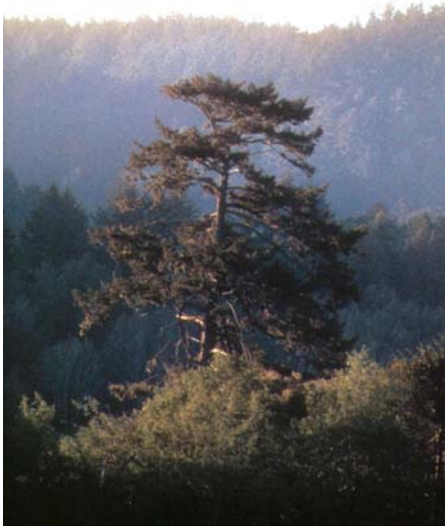
Plant Community Classification and Mapping Project
Final Report

Point Reyes National Seashore, Golden Gate National Recreation Area, San Francisco Water Department Watershed Lands, MountTamalpais,Tomales Bay, and Samuel P. Taylor State Parks



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Abstract

A comprehensive plant community classification and mapping project for a 155,000 acre study area of National Park Service lands in San Francisco Area was conducted between 1997 and 2003. Eighty seven plant communities were described using 366 vegetation plots collected in the various habitats throughout the study area. The vegetation plots were also used as training data for photo interpreters to map plant comminutes using 1:24,000 true color photos. The Minimum Mapping Unit (MMU) was set at 0.5 hectares. Seventy-four plant community or mapping units were delineated using the aerial photographs. The accuracy, at the finest botanical level of resolution, varied by class from 0 to 100%. In addition to using the National Vegetation Classification System, we created a custom classification hierarchy based on ecological similarity as determined during an ordination analysis of the 366 training plots. This custom classification was used as the basis of a modified 'fuzzy'(Congalton and Green 1999) approach for accuracy assessment. Overall thematic accuracy varied from 44% at the association level to 87% at the life form level.

Acknowledgements

This plant community classification and mapping project was part of a comprehensive joint venture between the U.S. Geological Survey (USGS) and the National Park Service (NPS) to map and describe the existing (currently on the ground) plant communities in the National Parks of the United States. This effort was initiated by the National Park Service in Point Reyes National Seashore (PRNS) in 1996 after the Vision Fire burned within a 12,000 acre perimeter in the center of the Seashore in October of 1995. This collaborative effort was conducted in part through a contract with Environmental Systems Research Institute (ESRI). Subcontractors included The Heritage Ecologist with the California Department of Fish and Game, NatureServe (formally The Nature Conservancies Heritage Program), and Aerial Information Systems (AIS) of Redlands California. The plant community classification and initial draft plant community key were developed by Heritage Ecologist, Todd Keeler-Wolf. The photo interpretation was conducted by Aerial Information Systems of Redlands California with John Meinke as the lead aerial photo interpreter. National Park Service staff collected all the training data that went into the plant community classification, conducted the accuracy assessment and finalized the plant community key. Sarah Allen, science advisor for PRNS, and Terri Thomas, Chief of Natural Resources Management at Golden Gate National Recreation Area (GGNRA), initiated the project in 1994, and Dave Schirokauer took over managing the project in 1999. Debbie Johnson of Aerial Information Systems and Doug Cribbs, Tony Curtis, and Randy Vaughn of ESRI were also instrumental in completing this work. Lorraine Parsons' critical review of this document and the associated appendices was instrumental in finalizing the report. Major funding was provided by the National Park Service's Fire Program and Inventory and Monitoring Program along with PRNS and Golden Gate National Recreation Area (GGNRA).

Structure of this document

This project occurred in three sequential stages which is reflected in the three major sections of this report: 1) training plot data collection, plant community classification and description, 2) Photo interpretation based delineation of plant communities and mapping units, and 3) thematic accuracy assessment of the GIS based plant community map.

Background

Introduction

The USGS and NPS formed a partnership in 1994 to map and classify the vegetation of the United States' National Parks using NatureServe's National Vegetation Classification, the standard adopted for reporting vegetation information among federal agencies (Grossman *et al.* 1998). Goals of the project include providing reference ecological information to resource managers in the parks, putting these data into regional and national contexts, and providing opportunities for future inventory, monitoring, and research activities. Each park generally follows a standardized field sampling and data analysis regime to document the park's plant communities. These data are used to create a plant community key and formally describe plant communities (alliances and associations) through an ordination analysis of the field plot data. These data are also used as 'training data' for aerial photo interpreters to determine the photo signature of the plant communities being described. After a draft classification, plant community key, and map are produced, the parks conduct an accuracy assessment of the plant community map.

During the accuracy assessment, vegetation plot data that can be keyed to a specific plant community (and was not used as training data), are compared with the plant community labels the photo interpreters applied to the map. In order to improve the map's accuracy, another iteration of photo interpreting and merging of mapped plant community types into broader mapping units typically occurs prior to finalizing the plant community map.

The final products consist of a digital and hardcopy vegetation map, descriptions of each plant community type, a field key to the plant communities, an accuracy assessment report, and metadata. This report describes the work conducted at PRNS, GGNRA, The San Francisco Municipal Water District Lands, and adjacent cooperating Mount Tamalpais, Tomales Bay, Angle Island, and Samuel P. Taylor State Park Units, conducted from 1997 to 2003.

The Vision Fire

Between October 3rd and October 7th, 1995, the Vision Fire burned about 9,000 acres (within a 12,000 acre burn area) of private, state, and federal lands. Over 90 percent of the burned area was within PRNS. In addition to burning wildlands, the fire consumed 45 structures in the town of Inverness Park. Fanned by winds up to 50 miles per hour, the fire moved quickly, burning 6,521 acres in 24 hours.

Due to the wildland/urban interface present and the associated threats to life and property, fire suppression efforts were aggressive. Logistics, coordination, and planning were

complicated, and decisions had to be made quickly. At the time of the fire, PRNS did not have a vegetation map. Had a map been available, it would have been of great assistance in making the crucial decisions associated with suppression of a major fire. The map would have helped in projecting rates and direction of fire spread, in implementing logistics and planning, and in ensuring firefighter and public safety.

The natural resources of the Seashore, particularly vegetation and soils, were subject to significant adverse impacts as a result of the fire and suppression activities. These impacts primarily were associated with 23.1 miles of bulldozed fireline (13.6 miles occurred on slopes greater than 30%), 6.4 miles of handline in designated wilderness, 13 helispots, and trees felled in streams. The Department of the Interior's interagency Burned Area Emergency Rehabilitation (BAER) team arrived at the Seashore during the fire to assess the effects of the fire and fire suppression efforts on natural and cultural resources. A vegetation map would have been invaluable to the BAER team for impact assessment and for post-fire rehabilitation planning and implementation. Without a map, several of the team's post-fire analyses were only partially completed or were only moderately reliable. In addition, post-fire assessments of fuels and canopy cover, and determination of priority areas for prescribed burns require current information on vegetation types and distribution, information that can be interpreted from plant community maps.

