna armata*, *Viguiera parishii,* or *Yucca schidigera*. Shrubs < 3 m tall; open canopy. Shrub canopy is two-tiered. Emergent *Yucca brevifolia* may be present in the Mojave Desert and *Fouquieria splendens* present in the Sonoran Desert. Ground layer open; annuals seasonally present.

**Habitat:** Alluvial fans, bajadas, upland slopes; minor washes and rills. Soils well-drained, colluvial, sandy, and/or alluvial, often underlain by a caliche hardpan; may be calcareous and/or have pavement surface.

**Distribution:** Mojave Desert, Sonoran Desert, Colorado Desert, Southeastern Great Basin, Nevada, Arizona, Sonora, Baja California.

**Elevation:** -75 to 1,200 m

**NDDB Rank:** G5 S5 Some associations are rare (e.g., those with high *Pleuraphis* cover, and with high diversity of perennials), some are threatened (west Mojave Desert types that are grazed and burned)

**Synonyms:**
Holland: Mojave creosote bush scrub (34100 *in part*), Sonoran creosote bush scrub (33100 *in part*)
Barry: G74 G7411211
Brown, Lowe and Pase: 153.112, 153.141, 154.112
Cheatham and Haller: Mojave creosote bush scrub, Sonoran creosote bush scrub
Rangeland: SRM 211, SRM 506
Thorne: Creosote bush scrub
WHR: Desert scrub

**References:** Burk (1977), Holzman (1994), Hunt (1966), MacMahon (1988), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Thorne (1982), Turner (1982b), Turner and Brown (1982), Vasek and Barbour (1977): plot-based descriptions are based on Keeler-Wolf et al. (1998)

**Membership Rules**: *Larrea tridentata* and *Ambrosia dumosa* present (≥ 1% cover), *Ambrosia dumosa* may have higher cover than *Larrea tridentata.* No shrub with cover greater than *Larrea tridentata* or *Ambrosia dumosa,* with the following exceptions: *Krameria* spp., *Bebbia juncea, Ericameria teretifolia,* or *Acamptopappus spherocephalus*. *Ephedra nevadensis* or *Opuntia acanthocarpa* may have higher cover, but no more than three times.

**Comments:** The co-occurrence of the medium to tall shrub *Larrea tridentata* over the subshrub *Ambrosia dumosa* defines the matrix vegetation of the vast majority of the California hot deserts. This is the most widespread and abundant desert alliance in California. It covers 58% of the California Mojave Desert (Thomas 1996), over 14% of Anza-Borrego Desert State Park (Keeler-Wolf et al.1998), and probably over 70% of the Colorado and Sonoran deserts of California (BLM 2001). It is the modal vegetation of the bajadas, alluvial fans, and lower slopes of these areas, with a wide range of variability defined within the alliance. Conditions range from extremely hot, dry stands with very low species diversity below sea level in Salton Sink and Death Valley to relatively diverse mesic stands at > 1100 m in the eastern Mojave Desert (e.g., Clipper Valley).

The *Larrea tridentata* Shrubland is in some cases a degraded version of the *Larrea tridentata-Ambrosia dumosa* Shrubland with little or no *Ambrosia dumosa*, a result of very poor shallow soils or heavy grazing pressure. The *Ambrosia dumosa* Dwarf-Shrubland shows relatively high recent disturbance from fire or mechanical removal of vegetation, or occurs on relatively clay-rich soils. *Atriplex confertifolia*, *Coleogyne ramosissima, Grayia spinosa,* and *Yucca schidigera* Shrublands and *Yucca brevifolia* Wooded Shrubland occur at moister and/or cooler settings. *Larrea tridentata-Encelia farinosa* Shrubland occurs in hotter, more exposed settings than does *Atriplex hymenelytra* Shrubland. *Hymenoclea salsola* Shrubland occurs in heavily grazed and otherwise disturbed settings. *Atriplex polycarpa* and *Atriplex spinescens* Shrublands occur in heavier-soil, more alkaline settings.

Much has been written on the ecology of these two species (Vasek and Barbour 1977, FEIS 2001). *Larrea tridentata* is a very long-lived shrub (up to 10,000 + years in clones) and under good conditions develops a deep and widely spreading root system. *Ambrosia dumosa* is a short-lived shrub living generally < 50 years, although it does have limited cloning abilities, with relatively shallow and restricted roots. Both species tap different water resources and employ different strategies for desert survival. *Ambrosia dumosa*, with its high recruitment and mortality rates, dominates in the colonizing stage and *Larrea tridentata*, with low recruitment and mortality, eventually dominates the landscape, although colonizing species usually remain present. In the Sonoran Desert, *Larrea tridentata* uses *Ambrosia dumosa* as a nurse plant (McAuliffe 1988). *Larrea tridentata* exhibits root-mediated allelopathy. In a laboratory study, test roots grew freely through soil occupied by *Ambrosia dumosa* roots, but *Ambrosia dumosa* test roots grew at reduced rates into soil occupied by *Larrea tridentata.* Mature *Larrea tridentata* may be allelopathic to its own seedlings, thus encouraging an open community structure (FEIS 2001).

Natural disturbance in most *Larrea tridentata-Ambrosia dumosa* stands involves shifting moisture availability related to series of wet and dry years. Both species may die following severely long periods of drought, but *Larrea tridentata* typically will persist longer and can resprout from the base when moisture returns. *Ambrosia dumosa* individuals die more quickly from drought stress, but will regenerate from seed banks and off-site dispersal quickly following sufficient precipitation. Wind and substrate deflation also act as disturbance agents in some stands on sandy substrates. Both species will grow in sand. However*,* *Larrea tridentata* tends to persist and dominate on deeper mobile sand dunes, while both *Ambrosia dumosa* and *Larrea tridentata* occupy dune aprons, sand sheets, and stabilized dunes. Vasek (1980) studied succession on a cleared and bulldozed site in the eastern Mojave Desert. He found rapid recolonization by *Ambrosia dumosa, Encelia farinosa, Opuntia bigelovii,* and *Stephanomeria pauciflora,* while *Larrea tridentata* colonized more slowly.

In the modal Mojave, Colorado, and Sonoran desert landscapes, both species tend to co-occur in mixed stands. *Ambrosia dumosa* occurs without *Larrea tridentata* in active wash terraces with a higher salinity or alkalinity than *Larrea tridentata* can tolerate. *Ambrosia dumosa* also occurs in recently disturbed areas, where it can more quickly recolonize by seed than *Larrea tridentata*. *Larrea tridentata* occurs without *Ambrosia dumosa* in areas where grazing or drought stress has eliminated *Ambrosia dumosa.* The *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance is replaced by *Atriplex polycarpa, Atriplex canescens,* or *Atriplex spinescens* Shrublands in alkaline soils and gives way to *Larrea tridentata - Encelia farinosa or Atriplex hymenelytra* Shrubland in extremely hot, dry situations.

*Larrea tridentata* and *Ambrosia dumosa* are poorly adapted to fire because of their limited sprouting ability (FEIS 2001). The resinous foliage of *Larrea tridentata*, however, is very flammable. Even low-intensity fires can cause close to 100% mortality in both shrubs (Brown and Minnich 1986). The recent invasion of non-native grasses in the hot deserts of California has rapidly increased fire frequencies and has led to the destruction and degradation of many acres of *Larrea tridentata-Ambrosia dumosa* Shrubland particularly in the western Mojave and Colorado deserts. Although fire may be as a natural exclusionary process for *Larrea tridentata* in Arizona, New Mexico, and in Texas desert grasslands (FEIS 2001) it is a de-stabilizing influence in the California deserts, where adjacent desert grasslands typically occur without fire.

**Regional Status:**
**Mojave Desert**: This alliance occurs throughout the Mojave Desert. The range of variability of this alliance is better studied and probably wider than in any other part of its range. Associations have been defined that range from simple two species co-dominance to high-diversity, mid-desert scrubs with up to 20 co-occurring perennials. In the northern Mojave Desert (northern Death Valley National Park), it occurs adjacent to *Grayia spinosa, Atriplex confertifolia,* and other Great Basin characteristic alliances, while in the southern Mojave Desert it occurs adjacent to *Opuntia bigelovii, Viguiera parishii*, and other Colorado and Sonoran Desert characteristic alliances. Virtually all stands have some component of non-native grass. *Bromus madritensis* is the most common in upland and upper bajada sites, while *Schismus* spp. is more common in lower-lying areas. *Bromus madritensis* acts as the principal fuel for fires in the area, although following years of high rainfall *Schismus* may also carry fire (M. Brooks, personal communication). Human mediated fires have converted *Larrea tridentata-Ambrosia dumosa* Shrublands to stands dominated by *Bromus spp., Brassica tournefortii*, *Salsola* spp. and other weedy species. In the south Mojave Desert some *Larrea tridentata-Ambrosia dumosa*

Shrublands have been converted to *Encelia farinosa* stands, although this is more common in the Colorado Desert.
**Southeastern Great Basin:** The alliance is restricted to Saline and Eureka valleys and the lowest elevation slopes of the Inyo, Grapevine, Coso and Argus mountains where they border the Mojave Desert. Northernmost stands in Eureka Valley are relatively simple (mostly *Larrea tridentata Ambrosia dumosa-Psorothamnus fremontii* association). The alliance forms mosaics with *Atriplex confertifolia, Atriplex hymenelytra, Ephedra funerea,* and *Artemisia nova* Shrubland, the latter two particularly on calcareous substrates.

**Management Considerations:** Human-caused fire following the introduction of the non-native annual grasses (in particular *Bromus madritensis*) is a threat to this alliance. This is particularly true after a sequence of relatively wet years as has occurred in the last two or three decades (R. Minnich, personal communication). A series of dry years tends to reduce the threat due to the lack of *Bromus* spp. germination and flashy fuel build-up. Because *Bromus* species do not survive in the seed bank more than a few years, prolonged drought may eliminate these species from the drier portions of the desert. Long-term intensive grazing has also degraded thousands of acres of *Larrea tridentata-Ambrosia dumosa* stands into disturbed *Larrea tridentata* Shrubland stands by eliminating the more palatable *Ambrosia dumosa* from the understory. The relationship between disturbance (primarily grazing, but also OHV activity, mining, and military operations) and the invasion of exotic grasses has brought an immense change to this alliance and the California deserts. Fire ignitions have increased substantially in the desert, primarily in this alliance. Wildlife habitat values of this alliance are strongly altered because of fire. Relatively exotic-free areas should be identified and defended against excessive human-caused disturbances.

## *Larrea tridentata - Encelia farinosa* Shrubland Alliance

Figure A27. *Larrea tridentata-Encelia farinosa* Shrubland Alliance, Panamint Mountains

*Larrea tridentata* and *Encelia farinosa* are the important or conspicuous shrubs in canopy. *Agave deserti, Ambrosia dumosa, Atriplex hymenelytra, Bebbia juncea, Eriogonum inflatum, Dasyochloa pulchella, Fagonia laevis, Ferocactus cylindraceus, Krameria grayi, Opuntia bigelovii, O. basilaris*, or *Stephanomeria pauciflora* may be present. Emergent *Fouquieria splendens* may be present in the Sonoran Desert. Shrubs < 3 m tall; open to intermittent, two-tiered canopy. Trees < 5 m tall; scattered canopy. Ground layer open; annuals seasonally present.

**Habitat:** Alluvial fans, bajadas, colluvium, upland slopes, small washes, and rills. Soils well drained, rocky, may have desert pavement surface, often derived from granitic or volcanic rock.

**Distribution:** Mojave, Sonoran, and Colorado deserts; Arizona, Nevada, Utah, Mexico.

**Elevation:** -75 to 1,400 m

**NDDB Rank:** G5 S4

**Synonyms:**

Sawyer and Keeler-Wolf (1995): Brittlebush series (in part), Creosote bush series (in part)

Holland: Mojave creosote bush scrub *in part* (34100), Sonoran creosote bush scrub *in part* (33100)
Barry: G7411221
Brown, Lowe and Pase: 154.126
Cheatham and Haller: Creosote bush scrub
PSW-45: Encelia series
CALVEG: Encelia series
WHR: Desert scrub
Munz: Creosote bush scrub

**References:** Barbour (1994), Burk (1977), Hunt (1966), MacMahon (1988), Pase and Brown (1982), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Vasek and Barbour (1977); plot-based descriptions are found in Minnich et al. (1993) and Keeler-Wolf et al. (1998).

**Membership Rules**: *Encelia farinosa* > 1% cover with *Larrea tridentata* at least 1%. *Ambrosia dumosa* may be present. Widespread on hot (southerly exposure) mountain slopes and upper bajadas.

**Comments:** Many of the stands formerly considered part of the *Encelia farinosa* series and *Larrea tridentata* series (Sawyer and Keeler-Wolf 1995) are actually composed of a mixture of both species. *Larrea tridentata-Encelia farinosa* Shrubland is analogous to the *Larrea tridentata-Ambrosia dumosa* Shrubland but occurs on hotter, rockier, and often steeper environments. In areas where both alliances occur, *Larrea tridentata-Encelia farinosa* Shrubland tends to occupy steeper, southerly or westerly exposures, while *Larrea tridentata-Ambrosia dumosa* Shrubland occupies more gentle slopes having northerly or neutral exposures. Compared to *Larrea tridentata-Ambrosia dumosa* Shrubland, *Larrea tridentata-Encelia farinosa* Shrubland tends to be less diverse and has a lower proportion of annual herbs (in higher rainfall years). It also does not tolerate sandy or clay-rich soils as much as *Larrea tridentata-Ambrosia dumosa* Shrubland.

This alliance is related to both the *Encelia farinosa* and the *Larrea tridentata-Ambrosia dumosa* Shrubland Alliances. This alliance represents a drought-tolerant extension of the *Larrea tridentata* Shrubland, which is less cold-hearty and more heat-tolerant than *Larrea tridentata-Ambrosia dumosa* Shrubland.

*Encelia farinosa*, like *Ambrosia dumosa*, is a sub-shrub that forms an open to intermittent subcanopy beneath the taller *Larrea tridentata* shrubs. However, it is even more tolerant of hot, dry conditions and is more of an aggressive colonizer than *Ambrosia dumosa*. Leafing and flowering is opportunistic whenever moisture is available. *Encelia farinosa* rapidly colonizes burns and other disturbance in both the south coastal scrub and desert vegetation (FEIS 2001). *Encelia farinosa* is short lived; maximum reported age 32 yrs (FEIS 2001), It reproduces entirely by seed and resprouts weakly from damaged stems. It is frost-sensitive, limiting the elevation at which it occurs and its geographic range. It grows poorly on clay soils, but survives on coarse, steep, and very rocky soils better than *Ambrosia dumosa*. It may replace longer-lived perennials after fire and, once established, may persist as an alliance for decades. The species is allelopathic to several winter annuals (FEIS 2001), suggesting that biodiversity will be reduced if the alliance replaces other desert vegetation. It is fire-sensitive, intolerant of heat from fire, making resprouting weak or non-existent; however, it recolonizes from off-site seed readily. Recurrent desert fire selects for *Encelia farinosa* over longer-lived shrubs.

In general, because of the hot, dry conditions of most stands, *Larrea tridentata-Encelia farinosa* Shrubland is typically even more open than in stands of *Larrea tridentata-Ambrosia dumosa* Shrubland. Despite the colonizing properties of *Encelia farinosa*, the *Larrea tridentata-Encelia farinosa* Shrubland is generally stable, occupying rocky harsh sites that are not conducive to *Larrea tridentata-Ambrosia dumosa* Shrubland. Seral stages following fire, or other unnatural disturbance, are likely to involve a state dominated by *Encelia farinosa* Shrubland for several years before *Larrea tridentata* and other long-lived shrubs re-establish.

**Regional Status:**
**Mojave Desert**: This alliance occurs throughout the Mojave Desert except in the northernmost and westernmost parts. In most parts of the Mojave Desert, it is an alliance of moderate to steep slopes with rocky substrates. It may occupy limestone and other calcareous mountains such as Nopah Range and Silurian Hills, and granitic and volcanic substrates. It is likely that higher species diversity occurs in the limestone settings where several calcophiles can co-occur. The northernmost stands occur on volcanic substrate near Panamint Springs on the boundary of the Southeastern Great Basin.

**Management Considerations:** This is another alliance where coincidence of non-native annual grass invasion and human-related fires can threaten the structure and diversity of the vegetation. The rocky, steep nature of many of the stands precludes the establishment of dense cover of *Bromus madritensis.* Thus the resistance of this alliance to non-natural fire and weed invasion is higher than for the *Larrea tridentata-Ambrosia dumosa* Shrubland.

## *Larrea tridentata* Shrubland Alliance

Figure A28. *Larrea tridentata* Shrubland Alliance, Stovepipe Wells

*Larrea tridentata* is the sole or important shrub in canopy. *Acamptopappus spherocephalus, Acamptopappus shockleyi*, *Atriplex confertifolia*, *Atriplex hymenelytra*, *Atriplex polycarpa*, *Brickellia incana*, *Ephedra californica*, *Ephedra nevadensis, Hymenoclea salsola*, or *Lycium andersonii* may be present. Shrubs < 4 m tall; canopy open. Emergent *Yucca brevifolia* or *Prosopis glandulosa* may be present. *Achnatherum speciosum, Eriogonum inflatum*, *Eriophyllum confertiflorum, Poa secunda,* or *Pleuraphis rigida* may be present. Ground layer open; annuals seasonally present.

**Habitat:** Alluvial fans, bajadas, upland slopes, minor intermittent wash channels, and upland slopes. Soils well drained, may have desert pavement surface.

**Distribution:** Mojave Desert, Sonoran Desert, Colorado Desert, Southeastern Great Basin, Southern California Mountains and Valleys, Arizona, Nevada, New Mexico, Texas, Mexico.

**Elevation:** -75 to 1,000 m

**NDDB Rank:** G5 S5

**Synonyms:**
Holland types: Mojave creosote bush scrub (34100 *in part*), Sonoran creosote bush scrub (33100 *in part*)
Barry: G74 G7411211 CLADI20
Brown, Lowe and Pase: 153.111, 153.113, 153.111
Cheatham and Haller: Mojave creosote bush scrub, Sonoran creosote bush scrub
PSW-45: Creosote bush series
Rangeland: SRM 211
Stone and Sumida: Creosote bush scrub
Thorne: Creosote bush scrub
WHR: Desert scrub
CALVEG: Creosote bush series
Munz: Creosote bush scrub

**References:** Burk (1997), Holzman (1994), Hunt (1966), MacMahon (1988), O'Leary and Minnich (1981), Paysen et al. (1980), Phillips and MacMahon (1981), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Turner (1982b), Turner and Brown (1982), Vasek (1980), Vasek and Barbour (1977), Vasek et al. (1975); plot-based descriptions are based on Davidson and Fox (1974), McHargue (1973), Randall (1972), Vasek and Barbour (1977), Minnich et al. (1993) Spolsky (1979) and Keeler-Wolf et al. (1998).

**Membership Rules**: *Ambrosia dumosa* or *Encelia farinosa* absent or less than 1% cover. No shrub with cover greater than *Larrea tridentata* with the following exceptions: *Krameria* spp. *Bebbia juncea, Ericameria teretifolia* or *Acamptopappus spherocephalus*. *Ephedra nevadensis* or *Opuntia acanthocarpa* may have higher cover, but no more than twice the cover.

**Comments:** This alliance is part of the creosote bush scrub ecological system which is a collection of alliances. Following substantial data analysis of plot data collected in this project and others (Keeler-Wolf et al.1998), we define this alliance somewhat differently than Sawyer and Keeler-Wolf (1995). In *Larrea tridentata* Shrubland, *Larrea tridentata* dominates and *Ambrosia dumosa* is absent or < 1% cover (see *Larrea tridentata-Ambrosia dumosa* Shrubland). Those stands with *Larrea tridentata* that contain an understory of *Encelia farinosa* are now considered part of the *Larrea tridentata-Encelia farinosa* Shrubland. *Larrea tridentata-Ambrosia dumosa* Shrubland is the most common vegetation alliance in the Mojave, Colorado and Sonoran deserts of California, while the *Larrea tridentata* Shrubland is less common and less diverse. The *Larrea tridentata* Shrubland is in some cases a degraded form of the *Larrea tridentata-Ambrosia dumosa* Shrubland, often as the result of prolonged livestock or burro grazing (see below). It may also represent a natural state related to extreme xeric settings on certain rocky slopes or desert pavements, where *Larrea tridentata* forms low cover stands without *Ambrosia dumosa* or *Encelia farinosa*. It also may occur in or adjacent to certain small washes or rills, or on sand sheets or dune aprons. In some cases, it forms a diverse scrub in the mid elevations of the eastern Mojave Desert with greater than 10 species of other woody perennials.

*Larrea tridentata* is a very long-lived shrub (up to 10,000 + years in clones) and under good conditions develops a deep and widely spreading root system. *Larrea tridentata*, with low recruitment and mortality, eventually dominates the landscape throughout most of the California hot desert. However, in most unaltered settings, it occurs with the subshrub *Ambrosia dumosa*. In the Sonoran Desert, *Larrea tridentata* uses *Ambrosia dumosa* as a nurse plant McAuliffe (1988). Mature *Larrea tridentata* may be allelopathic to its own seedlings, thus encouraging an open community structure (FEIS 2001). Where *Larrea tridentata* occurs without *Ambrosia dumosa,* disturbance history may be responsible. *Ambrosia dumosa,* as a small, relatively palatable subshrub, is more vulnerable to browsers such as cattle, sheep, and burros (FEIS 2001). In many parts of the desert, *Larrea tridentata-Ambrosia dumosa* Shrubland has been converted to *Larrea tridentata* Shrubland by the long-term effects of livestock foraging (personal observation). However, in certain settings, natural disturbance patterns may be the cause of the sole dominance by *Larrea tridentata*. *Larrea tridentata* is a more drought-resistant species than *Ambrosia dumosa* or *Encelia farinosa. Larrea tridentata* may die following severe long periods of drought, but it typically will persist longer and can resprout from the base when moisture returns than many of the subshrubs with which it associates. Thus, certain stands of *Larrea tridentata* Shrubland may be the result of locally intense drought conditions that have eliminated, at least temporarily, *Ambrosia dumosa* and other species. In deep, sandy soils *Larrea tridentata* can survive more effectively than *Ambrosia dumosa* because of its deep spreading root system. In sandy situations it often co-occurs with the grass *Pleuraphis rigida* as an understory component. Along certain washes and wash terrace deposits with somewhat alkaline soils, *Larrea tridentata* co-dominates with *Atriplex polycarpa*. *Larrea tridentata* may also form semi-riparian stands along low-gradient, sandy and silty washes. It may form stands in small, low alkalinity, or salinity basins with fine, silty soils.