The Seashore’s resource managers were in the process of developing a vegetation map and the fire reinforced the recognition of the critical gap in plant community resources inventory data. Financial support came from NPS FIREPRO, the GGNRA, the NPS I&M Program, the California State Department of Parks and Recreation, and the Gulf of the Farallones National Marine Sanctuary, as well as PRNS.

Vegetation Sampling And Plant Community Classification

The U.S. National Vegetation Classification (USNVC), developed by The Nature Conservancy (now NatureServe) and the Association for Biodiversity Information, in partnership with the network of Natural Heritage Programs, was used to classify the vegetation in PRNS- GGNRA study area. A first edition of the classification has been released that provides a thorough introduction to the classification, its structure, and the list of vegetation units known from the United States, as of April 1997 (Grossman *et al.* 1998). The classification is a hierarchical system with physiognomic features at the highest levels of the hierarchy and floristic features at the lower levels determining group membership. The physiognomic units have a broad geographic perspective while the floristic units have local and site-specific perspective (Grossman et al. 1998).

The physiognomic-floristic classification includes all upland terrestrial vegetation and all wetland vegetation with rooted vascular plants. The USNVC hierarchy has seven levels, with five physiognomic levels and two floristic levels (Table 1). The basic unit of the physiognomic portion of the classification is the “formation,” a type defined by dominance of a given growth form in the uppermost stratum and characteristics of the environment (e.g., cold-deciduous alluvial forests). The physiognomic portion of the classification is based upon the UNESCO world physiognomic classification of vegetation (Drake and Faber-Langendoen 1997). As of this writing, the descriptions of several formations in our study area are still under development.

The floristic levels include alliances and associations. The alliance is a physiognomically uniform group of plant associations that share dominant or diagnostic species, usually found in the uppermost strata of the vegetation. For forested types, the alliance is roughly equivalent to the “cover type” of the Society of American Foresters. Alliances also include non-forested types.

The association is the lowest level in the national classification. The association is defined as “a plant community of definite floristic composition, uniform habitat conditions, and uniform physiognomy” (see Flahault and Schroter 1910 in Moravec 1993).

During the accuracy assessment phase of this project we also created a custom classification based on ecological groupings of plant communities with three hierarchical levels. These three levels of ecological clustering were specifically to improve the user accuracy of the final plant community map. Refinements to the classification occurred iteratively throughout the mapping and accuracy assessment phases of the project as additional information became available.

Table 1. The USNVC's Physiognomic-floristic Hierarchy for Terrestrial Vegetation (from Grossman et al. 1998) and custom ecological groupings* based classification developed during the PRNS-GGNRA project. A complete crosswalk between the levels in the classification hierarchy is available in Appendix C.

Level	**Primary Basis For Classification**	**Example**
Class	Growth form and structure of vegetation	Woodland
Subclass	Growth form characteristics, e.g., leaf phenology	Evergreen Woodland
Group	Leaf types, corresponding to climate	Winter-rain Evergreen Sclerophyllous Forest and Woodland
Subgroup	Relative human impact (natural/semi-natural or cultural)	Winter-rain Evergreen Sclerophyllous Forest and Woodland
Formation	Additional physiognomic and environmental factors, including hydrology	Lowland or Submontane Winter-rain Evergreen Sclerophyllous Forest
Alliance	Dominant/diagnostic species of uppermost or dominant stratum	*California Bay*
Association	Additional dominant/diagnostic species from any strata	*Umbellularia californica / Quercus agrifolia / Toxicodendron diversilobum*
Superalliance (Microcluster)*	Groups vegetative associations based on shared dominant species and other shared floristic, physiognomic and ecological properties. This grouping provides an ecological perspective, emphasizing the shared geographic, site, and disturbance regimes that shape vegetation patterns. These are narrower than the formation level of the USNVC.	*California Bay- Coast Live Oak*
Mesocluster*	Groups vegetative associations based on broadly shared ecological processes and floristics. This grouping provides an ecological perspective emphasizing the shared geographic, site, and disturbance factors that shape vegetation patterns. These are broad vegetation types within a biogeographic region that share similar habitats (e.g., ecological processes, abiotic factors, and environmental gradients) and that have broadly similar species composition. Mesoclusters are similar to the USNVC formation level.	*Forest: California Bay, Douglas-fir, and Coast Live Oak*
Supercluster*	Groupings of mesoclusters sharing similar physiognomy and ecological context. These superclusters are aggregations of vegetation associations that are similar to the sub-class level in the USNVC.	*Evergreen Forest and Woodland*

Not all plant communities were equally mappable at the minimum mapping unit (0.5 hectares) and the scale of the aerial photographs (1:24,000) chosen for this project . Coordination between the aerial photo interpreters and the vegetation classification teams determined the best way to map the types, whether directly at the association level, the higher classification levels, such as at the alliance, or as a mosaic or mapping unit. Thus, not all plant communities which exist on the ground and are described in this report are directly displayed on the plant community map. However, every described plant community is at least a member of a mapping unit.

Study Area

The 155,000 acre study area occurs within portions of four ecological subsections; Point Reyes (263Ak), Marin Hills and Valleys (263Al), San Francisco Peninsula (261Ai), and Santa Cruz Mountains (261Af) (Miles and Goudey 1997).

Point Reyes National Seashore was established in September of 1962 and encompasses approximately 71,000 acres of diverse habitats, including grasslands, coastal scrub, broadleaved evergreen woodlands and coniferous forests. Within the general vicinity of the National Seashore there are a number of public and private land holdings that have also been interpreted and mapped for the project. These include the following areas:

- Privately owned land including portions of the town of Inverness, Olema, and Bolinas, land east of the Bear Valley Trail to Olema Creek, Audubon Canyon Ranch, and a narrow band along State Highway 1 north to Preston Point.
- Samuel P. Taylor State Park
- Tomales Bay State Park
- Stinson Beach

Areas in the general vicinity of PRNS that were not part of the mapping effort include:

- The Marin Municipal Water District (Kent Lake Area)
- Portions of the towns of Bolinas, Inverness Park, Stinson Beach and Inverness
- Audubon Canyon Ranch
- Duxbury Reef Reserve and Point Reyes Headlands Reserve (below the mean high water)
- Gulf of the Farallones National Marine Sanctuary

Golden Gate National Recreation Area, established in 1983, covers over 76,000 acres of land, including extensive stands of chaparral, coastal scrub, grasslands, broadleaved woodlands, and old growth redwood forests. Within the general vicinity of the GGNRA there are a number of public and private land holdings that have been interpreted and mapped for the project. They include the following areas:

- Golden Gate National Recreation Area
- Muir Woods National Monument
- Mount Tamalpais State Park
- Marin Headlands
- The Presidio of San Francisco
- Angel Island State Park (delineated, but only partially interpreted due to lack of training data)
- Fort Funston
- Sweeny Ridge
- The San Francisco Municipal Water District Lands

Areas in the general vicinity of the GGNRA that were not part of the mapping effort include:

- Adjacent Mid Peninsula Regional Open Space lands
- Edgewood County Park
- Portions of Montara State Beach and San Pedro Valley County Park

PRNS & GGNRA - General Description

PRNS is located southwest of Tomales Bay on the western side of the San Andreas Fault Zone. East of the National Seashore, the Bolinas Ridge runs in a northwest to southeasterly direction with elevations averaging around 1,500 feet. Within the park boundaries, the Inverness Ridge runs parallel to the Bolinas Ridge, just west of the towns of Inverness, Inverness Park, Point Reyes Station and Olema. Several peaks along the Inverness Ridge (Mount Vision, Point Reyes Hill, Mount Wittenberg and Firtop) are around 1,300 feet. West of the Inverness Ridge, the land slopes gently towards the Point Reyes Beach, much of it occupied by pastoral lands. The northern 10 percent of the Point Reyes Peninsula is occupied by a Tule Elk Reserve. It extends from approximately Pelican Point to the Tomales Bluff. Located south of Mount Vision and west of the Phillip Burton Wilderness Area, the Drakes Estero and Estero De Limantour form a substantial portion of the low areas within the park. The Limantour Spit forms a barrier to the Drakes Bay with a small opening of several hundred feet on the western edge of the estuaries. The southern part of the National Seashore along with the steep cliffs just below the Point Reyes Lighthouse and the Sea Lion Overlook are primarily within the Phillip Burton Wilderness Area. The southeastern edge of the National Seashore beyond the Phillip Burton Wilderness Area adjoins the town of Bolinas.

Golden Gate National Recreation Area is divided up into two general areas: the northern half administered by the PRNS, and the southern portions administered by the GGNRA and other public agencies. The northern portions lie just east of the San Andreas Fault Zone (the Olema Valley) and form a substantial portion of the Bolinas Ridge. Further south, but still within the administrative jurisdiction of the NPS is the Marin Headlands area, located south of the Muir Woods National Monument. South of the Golden Gate Bridge, GGNRA is made up of numerous small beaches including Ocean Beach, Lands End, China Beach, and Baker Beach. Included in this portion of GGNRA is the Presidio of San Francisco north of California Street. South of Fort Funston is the Sweeny Ridge, which contains the southernmost portions of the GGNRA.

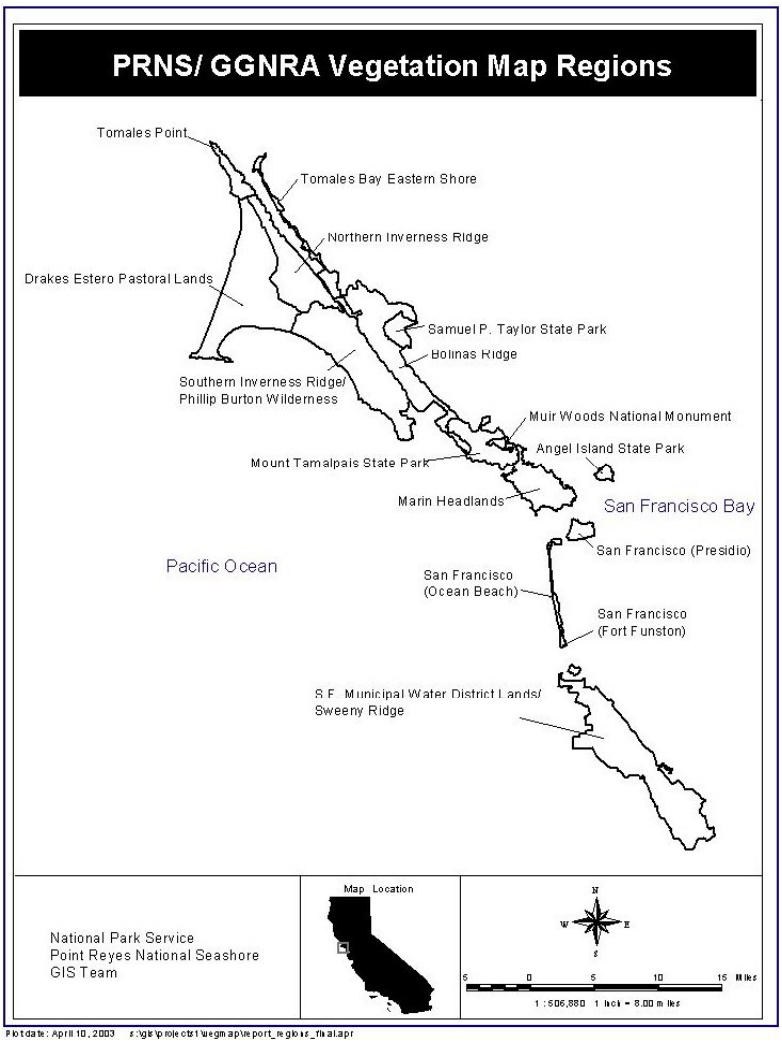
PRNS - General Regions

For purposes of general mapping, descriptions and sample allocation, the PRNS portion of the study area was divided into seven mapping regions pertaining primarily to its geo - environmental location, vegetation communities, and administrative status. See Figure 1, the seven regions of the study area are:

1. *The Northern Inverness Ridge*
2. *The Southern Inverness Ridge including most of the Phillip Burton Wilderness*
3. *The pastoral lands surrounding Drakes Estero*
4. *Samuel P. Taylor State Park*
5. *The interior portions of the study area adjacent to the eastern shores of Tomales Bay*

6. *Tomales Point*
7. *Golden Gate National Recreation Area north of Mt. Tamalpais State Park*

Figure 1 - Index map to regions within the study area.