*Larrea tridentata* is poorly adapted to fire because of its limited sprouting ability (FEIS 2001). Its resinous foliage, however, is very flammable. Even low-intensity fires can cause close to 100% mortality (Brown and Minnich 1986). The recent invasion of non-native grasses in the hot deserts of California has rapidly increased fire frequencies and has led to the destruction and degradation of many acres of *Larrea tridentata-Ambrosia dumosa* Shrubland, particularly in the western Mojave and Colorado deserts. Although fire is a natural exclusionary process for *Larrea tridentata* in Arizona, New Mexico, and Texas desert grasslands (FEIS 2001), it is a de-stabilizing influence in the California deserts where adjacent desert grasslands typically occur without fire.

**Regional Status:**
**Mojave Desert** This alliance occurs throughout the Mojave Desert. The degraded form is particularly common in the central and western Mojave Desert probably because of the combined effects of grazing, fire, and mechanical OHV and military operations disturbance.

**Management Considerations:** Presence of this alliance may be indicative of certain disturbance (either grazing, or mechanical disturbance) patterns that have caused local degradation of the more common *Larrea tridentata-Ambrosia dumosa* Shrubland. In general, extremely xeric settings with southerly exposures and steep rocky slopes are more likely to be natural *Larrea tridentata* Shrublands than those of less extreme situations where the subshrub *Ambrosia dumosa* and other species may have been eliminated because of excessive disturbance.

## *Lepidospartum squamatum* Intermittently Flooded Shrubland Alliance

Figure A29. *Lepidospartum squamatum* Intermittently Flooded Shrubland Alliance

*Lepidospartum squamatum* is the sole, dominant, or important shrub with other shrubs in the canopy. *Artemisia californica, Baccharis salicifolia, Encelia farinosa, Eriogonum fasciculatum Eriodictyon crassifolium, Hymenoclea Salsola, Eriastrum densifolium* ssp. *sanctorum, Dodecahema leptoceras, Isomeris arborea, Juniperus californica, Lotus scoparius, Opuntia littoralis, O. parryi, Malosma laurina, Rhus integrifolia, Rhus trilobata, R. ovata, Sambucus mexicana, Toxicodendron diversilobum* or *Yucca whipplei* may be present. Emergent trees such as *Cercocarpus betuloides, Juglans californica, Platanus racemosa,* or *Populus fremontii* may be present. Shrubs < 1.5 m tall; canopy continuous, intermittent, or open. Ground layer variable, may be grassy.

**Habitat:** Intermittent channels along washes and streams across alluvial fans and in semi-arid to arid valleys. Habitats intermittently flooded. Water chemistry: fresh. Cowardin class: riverine or palustrine shrub-scrub wetland.

**Distribution:** Mojave Desert, Southeastern Great Basin, Southern California Mountains and Valleys, Southern California Coast, Sierra Nevada, Sierra Nevada Foothills, Central California Coast Ranges, Colorado Desert.

**Elevation:** 50 to 1,500 m

**NDDB Rank:** G2 S2 (some associations are G1 S1.1)

**Synonyms:**
Holland: Riversidean alluvial fan sage scrub (32720 *in part*), Mojave Desert wash scrub (63700 *in part*), Alluvial fan chaparral (37H00 *in part*)
Barry: G7411221
Munz: Creosote bush scrub, Coastal Sage scrub

**References:** Barbour and Wirka (1997), Hanes et al. (1989), Kirkpatrick and Hutchenson (1977), Magney (1992), Smith (1980); plot-based descriptions are found in Hanes et al. (1989), Kirkpatrick and Hutchinson (1977), Smith (1980), Gordon and White (1994), Boyd (1983), Barbour and Wirka (1997)

**Membership Rules:** Vegetation characterized by the broom-like *Lepidospartum squamatum* (scale-broom). Stands concentrated along washes on eastern base of the San Bernardino Mountains in the extreme southwest portion of the mapping area. Other smaller stands occur at mid-elevations throughout the desert.

**Comments:** Early understanding of this alliance comes from the studies of Alluvial fan scrub (Smith 1980, Holland 1986, Haynes et al. 1989) that is a collection of vegetation assemblages based largely on disturbance histories at a given site. *Lepidospartum squamatum* Intermittently Flooded Shrubland is strongly tied to fluvial disturbance associated with intermittent streams and washes. *Lepidospartum squamatum* is an indicator and may or may not be the dominant species. In general, those stands with the most recent and regular disturbances tend to be more strongly dominated by *Lepidospartum squamatum*, while those with longer disturbance intervals tend to have higher diversity of woody species and lower absolute cover of *Lepidospartum squamatum*. The distribution of this alliance is centered in the Southern California Mountains and Valleys, and it ranges into the adjacent sections.

Ecologically, it is similar to several other shrubby wash alliances in the Mojave Desert including *Baccharis sergiloides* and *Ericameria paniculata* Intermittently Flooded Shrublands and *Hymenoclea salsola* Shrubland. However, it appears to be more restricted to the desert/cismontane transition zone and does not appear to tolerate the environmental conditions of the main core of the Sonoran, Mojave, or Colorado deserts. There is some evidence suggesting geographical replacement or fine-scale ecological differentiation of shrubby wash alliances depending upon the section in which the alliance occurs. For example, in the Mojave Desert *Lepidospartum squamatum* Intermittently Flooded Shrubland only occurs along the western margin and does not usually co-occur with other related shrubs of other alliances (Barbour and Wirka 1997).

*Lepidospartum squamatum* Intermittently Flooded Shrubland is fluvial disturbance-related. All stands known are associated with single or braided channel streams that have widely fluctuating flows and are generally intermittent. Stands are highly variable in age. Stand associates, flooding regimes, and successional characteristics have been studied elsewhere in California (Barbour and Wirka 1997, Woods and Wells 1996), but not in the Mojave Desert.

**Regional Status:**
**Mojave Desert:** Stands occur in the western Mojave Desert and the southern Mojave Desert along the boundaries of the Southern Sierra Nevada and Transverse ranges. Some of the best stands occur at Red Rock Canyon State Park and near Valyermo (Big Rock Wash).
**Southeastern Great Basin** Stands occur in the Argus Mountains and in other portions of China Lake Naval Weapons Center (M. Bagley, personal communication).

**Management Considerations:** Interruption of natural fluvial processes in many of the historic stands involves construction of dams, channelization, and gravel mining. The destruction of many older stands to create housing and golf courses has been cause for much concern in the core of its distribution (Southern California Mountains and Valleys). A few recent conservation acquisitions have preserved some stands, but upstream dams and flood control modifications do not bode well for the long-term persistence of many of these. Natural processes are being interrupted less frequently on the desert side of the Southern California Mountains and Valleys and elsewhere.

## *Menodora spinescens* Dwarf-shrubland Alliance

Figure A30. *Menodora spinescens* Dwarf-Shrubland Alliance, Last Chance Range

*Menodora spinescens* is dominant or important in canopy. *Artemisia spinescens, Atriplex confertifolia, Coleogyne ramosissima, Ephedra nevadensis, Hymenoclea salsola, Krascheninnikovia lanata, Lepidium fremontii, Lycium andersonii, Sphaeralcea ambigua, Stanleya elata,* or *Tetradymia axillaris* may be present. *Yucca brevifolia* may be a scattered, emergent tree or tall shrub. Shrub height 0.5-2 m.

**Habitat:** Ridges, slopes, upper alluvial fans, and bajadas. Soils bedrock or alluvium-derived.

**Distribution:** Mojave Desert, Southeastern Great Basin, Nevada.

**Elevation:** 900 to 1,500 m

**NDDB Rank:** G4 S4

**Synonyms**:
Holland: Mojave mixed woody scrub (34210), Mojave mixed woody and succulent scrub (34240), Blackbrush scrub (34300), Mojavean juniper woodland and scrub (72220), Joshua tree woodland (73000)
Barry: G74G7411112BJUCA00
Cheatham and Haller: Mojavean pinyon juniper and Joshua tree woodlands
PSW-45: Joshua tree series
Thorne: Joshua tree woodland
WHR: Joshua tree
CALVEG: Joshua tree
Munz: Joshua tree woodland, Shadscale scrub, and Creosote bush scrubs

**References:** Beatley 1976

**Membership Rules**: *Menodora spinescens* ≥ 2% cover, no other single species with greater cover, although many other species may be present. It is represented by a few localized stands in well-defined, shallow, rocky soils characteristically just above *Larrea tridentata-Ambrosia dumosa.*

**Comments:** This alliance is one of several related dwarf shrub alliances of the mid-elevation Mojave Desert. *Menodora spinescens* is typically a low, compact, thorny shrub that usually occurs on shallow, rocky soils of uplands. Although the species is widespread from the upper *Larrea tridentata-Ambrosia dumosa* Shrubland into the lower *Pinus monophylla - (Juniperus osteosperma)* Woodland, it only locally dominates. It appears to be sensitive to disturbance such as intensive grazing and fire, and tends to occur in relatively stable sites. In the Mojave Desert, this alliance occupies similar environments to the upland associations of the *Atriplex confertifolia* and *Ephedra nevadensis* Shrublands. Seral relationships are uncertain, but the presence of *Menodora spinosa* in areas otherwise occupied by upland associations of *Atriplex confertifolia* Shrubland suggests that it may remain a more stable component to some stands where

*Atriplex confertifolia* increases and decreases as a result of natural pathogen disturbance (see *Atriplex confertifolia* Shrubland Alliance).

*Menodora spinescens* occurs in the northern, eastern, and southern Mojave Desert and adjacent Southeastern Great Basin. It is leafless most of the year and presents itself as a dense, low green-stemmed, and extremely spiny low shrub. Although the species is common and widespread, *Menodora spinescens* Shrubland occurs locally. Little is known of natural disturbance patterns in this vegetation. Webb et al. (1988) has shown that *Menodora spinescens* tends to colonize disturbed sites in Death Valley at a low rate, similar to *Larrea tridentata.* It is thought to be a stress tolerator, but may have a more competitive strategy than *Larrea tridentata,* as suggested by its opportunistic flowering and leafing phenology. Where large stands occur, they are usually above the *Larrea tridentata-Ambrosia dumosa* Shrubland and below the *Pinus monophylla - (Juniperus osteosperma)* Woodland*, Juniperus osteosperma* Wooded Shrubland*,* or *Artemisia tridentata* Shrublands. Associated alliances are *Coleogyne ramosissima* Shrublands (generally at slightly higher elevations), *Atriplex confertifolia* Shrublands (often on more xeric exposures), and *Grayia spinosa* Shrublands (generally on deeper soils). In the few places where it associated with *Artemisia tridentata* Shrubland, *Menodora spinescens* Shrubland tends to occur on relatively steep, xeric, southerly-facing exposures.

**Regional Status:**
**Mojave Desert:** Stands occur in the southern and eastern Mojave Desert north through Death Valley National Park. Some stands have been subjected to long-term grazing (e.g., near Cima Dome). Although most stands are on rocky soils of pediments and low-gradient hills, some stands occur on upper bajadas on alluvial soil (Greenwater Valley). Effects of fire are unknown but likely detrimental.
**Southeastern Great Basin:** The alliance occurs in upper-elevation portions of Death Valley National Park. Some of the most extensive stands occur in this region including those in the Inyo and Last Chance ranges, and in the Darwin area.

**Management Considerations:** This alliance requires further study before any detailed recommendations are made. It is likely to be fire-sensitive, but may tolerate some degree of grazing due to its extremely spiny habit.

## *Nolina parryi* Shrubland Alliance

Figure A31. *Nolina parryi* Shrubland Alliance, Kingston Mountains

*Nolina parryi* is the dominant or important shrub in overstory. *Pinus monophylla* or *Juniperus californica* may be present in tree layer. Emergent trees may be present over a shrub canopy. *Artemisia ludoviciana, Coleogyne ramosissima, Eriogonum fasciculatum, Eriogonum heermannii, Ericameria teretifolia, Gutierrezia microcephala, Opuntia acanthocarpa, Salazaria mexicana, Salvia mohavensis, Thamnosma montana,* or *Yucca schidigera* may be present in the overstory. *Achnatherum speciosum* and *Poa secunda* may form a scattered grass understory. Shrubs 0.5-4 m tall; canopy is intermittent to open. Grasses 0.5-1 m tall; canopy is intermittent to open.

**Habitat:** Ridges, slopes. Soils bedrock or colluvium derived. Substrates largely granitic or crystalline metamorphic (including calcareous types).

**Distribution:** Mojave Desert, Southern California Mountains and Valleys, Sierra Nevada

**Elevation:** 600 to 2,100 m

**NDDB Rank:** G3 S2.2

**Synonyms**:
Holland: Mojave Mixed woody scrub, Blackbrush scrub
Barry: G7411111
Cheatham and Haller: Enriched desert scrub

Stone and Sumida: Nolina woodland
Thorne: Semi-succulent scrub
WHR: Desert succulent scrub
Munz: Shadscale scrub, Pinyon-juniper woodland

**References:** Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Stone and Sumida (1983).

**Membership Rules**: *Nolina parryi* dominant tall shrub (> 3% cover), evenly distributed over scattered low shrubs and herbs. Uncommon, scattered in extreme southwest of study area and in Kingston Range.

**Comments:** *Nolina parryi* is a conspicuous tufted liliaceous shrub to small tree (up to 5m) that forms scattered stands in desert or desert-border mountains. *Nolina parryi* Shrubland is one of several mid-elevation xeromorphic upland scrub alliances above the broad belt of *Larrea tridentata-Ambrosia dumosa* Shrubland, but below the high-elevation scrubs with *Artemisia tridentata* Shrubland and the *Pinus monophylla - (Juniperus osteosperma)* Woodland. It is localized in the Mojave Desert, the Peninsular Ranges, and the southern Sierra Nevada.

Natural disturbance in *Nolina parryi* Shrubland was probably limited to occasional fires, which had a likely neutral or negative effect. Related species (*Nolina microcarpa*) have been shown to crown-sprout from the caudex in low-severity fires. However, the thick thatch of leaves that develops on older plants tends to increase heat, and thus older plants tend to succumb to moderate-to-severe fire (FEIS 2001). Anecdotal evidence (T. Keeler-Wolf personal communication, Desert Workshop 2000). suggests that individual *Nolina* spp. are relatively fire hardy and will resprout. *Nolina parryi* Shrubland tends to occur in steep, very rocky areas or on moderately steep desert slopes where total vegetation cover is less than 40%. *Nolina parryi* stands are highly localized; they regularly occur in steep rocky slopes or on bouldery terrain. This suggests that the alliance requires more moisture (channeled along cracks in bedrock) than is modally available. Stands tend to decrease off outcrops, where they are replaced by other vegetation better adapted to deeper soils. This includes *Coleogyne ramosissima, Salazaria mexicana, Eriogonum fasciculatum, Juniperus californica,* and *Quercus cornelius-mulleri* Shrublands. At the upper limits of its elevation range, *Nolina parryi* gives way to *Pinus monophylla* or *Pinus jeffreyi*-dominated alliances.

**Regional Status:**
**Mojave Desert:** Stands are known in the Kingston Range where they occupy the steep granitic slopes, particularly on southerly exposures between *Coleogyne ramosissima* Shrubland at the lower extent and *Pinus monophylla- (Juniperus osteosperma)* Woodland at the upper extent. Responses to fires within portions of the stands in the Kingston Range have not been described.

**Management Considerations:** Stands occur localized and appear naturally uncommon. As they are typically isolated from dense vegetation and from human influence, the alliance is likely to maintain similar disturbance patterns to pre-European days. As adjacent vegetation is becoming more prone to frequent fire, further study and monitoring of post-fire response to individuals of *Nolina parryi* would be useful.

## ***Panicum urvilleanum*** **Sparsely Vegetated Herbaceous Alliance**

Figure A32. *Panicum urvilleanum* Sparsely Vegetated Herbaceous Alliance, Kelso Dunes

*Panicum urvilleanum* is the sole dominant or important grass in the canopy. *Helianthus annuus, Oenothera deltoides, Dicoria canescens,* or *Achnatherum hymenoides* may be present.
Canopy open, usually < 10% total vegetation.

**Habitat:** Sand bodies. Active, partially stabilized dunes and sand fields.

**Distribution:** Mojave Desert, Sonoran Desert, Colorado Desert, Southeastern Great Basin.

**Elevation:** -10 to 1200 m

**NDDB Rank**: G3 S1.2

**Synonyms**:
Sawyer and Keeler-Wolf: *Abronia villosa* series (in part)
Holland: Active desert dunes, Stabilized and partially stabilized dunes, Stabilized and partially stabilized desert sand fields
Barry: G7411323
Cheatham and Haller: Partially stabilized desert dunes, Stabilized desert dunes

PSW-45: Croton series
Stone and Sumida: Sand plant community
Thorne: Desert dune sand plant
WHR: Desert scrub

**References:** Henry (1979), Thorne (1982), Paysen et al. (1980), Vasek and Barbour (1977); plot-based descriptions are found in the California NDDB.

**Membership Rules:** Vegetation characterized by the presence of *Panicum urvilleanum* (dune panic grass). Usually a sparse rhizomatous grassland of open-dune areas, typically < 10% cover. Rare in Mojave Desert, associated with deep dune deposits at Kelso Dunes and Devils Playground.

**Comments:** *Panicum urvilleanum* generally forms a sparse cover on open dunes and deep sand deposits. The alliance usually occurs on the core of the large dune systems on the deepest sand and may occupy active tall dunes with relatively steep faces. In those settings, it is usually the sole dominant species and spreads across dunes with long underground rhizomes. Although perennial, cover varies annually based on precipitation.

Sand dunes are used for many uses other than passive recreation. Grazing has occurred on the Kelso Dunes. Algodones (Imperial) and Dumont dunes are open to motorized recreation. Eureka Dunes have been subjected to sand-boarding. *Panicum urvilleanum* Sparsely Vegetated Herbaceous alliances are usually far from the edges of dune systems and experience shifting sands more than alliances of the thinner sand sheets and dune margins.

**Regional Status:**
**Mojave Desert:** The alliance occurs on the Kelso Dunes.
**Southeastern Great Basin:** The alliance occurs on the Eureka Dunes.

**Management Considerations:** Sand sheets and dunes are relatively rare and many are degraded by OHV use and disruption of sand sources. Protection from impacts has been implemented on a portion of California dunes, but many such as Dumont, Algodones, and Rice Valley dunes have had long-term quantifiable negative impacts. Other dunes should be surveyed for this alliance. The alliance is very rare in California.

## *Phragmites australis* Semipermanently Flooded Herbaceous Alliance

Figure A33. *Phragmites australis* Semipermanently Flooded Herbaceous Alliance, Salt Creek

*Phragmites australis* is the sole dominant species in herbaceous layer. *Anemopsis californica, Juncus balticus, J. mexicanus, J. cooperi, Schoenoplectus americanus, Schoenoplectus acutus,* or *Schoenoplectus californica* may be present. Emergent *Salix* species and *Populus fremontii* may be present. Grass < 4 m tall; cover continuous.

**Habitat:** Habitat permanently saturated with shallow water table. Water chemistry: fresh, mixohaline, mixosaline. Cowardin class: palustrine persistent emergent wetland. The national list of wetland plants (Reed 1988) lists *Phragmites australis* as a Facultative Wetland.

**Distribution:** Widespread throughout California, but largely within California Dry Steppe Province, American Semi-desert and Desert Province, and Intermountain Semidesert and Desert Province. It is virtually cosmopolitan.

**Elevation:** -45 to 1,600 m

**NDDB Rank:** G5 S3.2

**Synonyms:**

Holland: Transmontane alkali marsh (52320), Cismontane alkali marsh (52310), Transmontane freshwater marsh (52420), Coastal and valley freshwater marsh (52410)
Barry: G7412331
Cheatham and Haller: Coastal and valley freshwater marsh, Great Basin freshwater marsh, Valley alkali marsh, Great Basin alkali marsh
Thorne: Alkali meadow, freshwater marsh
WHR: Fresh emergent wetland
Munz: Freshwater marsh

**References:** Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Marks et al. (1994), FEIS (2001).

**Membership Rules**: *Phragmites australis* ≥ 2%. Usually associated with alkali wetlands adjacent to playas, alkali springs, and meadows; may also occur in freshwater wetlands**.**

**Comments:** *Phragmites australis* Semipermanently Flooded Herbaceous Alliance behaves differently in different regions of the state. In the Mojave Desert and Southeastern Great Basin, the alliance is limited to naturally occurring, unmanaged fresh or alkaline springs, slow creeks, and marshes in typically small stands adjacent to other wetland alliances. In general, *Phragmites australis* Semipermanently Flooded Herbaceous Alliance occurs in drier settings than *Schoenoplectus americanus* Semipermanently Flooded Herbaceous and *Typha (angustifolia, latifolia) – (Schoenoplectus* spp.) Semipermanently Flooded Herbaceous Alliance, but in moister settings than *Pluchea sericea* Seasonally Flooded Shrubland, *Juncus cooperi* Seasonally Flooded Herbaceous, and *Sporobolus airoides* and *Distichlis spicata* Intermittently Flooded Herbaceous Alliances.

In the Great Valley, it often acts as a ruderal alliance invading managed wetlands and proliferating in mowed, burned, or otherwise frequently disturbed marshes. Typical stands in either situation are monospecific, with only a few other plants entering into the periphery of the dense clonal clumps.