The Northern Inverness Ridge
This area is located south of Pelican Point and includes Tomales Bay State Park, land west of the town of Inverness and south to approximately the Limantour Road. The southern extent of this zone is defined approximately by the southern most stands of bishop pine. Much of the area contains extensive stands of bishop pine (*Pinus muricata*), often with a mix of coast live oak (*Quercus agrifolia*) and madrone (*Arbutus menziesii*). This area was most affected by the Vision Fire in October of 1995.

The Southern Inverness Ridge
Occupying the majority of the Phillip Burton Wilderness area, this region is somewhat cooler and foggier and receives more rainfall than the northern portions of the Inverness

Ridge. Much of the area is covered with stands of Douglas-fir (*Pseudotsuga menziesii*) that give way to various associations within the coyote brush alliance closer to the coast. The lower elevations contain extensive open stands of coyote brush (*Baccharis pilularis*) often with native grasses including California oatgrass (*Danthonia californica*) and purple needlegrass (*Nassella pulchra*). There are several natural lakes within this region, including Bass Lake, Wildcat Lake and Pelican Lake.

The Pastoral Lands Surrounding Drakes Estero
Much of this low lying region is dominated by several types of both native and non - native perennial grasslands due to the working dairy and cattle ranches in the area. Several large estuaries are found within this region, including Abbotts Lagoon, Drakes Estero, and Estero De Limantour. This area contains the most significant stands of Pacific reedgrass alliance (*Calamagrostis nutkaensis*) in addition to non - native perennials such as velvetgrass (*Holcus lanatus*). Many of the swales in this region contain sedge - rush type meadows. Closer to the Point Reyes Beach, extensive stands of tufted hairgrass alliance (*Deschampsia cespitosa*) are found adjacent to the Sir Francis Drake Highway. Along the Point Reyes Beach proper much of the dune has been stabilized by the exotic European beach grass (*Ammophila arenaria*). Small stands of dune sagebrush (*Artemisia pycnocephala*) and goldenbush (*Ericameria ericoides*) occur on back dunes slightly inland from the European beach grass. Significant stands of yellow bush lupine (*Lupinus arboreus*) occur in the area.

Samuel P. Taylor State Park
Samuel P. Taylor State Park is bisected by the Sir Francis Drake Blvd. and Lagunitas Creek. Its southern boundary is with the Marin Municipal Water District and the western edge of the Bolinas Ridge. On the hills to the south and west of Lagunitas Creek (on north to east-facing slopes), extensive stands of Douglas-fir alliance (*Pseudotsuga menziesii*) occur. Narrow corridors of coast redwood (*Sequoia sempervirens*) or mixes of Douglas-fir (*Pseudotsuga menziesii*) and coast redwood are found down slope in concave draws and riparian zones, especially along Lagunitas Creek. Extensive stands of California annual grasslands occur on west and south-facing slopes north of the highway. Broadleaf woodland communities, including stands of California bay alliance *(Umbellularia californica)* with lesser amounts of coast live oak alliance (*Quercus agrifolia*), often extend up south-facing drainages.

The Interior Portions of Study Area, Adjacent to the Eastern Shores Tomales Bay
This narrow band along California Highway 1 contains GGNRA land administered by the NPS. There are numerous private inholdings along this corridor, which stretches from Point Reyes Station to Preston Point. The dominant communities are California annual grasslands, although one area near Millerton contains a significant stand of California oat grass (*Danthonia californica*). Small stands of the invasive shrub gorse (*Ulex europaeus*) were noted just east of Preston Point on south-facing slopes.

Tomales Point
Located north of the Historic Pierce Point Ranch and McClures Beach, this portion of the study area is occupied primarily by low rolling hills, steep cliffs and grasslands. Access is limited and is restricted primarily to the Tomales Point Trail. The western portions of Tomales Point are dominated by perennial grasses including: velvetgrass *(Holcus lanatus),* ryegrass *(Lolium sp.),* tall forbs including wild radish *(Raphanus sativa)* and small evergreen shrubs such as yellow bush lupine *(Lupinus arboreus).* Further east, on the bay side of Tomales Point, there are small stands of blue blossom *(Ceanothus thyrsiflorus).* Small riparian areas that are fed by creeks draining into Tomales Bay support stands of arroyo willow *(Salix lasiolepis)* and red alder *(Alnus rubra).*

Golden Gate National Recreation Area North of Mt. Tamalpais State Park
This region contains the only significant stands of chaparral in the study north of Mount Tamalpais State Park. It is bounded on the west by the Olema Valley, and ends at the crest of the Bolinas Ridge. Portions of the ridge support mixed stands of coast redwood (*Sequoia sempervirens*) and Douglas-fir (*Pseudotsuga menziesii*). Upper slopes and ridge tops support a number of chaparral communities, including stands of sensitive manzanita (*Arctostaphylos nummularia*). Most of this area is administered by PRNS.

Golden Gate National Recreation Area - General Regions

For purposes of general mapping descriptions, the GGNRA portion of the study area was divided into six mapping regions relating primarily to its geo-environmental location, vegetation communities, and administrative status. See Figure 1, the six regions of the Study Area include:

1. *Mount Tamalpais State Park*
2. *Muir Woods National Monument*
3. *The Marin Headlands and Tennessee Valley Region*
4. *Angel Island*
5. *The San Francisco Area*
6. *Sweeney Ridge and the San Francisco Watershed*

Mount Tamalpais State Park
Mount Tamalpais State Park is located just north of Muir Beach and includes the coastal areas around Rocky Point. It continues to the northeast along a narrow corridor adjacent to Ridgecrest Boulevard to the summit of Mt. Tamalpais. Its boundaries follow the Bolinas Ridge just north of the town of Stinson Beach. Much of the park contains extensive stands of California annual grasslands and chaparral, including several rare species of manzanita. The northernmost extensive stands of coyote brush (*Baccharis pilularis*) - California sagebrush (*Artemisia californica*) are found on south-facing slopes just east of Bolinas Lagoon.

Muir Woods National Monument
Muir Woods National Monument is completely surrounded by Mt. Tamalpais State Park and occupies the majority of the watershed for Redwood Creek. On lower north and east trending slopes, extensive stands of old-growth redwood and Douglas-fir forests still exist.

The Marin Headlands and Tennessee Valley Region
This region contains the actual Marin Headlands area north of Bonita Cove and the low hills and valleys, including the Tennessee, Gerbode and Oakwood valleys. This zone contains some of the most extensive stands of purple needle grass in the study, in addition to other types of both native and non-native perennial grasses. Coastal access is limited for the most part to the Coyote Ridge, Coastal, and Tennessee Valley trails.

Angel Island State Park
Located in the San Francisco Bay just east of Sausalito, Angel Island State Park is predominantly broadleaf hardwood communities, both native and exotic. Much of the island is covered with a mix of live oak and bay, with non - native invasive stands of Monterey pine and blue gum eucalyptus (*Eucalyptus globulus*). Recent efforts have been successful in removing much of the eucalyptus from the island. Vegetation polygons were delineated, but not labeled for this portion of the study area due to the lack of training data.

The San Francisco Area
This region includes the San Francisco Presidio, the beaches west of the city, Lands End and Fort Funston. Much of the area is covered with non - native species. However, there are several stands of coyote brush (*Baccharis pilularis*) mixed with lizard - tail (*Eriophyllum staechadifolium*). Several restoration efforts are ongoing in the Fort Funston area to re-introduce dune habitat that was previously invaded by stands of ice plant.

Sweeny Ridge and the San Francisco Municipal Water District Lands
This is the largest and southern-most region in the GGNRA area of the study. The area contains certain communities, such as the holly-leaved cherry alliance (*Prunus ilicifolia*), and Eastwood manzanita alliance (*Arctostaphylos glandulosa*) that are more frequently found in the southern portion of the state. The region is extremely diverse and occupies an area just west of the Interstate 280 Freeway and generally east of Montara Mountain and Skyline Boulevard. Extensive stands of coast redwood (*Sequoia sempervirens*) with an understory of tanoak (*Lithocarpus densiflorus*) occur along Skyline Boulevard in the western edge of the study. Down-slope from Skyline Boulevard, in the canyons and ravines, Douglas-fir (*Pseudotsuga menziesii*) mixed with bay or bay and live oak can be found. At lower elevations, closer to the Crystal Springs Reservoirs on south facing slopes and ridgelines, extensive stands of chamise (*Adenostoma fasciculatum*) or mixes of chamise - Eastwood manzanita (*Arctostaphylos glandulosa*) occur.

Project timeline

The following section is a short outline, listed in chronological order, of this project.

March 12, 1994
- Aerial photography for the northern portions of the study flown

August 8, 1995
- Aerial photography for the southern portions of the study flown

December 5, 1995
- Initial costs and contract drawn up between PRNS and ESRI

September 1996
- Preliminary efforts by Todd Keeler - Wolf and Laura Nelson in developing a list of possible vegetation communities

March of 1996
- Post fire aerial photography flown

October 24, 1996
- Preliminary Vegetation Scoping Meeting (ESRI - NatureServe – PRNS, GGNRA)

January 20, 1997
- AIS receives photography and meta - data from NPS

March 1997
- Field reconnaissance effort with AIS and Todd Keeler-Wolf

March 31, 1997
- Preliminary mapping classification for the study area developed

April - June 1997
- Preliminary line work and initial polygon labels interpreted and sent to Todd Keeler - Wolf in 3 shipments.

October 1998
- Plot sampling effort complete for study a total of 366 plots
- Copies of field overlays delivered to AIS for review against initial PI calls
- Updates and corrections made to the photo overlays

February 1999
- The PRNS Classification Supported by Plots completed
- Three - day field verification effort completed

March 1999
- Updates and corrections made to the photo overlays based on the three - day field verification trip

June 9, 1999
- Geo - referencing (rectification) of the first twelve modules in the grassland areas around Drakes Bay delivered to NPS

June 1999
- Accuracy assessment efforts begin

October 1999
- Second set of modules delivered to NPS, AA points selected and delivered to NPS - copy sent to Todd Keeler - Wolf

November 1999

- Third set of modules delivered to NPS (All regions except the San Francisco Presidio and Angel Island)

January 2000

- Delivery of modules to NPS both with and without quad boundaries
- Completion of fire attribute assignment to shrub and tree polygons in the Vision Fire area

July 2002

- Accuracy assessment results reviewed by NPS, AIS, and Heritage Ecologist during a meeting in Redlands at AIS.
- Final set of accuracy plots to be used in accuracy assessment agreed on by all parties.

August 2003

- Final GIS database delivered to NPS. Draft reports accepted by NPS and contract with ESRI completed.

Methods

The field and analytical methods used to develop the plant community classification generally followed the procedures outlined by the USGS / NPS Vegetation Mapping Program (USGS 1994). Detailed documentation on the USGS/NPS vegetation mapping and classification methodology is available at the web site associated with this project (http://biology.usgs.gov/npsveg/index.html). Following is a presentation of the methodology as it was applied to the PRNS / GGNRA study area.

Collecting Training Data

PRNS / GGNRA is considered a large - sized mapping area (USGS 1994) and is extremely diverse, over one thousand plant species are known to occur within the 155,000 acre study area. A carefully thought-out and implemented sampling scheme for the collection of training data is essential to the success of any vegetation mapping project. A formal GRADSECT (Gillison and Brewer 1985) sampling approach, as suggested in the USGS –NPS vegetation mapping guidelines, was never implemented. Instead, an informal, opportunistic GRADSECT approach was adopted, based on expert opinion of the contracted ecologists (Todd Keeler-Wolf, California Heritage Ecologist and Michael Schindel, Oregon Heritage Program). This opportunistic site selection process was based on knowledge of varying climate, geology, and topography throughout the complex study area. The goal in acquiring training data was to collect detailed vegetation data from three representative stands for each type of preliminary plant community known to occur in the study area. For plant community types that were known to occur in more than one of the 13 zones in the study area, representative sampling sites were selected in each of the zones in which the type occurred. Ideally ten plots of each plant community in the study area should be sampled to author a plant community type. However, due to budgetary constraints a minimum of three plots was used during the plant community classification stage of this project. During the accuracy assessment phase of the project more than 1600 vegetation plots were sampled. In the future, we will re-run the classification (ordination analysis) to include these additional 1600+ plots to refine and update the classification. This updated classification will become the basis for designing and implementing a long-term monitoring program for a subset of plant communities within the San Francisco Bay Area Inventory and Monitoring Network.

A one day meeting was held on October 24, 1996 to bring together project team members from the NPS, AIS, ESRI, and The Nature Conservancy (now NatureServe). This meeting focused primarily on discussing the Vegetation Inventory and Mapping Program, existing park data, and specific interests and issues of the park.

At this meeting, a preliminary classification derived from published information on California vegetation and on an unpublished compilation of local data, was presented. This classification was refined following the joint reconnaissance trips in March 1997 with the air photo interpreter team, NPS ecologists, and the vegetation classification team (Keeler-Wolf and Schindel).