*Phragmites australis* Semipermanently Flooded Herbaceous Alliance typically occurs in seasonally flooded wetlands. Natural disturbance in stands is largely limited to fluvial disturbance except for occasional late-season fires in marshland. The primary mode of regeneration is vegetative. However, seed banks may build up in marshes and seeds may germinate in vegetation-free areas following water draw-down (FEIS 2001). Many of the stands along the major perennial creeks and rivers in the deserts probably flooded annually, and broken and damaged nodal sections of the strong rhizomes and rapidly growing stolons would break and establish on sand and gravel bars. In managed wetlands, burning, plowing, mowing, and other clearing techniques in conjunction with artificial draw-down, tend to spread the stands through vegetative regeneration and via seed banks. Most fire does not kill *Phragmites australis* Semipermanently Flooded Herbaceous stands. Only deep-burning peat fires can kill the rhizomes, which may run as deep as 100-200 cm (FEIS 2001).

**Regional Status:**
**Mojave Desert:** The alliance occurs in alkaline and freshwater marshes and along creeks throughout the Mojave Desert. In those situations, it often shares the marshes with various alliances that segregate based on moisture and alkalinity/salinity tolerances. Largest stands in the Mojave Desert may be along the Amargosa River between Shoshone and Tecopa.

**Management Considerations:** Stands in the desert sections are generally non-invasive. *Tamarix* may invade stands of this alliance. Stands in managed wetlands in the Sacramento-San Joaquin River delta respond to certain management practices by proliferating vegetatively and via seed. Managers concerned with the invasive qualities of *Phragmites australis* Semipermanently Flooded Herbaceous Alliance should consider its ecological setting in adjacent unmanaged wetlands, where it is generally stable and non-invasive.

## *Pinus flexilis* Woodland Alliance

No photograph is available.

*Pinus flexilis* is the sole or dominant tree in canopy. *Abies concolor, Pinus albicaulis, P. balfouriana, P. contorta ssp. murrayana, P. jeffreyi,* or *P. longaeva* may be present. Trees < 18 m tall; canopy open. Shrubs are either infrequent or common. Ground layer sparse.

**Habitat:** All slopes, especially ridges and upper slopes below tree line. Soils commonly granitic-derived.

**Distribution:** Sierra Nevada (southern subalpine area), Southern California Mountains and Valleys, Mono, Southeastern Great Basin, from British Columbia east to Alberta, south to Texas, and west to California.

**Elevation:** 2,200 to 3,350 m

**NDDB Rank**: G4 S3.2

**Synonyms**:
Holland: Limber pine forest
Barry: G7411112 BPIFL20
Cheatham and Haller: Southern California subalpine forest
PSW-45: Limber pine series
Thorne: Limber pine forest
WHR: Subalpine conifer

**References:** Barney (1980), Griffin and Critchfield 1972, Paysen et al. (1980), Thorne (1976) Vasek and Thorne (1977); plot-based descriptions are found in Keeler-Wolf and Keeler-Wolf (1976), Keeler-Wolf (1989), Keeler-Wolf (1990b), Taylor (1979) in Keeler-

Wolf (1990b), Talley (1978) in Keeler-Wolf (1990b), Ball (1976) in Keeler-Wolf (1990b).

**Membership Rules:** *Pinus* flexilis is the major tree species (> 55% relative cover and > 25% absolute cover). Typically occurs on more gently sloping northerly exposures than *Pinus longaeva*, only on highest portion of Inyo and Panamint mountains.

**Comments:** *Pinus flexilis* grows in dry, rocky, exposed sites from the foothills to alpine, defining both lower and upper limits of tree growth in many mountain ranges. Outside California, it mixes with *Populus tremuloides* in a mixed forest that is part of a broad mosaic with conifer forests, shrublands, and grasslands that symbolizes much of the West. In the southern Rocky Mountains, it grows with *Pinus longaeva* and other high-elevation conifers as in California.

*Pinus flexilis* is a slow-growing, long-lived tree the can be replaced on productive sites by more shade-tolerant species, but is persistent on non-productive sites. Trees have thin bark; even moderate fire kills large trees with thicker bark. Seedlings establish from cached seed. Intermediate fire frequency permits coexistence of *Pinus flexilis* with other trees on productive sites, and it is common in locations with long fire intervals of low-intensity fire.

**Regional Status:**
**Southeastern Great Basin**: The alliance occurs in the Inyo Mountains and Panamint Range, where it grows with *Pinus longaeva*. It also occurs along the California-Nevada border in the Grapevine Mountains in Death Valley National Park.

**Management Considerations:** Several recently killed stands of *Pinus flexilis* Woodland occur along the east slope of the Sierra Crest between Tioga Pass and Lundy Canyon in the Mono Basin. A blister rust or a related fungus apparently attacked these stands.

## *Pinus longaeva* Woodland Alliance
No photograph is available.

*Pinus longaeva* is the sole, dominant, or important tree with *Pinus flexilis* in the canopy. Trees < 18 m tall; canopy open. Shrubs are infrequent or conspicuous; the ground layer is sparse.

**Habitat:** All slopes, especially ridges and upper slopes below tree line. Soils are dolomite, limestone, or granite-derived.

**Distribution:** Mono, Southeastern Great Basin Mojave Desert, Intermountain West.

**Elevation:** 2,600 to 3,600 m

**NDDB Rank:** G4 S2.3

**Synonyms**:
Holland: Bristlecone pine forest
Barry: G7411112 BPILO00
Cheatham and Haller: Bristlecone pine forest
PSW-45: Bristlecone pine series
Thorne: Bristlecone pine woodland
WHR: Subalpine conifer

**References:** *Pinus longaeva* range in California (Griffin and Critchfield 1972). Beasley and Klemmedson (1980), Billings and Thompson (1957), Fritts (1969), Lanner (1984), Lloyd and Mitchell (1973), Marchand (1973), Mooney (1973), Mooney et al. (1962), Paysen et al. (1980), Schulman (1954), Vasek and Thorne (1977), Wright and Mooney (1965); plot-based descriptions are found in Taylor (1979) in Keeler-Wolf (1990b)

**Membership Rules**: *Pinus flexilis* ≥ 25% cover or total cover greater than either shrubs or herbaceous. Found only in the highest portions of the Inyo and Panamint mountains. When occurring with *Pinus flexilis*, as on the upper, east-facing slopes of Wacoba Mtn. (Inyo Mountains), it may have equal cover with *Pinus longaeva*.

**Comments:** *Pinus longaeva* may form single-species stands or mix with *Pinus flexilis*. The most famous stands are at Schulman Grove in the White Mountain Research Natural Area (Keeler-Wolf 1990b) and in the Ancient Bristlecone Pine Botanical Area in Mono Co. Here *Pinus longaeva* grows on dolomite. Keeler-Wolf (1990b) qualitatively describes forests of *Pinus longaeva* and *Pinus flexilis* at Whippoorwill Flat RNA in Inyo Co. *Pinus longaeva* is a rare (CNPS List 4) plant (Skinner and Pavlik 1994).

*Pinus longaeva* is a long-lived (5,000 years) conifer. Trees retain needles up to 30 years, and have deep and spreading roots. Cones ripen and seed dispersal occurs in the fall. Clark's nutcracker, other birds, and small mammals cache seeds. *Pinus longaeva* stands are open with a ground cover of bare soil and rock with a few scattered herbs. Lightning caused fire is restricted to individual trees.

**Regional Status:**
**Southeastern Great Basin:** The alliance occurs on ridges and peaks of the Inyo and Panamint mountains.

**Management Considerations:** No additional information is available.

## *Pinus monophylla* Sparsely Wooded Shrubland Alliance

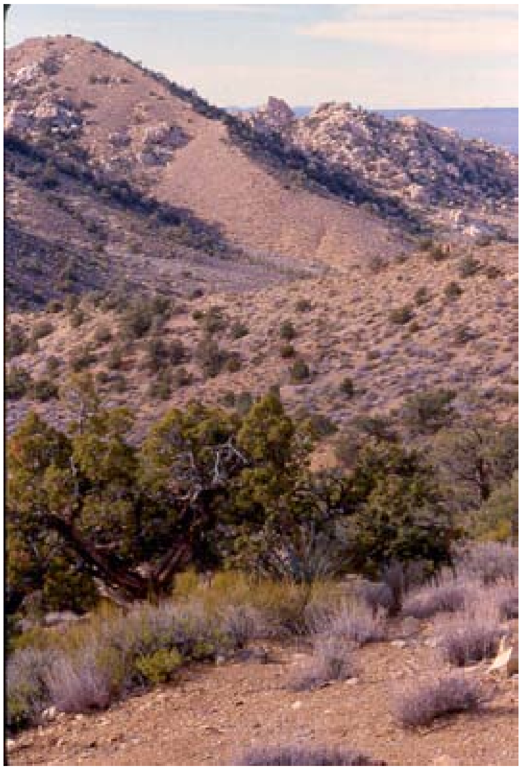

Figure A34. *Pinus monophylla* Sparsely Wooded Shrubland, Mid Hills, San Bernardino County.

*Pinus monophylla* is present as an emergent tree over a shrub canopy. *Juniperus osteosperma, Juniperus californica, J. occidentalis* ssp. *australis, Quercus cornelius-mulleri,* or *Quercus john tuckeri* may be present as emergent trees or large shrubs over a shorter shrub canopy. *Artemisia tridentata, Artemesia nova, Artemesia arbuscula*, *Chrysothamnus viscidiflorus, Chrysothamnus nauseosus, Ephedra viridis, Eriogonum fasciculatum, Eriogonum umbellatum, Grayia spinosa, Opuntia erinacea, Purshia tridentata, Purshia stansburiana,* or *Yucca baccata* may be present. Trees < 15 m tall; canopy intermittent to open. Shrubs common. Ground layer absent, sparse, or grassy.

**Habitat:** Alluvial fans, pediments, slopes, ridges, canyons, and ravines at lower elevations. Soils commonly coarse sand and/or rocky, well drained, ranging to sandy loam. Canyon bottoms and small desert mountain drainageways, intermittently flooded streamcourses.

**Distribution:** Southeastern Great Basin, Mono, Mojave Desert, Sierra Nevada, Southern California Mountains and Valleys, Nevada, Utah, Arizona, Idaho

**Elevation:** 1,000 to 1,800 m

**Synonyms:**
Sawyer and Keeler-Wolf (1995): Single-leaf pinyon series (*in part*), Single-leaf pinyon-Utah juniper series (*in part*)
Holland: Great Basin pinyon woodland (72122), Mojavean pinyon woodland (72210), Great Basin pinyon-juniper woodland (72121), Peninsular pinyon woodland (72310)
Cheatham and Haller: Pinyon-juniper woodland
PSW-45: Pinyon series
CALVEG: Single-leaf pinyon-Utah Juniper series
Rangeland: SRM 412
Thorne: Pinyon-juniper woodland
Munz: Juniper-pinyon woodlands
WHR: Pinyon-juniper

**References:** Brown (1982), Griffin and Critchfield (1972), Meeuwig et al. 1990, Meeuwig and Bassett (1983), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Thorne (1982), Tueller et al. (1979), Vasek and Thorne (1977), West (1994); plot-based descriptions are found in Keeler-Wolf (1990a), Parikh (1993), Vasek and Thorne (1977), Keeler-Wolf and Keeler-Wolf (1976), Keeler-Wolf (1989) in Keeler-Wolf (1990b), Keeler-Wolf et al. (1998)

**Membership Rules:** *Pinus monophylla* ≥ 1% but < 25% cover. *Juniperus osteosperma* or *californica* may be present but with low cover. Dominant strata are shrubs. *Pinus monophylla* occurs over a sparse to relatively dense cover of shrubs, widespread in all of the higher mountains of mapping area.

**Comments:** We included this alliance in the pinyon-juniper ecological system with *Pinus monophylla* – (*Juniperus osteosperma*) Woodland and *Juniperus californica* or *Juniperus osteosperma* Wooded Shrubland Alliance. Stands with an emergent layer of *Pinus monophylla* generally < 25% cover over a varied shrub canopy are considered part of this wooded shrubland alliance. It occupies lower, drier and warmer sites than the *Pinus monophylla* – (*Juniperus osteosperma*) Woodland alliance. The alliance occurs with *Artemisia tridentata, Artemesia nova, Artemesia arbuscula* and *Cercocarpus ledifolius* scrubs in the Southeastern Great Basin, the eastern Sierra Nevada, and the Mono. In the Transverse and Peninsular ranges, it is associated with *Cercocarpus ledifolius*, *Coloegyne ramosissima* and *Juniperus californica* scrubs at lower elevations. In the Southeastern Great Basin and Mono, it occupies topographic settings between *Juniperus osteosperma* or deep-soil *Artemisia tridentata* associations and shallow-soil versions *of Artemesia tridentata, Artemesia arbuscula,* or *Artemisia nova* scrubs.

*Pinus monophylla* is a slow- to moderately fast-growing tree with a maximum age of several hundred years. It is an obligate seeder and does not sprout after fire. Small-to-moderate-sized individuals are killed by moderate fire. For example, where *Pinus monophylla* trees have recently invaded sagebrush-grassland communities, young trees < 1.2 m are easily killed (FEIS 2001). Associated species may vary, but most (*Juniperus* spp., *Cercocarpus ledifolius, Artemisia* spp.) are not strongly fire-adapted, and stands are eliminated by repeated moderate fire. Stand-replacing fires were probably uncommon naturally. Fire has always been a natural process in the *Pinus monophylla* alliance, although the extent and frequency of fires have increased in many areas as a result of human ignition rates and the invasion of non-native annual grasses, in particular *Bromus tectorum*. Much of the following information is taken from the FEIS 2001 account of *Pinus monophylla*.

High temperatures, moderate winds, dry weather, and generally dense stands (> 1000 trees per ha) are necessary for crown fire to carry in *Pinus monophylla* stands. The effect of fire depends largely upon stand structure and understory composition. The historic regimes were likely based on relatively localized lightning strike ignitions that were limited by relatively wide spacing of trees, low shrub and grass understory density, and natural fuel breaks in rugged mountainous terrain. Lightly grazed ecotonal areas with a dense understory burn easily. Fire does not carry in some open stands.

Following fire, *Pinus monophylla* is absent from early successional stages. Seedlings reestablish primarily via the postburn food caches of birds and rodents; successful establishment requires a nurse plant. Apparently, the rate of *Pinus monophylla* reinvasion of burned areas is determined by relay floristics. In general, if adjacent stands remain, *Pinus monophylla* becomes established 20 to 30 years after fire.

**Regional Status:**
**Mojave Desert:** Stands occur in the eastern Mojave Desert. Some contain relict elements such as *Pinus edulis, Quercus chrysolepis, Quercus turbenella, Abies concolor, Garrya flavescens,* and *Arctostaphylos pungens*.
**Southeastern Great Basin:** *Pinus monophylla* woodlands are widespread in all the mountains > 1800 m in the Southeaster Great Basin and include those with *Juniperus, Cercocarpus*, and *Artemisia* spp. as the principal associates. Some unusually large-stature stands exist at Whippoorwill Flat in the Inyo Mountains (Keeler-Wolf 1989).

**Management Considerations:** As this alliance consists of open to very open stands of *Pinus monophylla*, they are particularly susceptible to decimation by fire. All of the shrubs associated with the currently defined associations in this alliance are re-sprouters and are thus capable of re-establishing dominance before the establishment of *Pinus monophylla* in the overstory. It is likely that this is a transient community in many areas and will convert to shrubland under relatively high fire frequencies.

## *Pinus monophylla – (Juniperus osteosperma)* Woodland Alliance

Figure A35. *Pinus monophylla - (Juniperus oseteosperma)* Woodland Alliance, Clark Mountain (*Abies concolor* Unique Stands along crest)

*Pinus monophylla* is the sole, dominant, or important tree in canopy. *Juniperus osteosperma, Juniperus californica, J. occidentalis* ssp. *australis, Pinus jeffreyi, Quercus chrysolepis, Quercus cornelius-mulleri,* or *Quercus john-tuckeri* may be present as emergent trees over a shrub canopy. *Artemisia tridentata, Artemesia nova, Artemesia arbuscula*, *Chrysothamnus viscidiflorus, Chrysothamnus nauseosus, Ephedra viridis, Eriogonum fasciculatum, Eriogonum umbellatum, Grayia spinosa, Opuntia erinacea, Purshia tridentata, Purshia stansburiana,* or *Yucca baccata* may be present. Trees < 15 m tall; canopy intermittent to open. Shrubs common. Ground layer absent, sparse, or grassy.

**Habitat:** Alluvial fans, pediments, slopes, ridges, canyons, and ravines at lower elevations. Soils commonly coarse sand and/or rocky, well drained, ranging to sandy loam. Canyon bottoms and small desert mountain drainageways, intermittently flooded streamcourses.

**Distribution:** Southeastern Great Basin, Mono, Mojave Desert, Sierra Nevada, Southern California Mountains and Valleys, Nevada, Utah, Arizona, Idaho

**Elevation:** 1,000 to 2,800 m

**NDDB Rank:** Unknown

**Synonyms:**

Sawyer and Keeler-Wolf : Single-leaf pinyon series (*in part*), Single-leaf pinyon-Utah juniper series (*in part*)
Holland: Great Basin pinyon woodland (72122), Mojavean pinyon woodland (72210), Great Basin pinyon-juniper woodland (72121), Peninsular pinyon woodland (72310)
Cheatham and Haller: Pinyon-juniper woodland
PSW-45: Pinyon series
CALVEG: Single-leaf pinyon-Utah Juniper series
Rangeland: SRM 412
Thorne: Pinyon-juniper woodland
Munz: Juniper-pinyon woodlands
WHR: Pinyon-juniper

**References:** Brown (1982), Griffin and Critchfield (1972), Meeuwig et al. 1990, Meeuwig and Bassett (1983), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Thorne (1982), Tueller et al. (1979), Vasek and Thorne (1977), West (1994): plot-based descriptions are found in Keeler-Wolf (1990a)**,** Parikh (1993), Vasek and Thorne (1977), Keeler-Wolf and Keeler-Wolf (1976), Keeler-Wolf (1989) in Keeler-Wolf (1990b), Keeler-Wolf et al. (1998)

**Membership Rules:** *Pinus monophylla* ≥ 25% cover or total cover greater than either shrubs or herbaceous cover. No other tree species approaches or exceeds it in cover. *Juniperus osteosperma* may be present. Restricted to cooler, moister sites than *Pinus monophylla* Wooded Shrubland alliance. Keeler-Wolf et al. (1998) *Pinus monophylla* dominant tree (≥ 5% cover) over varied shrub understory, *Pinus monophylla* taller and more conspicuous than any other species.

**Comments:** We included this alliance in the pinyon-juniper ecological system with *Pinus monophylla* Wooded Shrubland and *Juniperus californica* or *Juniperus osteosperma* Wooded Shrubland Alliance. Stands with an emergent layer of *Pinus monophylla* generally < 25% cover over a varied shrub canopy are considered to be *Pinus monophylla* Wooded Shrubland Alliance. *Pinus monophylla* – (*Juniperus osteosperma*) Woodland alliance occupies higher, cooler sites than the *Pinus monophylla* Wooded Shrubland Alliance. It occurs with *Artemisia tridentata, Artemesia nova, Artemesia arbuscula* and *Cercocarpus ledifolius* scrubs in the Southeastern Great Basin, the eastern Sierra Nevada, and the Mono. In the Transverse and Peninsular ranges, it is associated with *Cercocarpus ledifolius*, *Coloegyne ramosissima* and *Juniperus californica* scrubs at lower elevations. In the Southeastern Great Basin and Mono, it occupies topographic settings between *Juniperus osteosperma* or deep-soil *Artemisia tridentata* associations and shallow-soil versions *of Artemesia tridentata, Artemesia arbuscula,* or *Artemisia nova* scrubs.

*Pinus monophylla-(Juniperus osteosperma)* Woodland Alliance is the highest elevation regional vegetation of the Mojave Desert. It occurs with *Artemisia tridentata, Artemesia nova, Artemesia arbuscula* and *Cercocarpus ledifolius* scrubs and with *Pinus jeffreyi, Pinus contorta murrayana, Pinus flexilis,* and *Pinus longaeva* woodlands in the Southeastern Great Basin, the eastern Sierra Nevada, and the Mono. In the Transverse and Peninsular ranges, it is associated with *Cercocarpus ledifolius*, *Coloegyne* *ramosissima* and *Juniperus californica* scrubs (at lower elevations) and occurs adjacent to *Pinus flexilis* and *Pinus contorta murrayana* alliances at higher elevations. In the Southeastern Great Basin and Mono, it occupies topographic settings between *Juniperus osteosperma* or deep-soil *Artemisia tridentata* associations (below) and shallow-soil versions *of Artemesia tridentata, Artemesia arbuscula,* or *Artemisia nova* scrubs or woodlands of *Pinus flexilis* or *Pinus longaeva* (above). In parts of the Panamint, Inyo and White mountains, an upper-elevation *Artemisia tridentata* scrub separates *Pinus monophylla* stands from *Pinus flexilis* or *Pinus longaeva* stands, suggesting upslope retreat of *Pinus flexilis* and *Pinus longaeva* (Keeler-Wolf 1990b).

*Pinus monophylla* is a slow- to moderately fast-growing tree with a maximum age of several hundred years. It is an obligate seeder and does not sprout after fire. Small-to-moderate-sized individuals are killed by moderate fire. For example, where *Pinus monophylla* trees have recently invaded sagebrush-grassland communities, young trees < 1.2 m are easily killed (FEIS 2001). Associated species may vary, but most (*Juniperus* spp*., Cercocarpus ledifolius, Artemisia* spp.) are not strongly fire-adapted, and stands are eliminated by repeated moderate fire. Stand-replacing fires were probably uncommon naturally. Fire has always been a natural process in the *Pinus monophylla* alliance, although the extent and frequency of fires has increased in many areas as a result of human ignition rates and the invasion of non-native annual grasses, in particular *Bromus tectorum*. Much of the following information is taken from the FEIS 2001 account of *Pinus monophylla*.