This reconnaissance trip clarified both the nature of the classification units and their aerial photo signatures. The minimum mapping unit of 0.5 ha guided the creation of a set

of rules on how to map each plant community type. In several cases, the scale of the aerial photography dictated that plant communities be aggregated into broader mapping units. Based on the reconnaissance trip, the air photo interpreters attempted to identify all of the different aerial photo signatures that might correspond to the vegetation types and mapping units. By April of 1997, mapping protocols (see mapping report section of this document) were sufficiently stabilized to permit the air photo interpreters to begin delineating polygons throughout the mapping area. Between April and June 1997, three shipments of preliminary line work were sent to the Heritage ecology classification team.

The sampling allocation was an iterative process. Several times throughout the field sampling period from June 1997 to September 1998, the Heritage ecologists took the aerial photographs delineated by the photo interpreters and selected polygons for field visits based on the following guidelines:

- Each vegetation type mapped by the photo interpretation team was to be selected from each of the thirteen geographic regions in which it occurred.
- If different driving environmental variables existed in certain parts of the mapping area (for example ultramafic geology or areas above the average summer fog belt), they were identified for sampling even if preliminary delineations by the air photo interpreters did not indicate distinctly different vegetation signatures.
- Each selected polygon was chosen subjectively based on its accessibility (including land ownership, distance from roads or trails, terrain considerations).
- A sufficient number of polygons were selected each time to provide field crews working in GGNRA, PRNS, and California State Parks with alternate sample sites in case those originally chosen proved to be inaccessible.
- Additional vegetation types were added to the preliminary classification based on feedback from field crews. These new types were added to the sample allocation.
- Additional sampling sites were selected by the sampling crew to capture plant community types that were not selected by the aerial photo interpreters.

Selected polygons were marked using orange grease pencil on acetate copies of the linework overlaid and affixed onto contact prints of the aerial photographs. Sets of marked up photos were sent back to the field crews, who took the selected photos, or scanned copies of them, out into the field to assure proper orientation. Regular communication between the NPS field crews and the Heritage ecologists was assured by periodic conference calls.

Plot Sampling

Training data plots were collected using the California Native Plant Society Relevé Field Protocol (see CNPS website: http://www.cnps.org/cnps/vegetation/protocol.php for complete methodology and field form). This methodology meets and exceeds the minimum criteria for vegetation plot data needed to conform to the national vegetation

classification. Plots were placed subjectively by the crews by selecting a representative portion of the polygon (selected by the photo interpretation and vegetation classification teams). Plots were of variable size (generally 400m^2 for scrub and herbaceous vegetation and 1000m^2 for forests and woodlands) and shape. When canopy conditions permitted, the plot's location was recorded with GPS. Plots were not permanently marked.

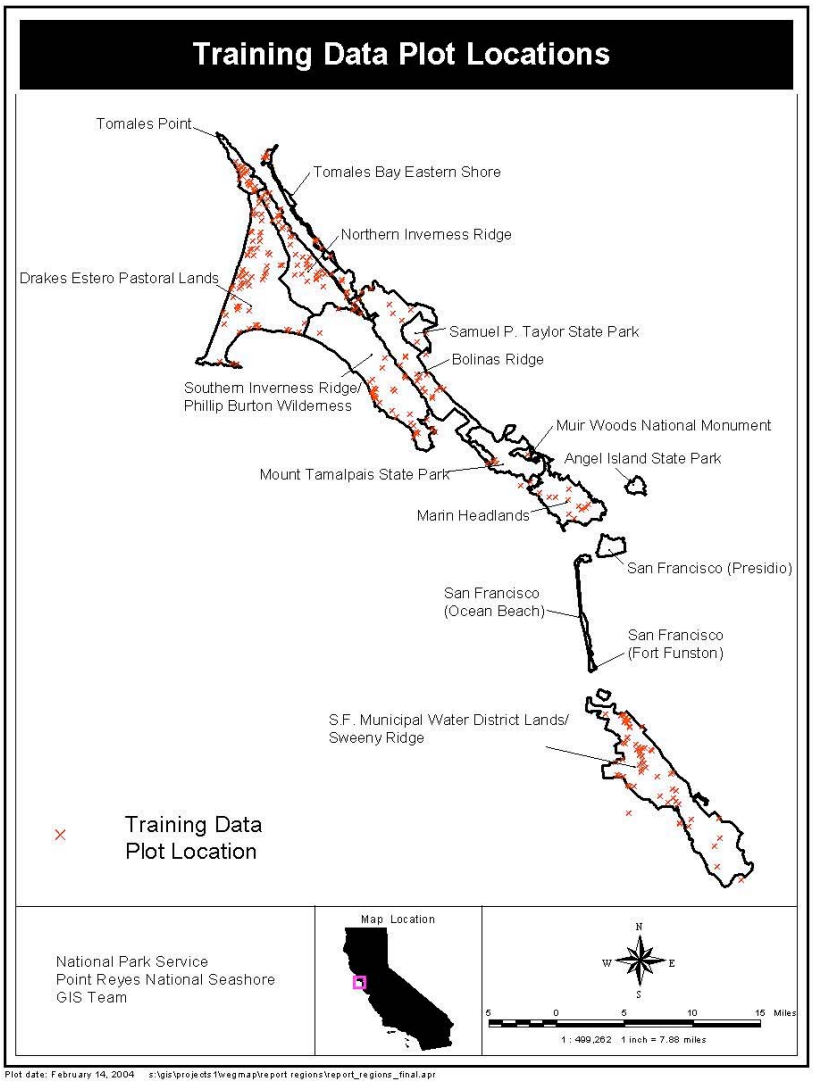
Plot sizes were set at 1000 m^2 for forests and woodlands and 400 m^2 for shrublands and herbaceous vegetation. The plots dimensions were variable. When possible, plots were placed subjectively in the most representative part of each stand of vegetation. Cover and height were estimated for each stratum (herbaceous, shrub, and tree). Cover of dominant life form was also estimated. All the species of each stratum were listed and percent cover was estimated. Additional species within the vegetation unit or polygon that occurred outside of sampled plots (generally within 2 m of the plot border) were listed separately. Species that were not identifiable in the field were collected for later identification. In addition to floristic information, the following environmental information was recorded on field forms: surficial geology, hydrologic (flooding) regime, soil drainage regime, soil texture, slope, aspect, topographic position, and evidence of disturbance. Coordinates of each plot were recorded in Universal Transverse Mercator (UTM) projection (Zone 10 NAD 83) using a Trimble ProXLGPS unit. A provisional name for the vegetation type was assigned to the plot. Field sampling for the 'training data' was completed in fall 1998. Data from a total of 366 plots were collected.

Creating the Plant Community Classification

The sampling began prior to the release of the NatureServe - NPS Plots database, so a separate database was created by CNPS vegetation ecologist Bruce Bingham. All data were entered into a database developed specifically for this mapping project. Data quality control was conducted by NPS staff. The database was returned to the contractor several times for corrections.