High temperatures, moderate winds, dry weather, and generally dense stands (> 1,000 trees per ha) are necessary for crown fire to carry in *Pinus monophylla* stands. The effect of fire depends largely upon stand structure and understory composition. The historic regimes were likely based on relatively localized lightning strike ignitions that were limited by relatively wide spacing of trees, low shrub and grass understory density, and natural fuel breaks in rugged mountainous terrain. Lightly grazed ecotonal areas with a dense understory burn easily. Fire does not carry in some open stands.

Following fire, *Pinus monophylla* is absent from early successional stages. Seedlings reestablish primarily via the postburn food caches of birds and rodents; successful establishment requires a nurse plant. Apparently, the rate of *Pinus monophylla* reinvasion of burned areas is determined by relay floristics. In general if adjacent stands remain, *Pinus monophylla* becomes established 20 to 30 years after fire, but cover and density are relatively low until approximately 60 years after a fire, when tree dominance begins to exceed that of the understory. Pinyons are able to dominate a site within 100 to 150 years of burning. As tree dominance increases and the understory is gradually suppressed, the ability of the understory to carry fires intense enough to kill larger trees also decreases. Fire supression in some stands has led to denser-than-historic stands, which may burn with increasing frequency due to dense, fine, non-native grass fuels. Natural disturbance regimes also include periodic avalanches in snow chutes in the higher mountains.
In the Transverse Ranges (Brown and Minnich 1986), fire in naturally dense stands tends to be passive crown fires with fire size up to 7,000 ha. Periodic fire regimes may be

around 200 years and have not changed substantially over the past several hundred years (R. Minnich, personal communication).

**Regional Status:**
**Mojave Desert:** Stands occur in the eastern Mojave Desert; some contain relict elements such as *Pinus edulis, Quercus chrysolepis, Quercus turbenella, Abies concolor, Garrya flavescens,* and *Arctostaphylos pungens*.
**Southeastern Great Basin:** *Pinus monophylla* woodlands are widespread in all the mountains > 1800 m in the Southeastern Great Basin and include those with *Juniperus, Cercocarpus* and *Artemisia* spp. as the principal associates. Some unusually large stature stands exist at Whippoorwill Flat in the Inyo Mountains (Keeler-Wolf 1989).

**Management Considerations:** Prescribed fire has commonly been used by range managers to open up *Pinus monophylla* stands and promote grass and other forage species. However, it is no longer an effective management option on some *Pinus monophylla* sites where prolonged tree dominance due to fire suppression has reduced the understory. Fuels on such sites are often insufficient to carry fire. In addition, understory plants in closed stands do not withstand fire as well as those in more open stands. When fires occur in closed stands, they are usually of such high severity that soil seed reserves are depleted. Without successful post-fire seeding, highly flammable annual grass communities often establish. Losses due to fire in some areas of its range are likely a combination of fire suppression and high cover of *Bromus tectorum.*

## *Pleuraphis rigida* Herbaceous Alliance

Figure A36. *Pleuraphis rigida* Herbaceous Alliance, East of Superior Lake

*Pleuraphis rigida* is the sole or dominant grass in ground layer. *Achnatherum hymenoides, Ambrosia dumosa, Bouteloua eriopoda, Bromus madritensis, Dalea mollossima, Ericameria cooperi, Gutierrezia sarothrae, Panicum urvilleanum,* or *Sphaeralcea ambigua* may be present. Scattered trees and shrubs are typically emergent including the species: *Acacia greggii, Atriplex canescens, Chilopsis linearis, Ephedra californica, Ephedra nevadensis, Hymenoclea salsola, Larrea tridentata, Lycium andersonii, Opuntia acanthocarpa, Petalonyx thurberi, Yucca brevifolia,* and *Yucca schidigera*. Grass < 1 m tall; canopy open to intermittent. Shrubs < 3 m tall; open canopy. Trees < 6 m tall; scattered canopy. Annuals may be seasonally present.

**Habitat:** Flat ridges, lower bajadas, slopes, dune aprons and stabilized dunes. Soils well drained, may be sandy or rocky. Growth is poor on clays.

**Distribution:** Mojave Desert, Sonoran Desert, Colorado Desert, Southern California Mountains and Valleys, south Nevada, Arizona, Mexico.

**Elevation:** 500 to 1,400 m

**NDDB Rank:** G3 S2.2 (some associations may be more rare)
**Synonyms:**
Holland types: Mojave mixed steppe (34220 *in part*), Mojave yucca scrub and steppe (34230 *in part*), Sonoran creosote bush scrub (33100 *in part*), Mojave creosote bush scrub (34100 *in part*)
Barry: G7411331 BHIRI00
Cheatham and Haller: Creosote bush scrub
PSW-45: Galleta grass series
Thorne: Creosote bush scrub
CALVEG: Galleta series
Munz: Creosote bush scrub, Joshua tree woodland

**References:** Brown (1982), Burk (1977), Paysen et al. (1980), Sawyer and Keeler-Wolf (1995), Reid et al. (1999), Vasek and Barbour (1977); plot-based descriptions are found in Minnich et al. (1993), Keeler-Wolf et al. (1998).

**Membership Rules:** *Pleuraphis rigida* ≥ 2%. This species occurs in low sandy areas and occasionally in uplands at mid elevations, often with emergent shrubs such as *Yucca schidigera* and *Ephedra nevadensis*. As an alliance in the Mojave Desert, it is generally uncommon in upland areas and more common in low sandy areas. Keeler-Wolf et al. (1998) defines upland stands: *Pleuraphis rigida* dominant (> 60% relative cover, usually 10-35% actual cover) may have emergent shrubs up to 10% actual cover.

**Comments:** Many other classifications include this alliance in creosote bush scrub type assemblages. Stands of *Pleuraphis rigida* Herbaceous Alliance often form fine-grain mosaics with stands *of Larrea tridentata, Larrea tridentata-Ambrosia dumosa*, *Yucca brevifolia* Wooded or *Yucca schidigera* Shrublands. *Pleuraphis rigida* may be a common ground layer species in shrub or tree-dominated stands. Almost all California stands have at least 1% shrubs or trees emergent.

*Pleuraphis rigida* Herbaceous Alliance is a relatively rare alliance in the California deserts. It is considered as a warm-rain-season species and does not occur in the western Mojave Desert where cold season rain predominates (G. Harris, personal communication). Its range has probably decreased in areas with prolonged heavy grazing. It occurs either in open stands around margins of dunes or other sandy areas at low elevations, or in more closed mid-elevation upland sites on slopes and bajadas. In dune areas, it gives way to very open stands of *Panicum urvillianum* Sparsely Vegetated Herbaceous Alliance on the deepest sand deposits and is often interspersed with small stands of the *Abronia villosa* Sparsely Vegetated Alliance. *Pleuraphis rigida* was previously *Hilaria rigida* and is referred to as such in existing ecological literature.

*Pleuraphis rigida* is an unusual shrubby-looking grass with exposed renewal buds raised above the ground. It tolerates drought better than any other species in the genus (FEIS 2001). Its clumped growth form is a result of the tillers and short rhizomes it produces. Although fire effects are not well known, compared to other species in its genus, it is likely to be relatively sensitive to fire, particularly in its dried state (FEIS 2001). Although evidence is scant, observations suggest *Pleuraphis rigida* stands have declined in areas with long-term, moderate-to-heavy grazing pressure (T. Keeler-Wolf personal communication, Desert Workshop 2000).

In the lower Colorado River Valley of the Sonoran Desert and in some Mojave Desert communities, *Pleuraphis rigida* serves as the main stabilizer over wide areas of sand dunes. Stands in dune areas are relatively open and less likely to carry fire than even the open stands on rocky substrates. Thus, shifting sand and wind deflation are the primary agents of disturbance.

Some of the upland stands are affected by recent fire and seem to have maintained or extended themselves (Keeler-Wolf, personal communication) although they may be invaded by other shrubby disturbance related species.

**Regional Status:**
**Mojave Desert:** *Pleuraphis rigida* Herbaceous Alliance occurs in the eastern and southern Mojave Desert. It does not occur in the western Mojave Desert because of the paucity of warm-season rains compared to the central and eastern Mojave Desert. Most of the stands in the eastern and southern Mojave Desert are associated with sandy substrates (Devil’s Playground, Kelso Dunes, Rasor Road, Cronese Lakes, Pinto Basin), but several upland stands exist (e.g., Clipper Valley, Joshua Tree National Park, Lanfair Valley). Some of these upper elevation stands have been grazed and burned and contain higher cover of disturbance-related emergent shrubs such as *Opuntia acanthocarpa, Sphaeralcea ambigua, Gutierrezia microcephala*, and *Hymenoclea salsola*.

**Management Considerations:** Altered fire frequencies and increased livestock grazing have likely affected the non-sandy stands of *Pleuraphis rigida* throughout its range. It is particularly susceptible to these impacts when the grass is dry (most of the time). Further studies should be conducted to monitor change in the particularly sensitive upper elevation non-sandy stands. Stands on shallow sandy soil are frequently invaded by the aggressive non-native annual *Brassica tournefortii*. Intensive livestock grazing has possibly negatively affected both sandy and non-sandy stands.

## *Pleuraphis jamesii* Herbaceous Alliance

Figure A37. *Pleuraphis jamesii* Herbaceous Alliance, Inyo County

*Pleuraphis jamesii* is the sole or dominant grass in ground layer. *Bouteloua gracilis, Elymus elymoides, Eriogonum wrightii, Muhlenbergia porteri,* or *Sphaeralcea ambigua* may be present. Emergent shrubs such as *Artemisia tridentata*, *Ephedra nevadensis, Ephedra viridis*, *Eriogonum fasciculatum, Gutierrezia microcephala,* or *Opuntia acanthocarpa* may be present. Emergent *Yucca brevifolia* may be present. Grass < 1 m tall; cover is open to intermittent.

**Habitat:** Upper bajadas, gentle to moderately steep slopes, valleys, mesas. Soils range from deep, coarse, sandy soils to gravelly or rocky sites.

**Distribution:** Mojave Desert, Southeastern Great Basin Nevada, Utah, Colorado, Wyoming, Texas, Oklahoma.

**Elevation:** 1,200 to 2,800 m

**NDDB Rank:** G3 S2.2

**Synonyms:**

Holland types: Mojave mixed steppe (34220 *in part*), Mojave yucca scrub and steppe (34230 *in part*), Sonoran creosote bush scrub (33100 *in part*), Mojave creosote bush scrub (34100 *in part*)
Barry: G7411331 BHIRI00
Cheatham and Haller: Creosote bush scrub
PSW-45: Galleta grass series
Thorne: Creosote bush scrub
CALVEG: Galleta series
Munz: Creosote bush scrub, Joshua tree woodland

**References:** Brown (1982), Burk (1977), Paysen et al. (1980), Sawyer and Keeler-Wolf (1995), Reid et al. (1999), Vasek and Barbour (1977).

**Membership Rules**: Herbaceous cover exceeds cover of trees or shrubs, *Pleuraphis jamesii* > 2% cover. This species occurs in upper mid-elevation Mojave Desert of the eastern part of the mapping area, often associated with *Yucca brevifolia*, *Opuntia acanthocarpa* and *Gutierrezia spp.*

**Comments:** In California, *Pleuraphis jamesii* Herbaceous is restricted to the eastern Mojave Desert near the New York Mountains, Lanfair Valley, and the Mid Hills and in the Southeastern Great Basin in the Inyo and Panamint mountains. It occurs locally in small patches associated with stands of the following alliances: *Yucca brevifolia* Wooded Shrubland; *Artemisia tridentata, Coleogyne ramosissima, Ephedra nevadensis, Ericameria nauseosa,* and *Krascheninnikovia lanata* Shrublands; and *Pleuraphis rigida* Herbaceous Alliance. This is a more cold desert shrub-steppe than the *Pleuraphis rigida* Herbaceous Alliance, ranging well into the northern Great Basin and adjacent Great Plains. However, it is not known from other portions of the Californian Great Basin. It may be restricted in California to areas of relatively high summer precipitation.

This alliance is more resistant to grazing and fire than the *Pleuraphis rigida* Alliance. Compared to *Pleuraphis rigida*, this species has a lower growth habit and is more strongly rhizomatous, often forming an open turf or sod. It has the reputation in some parts of its range as being tolerant of heavy grazing. It is a better soil stabilizer than *Pleuraphis rigida* due to its rhizomatous nature. Some evidence suggests that in drier parts of its range (north-central Arizona), it is not as tolerant of grazing, and increased grazing pressure can reduce its distribution (FEIS 2001). This is likely to be the case in California. *Pleuraphis jamesii* regenerates primarily through rhizome expansion. *Pleuraphis jamesii* resprouts from rhizomes following fire. Reestablishment is usually completed within 2 years. In some parts of its range, with repeat burns, *Pleuraphis jamesii* Herbaceous Alliance may spread at the expense of other shrubs injured by fire. After winter burns conducted when soil moisture was sufficient, it yielded 75 % as much forage the first growing season as the unburned control. It is more susceptible to heat and desiccation during periods of low humidity.

**Regional Status:**
**Mojave Desert:** The alliance occurs in the New York Mountains, Lanfair Valley, and the Mid Hills.
**Southeastern Great Basin:** Stands in the Inyo Mountains are generally small (< 5 ha) and may occur on relatively steep slopes adjacent to valley bottoms associated with *Artemisia tridentata* and *Grayia spinosa* Shrublands and *Yucca brevifolia* Wooded Shrublands. The clonal stands may occur in shallow ravines or swales where soil is slightly better developed and/or moisture is more available. Some stands in the Inyo Mountains ascend to 2,800 m (T. Keeler-Wolf personal communication, Desert Workshop 2000). Stands also occur in the Panamint Mountains and in Deep Springs Valley (T. Keeler-Wolf personal communication, Desert Workshop 2000).

**Management Considerations:** This is a rare alliance in California and exists here at the limits of its range. All stands should be monitored and managed for long-term persistence. Fire in the California portion of its range is uncommon. The few stands observed have had a history of grazing and contain disturbance-related shrubs and non-native annual grasses including *Bromus tectorum.* The local effects of grazing should be monitored and appropriate action taken, if necessary.

## *Pluchea sericea* Seasonally Flooded Shrubland Alliance

Figure A38. *Pluchea sericea* Seasonally Flooded Shrubland Alliance, Devils Cornfield, Death Valley National Park

*Pluchea sericea* is the sole or dominant shrub in canopy. *Allenrolfea occidentalis, Atriplex torreyi, Atriplex canescens, Baccharis sergiloides, Baccharis emoryi, Distichlis spicata, Salix exigua, Suaeda moquinii, Schoenoplectus americanus, Tamarix* spp., or

*Typha angustifolia* may be present. Shrubs < 5 m tall; canopy continuous to open. Ground layer sparse to grassy.

**Habitat:** Habitats seasonally flooded, saturated. Water chemistry: fresh, mixohaline. Canyon bottoms, irrigation ditches, streamsides, around springs, and seasonally wet flats in basins and playa margins. Cowardin class: Palustrine shrub-scrub wetland. The national list of wetland plants (Reed 1988) lists *Pluchea sericea* as a Facultative Wetland species.

**Distribution:** Central California Coast Ranges, Great Valley, Southern California Coast, Mojave Desert, Colorado Desert, Sonoran Desert, Arizona, Nevada, New Mexico, Texas, Mexico.

**Elevation:** -75 to 600 m

**NDDB Rank:** G4 S3.3

**Synonyms:**
Holland: Arrowweed scrub (63820)
Barry: G7411211
Cheatham and Haller: Bottomland woodlands and forest
PSW-45: Arrow weed series
Thorne: Riparian woodland
WHR: Desert riparian
Munz: Creosote bush scrub

**References:** Paysen et al. (1980), Sawyer and Keeler-Wolf (1995), Reid et al. (1999)

**Membership Rules:** *Pluchea sericea* ≥ 2% cover. No other species with greater or equal cover. Occurs as narrow stringers at alkaline springs and seeps and as rare extensive stands on alkaline flats such as Devil's Golfcourse and Saline Valley.

**Comments:** *Pluchea sericea* Seasonally Flooded Shrublands often form pure stands. Secondary species, if present, vary regionally. *Pluchea sericea* Seasonally Flooded Shrublands may form a fine mosaic with other wetland alliances. This alliance is widespread in the warm deserts of California. It exists adjacent to many saline/alkaline springs in Death Valley National Park, along the Colorado River, and in the Colorado Desert. It may form dense, small stands adjacent to other wetland alliances such as *Schoenoplectus americanus, Distichlis spicata, Sporobolus airoides, Typha, Prosopis glandulosa, Pluchea pubescens*, and *Salix exigua.* At the Devil's Cornfield in Death Valley National Park and in parts of the Saline Valley, this alliance covers extensive flats and forms open shrublands with wide patches of sparsely vegetated *Distichlis spicata* Intermittently Flooded Herbaceous Alliance beneath the shrubs, over a strongly alkaline soil crust. In such cases, the groundwater is available a few feet below the surface but is rarely present at the surface.

*Pluchea sericea* Seasonally Flooded Shrublands are strongly tied to moisture and can tolerate relatively saline and alkaline conditions. Two phases exist, Devil's Cornfield type and spring type, and each is clearly affected by different ecological regimes. The Devil's Cornfield type probably establishes under abnormally wet conditions and persists by tapping into the subterranean water supply. Wind-induced deflation and accretion may isolate and build up fine sandy soil mounds around the bases of the shrubs. Competition for water may also limit establishment of *Pluchea sericea* in the interstices between shrubs. These mounds may have lower salinity than the basal soils. The dense narrow switches of *Pluchea sericea* Seasonally Flooded Shrublands stem along permanent springs. Slow-flowing streams have 100 % cover and likely suffer from occasional flooding events or die from fluctuations in the water table. Groundwater pumping may be a problem for persistence in some areas.

Fire effects, age, and asexual reproduction have not been quantified for this alliance. The plant flowers and sets seed over a long season and probably colonizes open moist sites readily from wind-blown seed. Resprouting has been observed (T. Keeler-Wolf personal communication, Desert Workshop 2000).

**Regional Status:**
**Mojave Desert:** Stands of both types occur in this region, although the spring type stands (typically < 1 ha in size) are by far the most frequent.

**Management Considerations:** Groundwater pumping, grazing pressures, *Tamarix* invasion, and other recreational uses of desert springs and riparian area are negatively affecting some stands of this alliance.

## *Populus fremontii* Seasonally Flooded Woodland Alliance

Figure A39. *Populus fremontii* Seasonally Flooded Woodland Alliance, Darwin Falls

*Populus fremontii* is the sole, dominant, or important tree in canopy. *Acer negundo, Fraxinus latifolia, Juglans californica* and hybrids, *Platanus racemosa, Salix exigua, Salix gooddingii, Salix laevigata, Salix lasiolepis, Salix lucida* ssp. *lasiandra,* or *Salix lutea* may be present. Trees < 25 m tall; canopy continuous or open. Shrubs and *Vitis californica* lianas (woody vines) are infrequent to common. Ground layer variable.

**Habitats:** Soils temporarily or seasonally flooded, saturated. Water chemistry: fresh. Riparian corridors, flood plains subject to high-intensity flooding. flood plains, low-gradient depositions along rivers, streams, seeps, stream and river banks, and terraces. Cowardin class: Palustrine forested wetland. The National Inventory of Wetland Plants (Reed 1988) lists *Populus fremontii* as a Facultative Wetland species.

**Distribution:** Central California Coast, Southern California Coast, Klamath Mountains, Northern California Coast Ranges, Northern California Interior Coast Ranges, Sierra Nevada Foothills, Great Valley, Central California Coast Ranges, Southern California Mountains and Valleys, Mojave Desert, Sonoran Desert, Colorado Desert and the western U.S.

**Elevation:** 0 to 2,400 m

**NDDB Rank:** G4 S3.2

**Synonyms**:
Holland: Central Coast cottonwood-sycamore, Southern cottonwood-willow, Great Valley cottonwood, Great Valley mixed, Modoc-Great Basin cottonwood-willow, Mojave, and Sonoran cottonwood-willow riparian forests
Barry: G7411121 BPPFR20.
Cheatham and Haller: Central Valley bottomland, Northern riparian, Southern riparian, Southern alluvial woodlands
PSW-45: Cottonwood series
Rangeland: SRM 203
Thorne: Riparian woodlands
WHR: Valley foothill, Desert riparian

**References:** Bowler (1989), Capelli and Stanley (1984), Conard and Robichaux (1980), Faber et al. (1989), Griffin and Critchfield (1972), Holstein (1984), MacMahon (1988), McBride (1994), Minckley and Brown (1982), Paysen et al. (1980), Sands (1980); plot-based descriptions are found in Gray and Greaves (1984), Conard and Robichaux (1980), Bahre and Whitlow (1982); Hanes (1976), Zembal (1989), Spolsky (1979), Keeler-Wolf et al. (1998).

**Membership Rules:** *Populus fremontii* dominates stands (> 50% relative cover in tree layer). The temporary forest and seasonally flooded woodland types are not documented in California. The California associations defined in the deserts apply to the temporarily flooded woodland type, which occurs throughout the southwest U.S.

**Comments:** *Populus fremontii* Seasonally Flooded Woodland may dominate or mix with other trees in wetland settings. Most stands have been eliminated, reduced in size and extent, or altered greatly, especially in areas amiable to agriculture. Structure and composition of remaining stands are changed as a result of hydrologic alternations, introduction of exotic species, grazing, clearing, cutting for fence posts, fuel and wood projects, and other human impacts.

*Populus fremontii* is a fast-growing, short-lived tree that is intolerant of shade. Copious wind-dispersed seed are produced in the spring and are viable for up to 5 days. Seeds germinate on moist alluvium and other recently disturbed sites. Seedlings establish in areas where subsurface water is available during the growing season. *Populus fremontii* vegetatively regenerates by root suckers, but seed is the primary mode of reproduction. Trees are damaged by cutting. Trees will resprout after fire if the trees are not old. Extensive riparian stands usually originate from a major disturbance event.