The analysis of plot data collected in 1997 - 1998 was undertaken using the PC - Ord software suite of ordination and classification tools (McCune and Mefford 1997). PC - Ord allows disparate types of data to be fed directly into classification programs such as TWINSPAN (Hill 1979) or Cluster Analysis (McCune and Mefford 1997.

Figure 2. Location of the 366 training data plots. Training data was not collected within the Vision Fire area.



Following the 1997 - 1998 sampling 366 vegetation plots were available for analysis. The classification analysis for all sampling data followed a standard process. First, all sample - by - species information was subjected to two basic TWINSPAN runs. The first was based on 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 TWINSAP run was based on the standard default run where cover values are converted to 5 different classes including:

- Class I Merely present - 2%
- Class II >2 - 5%
- Class III >5 - 10%
- Class IV >10 - 20% and
- Class V >20% cover

These cover values are reasonable for most vegetation. The first three cover classes compose the majority of the species values in our plots. This second run demonstrated the effects of cover values on 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 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. The consistent groupings identified in each run were subsequently compared.

Following the identification of 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. Specifically, the TWINSPAN algorithm starts by using reciprocal averaging to divide up the species cover data starting with the most dissimilar plots and working to the most similar (thus considered a divisive technique). Cluster Analysis uses predetermined linkage algorithms to start with plots that are most similar and progress to show the sequence of coarser divisions between all of the plots (agglomeration). 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 (plots in ecotones) or outliers with no similar samples in the data set.

1. Initial TWINSPAN runs were made to break the data into finer subsets which were reanalyzed using TWINSPAN and cluster analysis this process is known as progressive fragmentation (Bridgewater 1989). Subsets included riparian shrub and tree dominated plots, upland herbaceous plots, shrub - dominated plots, and non-riparian tree dominated plots.
2. Following cluster analysis and TWINSPAN analysis of all subsets, each plot was revisited within the context of the cluster it had been assigned to in order to quantitatively define the membership rules for each association or alliance. These membership rules were defined by species constancy and species cover values and were translated into a preliminary plot - based classification and field key.
3. The preliminary classification and field key was tested in the field during the accuracy assessment of 1999 - 2000 and was refined into the plant community classification, descriptions, and key presented in this report.

This data-set was to be used as the principal means of defining the plant community compositions throughout the mapping area. Careful scrutiny of the membership of each

group helped establish membership rules for each plant community and set standards for the written plant community descriptions.

In general the process followed these steps:

a. Run outlier analysis on data, including sub-sets, to determine most distantly related plots.

b. Run presence - absence TWINSPAN to determine general arrangement of species along the gradient of axis 1 of DCA (both Reciprocal Averaging techniques of species - by - sample scores).

c. Run different permutations of TWINSPAN to see the general variation in arrangement of samples. These permutations were based on 1) shifting the pseudospecies cut values using from 1 to 6 cut levels and 2) allowing the minimum group size to vary from 2 to 5. Samples generally held together well, and the main gradient did not vary.

d. Settle on the final representative TWINSPAN run to use in the preliminary labeling.

e. Preliminarily label alliance and association for each of the samples.

f. Identify major break points (main divisions) in TWINSPAN of full data set and subject major subsets of data to individual TWINSPAN runs.

g. Run cluster analysis (Ward's method) to test congruence with the subsetted TWINSPAN groupings.

h. Develop decision rules for each association and alliance based on the most conservative group membership possibilities by reviewing species cover on a plot by plot basis.

i. Use decision rules developed above to assign plant community names to the existing plot data.

Despite the strong influence of outlier plots (plots 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 analysis. Although outliers were typically removed for additional analysis to clarify the main groupings of samples, they were considered as valid samples in the final enumeration and description of types. Because the sampling scheme tended to under-represent the rare types, due to their rare biotic environments, these relatively unique samples were considered important. They were often the only representatives of rare associations or alliances defined from areas beyond the boundary of the study. In some cases, they represented unusual, undescribed plant communities and were viewed as affording perspective into unusual vegetation types that deserve further sampling.

Description Writing

Following the analysis of the plot data and the development of the draft key and classification, descriptions were written using the currently available template provided by the Association for Biodiversity Information (now NatureServe). Two primary writers were Michael Schindel (ABI Oregon Heritage program) and Sau San (California Native

Plant Society). Todd Keeler-Wolf (California Heritage) also wrote several descriptions and edited all of the descriptions, including all of the alliance-level descriptions. The plant community descriptions are available in Appendix B of this report.

Results And Discussion

A total of 97 plant communities were identified in the study area. This included 33 alliances with no associations described, 3 mapping units with no associations described, 25 alliances with one or more associations, and 3 mapping units with one or more associations. A detailed chart displaying these plant communities within the hierarchical NVCS and a custom plant community classification developed during this project is contained in Appendix C. A total of 64 new vegetation associations (most botanically detailed level of plant community designation) were described during this survey. An additional 17 variants were recognized because they contained structural or floristic patterns somewhat different from other stands in the type. However, there were insufficient samples taken to substantiate their validity as vegetation associations. Although not described, these variants are indicated in the vegetation key (where they are labeled as " preliminary" with their most dominant species used as an identifier). A total of 366 vegetation plots (training data) were sampled. Because this was one of the first systematic quantitative inventories of the plant communities of the Central Coast of California, 51 of the 64 described associations and alliances were not described prior to this study (Sawyer and Keeler - Wolf 1995). These are being incorporated into the continuously revised State and National Vegetation Classification Systems.

Analysis of the vegetation plot data identified eleven main ecological groups or mesoclusters (Table 2). The mesocluster designation was derived during the accuracy assessment phase of this project in order to increase the user accuracy of the photo-interpretation based vegetation map (see the accuracy assessment report section of this document). The membership of these groups is based on broadly shared ecological processes and vegetation, rather than on the USNVC hierarchy alone. Such groupings provide a more ecological perspective on the relationship between various associations and alliances, emphasizing the shared geographic, site, and disturbance factors that shape vegetation patterns. These mesoclusters may be considered as broad vegetation types within a biogeographic region that share similar habitats (e.g., ecological processes, abiotic factors, and environmental gradients) and that have broadly similar species composition. Mesoclusters are aggregations of vegetation sample plots that are broader than the standard National Vegetation Classification Alliance and Association definitions, but narrower, typically than the formation level in the National Classification hierarchy.