*Populus fremontii* is browse for livestock and wildlife and supplies cool shady cover for many animals in the summer. The fire interval was probably long in original stands. Those invaded by *Tamarix* species have a shorter fire interval of 10-20 years in Arizona (Ohmart et al. 1977).

**Regional Status:**
**Mojave Desert**: The alliance occurs locally with the most extensive stands occurring along the Mojave River.

**Management Considerations:** Many *Populus fremontii* Seasonally Flooded Woodland stands are extirpated. Natural flooding regimes and reduced water availability through groundwater pumping, livestock use, irrigation schemes, competition from exotics, and direct habitat destruction have taken their toll on this alliance throughout much of its California range.

## *Prosopis glandulosa* Shrubland Alliance

Figure A40. *Prosopis glandulosa* Shrubland Alliance, East of Tecopa

*Prosopis glandulosa* is the sole canopy shrub or small tree. Trees or shrubs < 10 m tall; canopy continuous or open. *Atriplex canescens, Atriplex polycarpa, Allenrolfea occidentalis, Isocoma acradenia, Rhus ovata, Salix exigua,* or *Suaeda moquinii* may be present.

**Habitat:** It occurs along rarely flooded margins of arroyos and washes, floodplains, fringes of playa lakes, sand dunes, stream banks, river terraces, surrounding alkali sinks, and washes. Soils intermittently flooded, saturated. Water chemistry: fresh. The National Inventory of Wetland Plants (Reed 1988) lists *Populus glandulosa* var. *torreyana* as a Facultative Upland species.

**Distribution:** Mojave Desert, Colorado Desert, Sonoran Desert, Southeastern Great Basin Baja California, Arizona, south Nevada, New Mexico, Texas.

**Elevation:** -75 to 1,100 m

**NDDB Rank:** G4 S3.2 (some associations may be S2.2 or lower)

**Synonyms:**
Sawyer and Keeler-Wolf: Mesquite series (Tree dominated, *in part*)
Holland: Mesquite bosque (61820 *in part*), Great Valley mesquite scrub (63420 *in part*)
Barry: G7411121
Brown, Lowe and Pase: 143.112, 143.152, 144.331, 153.131, 154.114, 154.173
Cheatham and Haller: Desert dry wash woodland, Southern alluvial woodland
PSW-45: Mesquite series
Thorne: Desert riparian woodland
WHR: Desert riparian

**References:** Brown (1982), Bukart (1976), Hilu et al. (1982), MacMahon (1988), Martin (1980), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Sharf et al. (1982), Vasek and Barbour (1977); plot-based descriptions are found in Bradley (1970), Spolsky (1979) and Keeler-Wolf et al. (1998).

**Membership Rules:** *Prosopis glandulosa* ≥ 2% cover. No other species with greater or equal cover. Trees and/or large shrubs of washes, dunes, or riparian stands.

**Comments:** *Prosopis glandulosa* is a deciduous, thorny shrub or small tree. The alliance may be composed of broad-crowned trees up to about 10 m in height (river margins), low (about 1 m tall), spreading, multi-stemmed shrubs (sandy, windswept soils, where dunes often form), or shrubs that are somewhat intermediate between these two extremes (springs, playa edges). In contrast to previous classifications, the NVC describes this alliance as a shrubland rather than woodland. This is in keeping with the recent plot descriptions obtained from the Mojave and Colorado deserts and the NVC, which describe all stands from California, Nevada, and western Arizona as dominated by relatively low-shrubby morphs of this variable species. The NVC describes woodland and seasonally flooded woodland alliances of *Prosopis glandulosa* (including both var. *glandulosa* and var. *torreyana*) as occurring in Texas, New Mexico, Arizona and Mexico.

This is a variable alliance in California occurring on dunes and playa edges, adjacent to both fresh and alkaline springs, and along washes and rivers. *Prosopis glandulosa* is a phreatophyte, occupying a number of situations where it has access to permanent undergroundwater. The deep roots of *Prosopis glandulosa* allow it to tap into constant water supplies up to at least 15 m below the surface (FEIS 2001). *Prosopis glandulosa* occurs along the Colorado and Mojave rivers, forming bosque (woodland) communities. It may occur adjacent to other wash or riparian alliances dominated by *Atriplex lentiformis, Atriplex canescens, Parkinsonia florida, Chilopsis linearis, Olneya tesota, Populus fremontii, Tamarix* sp.*, Salix gooddingii* and *Prosopis pubescens*. *Prosopis* *glandulosa* seems to be less flood-tolerant than other riparian species, and often dominates the outer floodplain. It occupies playa edges adjacent to stands of *Allenrolfea occidentalis* and *Atriplex canescens* Shrublands and *Suaeda moquinii* Intermittently Flooded Shrublands. It occurs at alkaline springs adjacent to herbaceous alliances including *Phragmites australis* and *Schoenoplectus americanus* Semipermanently Flooded, *Pluchea sericea* Seasonally Flooded, and *Salix exigua* Temporarily Flooded Shrublands. On dunes, it occurs adjacent to stands of *Abronia villosa* Sparsely Vegetated and *Atriplex canescens* Shrubland Alliances.

*Prosopis glandulosa* produces abundant seed. Many species of animals from small rodents to birds and ungulates relish the seeds, and dispersal is via animal gut or water. Although the seeds are high in protein, they are largely indigestible, and many pass through large mammals' digestive tracts intact and viable. Either means is effective in scarifying the seed, a treatment necessary for germination. *Prosopis glandulosa* seedlings commonly germinate from rodent caches. Seeds remaining in pods not consumed by animals most likely remain dormant until weathering breaks the seed coat. Seeds may remain viable for > 40 years (FEIS 2001).

In the deserts of southern California, conditions that favor plant establishment may occur only once every 5 to 10 years, following intense rains. Because *Prosopis glandulosa* seeds can remain viable for several years, seeds stored in the soil may germinate following such rains. *Prosopis glandulosa* can resprout if the aboveground portion of the plant is damaged or removed, such as by freezing weather, drought, fire, trampling, browsing, or cutting (FEIS 2001).

Natural disturbance processes in most California stands are related to flooding, shifting sand, and localized fire, particularly at the edge of the Peninsular ranges adjacent to chaparral stands. Groundwater pumping or alterations of the flooding regime have precipitated the decline of numerous stands in the California deserts. Little specific information exists on fire response of *Prosopis glandulosa*. Based on observations from prescribed fires and wildfires, top-kill and mortality of other mesquites (*Prosopis glandulosa* var. *glandulosa*, *Prosopis velutina*) are most influenced by the size of the plant and the intensity of the fire (FEIS 2001). Following a moderate summer fire in Anza-Borrego, *Prosopis glandulosa* shrubs resprouted weakly. Along the lower Colorado River, *Prosopis glandulosa* was reported to recover much slower following fire than *Salix gooddingii* and *Pluchea sericea*. The response of *Prosopis glandulosa* following fire in Joshua Tree National Park was found to vary with fire intensity. In general, it sprouted vigorously following low-intensity winter burns, but when plants were cut and the brush piled over the stumps to achieve a hot burn, plants displayed weak sprouting and poor regrowth (A.M. La Rosa, personal communication).

Frost sensitivity limits the alliance distribution to below 1,100 m in California, and may result in the low, shrubby forms at its extreme northerly and high-elevation occurrences. Fluvial activity along rivers and larger streams causes local site establishment when *Prosopis glandulosa* seeds germinate on bars, but also depletes stands by undercutting and erosion. It is likely that the dune and playa margin clonal stands are very old and only rarely are augmented by seedling recruitment.

**Regional Status:**
**Mojave Desert:** Stands on dunes, playa margins, springs, and riparian situations exist throughout the Mojave Desert. The westernmost stands occur in Fremont Valley and are degraded by groundwater pumping. The most extensive riparian stands may be near Tecopa. Several playa margin stands as at Cronese Dry Lakes have been invaded by *Tamarix sp*. Dune stands occur as far north as Mesquite Flat in Death Valley National Park.
**Southeastern Great Basin:** The northern-most stands of *Prosopis glandulosa* in California occur in the Saline Valley. These are adjacent to alkaline springs with *Phragmites australis, Schoenoplectus americanus* and *Juncus cooperi* dominated alliances on the eastern scarp of the Inyo Mountains and in the salty soil adjacent to the marsh on the west side of Salt Lake. They also occur adjacent to springs in the valley floor with *Salix exigua* Temporarily Flooded and *Prosopis pubescens* Shrublands, and on sand dune hummocks in the valley bottom. These stands are surrounded by *Larrea tridentata-Ambrosia dumosa, Allenrolfea occidentalis,* and *Pluchea sericea* Seasonally Flooded Shrublands.

**Management Considerations**: The chief use of western honey mesquite wood is for firewood. Some stands in California have been decimated, although cutting in the state is regulated by the native plant protection act. The sweet-tasting pods of *Prosopis glandulosa* are high in protein and sugars and are avidly eaten by most livestock. Livestock often remove the fruits as high on the tree as they can reach and eat fallen pods lying on the ground.

*Tamarix ramosissima,* and related species, is established along many rivers and desert wetlands of the California. In some areas, it has invaded and replaced *Prosopis glandulosa* Shrubland. Groundwater pumping is a serious threat in many locations.

*Prosopis glandulosa* Shrublands are one of the most degraded vegetation types in California. They were once much more common, reaching their peak height along the Colorado River. These mesquite shrublands were an early target for firewood cutting and construction materials and were grazed by livestock. More recently, they have been removed to make way for agriculture or construction and damaged, and in some cases eliminated, by falling water tables due to extensive groundwater pumping (D. Bainbridge, personal communication).

## *Prosopis pubescens* Shrubland Alliance

Figure A41. *Prosopis pubescens* Shrubland Alliance, Shoshone

*Prosopis pubescens* is the dominant or important large shrub in canopy. *Prosopis glandulosa, Baccharis salicifolia, B. emoryi, Isocoma acradenia, Salix exigua, Populus fremontii, Suaeda moquinii, Atriplex canescens, Atriplex polycarpa,* or *Sporobolus airoides* may be present. Large shrubs or small trees < 8 m tall; canopy open to intermittent. Ground layer open to intermittent; may be grassy.

**Habitat:** Habitat intermittently saturated with shallow water table. Water chemistry: fresh, mixohaline, mixosaline. Cowardin class: palustrine shrubland. The National Inventory of Wetland Plants (Reed 1988) list *Prosopis pubescens* as a Facultative Wetland species.

**Distribution:** Mojave Desert, Southeastern Basin and Range, Colorado Desert, Nevada, Arizona, New Mexico, Texas, Mexico.

**Elevation:** 0 to 800 m

**NDDB Rank:** G3 S2.2

**Synonyms:**
Sawyer and Keeler-Wolf (1995): Mesquite series (Tree dominated, *in part*)
Holland types: Mesquite bosque (61820 *in part*)
Barry: G7411121
Brown, Lowe and Pase: 143.112, 143.152, 144.331, 153.131, 154.114, 154.173

Cheatham and Haller: Desert dry wash woodland, Southern alluvial woodland
PSW-45: Mesquite series
Thorne: Desert riparian woodland
WHR: Desert riparian

**References:** Brown (1982), Bukart (1976), Hilu et al. (1982), Holland (1986) MacMahon (1988), Martin (1980), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Sharf et al. (1982), Vasek and Barbour (1977).

**Membership Rules:** *Prosopis pubescens* ≥ 2% cover. No other species of tree or tall shrub with greater or equal cover.

**Comments:** *Prosopis pubescens* is a deciduous, thorny, arborescent shrub or small tree. *Prosopis pubescens* Shrubland typically is restricted to riparian settings more than *Prosopis glandulosa* Shrubland, occurring around springs, desert streams and rivers, and not around dunes and playas. In California, this alliance is relatively rare, with individuals of the species occurring within stands of other alliances far more commonly than forming a distinct alliance. The most extensive stands known are in the Amargosa River Drainage between Shoshone and Tecopa. There they form open low woodlands in several broken stands surrounded by *Suaeda moquinii* Intermittently Flooded Shrubland, *Atriplex canescens* Shrubland, *Sporobolus airoides* Intermittently Flooded Shrubland or *Distichlis spicata* Intermittently Flooded Herbaceous. Other small stands occur in the Saline Valley, Death Valley and in Anza Borrego. Stands that were more extensive once existed along the lower Colorado River. However, many of these have been cleared or supplanted by *Tamarix* spp. stands (Holland 1986).

*Prosopis pubescens* Shrubland are associated with riparian settings like river terraces (Colorado River, Amargosa River) or in moist soil adjacent to springs. Although *Prosopis pubescens* has a deep root system similar to *Prosopis glandulosa*, *Prosopis pubescens* is usually more closely associated with shallow water tables and with fresh water sources. Disturbance events are typically intermittent and sporadic floods. The species produces abundant seed in characteristically twisted “screwbean pods”. Seeds are scarified by flooding events or by passing through animal guts (FEIS 2001). Seeds require some cover by soil for survival.

Fires in *Tamarix* species-dominated stands along the Colorado River have produced an overall reduction in *Prosopis pubescens* and an increase in Tamarix (FEIS 2001). Vogl and McHargue (1966) reported that the species resprouts weakly in the Coachella Valley.

**Regional Status:** No information available.

**Management Considerations:** The alliance is rare in California and is restricted to relatively sensitive habitats that have been degraded in part by woodcutting and by invasion of *Tamarix* spp. Further sampling and monitoring of stands is needed to describe variation and trends.

## *Prunus fasciculata* Intermittently Flooded Shrubland Alliance

Figure A42. *Prunus fasciculata* Intermittently Flooded Shrubland Alliance, Black Canyon (with scattered *Chilopsis linearis*, both plants dormant)

*Prunus fasciculata* is the sole or dominant shrub in canopy. *Achnatherum speciosum, Atriplex confertifolia, Ephedra nevadensis, Eriogonum fasciculatum, Grayia spinosa, Hymenoclea salsola, Krascheninnikovia lanata, Larrea tridentata*, *Lycium andersonii, Salvia dorrii*, *Thamnosma montana* or *Viguiera reticulata* may be present. Emergent *Acacia greggii, Juniperus osteosperma, J. californica, Pinus monophylla* or *Yucca brevifolia* may be present. Shrubs < 3 m tall; canopy continuous, intermittent, or open. Ground layer sparse.

**Habitat:** The alliance occurs on alluvial fans and bajadas, and intermittently flooded washes, arroyos and canyons in desert mountains. Soils alluvial, may be disturbed.

**Distribution:** Mojave Desert, Arizona

**Elevation:** 1,300 to 1,880 m

**NDDB Rank:** G3 S3.3

**Synonyms:**
Holland: Mojave mixed woody scrub (34210)
Cheatham and Haller

Munz: Creosote bush scrub, Shadscale scrub
WHR: Desert scrub

**References**: Beatley (1976) Evens (2000); plot-based descriptions are found in Evens (2000)

**Membership Rules:** *Prunus fasciculata* ≥ 2% cover. Must be ≥ 25% of total cover. *Gutierrezia sarothrae* may have higher cover. If *Prunus fasciculata* co-occurs with other tall shrubs such as *Acacia greggii*, it must have twice the cover of other species to make alliance definition. Typically of washes, but may occur on wash terraces and valleys.

**Comments:** *Prunus fasciculata* is a common, large shrub of wash margins in the upper Mojave Desert. It occurs as the highest elevation component of the wash continuum in the Mojave Desert. Thus, this alliance receives higher precipitation and cooler temperatures than other wash vegetation. It is characterized by the dominance of *Prunus fasciculata* but is most frequently mixed with several other shrubs.

Small stands of this alliance occur in canyons, arroyos, washes, and on disturbed upland sites (disturbed by livestock or OHV activity). The life-history attributes of *Prunus fasciculata* are not well known.

**Regional Status:**
**Mojave Desert:** Stands occur throughout the northern, eastern, southern, and central Mojave Desert. Most are in canyons and arroyos well up into the desert mountains (Evens 2000). Some stands occur on bedrock on the lower third of slopes above canyon bottoms, some in valleys or wash terraces with disturbance.

**Management Considerations:** More information is needed on the role these stands play in the upper Mojave Desert.

## *Psorothamnus spinosus* Intermittently Flooded Shrubland Alliance

Figure A43. *Psorothamnus spinosus* Intermittently Flooded Shrubland Alliance

*Psorothamnus spinosus* is the sole, dominant, or important tall shrub or small tree in canopy. *Parkinsonia florida, Acacia greggii, Chilopsis linearis*, or *Olneya tesota* may be present. Emergent trees may be present over a shrub canopy. *Hymenoclea salsola, Bebbia juncea, Hyptis emoryi, Larrea tridentata, Ambrosia dumosa, Encelia farinosa, Baccharis emoryi, Petalonyx thurberi*, or *Stephanomeria pauciflora* may form sparse to intermittent shrub layer. Shrubs < 3 m tall; intermittent or open canopy. Ground layer sparse; annual herbs or grasses seasonally present.

**Habitat:** The alliance occurs in washes, intermittent channels, arroyos, and intermittently flooded riverine or palustrine sites. The soils it occurs in are sandy, well drained, moderately acidic to slightly saline.

**Distribution:** Mojave Desert, Sonoran Desert, Colorado Desert, south Nevada, west Arizona, Baja California, Sonora.

**Elevation:** 0 to 900 m

**NDDB Rank:** G4 S3.3

**Synonyms**:
Holland: Mojave wash scrub (34250), Mojave Desert Wash Scrub (63700)
Barry: G7411124
Cheatham and Haller: Desert dry wash woodland

Thorne: Desert microphyll woodland
WHR: Desert wash
Munz: Creosote bush scrub

**References:** Johnson (1976), MacMahon (1988), Paysen et al. (1980), Thorne (1982), Turner and Brown (1982), Vasek and Barbour (1977), Sawyer and Keeler-Wolf (1995); plot-based descriptions are found in Keeler-Wolf et al. (1998)

**Membership Rules**: *Psorothamnus spinosus* must be at least 2% cover, although smaller shrubs may have up to twice the cover of the *Psorothamnus spinosus*. No other species with greater or equal cover. Occurs in low-elevation washes in southern and central portion of mapping area.

**Comments:** *Psorothamnus spinosus* Intermittently Flooded Shrubland occurs strictly in washes throughout the hot deserts of California. It is strongly tied to active wash and arroyo channels where flooding is relatively common. Sawyer and Keeler-Wolf (1995) included this alliance within the "blue paloverde-ironwood-smoketree series". Compared to other wash alliances characterized by tall woody shrubs or small trees, *Psorothamnus spinosus* occurs in the most active channels, prefers sandy, not bouldery or cobble substrates, and stands are relatively short-lived. It occurs farther north into the Mojave Desert (vicinity of Baker and the Cady Mountains.) and ascends to higher elevations (more cold-tolerant) than *Olneya* or *Parkinsonia* dominated alliances. This alliance in many cases occurs as part of a matrix with other shrub and small tree alliances comprising a patchwork of small stands within a wash system. Compared to *Chilopsis linearis* Intermittently Flooded Shrubland, it is less cold-tolerant and more likely to occupy wash bottoms as opposed to margins.

*Psorothamnus spinosus* Intermittently Flooded Shrubland is dependent upon intermittent flooding events for stand establishment. It is dominated by a relatively short-lived species with maximum ages probably not over 50 years. Seeds have a hard seed coat that requires scarification to germinate. Even-aged stands are common, although some stands have two or three age classes represented. It is possible that seeds survive for relatively long periods in the substrate and may even out-survive existing plants. Flood intensities are highly variable and range from < 2 cfs to > 10,000 cfs (Waananen and Crippen 1977). Peak discharge in many of the washes at 100 yr flood intervals is < 500 cfs (Waananen and Crippen 1977). It is likely that 25-year peak discharges as low as 16 cfs are adequate to initiate significant stand regeneration. The largest and densest stands occurs primarily on sand or small gravel within channels of a wash, suggesting that minor flooding is responsible for establishment of the denser stands in most cases. Resprouting is evident after mechanical damage.

**Regional Status:**
**Mojave Desert:** The alliance occurs along mostly moderate-sized washes in Pahrump, Silurian, Lanfair, and Piute Valleys. It is a warm-season rain species and consequently

does not occur in the western Mojave Desert (T. Keeler-Wolf personal communication, Desert Workshop 2000). It reaches elevations of over 800 m (upper Sleeping Beauty Wash). Associated alliances are *Hymenoclea salsola, Ericameria paniculata, Acacia greggii,* and *Chilopsis linearis* Intermittently Flooded Shrublands.

**Management Considerations:** *Psorothamnus spinosus* Intermittently Flooded Shrubland is a flood-related alliance that is relatively insensitive to human-mediated changes. For example, it occurs in many parts of the Sonoran Desert along modified channels adjacent to highways. A relatively frequent uninterrupted flooding regime is required and big wash systems are needed to represent this alliance over long-term in conservation planning. Intensive human use of washes (OHV and gravel mining) is detrimental to stands of the alliance.

## *Purshia stansburiana* Shrubland Alliance

Figure A44. *Purshia stansburiana* Shrubland Alliance, Clark Range

*Purshia stansburiana* is the dominant or important shrub in the canopy. *Agave utahensis, Artemisia nova, Ephedra viridis, Mortonia utahensis, Achnatherum speciosum, Prunus fasciculata, Thamnosma montana, Salvia mohavensis, Opuntia chlorotica* or *Yucca baccata* may be present. Emergent *Pinus monophylla* and *Juniperus osteosperma* may be present. Shrubs < 5 m; cover open. Ground layer sparse.

**Habitat:** The alliance occurs on steep slopes, cliffs, and hills, canyons and edges of intermittent watercourses. It occurs on soils that are well drained, shallow, rocky, rapidly permeable, and usually calcareous.

**Distribution:** Northern and eastern southern California Mountains, Mojave Desert, Southeastern Great Basin, Arizona, Utah.

**Elevation:** 1,000 to 2,100 m

**NDDB Rank:** G3 S3.2

**Synonyms**:
Holland: Great Basin mixed scrub, Big sagebrush, Sagebrush steppe
Barry: G74
Brown, Lowe and Pase: 132.15
Cheatham and Haller: Great Basin sagebrush
Rangeland: SRM 210
Thorne: Great Basin sagebrush scrub
WHR: Sagebrush
Munz: Sagebrush scrub

**References:** Reid et al. (1999), FEIS (2001)

**Membership Rules:** *Purshia stansburiana* ≥ 2% cover, no other single species with greater cover. Tends to occur in eastern Mojave Desert limestone mountains in washes in the pinyon and juniper belt.

**Comments:** In California, *Purshia stansburiana* Shrubland appears restricted to the mountains of the eastern Mojave Desert and adjacent Southeastern Great Basin. There it occurs in scattered stands often adjacent to *Pinus monophylla- (Juniperus osteosperma)* Woodland and *Purshia tridentata* or *Artemisia tridentata* Shrublands. Some stands of this alliance may have scattered trees. Most stands are on relatively steep slopes with either southerly or westerly exposures. Cover in the few stands sampled in California is low, averaging between 3 and 14% for all species. Virtually all stands observed occur on limestone or marble. Stands are usually relatively small, resulting from slope breaks and substrate changes.

*Purshia stansburiana* is a relatively long-lived shrub that typically reproduces by seed. According to FEIS (2001), it has varying ability to resprout that may vary geographically. In California, it is not considered a resprouter and is usually killed after fire. In other parts of its range (e.g., Utah) smaller to mid-size individuals usually resprout weakly, while arborescent individuals with a single large trunk tend to be killed by fire. Fire in the rocky, sparsely vegetated stands in California is probably very rare. Disturbance from flooding events is likely for the canyon bottom stands. Recruitment in some parts of its range is sporadic and limited (Reid et al. 1999).

**Regional Status:**
**Mojave Desert**: *Purshia stansburiana* Shrubland is locally present in stands occurring in the Clark, New York, and Providence mountains.
**Southeastern Great Basin:** The alliance probably occurs in the Inyo, White, Panamint, and Last Chance ranges.

**Management Considerations:** This alliance is rare and local in California.

## *Purshia tridentata* Shrubland Alliance

Figure A45. *Purshia tridentata* Shrubland Alliance

*Purshia tridentata* is the sole, dominant, or important shrub with *Artemisia tridentata* or *Ericameria nauseosa* in canopy. *Cercocarpus ledifolius*, *Chrysothamnus viscidiflorus, Ephedra viridis*, *Prunus andersonii* and/or *Tetradymia canescens* may be present. Emergent junipers, pines, or *Yucca brevifolia* may be present. Shrubs < 5 m tall; cover continuous, intermittent or open. Ground layer sparse or grassy.

**Habitat:** The alliance occurs on slopes and flats. It occurs on soils that are well drained and rapidly permeable.

**Distribution:** Klamath Mountains, Southern Cascades, subalpine Sierra Nevada, Modoc Plateau, northern and eastern Southern California Mountains and Valleys, Mojave Desert, Mono, Southeastern Great Basin, Northwestern Basin and Range, Nevada, Idaho.

**Elevation:** 1,000 to 3,400 m

**NDDB Rank:** G4 S3.2

**Synonyms**:
Holland: Great Basin mixed scrub, Big sagebrush, Sagebrush steppe
Barry: G74
Brown, Lowe and Pase: 132.15
Cheatham and Haller: Great Basin sagebrush
Rangeland: SRM 210
Thorne: Great Basin sagebrush scrub
WHR: Sagebrush
Munz: Sagebrush scrub

**References:** Neal (1994), Nord (1965), Young et al. (1977)

**Membership Rules:** *Purshia tridentata* ≥ 2% cover. If *Artemisia tridentata* or *Ephedra viridis* are present, they have less than 1% cover. Most stands in California have at least some *Artemisia tridentata* and usually some *Ericameria nauseosa*. A local type in high eastern and northern portions of mapping area.

**Comments:** Some stands of *Purshia tridentata* Shrubland may have scattered trees. The dominant species, *Purshia tridentata,* may be a component of other shrub alliances (see *Artemisia tridentata* and *Ericameria nauseosa* Shrubland). *Purshia tridentata* is also an important understory shrub in open woodland and forest alliances in transmontane California.

In *The Jepson Manual* (Hickman 1993), *Purshia tridentata* includes two varieties that are treated as species in many manuals. *Purshia tridentata* var. *glandulosa* and *Purshia tridentata* var. *tridentata* are generally differentiated by range, but both grow in the Southeastern Great Basin. Both varieties are included in *Purshia tridentata* Shrubland.

The dominant subspecies, *Purshia tridentata* var. *tridentata,* is a long-lived (125 years), deep-rooted shrub that varies greatly in habit and local ecotype response. An erect form tends to grow at lower elevations than a decumbent form that is more common at moister, higher ones. It establishes easily on disturbed sites that have some plant cover. Ants and birds, can carry cleaned and cached seeds, and rodents can carry seeds up to 350 m from source shrubs. Seedling establishment is sporadic and episodic, occurring in years of heavy seed crop, moderate rodent populations, sufficiently cold winters to promote seed ripening, and favorable spring and summer moisture and temperature conditions. Many stands tend to be all one age.

*Purshia tridentata* var. *tridentata* is important browse for livestock in the spring and wildlife in the winter. It is often killed by fire. It regenerates after fire by resprouting or by seedlings from cached seed. The erect form resprouts from buds just above the root collar; the decumbent from resprouts from buds just above the root collar or buds along layered branches. Young shrubs, less than 5-years old, and those over 60 years do not resprout as well as mid-aged, vigorously growing ones. Fires that reduce duff, litter, and competitive plants in years of favorable conditions are associated with high seedling establishment.

The other dominant subspecies, *Purshia tridentata* var. *glandulosa,* is also a long-lived, deep-rooted shrub, varying in habit and in local ecotype response. It establishes in the same manner as *Purshia tridentata* var. *tridentata* but grows in drier environments.

*Purshia tridentata* var. *glandulosa* is important browse, especially in the winter for mule deer. It is not easily killed by fire, readily resprouts after fire, and can persist with recurring fire. It regenerates after fire by resprouting from roots or buds just about the root collar, along upright and layered branches or by seedlings from cached seed.

**Regional Status:**
**Mojave Desert:** In the Mojave Desert the alliance is not common and generally restricted to granitic and metamorphic substrates in the eastern mountains.
**Southeastern Great Basin:** The alliance is found in the northern areas**.**

**Management Considerations:** This alliance is on the decline in much of its California range due to an altered fire regime (intervals have become too frequent and stands have been converted to *Ericameria nauseosa*, *Bromus tectorum* or *Taeniatherum caput-medusae*). Long-term intensive grazing has also reduced the vigor and reproductive capacity of some stands. Stands of this alliance are extremely important rangelands for livestock and for deer due to the palatability of *Purshia tridentata.* Thus, conservation management is economically and ecologically important.

## *Quercus turbinella* Shrubland Alliance

Figure A46. *Quercus turbinella* Shrubland Alliance

*Quercus turbinella* is the sole or important shrub or small tree in canopy. *Pinus monophylla* may be an emergent or small tree with near equal cover. *Fallugia paradoxa, Eriogonum wrightii, Galium munzii, Rhus trilobata, Artemisia ludoviciana, Gutierrezia sarothrae, Elymus elymoides,* or *Yucca baccata* may be present. Shrubs or small trees < 6 m tall; canopy intermittent to dense. Ground layer is open and includes native grasses such as *Poa fendleriana, Agrostis viridis*, and *Elymus elymoides*.

**Habitat:** The alliance occurs in intermittently flooded canyons in desert mountains on alluvial soils derived from granitic substrates (coarse- to medium- textured sand).

**Distribution:** Mojave Desert, Arizona, Nevada, Utah, New Mexico, Texas, Mexico.

**Elevation:** 1,200 to 2,000 m

**NDDB Rank:** G4 S1.3 (both California associations are rare and local in the eastern Mojave Desert)

**Synonyms:**
Holland types: Mojave Pinyon Pine Woodland (72210)
Cheatham and Haller types: Pinyon-Juniper Woodland
CALVEG: Pinyon Pine Series

Munz: Pinyon-Juniper Woodland

**References:** Evens (2000), Reid et al. (1999); plot-based descriptions are found in Evens (2000)

**Membership Rules:** Vegetation characterized by the scrub oak *Quercus turbinella*. Occurs in New York Mountains and perhaps Clark Mountains. *Quercus turbinella* is the dominant shrub or canopy tree ranging from 5-20% (Evens 2000). It may only slightly dominate over *Pinus monophylla* in some stands.

**Comments:** Some confusion in the past existed about the identity of desert scrub oaks along the western edge of the Mojave Desert and in the inner south coast ranges of California. These taxa were once called *Quercus turbinella*. Now these are considered *Quercus john-tuckeri, Quercus cornelius-mulleri,* or hybrids between several other scrub or tree oaks (Hickman 1993). *Quercus turbinella* Shrubland is rare in California. The alliance is common on the Mogollon Rim and in other parts of the Colorado Plateau (Reid et al. 1999) but in California, it has been observed only in the New York Mountains. In the New York Mountains, it occurs as a semi-riparian alliance along upper canyon watercourses within *Pinus monophylla* - *(Juniperus osteosperma)* Woodland. Evens (2000) discusses the *Quercus turbinella* Shrublands in the New York Mountains, where stands occur in steep-walled-canyon watercourses and slopes of decomposed granite with boulders and smoother bedrock surfaces.

The *Quercus turbinella* Shrubland in Arizona and New Mexico is a fire-type, which is adapted to fires by the ability to resprout vigorously from the basal root crown (Reid et al. 1999 and FEIS 2001). However, fire in the stands in the New York Mountains is probably rare. The size and arborescent life form of many of the individuals in these stands suggests that fire has not been a component for perhaps greater than 100 yrs. Flooding has initiated stem breakage and resprouting of some of the canyon bottom stands.

**Regional Status:**
**Mojave Desert:** New York Mountains

**Management Considerations:** This alliance and the two associations known from California are rare and localized.

## *Quercus chrysolepis* Forest Alliance

Figure A47. *Quercus chrysolepis* Forest Alliance

*Quercus chrysolepis* is the sole, dominant, or important tree with *Arbutus menziesii, Lithocarpus densiflorus, Pinus lambertiana,* or *Quercus garryana* in the tree canopy. *Abies concolor, Acer macrophyllum, Calocedrus decurrens, Pinus coulteri, Pinus monophylla, Pinus ponderosa, Pseudotsuga menziesii, Pseudotsuga macrocarpa, Quercus kelloggii,* and/or *Umbellularia californica* may be present. Trees < 30 m tall; canopy continuous, may be one- or two-tiered. Shrubs are infrequent. Ground layer is sparse or absent.

**Habitat:** This alliance occurs on all aspects, raised stream benches and terraces, and may occur in canyon bottoms near streams. It occurs on shallow, well-drained soils. The National Inventory of Wetland Plants (Reed 1988) does not list *Quercus chrysolepis*.

**Distribution:** Northern California Coast, Northern California Interior Coast Ranges, Central California Coastal Ranges, Klamath Mountains, Klamath River, Southern Cascades, Sierra Nevada, Southern California Mountains and Valleys, Mojave Desert, Baja California.

**Elevation:** 450 to 2,000 m

**NDDB Rank:** G5 S5. Some associations rare, including those in Mojave Desert

**Synonyms:**
Holland types: Canyon live oak forest, Canyon live oak ravine forest
Barry: G74 G7411111 CQUCH20
PSW-45: Canyon live oak series
Thorne: Northern mixed evergreen forest
WHR: Montane hardwood

**References:** Barbour (1988), Borchert and Hibberd (1984), Cooper (1922), Griffin and Critchfield (1972); Mallory (1980), McDonald et al. (1983), Minnich (1976, 1980), Myatt (1980), Paysen et al. (1980), Pavlik et al. (1991), Shreve (1927), Thornburgh (1990); plot-based descriptions are found in Gray (1978), Gudmonds and Barbour (1987), Sawyer and Stillman (1978) in Keeler-Wolf (1990b), Sawyer and Stillman (1977) in Keeler-Wolf (1990b), Taylor and Randall (1977) in Keeler-Wolf (1990b), Meier (1979) in Keeler-Wolf (1990b), Minnich (1980), Myatt (1980), White and Sawyer (1995), Keeler-Wolf (1988) in Keeler-Wolf (1990b), Gordon and White (1994), Evens (2000), Keeler-Wolf (1990b), Keeler-Wolf (1990), Keeler-Wolf (1992), Keeler-Wolf (1991), Keeler-Wolf (1990b), Minnich (1976), Evens (2000).

**Membership Rules:** Vegetation characterized by the relative dominance of *Quercus chrysolepis* (Canyon Live Oak) in the tree layer. Represented in the study area only by the rare canyon bottom stands in the higher eastern Mojave Desert such as Caruthers Canyon.

**Comments:** The dominant species, *Quercus chrysolepis,* is common in many alliances in the state. In the *Quercus chrysolepis* Forest, species other than *Pinus lambertiana* may occur but with low cover. If the conifer component is important, then the stand is assigned to a different forest alliance characterized by the dominant conifer species, or if the stand is composed of shrubs of *Quercus chrysolepis,* then it is assigned to a shrub alliance. Stands in the Mojave Desert are restricted to upper montane canyons and are usually surrounded by *Pinus monophylla – (Juniperus osteosperma*) Woodland.

**Regional Status:**
**Mojave Desert:** Only known from a few canyons in the eastern Mojave Desert above 1,400 m. Stands are generally well protected from fire in steep bouldery canyon bottoms and probably have lower fire frequency than the surrounding *Pinus monophylla - (Juniperus osteosperma)* Woodland.

**Management Considerations**: The *Quercus chrysolepis/Rhamnus illicifolia* association of this alliance is rare in California and probably covers less than 1,000 acres.

## *Salazaria mexicana* Shrubland Alliance

Figure A48. *Salazaria mexicana* Shrubland Alliance, Panamint Mountains

*Salazaria mexicana* is the sole or dominant shrub in canopy. *Achnatherum speciosum, Atriplex confertifolia, Ephedra nevadensis, Eriogonum fasciculatum, Grayia spinosa, Hymenoclea salsola, Krascheninnikovia lanata, Larrea tridentata*, *Lycium andersonii, Mirabilis bigelovii, Salvia dorrii*, *Thamnosma montana* or *Viguiera reticulata* may be present. Emergent *Acacia greggii* and *Yucca brevifolia* may be present. Shrubs < 3 m tall; canopy continuous, intermittent, or open. Ground layer sparse.

**Habitat:** The alliance occurs on slopes, hills, alluvial fans, bajadas, and intermittently flooded washes and arroyos. It occurs on colluvial and alluvial soils that may be disturbed.

**Distribution:** Mojave Desert, Arizona

**Elevation:** 875 to 1,680 m

**NDDB Rank:** G3 S3.3

**Synonyms:**
Holland: Mojave mixed woody scrub (34210)
Munz: Creosote bush scrub, Shadscale scrub
WHR: Desert scrub

**References**: Beatley (1976)

**Membership Rules:** *Salazaria mexicana* ≥ 2% cover. Other shrubs, if present, are each less than half the cover of *Salazaria mexicana* with the exception of *Salvia dorrii,* which may have higher cover.

**Comments:** We defined *Salazaria mexicana* Shrubland based on analysis of 15 stands collected as part of this project. It appears to be local and largely disturbance-related. It is characterized by the dominance of *Salazaria mexicana*, but most frequently is mixed with several other shrubs. The dominant species, *Salazaria mexicana,* also occurs in many mid- and upper-elevation Mojave Desert alliances: *Juniperus osteosperma* and *Yucca brevifolia* Wooded Shrublands and *Eriogonum fasciculatum, Ephedra nevadensis, Larrea tridentata-Ambrosia dumosa, Coleogyne ramosissima, Hymenoclea salsola,* and *Yucca schidigera* Shrublands.

Small stands of this alliance occur in washes and on disturbed upland sites (disturbed by livestock or OHV activity). The life-history attributes of *Salazaria mexicana* are not well known. Webb et al. (1988) demonstrate that *Salazaria mexicana* can re-establish ghost town sites readily. It is also common on actively eroding edges of alluvial terraces along with other disturbance related taxa such as *Hymenoclea salsola, Acamptopappus spherocephalus, Eriogonum inflatum,* and *Ephedra nevadensis.*

**Regional Status:**
**Mojave Desert:** Stands occur throughout the northern, eastern, southern, and central Mojave Desert. Most are in washes, some on slopes with disturbance. A few exist in rocky southwest-facing areas without evident disturbance.

**Management Considerations:** More information is needed on the role *Salazaria mexicana* Shrubland plays in the upper Mojave Desert.

## *Salix (exigua)* Temporarily Flooded Shrubland Alliance

Figure A49. *Salix (exigua)* Temporarily Flooded Shrubland Alliance, Mojave River near Victorville

*Salix exigua* is sole or dominant shrub in the canopy. *Populus fremontii, Baccharis salicifolia, Baccharis sergiloides, Baccharis emoryi, Alnus rhombifolia, Salix lasiolepis, Salix laevigata, Salix lucida,* or *Salix gooddingii* may be present. Emergent trees may be present. Shrubs < 7 m tall; canopy continuous. Ground layer is variable.

**Habitat:** The alliance occurs in habitats that are temporarily (seasonally) flooded or saturated such as floodplains, depositions along rivers, streams, and springs. Water chemistry: fresh. Cowardin class: Palustrine shrub scrub wetland. The national list of wetland plants lists *Salix exigua* as an Obligate Upland species.

**Distribution**: Central California Coast, Southern California Coast, Great Valley, Northern California Coast, Northern California Coast Ranges, Northern California Inner Coast Ranges, Sierra Nevada, Sierra Nevada Foothills, Central California Coast Range, Southern California Mountains and Valleys, Mojave Desert, Sonoran Desert, Colorado Desert, western North America.

**Elevation:** 0 to 2,700 m

**NDDB Rank**: G5 S3.2

**Synonyms**:
Holland: North coast riparian scrub, Central coast riparian scrub, Great Valley riparian scrub, Southern willow scrub, Mojave Desert riparian forest, Sonoran cottonwood-willow riparian forest, Modoc-Great Basin cottonwood-willow riparian forest, Southern cottonwood-willow riparian forest, Great Valley cottonwood riparian forest
Barry: G7411221
Cheatham and Haller: Bottomland woodlands and forests
PSW-45: Willow series
Thorne: Riparian woodland
WHR: Desert riparian, Coastal and Valley riparian

**References:** Bowler (1989), Brayshaw (1976), FEIS (2001), Holstein (1984), Paysen et al. (1980), Reid et al. (1999); plot-based descriptions are found in Evens (2000).

**Membership Rules:** *Salix exigua* dominates stands (> 50% relative cover in tree layer). Evens (2000) *Salix exigua* is dominant canopy species with cover ≥ 5%.

**Comments:** The *Salix exigua* Temporarily Flooded Shrubland is widespread and common throughout most of California. Genetic variations are likely and were responsible for prior separation of taxa such as " *Salix hindsiana*" (Hickman 1993). These shrubby willow thickets are common along rivers, streams and seeps in may ecological settings. There is great variation in the understory and shrub composition ranging from eastern Sierra mountain meadow stands to Mojave and Colorado desert oasis stands. Stands are often clonal with above-ground stems spreading by lateral roots with adventitious buds. The alliance often occurs as dense stands adjacent to other riparian/wetland vegetation.

The dominant species, *Salix exigua,* is a prolific seeder and can colonize isolated moist, sandy, or gravelly substrates via wind-dispersed seeds. The species spreads clonally via lateral roots and can spread across banks of rivers and streams rapidly (FEIS 2001). Individual stems rarely reach more than 6 cm diameter breast height (DBH) and 8 m in height. Hence, a stand usually develops into a network of dense small stems if water is regularly available through a series of growing seasons. *Salix exigua* can sprout readily following fire and will rapidly colonize burned riparian stands. *Salix exigua* clones probably do not live much longer than 50 years, and an average clonal stem is usually only 3-4 years old (FEIS 2001).

The standard view (e.g., Holland 1986, Sands 1980) of the stands along the Sacramento and other major California rivers is that this alliance is often the first to colonize point bars and cut banks, followed by *Populus fremontii* and other taller, longer-lived species. Rivers with flood control dams in place may have reduced acreage of *Salix exigua* stands and attained increases of stands of longer-lived tree willows such as *Salix lucida, Salix laevigata* and *Salix gooddingii*.

**Regional Status:** No information available.

**Management Considerations:** Because the alliance is so widespread, it is an integral part of riparian systems throughout most of the state. Its colonizing and stabilizing characteristics make it an important member in the riparian disturbance cycle, and reduced flooding regularity has diminished its representation along some rivers and streams.

## *Salvia dorrii* Dwarf-shrubland Alliance

No photograph is available.

*Salvia dorrii* is dominant in low shrub canopy. *Coleogyne ramosissima, Ericameria cooperi, Heliomeris multiflora, Castilleja angustifolia, Rhus trilobata*, or *Yucca baccata*, may be present. *Chilopsis linearis*, *Fallugia paradoxa, Prunus fasciculata,* or *Purshia stansburiana* may occur as emergent tall shrubs. *Pinus monophylla* may be an emergent tree. Shrubs < 2 m tall; canopy cover intermittent.

**Habitat:** The alliance occurs in intermittently flooded upper arroyos and canyons in desert mountains. It occurs in coarse, alluvial soils derived from calcareous substrates.

**Distribution:** Mojave Desert, Arizona

**Elevation:** 1,200 to 1,800 m

**NDDB Rank:** G3 S2.3

**Synonyms:**
Holland: Mojave mixed woody scrub (34210)
Munz: Pinyon-juniper woodland
Thorne: Pinyon-juniper
WHR: Desert scrub

**References**: Evens (2000), Reid et al. (1999); plot-based descriptions are found in Evens (2000).

**Membership Rules:** Evens (2000) *Salvia dorrii* is the dominant canopy subshrub averaging 7% cover.

**Comments:** The dominant species**,** *Salvia dorrii,* is a common shrub of the cooler western deserts. However, in California it is usually only a component of other alliances such as *Artemisia tridentata, Yucca schidigera, Juniperus osteosperma, Pinus monophylla, Salazaria mexicana*, and *Eriogonum fasciculatum* dominated alliances. It ranges to the edge of the deserts on calcareous substrates (e.g., Southern Sierra Nevada, Paiute Range, Keeler-Wolf 1989). Before recent work by Evens (2000) in the mountains of the eastern Mojave Desert, *Salvia dorrii* Dwarf-shrubland was not known from the state, but was known from eastern Oregon (Reid et al.1999). There it occurs on volcanic tablelands on shallow rock soil. In California, it is only known from rocky limestone alluvium in arroyos and canyons in the Providence and Clark mountains. There it occupies intermittently flooded washes and wash terraces and occurs adjacent to *Chilopsis linearis* and *Prunus fasciculata* Intermittently Flooded Shrublands within a surrounding matrix of upland alliances including *Pinus monophylla- (Juniperus osteosperma*) Woodland*, Juniperus osteosperma* Wooded Shrubland, and *Purshia tridentata* Shrubland.

Small stands of this alliance occur in canyons and arroyos. Stands are restricted to calcareous substrates that are subjected to intermittent flooding disturbance. The presence of *Salvia dorrii* in other alliance stands that have been subject to grazing, and fire suggests that the species is tolerant of some disturbance. However, the presence of *Coleogyne ramosissima* as an indicator (Evens 2000) in the eastern Mojave Desert stands suggests that disturbance is relatively infrequent (Webb et al. 1988).

**Regional Status:**
**Mojave Desert:** Stands have been studied only in the northeastern Mojave Desert. Most are in canyons and arroyos well up into the Clark Mountains (Evens 2000).

**Management Considerations:** More information is needed on the of role of *Salvia dorrii* Dwarf-shrubland in the upper Mojave Desert.

## *Sarcobatus vermiculatus* Shrubland Alliance
No photograph is available.

*Sarcobatus vermiculatus* is the sole or dominant shrub in canopy. *Allenrolfea occidentalis, Artemisia tridentata, Atriplex canescens, Atriplex confertifolia, Atriplex spinifera, Ericameria nauseosa, Chrysothamnus viscidiflorus*, *Frankenia salina, Kochia californica,* or *Suaeda moquinii* may be present. Shrubs < 3 m tall; canopy continuous or open. Ground layer variable and may be grassy.

**Habitat**: Badlands, plains, old lakebeds perched above current drainages, and stable sand dunes. Wetland habitats such as barrier beaches, dry lakebeds, lagoon bars that are intermittently flooded or saturated. Water chemistry: mixosaline. Cowardin class: Palustrine shrub-scrub wetland. The national list of wetland plants (Reed 1988) lists *Sarcobatus vermiculatus* as a Facultative Upland species.

**Distribution:** Mojave Desert, Mono, Northwestern Basin and Range, western U.S. and northern Great Plains.
**Elevation:** 100 to 2,000 m

**NDDB Rank:** G4 S2.2

**Synonyms**:
Holland: Desert greasewood scrub, Desert sink scrub
Brown, Lowe and Pase: 152.171, 153.171, 154.171

Cheatham and Haller: Alkali sink scrub, Saltbush scrub
PSW-45: Greasewood series
Rangeland types: SRM 414, SRM 501
Thorne: Alkali sink scrub
WHR: Alkali sink
Munz: Alkali sink

**References:** Burk (1977), MacMahon (1988), Paysen et al. (1980), Thorne (1982), Vasek and Barbour (1977), Young and Young (1976), West (1988); plot-based descriptions are found in Young et al. (1986), Ferren and Davis (1991)

**Membership Rules:** *Sarcobatus vermiculatus* (Greasewood) ≥ 2%. *Sarcobatus* is the relative dominant shrub cover and may have *Suaeda moquinii* and *Atriplex* spp. associated in lesser cover. Only known in study area from the alkali dunes and flats above the east shore of Owens Lake.

**Comments:** This alliance is part of the alkali sink ecological system, which is a collection of alliances including *Allenrolfea occidentalis* Shrubland*, Distichlis spicata* Intermittently Flooded Herbaceous, and/or *Suaeda moquinii* Intermittently Flooded Shrubland. The dominant species of each can occur in all of the alkali sink ecological system, but the alliance in which a stand is classed depends on which species dominates. *Allenrolfea occidentalis* tolerates higher salt concentrations than *Sarcobatus vermiculatus* (MacMahon and Wagner 1985), so the *Sarcobatus vermiculatus* Shrubland Alliance is located further from sink edges where both alliances occur.

The dominant species, *Sarcobatus vermiculatus,* is a long-lived, facultative halophyte that tolerates alkaline and saline soils. This winter deciduous shrub's seeds mature in the fall and fruits dehisce in the winter. Seeds germinate under conditions of warm temperature and long periods of soil moisture. Individual plants and populations respond to different osmotic potentials and salt concentrations, which suggests much ecotype variation within the species. Shrubs will resprout when stems are removed.

Livestock and wildlife browse *Sarcobatus vermiculatus* in the fall and winter and the species may increase in grazed areas. It readily resprouts in low- to moderate-intensity burns. Seeds easily disperse into recently burned areas from unburned shrubs. Many stands are very open and lack continuous fuel. Stands invaded by *Bromus tectorum* easily burn.

**Regional Status:**
**Southwestern Great Basin:** Stands of *Sarcobatus vermiculatus* are local at Owens Valley.

**Management Considerations:** Although widespread in much of the Great Basin, stands of *Sarcobatus vermiculatus* Shrubland are not common in California.

## *Schoenoplectus americanus* Semipermanently Flooded Herbaceous Alliance

Figure A50. *Schoenoplectus americanus* Semipermanently Flooded Herbaceous Alliance, Soda Lake

*Schoenoplectus americanus* is the sole, dominant, or important tall graminoid. *Anemopsis californica, Potentilla anserina, Distichlis spicata, Juncus cooperi, Juncus balticus, Schoenoplectus californicus, Typha* spp., or *Phragmites australis* may be present. Grass < 4 m tall; cover continuous. Dense to intermittent understory of short grasses and herbs may be present.

**Habitat:** Habitat permanently saturated with shallow water table. Water chemistry: fresh, mixohaline, mixosaline. Cowardin class: palustrine persistent emergent wetland. The national list of wetland plants (Reed 1988) lists *Schoenoplectus americanus* as an Obligate Wetland species.

**Distribution:** Widespread throughout California, but largely within California Dry Steppe Province, American Semi-desert and Desert Province, and Intermountain Semidesert and Desert Province, throughout much of North America.

**Elevation:** -45 to 1,500 m

**NDDB Rank:** G5 S3.2

**Synonyms:**
Holland: Transmontane alkali marsh (52320), Cismontane alkali marsh (52310), Transmontane freshwater marsh (52420), Coastal and valley freshwater marsh (52410)
Barry: G7412331
Cheatham and Haller: Coastal and valley freshwater marsh, Great Basin freshwater marsh, Valley alkali marsh, Great Basin alkali marsh
Thorne: Alkali meadow, freshwater marsh
WHR: Fresh emergent wetland
Munz: Freshwater marsh

**References:** Reid et al. (1999)

**Membership Rules**: Vegetation characterized by the relative dominance of *Schoenoplectus americanus* (Three-square or American Bulrush). Generally in permanently moist alkali springs, meadows, or streamsides. Most stands less than 5 ha in extent.

**Comments:** *Schoenoplectus americanus* Semipermanently Flooded Herbaceous Alliance occurs in many wetlands throughout California and the western U.S. The *Schoenoplectus americanus* alliance is most frequently associated with alkali or saline wetlands and may occur from coastal brackish marshes to interior settings adjacent to alkali playas and seeps. Data now exist to support the establishment of this alliance from the San Francisco Bay Delta to the Colorado and Mojave deserts and the Great Basin. In Texas and New Mexico, *Schoenoplectus americanus* is considered the dominant of a freshwater marsh alliance associated with high organic soil content with poor aeration and reduction of salinity (Reid et al.1999). In California desert stands, this alliance typically occupies the center of a small wetland where soil saturation is greatest. Associated with and often surrounding the stands are stands of other alliances that have reduced moisture requirements and are dominated by such species as *Phragmites australis, Juncus cooperi, Juncus balticus, Pluchea sericea, Atriplex spp., Sporobolus airoides* and *Distichlis spicata*. In the Bay Delta Region (Suisun Marsh), *Schoenoplectus americanus* Semipermanently Flooded Herbaceous Alliance occupies the inner portions of marshes away from the tidally influenced brackish bays and large sloughs. They occur along narrow tidal creeks and in saturated relatively freshwater marshs often adjacent to *Distichlis spicata* Intermittently Flooded Herbaceous patches. In Suisun Marsh, the alliance is habitat for both the rare species *Aster lentus* and *Cirsium hydrophilum* ssp. *hydrophilum*.

*Schoenoplectus americanus* is rhizomatous and can survive surface fires by resprouting from the underground rhizomes. Seeds are small and are wind-born assisted by capillary bristles. Stands are subject to decimation and degradation by drought and by modified hydrology. Some stands are large enough and sufficiently long-persisting to have produced peat layers. Some peat fires have occurred in fossil stands of this alliance adjacent to desert playas (Koehn Dry Lake) (M. Faul, personal communication).

**Regional Status:**
**Mojave Desert:** *Schoenoplectus americanus* Semipermanently Flooded Herbaceous Alliance occurs in alkaline and freshwater marshes and along creeks throughout the Mojave Desert. In some situations it often shares the marshes with various alliances that segregate based on moisture and alkalinity/salinity tolerances. In general, *Schoenoplectus americanus* Semipermanently Flooded Herbaceous Alliance occurs in the wettest settings along with *Typha* alliances, and in moister settings than *Phragmites australis* Semipermanently Flooded Herbaceous, *Pluchea sericea* Seasonally Flooded Shrubland, *Juncus cooperi* Seasonally Flooded Herbaceous, *Sporobolus airoides* and *Distichlis spicata* Intermittently Flooded Herbaceous Alliances. Largest stands in the Mojave Desert may be along the Amargosa River between Shoshone and Tecopa.

**Management Considerations:** *Schoenoplectus americanus* Semipermanently Flooded Herbaceous Alliance can be decimated by grazing (e.g., Owens Lake). The alliance is the most widespread, saturated, fresh-water-emergent wetland alliance of the California deserts and is thus indicative of high quality and important resources for wildlife. If the stand is disturbed, *Tamarix* spp. can invade. Elsewhere, other invasive exotic species have invaded stands. For example, perennial pepperweed (*Lepidium latifolia)* is a threat to the alliance in the Bay-Delta region and can invade and overtake stands of this alliance without apparent physical disturbance.

## *Sporobolus airoides* Intermittently Flooded Herbaceous Alliance

Figure A51. *Sporobolus airoides* Intermittently Flooded Herbaceous Alliance, Travertine Springs

*Sporobolus airoides* is the sole or dominant grass in the ground layer. *Distichlis spicata* or *Poa secunda* may be present. Emergent *Allenrolfea occidentalis, Atriplex lentiformis, Atriplex canescens,* or *Suaeda moquinii* shrubs may be present. Grass < 1 m tall; cover open.

**Habitat:** Habitat intermittently flooded or saturated. Water chemistry: saline. Valley bottoms or lower portions of alluvial slopes. Cowardin class: palustrine emergent saline wetland. The national list of wetland plants (Reed 1988) lists *Sporobolus airoides* as a Facultative species.

**Distribution:** Great Valley, Central California Coast Ranges, Mojave Desert, Mono, Southeastern Great Basin, Northwestern Basin and Range, western U.S.

**Elevation:** 0 to 2,100 m

**NDDB Rank:** G4 S2.2

**Synonyms**:
Holland: Valley sacaton grassland, Alkali meadow
Barry: G7412311 BSPAI00
Cheatham and Haller: Great Basin native grassland
PSW-45: Sacaton series
Thorne: Alkali meadow and aquatic
WHR: Wet meadow
Munz: Alkali sink

**References:** Bittman (1985), Brown (1982), Griggs (1980), Paysen et al. (1980), Thorne (1982), Werschskull et al. (1984); plot-based descriptions can be found in Ferren and Davis (1991) and Odion et al. (1992).

**Membership Rules:** Vegetation characterized by the canopy dominance of the bunchgrass *Sporobolus airoides*. Usually of margins of alkali springs and in alkali meadows as at Tecopa, Shoshone, and other sites along the Amargosa River. Most stands well below 5 ha in extent.

**Comments:** Many regional descriptions include this alliance in an alkali meadow ecological system. *Sporobolus airoides* or other species can dominate meadows of this habitat, so several alliances are included in the alkali meadow ecological system. Stands of *Sporobolus airoides* Intermittently Flooded Herbaceous Alliance form a fine scale mosaic with *Allenrolfea occidentalis, Atriplex canescens*, or *Atriplex lentiformis* Shrublands and with *Distichlis spicata* Intermittently Flooded Herbaceous or *Suaeda moquinii* Intermittently Flooded Shrubland at a coarser scale.

*Sporobolus airoides* is a tussock-forming grass with loosely clustered, coarse culms (to 1 m) that rapidly burn. It is tolerant of fire and grazing. *Sporobolus airoides* has an extensive range in the western United States including much of California, but the vegetation type is less extensive.

Shrubs have invaded alliance stands in New Mexico where overgrazing has occurred. Stands were extensive in the Tulare Lake Basin but are now greatly reduced by land conversion to agriculture.

**Regional Status:**
**Mojave Desert:** Stands are notable in the Amargosa Desert and occasional in playa settings in the northern Mojave Desert such as Mesquite Valley.
**Southeastern Great Basin:** Stands are expected in Fish Lake Valley and Saline Valley.

**Management Considerations**: This herbaceous alliance is a rare type in California. Groundwater pumping and invasive exotics threaten the alliance in some areas. A complete inventory of probable occurrences has not been completed.

## *Suaeda moquinii* Intermittently Flooded Shrubland Alliance

Figure A52. *Suaeda moquinii* Intermittently Flooded Shrubland Alliance, near Tecopa

*Suaeda moquinii* is the sole, dominant, or the most important shrub in overstory. *Frankenia salina, Allenrolfea occidentalis, Atriplex polycarpa, Atriplex canescens, Sarcobatus vermiculatus, Kochia californica,* or *Sporobolus airoides* may be present. Shrubs < 1.5 m tall; canopy open to closed.

**Habitat:** Lower alluvial fans, bajadas, toe-slopes adjacent to alkaline playas, and other alkaline/saline areas. Wetland habitats intermittently flooded or saturated. Water chemistry: mixosaline. Dry lakebeds, plains, old lakebeds perched above current drainages. Cowardin class: Palustrine shrub-scrub wetland. The national list of wetland plants (Reed 1988) lists *Suaeda moquinii* as a Facultative species.

**Distribution:** Mojave Desert, Sonoran Desert, Colorado Desert, Northwestern Basin and Range, Great Valley, Central California Coast Ranges, west Canada, Texas, Mexico.

**Elevation:** 0 to 1,300 m

**NDDB Rank:** G4 S3.2 (Great Valley associations are particularly rare)

**Synonyms:**
Holland: Desert sink scrub (36120 *in part*), Desert greasewood scrub (36130 *in part*), Valley sink scrub (36210 *in part*)
Barry: G7412321
Brown, Lowe and Pase: 153.171
Cheatham and Haller: Alkali sink scrub
PSW-45: Suaeda series
Thorne: Alkali sink scrub
WHR: Alkali sink
Munz: Alkali sink scrub
CALVEG: Suaeda series

**References:** Burk (1977), MacMahon (1988), Payson et al. (1980), Vasek and Barbour (1977), West (1988), Sawyer and Keeler-Wolf (1995); plot-based descriptions are found in Keeler-Wolf et al. (1998) and Bradley (1970).

**Membership Rules**: *Suaeda moquinii* ≥ 2% cover. No other species with greater or equal cover. Typically occupying strongly alkaline playas usually with distinct salt deposits in soil surface, but may occur in upland areas adjacent to playas (Owens Lake) where wind-blown salts are deposited.

**Comments:** *Suaeda moquinii* Intermittently Flooded Shrubland is largely restricted to alkaline substrates in desert or semi-desert environments. This alliance and *Allenrolfea occidentalis* and *Sarcobatus vermiculatus* Shrublands commonly occur around margins of and on dry and wet lakes and are often mapped co-jointly as an ecological system.

The alliance dominant, *Suaeda moquinii,* tolerates high salt concentrations. Although *Suaeda moquinii* typically occurs in low-lying areas around playas and basins, it also may range onto adjacent uplands, where it coexists with other desert sub-alkaline vegetation in such alliances as *Atriplex hymenelytra, Atriplex polycarpa*, and *Atriplex confertifolia* Shrublands.

Vegetation cover for the alliance may vary substantially (2 to > 80%). Disturbance effects are poorly known. However, *Suaeda moquinii* alliance appears opportunistic in its environment, occupying roadsides, other recently disturbed areas, bajada slopes, playas, and playa edges. Many plants appear to be short-lived and senesce and die in large groups, suggesting even-age stands, stemming probably from favorable moisture conditions. However, plants have lived to 100 years in Utah (R. Webb, personal communication). General observations (Keeler-Wolf, personal communication) suggest that *Suaeda moquinii* Intermittently Flooded Shrubland tolerates less flooding than *Allenrolfea occidentalis* Shrubland in playas in the Mojave Desert. Seeds are small (Young and Young 1986) and may establish easily following rain. Seeds are probably banked (T. Keeler-Wolf personal communication, Desert Workshop 2000). Seral relationships are simple due to the harsh environment. *Suaeda moquinii* alliance probably directly replaces itself following most disturbances.

**Regional Status:**
**Mojave Desert:** *Suaeda moquinii* Intermittently Flooded Shrubland occurs throughout the Mojave Desert but is generally restricted to low-lying alkaline playas and basins.
**Southeastern Great Basin:** *Suaeda moquinii* Intermittently Flooded Shrubland occurs around Saline Valley, where it occasionally ranges up on the lower bajadas. On the eastern shore of Owens Dry Lake, it ascends the lower bajadas of the Inyo Mountains and mixes with *Atriplex hymenelytra* and *Atriplex confertifolia.*

**Management Considerations:** *Suaeda moquinii* alliance is simple floristically and structurally. Management issues are direct alteration and disturbances such as evaporite mining and scraping and blading for road construction. In the stands with high cover, response to fire needs to be researched.

## *Tamarix* spp. Semi-Natural Temporarily Flooded Shrubland Alliance

Figure A53. *Tamarix* spp. Semi-natural Temporarily Flooded Shrubland Alliance, Carrizo Marsh

*Tamarix* species is sole or dominant shrub. *Acacia greggii, Atriplex* species, *Hymenoclea salsola, Populus fremontii,* or *Salix* species may be present. Shrubs < 5 m tall. Shrub canopy is continuous or open. Emergent trees may be present. Ground layer is sparse.

**Habitat:** Habitats intermittently flooded or saturated. Water chemistry: fresh, mixosaline. Arroyo margins, ditches, washes, and watercourses. Cowardin class: temporarily flooded palustrine shrub-scrub wetland. The national list of wetland plants (Reed 1988) lists *Tamarix* species as a Facultative Wetland species.

**Distribution:** Northern California Interior Coast Ranges, Central California Coast Ranges, Great Valley, Sierra Nevada Foothills, Southern California Coast, Mojave Desert, Sonoran Desert, Colorado Desert, central and western U.S.

**Elevation:** -75 to 800 m

**NDDB Rank:** G5 S5 (non native)

**Synonyms**:
Holland: Tamarisk scrub
Barry: G7411212 BTACH00
Cheatham and Haller: Alluvial woodlands

PSW-45: Salt-cedar series
Thorne: Desert riparian woodland
WHR: Desert riparian

**References:** Johnson (1987), Neill (1985), MacMahon (1988), Paysen et al. (1980)

**Membership Rules:** Vegetation dominated by tall shrubby invasive *Tamarix* spp. (either *T. ramosissima, T. chinensis*, or other similar species, not including the less invasive, taller T. *aphylla*). *Tamarix* spp. should strongly dominate (> 60% relative cover) over native tall shrubs and/or low trees in a stand.

**Comments:** *Tamarix*, commonly known as salt cedar, is an invasive exotic plant species. Five introduced species of *Tamarix* are known to grow in California. *Tamarix parviflora* and *Tamarix ramosissima* are the most common species (Hickman 1993) and are apparently the two most invasive species in California deserts and Central Valley. *Tamarix aphylla*, athel, is a taller tree that typically is not invasive in California; however, it is apparently invasive in Australia (T. Keeler-Wolf personal communication, Desert Workshop 2000).

*Tamarix* species are long-lived shrubs or trees. Seeds germinate on saturated soil or while afloat and establishing seedlings require moist soil. Once established, the plant resists desiccation. Plants resprout from root crowns, and freshly detached stems will root in moist soil.

*Tamarix* species are unpalatable for livestock and wildlife. Stands accumulate high fuel levels that readily burn when dry. Plants vigorously resprout after fire, and they increase flowering and seed production after fire. Mixed stands of *Tamarix* and native plants convert to *Tamarix* dominance after fire. *Tamarix* species supplant native plants and reduces water for wildlife. Ohmart et al. (1977) discuss its comparative value for wildlife habitat along the Colorado River.

**Regional Status:**
**Mojave Desert**: Tamarix spp. Semi-Natural Temporarily Flooded Shrubland occurs along the Mojave River and as stands or individuals at many springs.

**Management Considerations:** The impact of the *Tamarix* alliance to groundwater and stream flow is substantial (Reid et al.1999). Stands tend to invade and take over the wettest areas, while intermittently dry streambeds and springs are less likely invaded. The cost of time and labor to remove infestations of Tamarix from riparian and wetland settings is substantial. This involves a cycle of burning and stem poisoning, followed by pulling of young seedlings (T. Keeler-Wolf personal communication, Desert Workshop 2000). Active programs to remove tamarisk are ongoing in California.

## *Viguiera parishii* Shrubland Alliance

Figure A54. *Viguiera parishii* Shrubland Alliance, Joshua Tree National Park

*Viguiera parishii* is the dominant or important shrub in the canopy. *Agave deserti, Bebbia juncea, Ericameria teretifolia, Ephedra nevadensis, Eriogonum fasciculatum, Encelia farinosa, Ferocactus cylindraceus, Galium stellatum, Gutierrezia microcephala, Krameria grayi, Opuntia acanthocarpa, Pleuraphis rigida, Salazaria mexicana, Salvia dorrii, Simmondsia chinensis,* or *Yucca schidigera* may be present. Shrubs < 2 m tall; canopy intermittent or open. Emergent tall shrubs or trees < 5 m tall such as *Acacia greggii, Fouquieria splendens,* or *Juniperus californica* may be present. Ground cover is open to intermittent. *Achnatherum speciosum, Adenophyllum porophylloides, Bromus madritensis Echinocereus engelmannii, Mirabilis bigelovii,* or *Opuntia basilaris* may be present. Annuals seasonally present.

**Habitat:** Colluvial slopes and valleys, rocky to bouldery alluvium, steep to moderate slopes, and wash and arroyo margins. Soils well drained and derived from granitic or volcanic rock.

**Distribution:** Colorado Desert, Mojave Desert, Sonoran Desert, Southern California Mountains and Valleys, Arizona, Nevada.

**Elevation:** 900 to 1,400 m

**NDDB Rank:** G4 S4 (some associations may be rare)

**Synonyms:**
Holland: Sonoran mixed woody scrub (33210 *in part*), Mojavean mixed woody scrub (34210 *in part*)
Cheatham and Haller: Enriched desert scrub
Thorne: Semi-succulent scrub
WHR: Desert succulent scrub (*in part*), Desert scrub (*in part*)

**References:** CalFlora (2000), Keeler-Wolf et al. (1998); plot-based descriptions are found in Keeler-Wolf et al. (1998).

**Membership Rules:** *Viguiera parishii* ≥ 2% cover. No other species with greater or equal cover. On northerly slopes in the Mojave Desert generally above *Larrea tridentata-Ambrosia dumosa* or in washes in east Mojave Desert. Keeler-Wolf et al. (1998) defines *Viguiera parishii* with greater than or equal cover to any other single shrub with tall emergent *Juniperus californica, Rhus ovata* or other tall shrubs < 5%.

**Comments:** The alliance is newly defined following analysis of plot data from the Anza-Borrego Desert State Park vegetation mapping effort (Keeler-Wolf et al.1998) and from the 16 plots obtained in this Mojave Desert Vegetation Mapping project. The alliance is a facultatively deciduous scrub characterized by the shrub *Viguiera parishii*.

*Viguiera parishii* Shrubland occurs on moderate to steep slopes and some stands occur in washes. The alliance occupies a transitional area between the lower hot Sonoran desert and the higher and cooler Mojave Desert. It appears to be distributed from the desert edges of the Peninsular Ranges north to the borderland between the Sonoran and the Mojave deserts. Species characteristic of this alliance are a mix of upper- and lower-elevation characteristic species. There is some evidence that this alliance is disturbance-related, given species composition and the occurrence of the type in and adjacent to washes. In Anza-Borrego it was one of the largest of the upper desert alliances covering an estimated 26,000 acres (10,236 ha). Although the dominant species is widespread in the southern portion of the California deserts (CalFlora 2000) from sea level to 1,500 m, the alliance is more restricted.

The species *Viguiera parishii* is not treated in the FEIS (2001) database. It may be a relatively short-lived species averaging around 15-20 years (T. Keeler-Wolf personal communication, Desert Workshop 2000). It is a facultatively deciduous species that flowers profusely in good rain years and remains largely dormant and bare of leaves in low-rainfall years. *Viguiera parishii* probably regenerates from seed in seed banks. It is not known whether it resprouts following fire or other disturbance.

In Anza-Borrego, *Viguiera parishii* Shrubland occurs in areas that have sustained fires recently. However, on other parts of its range the alliance has not likely been subjected to fire. Occurrences of the alliance in washes in the eastern Mojave Desert are probably related to fluvial disturbance.

**Regional Status:**
Little is known of the regional status of this alliance.

**Management Considerations:** Since this vegetation covers a large area in the Peninsular Range/Colorado Desert borderland, it is important to understand its vegetation dynamics. More monitoring and a better understanding of the stability of this alliance will provide useful management information.

## *Viguiera reticulata* Intermittently Flooded Shrubland Alliance

Figure A55. *Viguiera reticulata* Intermittently Flooded Shrubland Alliance

*Viguiera reticulata* is dominant or important in canopy. *Ambrosia dumosa, Atriplex confertifolia, Encelia virginensis, Eriogonum fasciculatum, Gutierrezia microcephala, Hymenoclea salsola, Psorothamnus arborescens, Salvia dorrii, Salazaria mexicana, Senecio flaccidus,* or *Stephanomeria pauciflora* may be present. Canopy intermittent to open; short shrubs < 2 m tall. Sparse ground layer.

**Habitat:** Intermittently flooded arroyos, canyons and washes in desert mountains and on adjacent alluvial fans. Soils are alluvial, with gravel and/or cobble derived from calcareous substrates; texture is medium sand.

**Distribution:** Mojave Desert, Southeastern Great Basin, Nevada

**Elevation:** 700 to 1,900 m

**NDDB Rank:** G3 S3.2

**Synonyms:**
Holland: Mojave wash scrub (34250), Mojave creosote bush scrub (34100), Sonoran creosote bush scrub (33100)
Munz: Creosote bush scrub, Shadscale scrub, Pinyon-Juniper woodland

**References:** Reid et al. (1999), Peterson (1984), Evens (2000).

**Membership Rules:** *Viguiera reticulata* ≥ 2% cover. No other species with greater or equal cover. Of calcareous (mostly limestone) washes and arroyos in mountains in the mid- or upper-elevation eastern Mojave Desert.

**Comments:** *Viguiera reticulata* Intermittently Flooded Shrubland Alliance occurs on calcareous substrates throughout the mid and upper elevations of the eastern Mojave Desert and adjacent Southeast Great Basin. The alliance is locally common in washes where irregular flooding occurs. Six relevés were examined in the this project.

The species' life history is not well known. It is likely not a prolific stem or root sprouter and probably does not live for long periods. It seeds well after wet years and occupies recently disturbed ground whether in washes, road cuts, or other recently disturbed substrate. The species occurs in washes and occasionally on slopes in several vegetation alliances including *Encelia virginensis, Salazaria mexicana,* and *Grayia spinosa* Shrublands. However, *Viguiera reticulata* only forms its own alliance in washes.

**Regional Status:**
**Mojave Desert:** Stands may occur in northern Mojave Desert valleys adjacent to Southeastern Great Basin ranges.
**Southeastern Great Basin**: Stands are common on the east side of the Last Chance Range, the Cottonwood Mountains, the Funeral Range and the Panamint Mountains, all of which drain into Death Valley.

**Management Considerations:** More information on the role of *Viguiera reticulata* Intermittently Flooded Shrubland is needed.

## *Yucca brevifolia* Wooded Shrubland Alliance

Figure A56. *Yucca brevifolia* Wooded Shrubland Alliance, Cima Dome

*Yucca brevifolia* is the emergent small tree (< 14 m tall) and abundant over a shrub canopy. *Artemisia tridentata, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ephedra nevadensis, Eriogonum fasciculatum, Gutierrezia microcephala, Hymenoclea salsola, Krascheninnikovia lanata, Larrea tridentata, Lycium andersonii, Opuntia acanthocarpa, Tetradymia axillaris, Yucca schidigera,* or *Yucca baccata* may be present. Shrubs < 3 m tall; canopy intermittent or open. Emergent *Pinus monophylla, Juniperus californica,* or *Juniperus osteosperma* may be also present. Ground layer may include several cacti and perennial grasses including *Pleuraphis rigida, Pleuraphis jamesii, Achnatherum speciosum,* or *Poa secunda*. Annuals seasonally present.

**Habitat:** Gentle alluvial fans, ridges, and gentle to moderate slopes. Soils colluvial- and alluvial-derived. Coarse sand, very fine silt, gravel, or sandy loam. Many sites have bimodal soils with both coarse sands and fine silts.

**Distribution:** Mojave Desert, Southeastern Great Basin, Southern Nevada, western Arizona, southwestern Utah.

**Elevation:** 750 to 1,800 m

**NDDB Rank:** G4 S3.2 (some associations are rare)

**Synonyms:**
Holland: Joshua tree woodland (73000), Mojave mixed steppe (*in part* 34220), Mojave mixed woody scrub (*in part* 34210)
Brown, Lowe and Pase: 153.151, 153.152, 153.153
Cheatham and Haller: Joshua tree woodland
PSW-45: Joshua tree series
Stone and Sumida: Joshua tree community
Thorne: Joshua tree woodland
CALVEG: Joshua tree series
WHR: Joshua tree

**References:** Johnson (1976), MacMahon (1988), Paysen et al. (1980), Reid et al. (1999), Sawyer and Keeler-Wolf (1995), Thorne (1982), Turner (1982a, 1982b), Vasek and Barbour (1977); plot-based descriptions are in Hogan (1977), Vasek and Barbour (1977)

**Membership Rules:** *Yucca brevifolia* ≥ 1% cover, *Juniperus spp.* and/or *Pinus spp.* absent. Dominant understory species are shrub species such as *Coleogyne ramosissima, Opuntia ramosissima* or the perennial grass *Pleuraphis rigida*. Common in shallow upland soils throughout the Mojave Desert.

**Comments:** The alliance dominant, *Yucca brevifolia,* is a quintessential Mojave Desert plant. Its range defines the biological extent of the Mojave Desert more so than any other species. Its conspicuous and picturesque life form is the signature for the desert. However, *Yucca brevifolia* is by no means evenly distributed; different ecotypes occupy different subregions and each has somewhat different environmental requirements. It is present in both cool-season and warm-season rain zones (T. Keeler-Wolf personal communication, Desert Workshop 2000). Short-leaved, tall forms from the eastern Mojave Desert have been called *Yucca brevifolia* var. *jaegeriana*; long-leaved tall forms from the central, northern, and southern Mojave Desert have been called var. *brevifolia*; short, clonal, multi-stemmed individuals from the western Mojave Desert have been called var. *herbertii* (Munz 1974). Some ecotypes may be better adapted to sprouting from adventitious roots and stems following damage by fire and other mechanical disturbance. However, a great deal of plasticity exists in the species, motivating the most recent taxonomic treatments (Hickman 1993) to subsume the varieties into a single variable species.

Despite Rowlands' (1978) suggestion that *Yucca brevifolia* might be a constituent of grasslands and shrublands, our analysis of 146 relevés shows *Yucca brevifolia* to be a reasonably good indicator species. Thus, although a high degree of variation occurs in the shrub and herbaceous understory, *Yucca brevifolia* defines a *Yucca brevifolia* Wooded Shrubland of mid- and upper-elevation desert. In this alliance, *Yucca brevifolia* forms an open or scattered, emergent canopy over either a shrubby- or a grass-dominated understory.

*Yucca brevifolia* is a long-lived plant, whose exact age is difficult to determine since annual rings are not produced and since many individuals may regenerate vegetatively.

Juvenile *Yucca brevifolia* are generally unbranched; middle-aged plants are forked and dense. Older trees generally have a single stem and an open crown. Seedlings are uncommon on many harsh sites except following a series of wet years. Some researchers believe that sexual reproduction was much more important during more favorable climatic regimes (late Pleistocene), when summers were cooler and annual precipitation greater (FEIS 2001). Vegetative reproduction is now the most important mode of regeneration on many sites (FEIS 2001). *Yucca brevifolia* can sprout from the roots and from underground rhizomes. *Yucca brevifolia* rhizomes are fast growing and numerous. The var. *herbertii* has aerial stems connected by underground rhizomes 0.2-1.3 m in length that quickly grow to the surface. In var. *jaegeriana,* rhizome development may be related to precipitation and stimulated by damage or injury to the stem (FEIS 2001).

Natural stand dynamics are at least partially related to fire. Summer lightning strikes are relatively frequent in the high desert stands in the northern, southern, and eastern Mojave Desert with large individuals of *Yucca brevifolia* making suitable targets. The fire resistance of trees increases with age. The thick mat of dried leaves along the trunk decreases with age, and the corky bark of older trunks serves as a firebreak between surface fuels and the flammable shag on upper limbs (FEIS 2001). However, observations by R. Minnich (personal communication) suggest that even large trees are susceptible to fire, with many scorched trees dying within 5 years. Grazing history has changed the fire regime by increasing non-native annual grasses. Formerly the fire interval was probably once per century.

*Yucca brevifolia* is generally capable of vigorous root and stump sprouting after fire. Seed can remain viable in the soil for several years. Reestablishment through on-site or off-site seed is possible, particularly on more mesic sites or in favorable years. Little is known of the resprouting response of *Yucca brevifolia* to variable timing of fires and of the different ecotypes' responses to fire. According to Minnich (personal communication), vigorous sprouting may take place in some populations following fire, while other populations will not sprout. More seriously, those that do resprout tend to die within a few years either by rodent predation or by other causes.

Certain assemblages including *Yucca brevifolia/Lycium* spp., *Yucca brevifolia/Salazaria mexicana,* and *Yucca brevifolia/Opuntia acanthocarpa* probably occur as a response to disturbance including fire and grazing. Others including *Yucca brevifolia/Larrea tridentata-Eriogonum fasciculatum, Yucca brevifolia/Larrea tridentata-Ephedra nevadensis, Yucca brevifolia/Artemisia tridentata,* and *Yucca brevifolia/Coleogyne ramosissima* probably have lower fire frequencies. Frequencies in areas invaded by annual exotic grasses (*Bromus madritensis, Schismus* spp.) are likely to have increased because of both natural and human-caused ignitions and have changed the understory composition and density of *Yucca brevifolia*. There has likely been a reduction in stands with fire-sensitive shrubs (e.g., *Larrea tridentata, Coleogyne*) as a result. Destruction or degradation of individual stands has resulted from OHV activity and vandalism.

**Regional Status:**
**Mojave Desert:** In the western Mojave Desert clonal stands occur on the bajadas at the bases of the San Gabriel, Liebre, Scodie, and Tehachapi mountains. Most of them form a mosaic with *Larrea tridentata* Shrubland or are degraded with *Hymenoclea salsola, Ericameria linearifolia,* or *Ericameria nauseosa* as main shrub components. Stands in the eastern Mojave Desert are adjacent to *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance at lower elevations, *Coleogyne ramosissima* Shrubland Alliance at mid elevations and *Artemisia tridentata* Shrubland*, Pinus monophylla- (Juniperus osteosperma)* Shrubland*,* and *Juniperus osteosperma* Wooded Shrubland at upper elevations. Likewise, stands in Joshua Tree National Park occur in a variety of settings.
**Southeastern Great Basin**: The alliance occurs in the Coso, Inyo, and Cottonwood mountains where it is intermixed with *Artemisia tridentata, Atriplex confertifolia*, or *Coleogyne ramosissima* Shrublands or *Juniperus osteosperma* Wooded Shrubland. The alliance only occurs in a small area near Emigrant Pass in the Panamint Mountains**.**

**Management Considerations:** Livestock has heavily grazed many *Yucca brevifolia* Wooded Shrublands. Grazing does not improve range conditions, because of the extreme aridity and harshness of the environment. Efforts to improve these ranges tend to be expensive and yield few beneficial results (FEIS 2001). Extensive vandalism has occurred in many Joshua tree woodlands in California. Increased frequency of fires in *Yucca brevifolia* Wooded Shrubland, resulting from combined effects of human-caused ignition and fine fuels from non-native annual grasses, is likely to degrade certain assemblages. Natural fire regimes in various *Yucca brevifolia* Wooded Shrublands throughout the range of the alliance should be studied to determine the appropriate management actions.

## *Yucca schidigera* Shrubland Alliance

Figure A57. *Yucca schidigera* Shrubland Alliance, southern Nopah Range

*Yucca schidigera* is emergent small tree or tall shrub over a shrub or grass canopy. *Ambrosia dumosa, Coleogyne ramosissima, Encelia farinosa, Ephedra nevadensis, Eriogonum fasciculatum, Larrea tridentata, Opuntia acanthocarpa, Pleuraphis rigida, Salazaria mexicana,* or *Viguiera parishii* may be present. Trees < 5 m tall. Shrub and ground layer open to intermittent. Annuals seasonally present.

**Habitat:** Rocky slopes, upper bajadas, and alluvial fans. Soils well drained, derived from various substrates including granitic, limestone, volcanic, and metamorphic.

**Distribution:** Mojave Desert, Southern California Mountains and Valleys, Colorado Desert, Sonoran Desert, Nevada, Utah, Arizona, Baja California.

**Elevation:** 700 to 1,800m

**NDDB Rank:** G4 S4 (some associations, e.g., *Yucca schidigera/Pleuraphis rigida* rare; G2 S2.2)

**Synonyms:**
Holland: Mojave mixed steppe (34220), Mojave yucca scrub and steppe (34230)
Cheatham and Haller: Low desert scrub
Thorne: Semi-succulent scrub
CALVEG: Creosote bush series (in part)
Munz: Creosote bush scrub
WHR: Desert succulent scrub

**References:** Burk (1977), MacMahon (1988), Reid et al. (1999), Sawyer and Keeler-Wolf 1995, Thorne (1982); plot-based descriptions are found in Minnich et al. (1993), Keeler-Wolf et al. *(*1998)

**Membership Rules**: *Yucca schidigera* ≥ 2% other species including *Larrea tridentata* and *Ambrosia dumosa* may be equal or higher cover.

**Comments:** *Yucca schidigera* Shrubland is part of the creosote bush scrub ecological system, which is a collection of alliances. Much of what was classified as the most diverse upland Mojave Desert scrubs, (i.e., Mojave mixed woody scrub or mixed woody and succulent scrubs, Holland 1986) can now be classified as *Yucca schidigera* Shrubland.

*Yucca schidigera* is one of the most characteristic shrubs of the mid-elevation eastern and central Mojave Desert and desert slopes of the Transverse and Peninsular ranges. However, *Yucca schidigera* rarely is dominant, but is an indicator species even at relatively low cover values. Ordination and classification of 94 relevés in this project suggest that *Yucca schidigera* Shrubland is ecologically similar to the *Yucca brevifolia* Shrubland, but it tends to occur at slightly lower elevations and on shallower soils. *Yucca schidigera* Shrubland grades into *Larrea tridentata-Ambrosia dumosa* Shrubland at lower elevations and is similar to several other mid-elevation alliances including *Ephedra nevadensis* (rockier slopes), *Coleogyne ramosissima* (often caliche layer), *Grayia spinosa* (deeper alluvial soils), and *Eriogonum fasciculatum* and *Salazaria mexicana* (higher disturbance) Shrublands.

The indicator species, *Yucca schidigera,* is a long-lived species indicative of long-persisting stands of vegetation. Evidence suggests that the slow-growing *Yucca schidigera* is particularly susceptible to deep soil disturbances and recovers very slowly (Tratz 1978). Although *Yucca schidigera* may persist for long periods; other components of the stand may be less persistent. Unlike several associated desert species, fire usually does not kill *Yucca schidigera,* even when aboveground vegetation is totally consumed. In chaparral-desert ecotones of southern California, less than 10% of all Mojave Desert yuccas were actually killed by fire (Tratz 1978). In desert grassland, only a few plants were killed by a summer fire, which removed old shoots to or near the ground level (Vasek et al. 1975). Mechanical injury other than fire can also result in re-sprouting, although the more severe the injury, the less vigorous the sprouting (Vasek et al. 1995). It can sprout from roots protected by overlying soil, or from surviving active tissues at the stem base. Certain dry, rocky sites occupied by *Yucca schidigera* may lack sufficient fuels to carry a fire under ordinary circumstances. It is likely that stands with a high understory cover of *Pleuraphis* spp. or disturbance-related shrubs may have had higher fire frequencies than those with long-lived, non-sprouting desert shrubs.

Very few seedlings have been observed on many of the harsher *Yucca schidigera* Shrubland sites. Reproduction by seed may have been much more important during more favorable climatic regimes. Most regeneration now probably occurs through root sprouting, after fire or mechanical disturbance.

**Regional Status:**
**Mojave Desert**: *Yucca schidigera* Shrubland occurs in the eastern part of the Mojave Desert. It does not occur west of Victorville and is largely absent from the Searles, Panamint, and Owens Valleys due to its preference for warm-season rains (T. Keeler-Wolf personal communication, Desert Workshop 2000). It occurs regularly above 900 m. It appears to replace *Yucca brevifolia* Shrubland in parts of the Mojave National Preserve but may co-occur with it in other areas. It does not occur commonly with *Pleuraphis rigida* understory, and its most widespread associations are with *Larrea tridentata* and *Ambrosia dumosa*.

**Management Considerations:** This is a naturally diverse upland alliance, and much of its biodiversity is due to the diversity of non-fire-adapted slow-growing, non-sprouting shrubs. Continued high fire frequencies in stands of *Yucca schidigera* Shrubland will reduce the diversity of non-fire resistant species and increase the cover of fire adapted grasses and short lived colonizing perennials. Other disturbance-adapted alliances such as *Acacia greggii, Ericameria teretifolia, Eriogonum fasciculatum,* and *Salazaria mexicana* Shrublands may increase relative to *Yucca schidigera* Shrublands if fire and the fire-carrying annual grasses continue to increase in the desert. Response of *Yucca schidigera*

Shrublands to fire may vary according to fire severity and intensity, season of burn, and specific site characteristics. These factors should be investigated.