The mesocluster level plant communities were determined by analyzing the TWINSPAN and cluster analysis diagrams of the vegetation plots (see figure 3). Because these groups were typically defined by the mid-level breaks in TWINSPAN and Cluster Analysis algorithms, we call them "mesoclusters" indicating their mid-level position in the numerical classification of the plots. They are ordered below as they appeared from left to right on the first ordination axis selected in the final representative TWINSPAN run.

Table 2. The mesocluster level plant communities.

Freshwater wetland herb
Dune vegetation
Moist coastal grasslands
Drier grassland and open coyote brush scrub
Dense coyote brush and related scrubs
Forests dominated by California bay, Douglas-fir, and coast live oak
Forests dominated by tanoak and coast redwood
Riparian forests dominated by willow (*Salix* spp.) and red alder
Bishop pine forest - mesic chaparral (including chinquapin, sensitive manzanita, and blue blossom Ceanothus)
Xeric chaparral (including serpentine and non - serpentine types)
Salt marsh.

In addition to the mesocluster designation, we defined two additional levels within the custom classification hierarchy developed during the accuracy assessment phase of this project. The superalliance level which is more detailed, and the supercluster level which is broader than the mesocluster level. Please see table 1 for definition of these levels. Developing, defining and assigning the membership to the superalliance, mesocluster, and supercluster (Appendix C) was essential to providing a usable map product (see the accuracy assessment report included in this document).

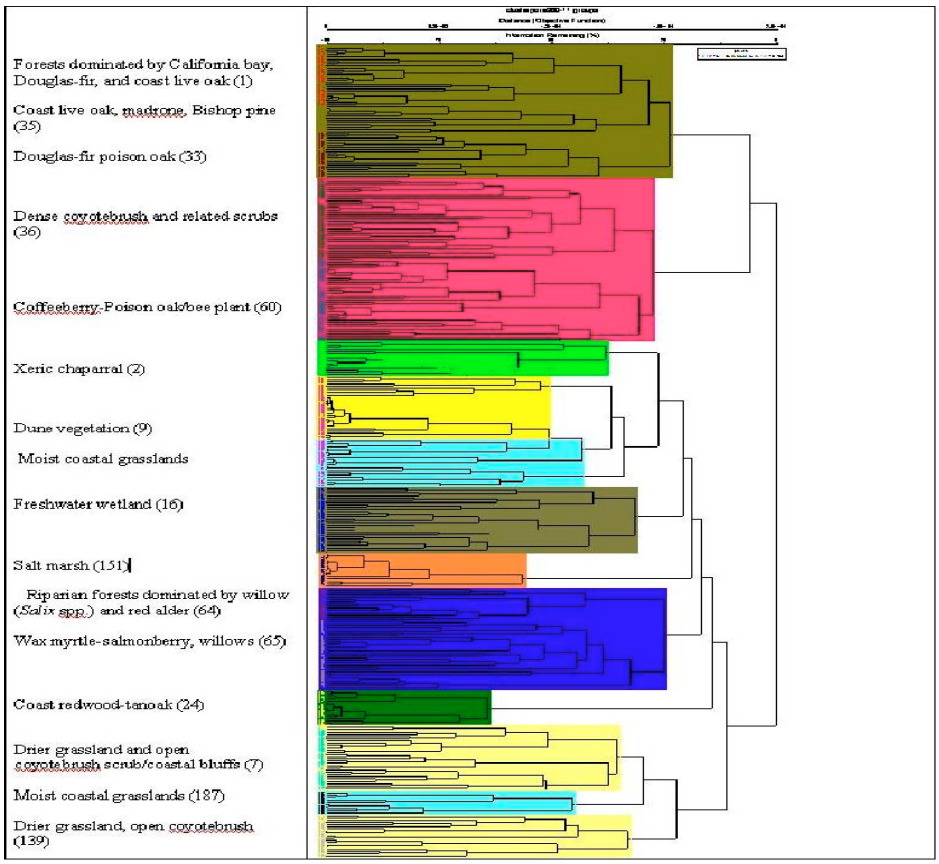
The difference between the USNVC, a floristic and physiognomic classification, and the true ecological relationships between the plant community types became apparent after an initial accuracy assessment had been completed. In order to provide a plant community map product with a reasonable level of thematic accuracy, while retaining as much botanical resolution as possible, we were required to look beyond the USNVC hierarchy. We derived our own classification hierarchy based on the results of the cluster analysis conducted on the training data. We settled on using The natural ecological groupings of the superalliance, mesocluster, and supercluster (Appendix C), These groupings did not always have a one-to-one relationship between the middle and upper hierarchical units of USNVC and their ecological setting. For example, the most extensive vegetation alliance, the coyote brush (*Baccharis pilularis*) alliance, had individual associations that occurred within dense coyote brush and related scrubs, moist coastal grasslands, drier coastal grasslands, and dune vegetation. Vegetation alliances characterized by the dominance of shrubs did not always fall into meso - cluster groups that were shrub - dominated. For example, plots of the hazel (*Corylus cornuta*) alliance were clustered within all plots that contained forests dominated by California bay, Douglas-fir, and coast live oak. These issues had bearing on the ability to assess the accuracy of the map in a meaningful way and drove the development of the superalliance, mesocluster, and supercluster groupings of plant.

Field survey methods resulted in a comprehensive survey of the vegetation at the alliance level. Additional use of the classification for a California Native Plant Society “Alliance-a-thon” in May 1999 netted only a few new minor additions in the Point Reyes portion of the mapping area. Following the use of the key for several months during the accuracy assessment phase of this project, several variants were found to not be included. At this

point, NPS staff began a major revision of the key. Specifically, several inconsistencies in percent cover cutoffs for different portions of the key were corrected, and several new types were added. The key was also made more user-friendly by creating links between vegetation types that are similar even though they are within different life forms.

The results of the opportunistic and iterative sample allocation proved to be somewhat effective. However, the associations described did not always fit our field plot species composition. A process where classification plots could be collected over a longer period and in an iterative manner (testing and re - testing the key and augmenting samples and modifying the key accordingly) would have produced a more complete plant community classification. Following the formal GRADSECT approach as suggested in the USGS-NPS vegetation mapping documentation also might have improved the sampling process.

Figure 3: Example of mesoclusters within a cluster analysis for the full data set of 366 plots. The different colored groupings are different mesoclusters defined in the Ward's method Euclidian distance cluster analysis (McCune and Mefford (1997). The coloring shows the extent of the mesocluster and indicates where the break in the cluster linkages occur, which define the uniqueness and distinctiveness (judged from Euclidian Distance, a similarity measure) of each mesocluster. Names on the left are generic labels for the 15 total groups of plots selected in this individual run of cluster analysis and the number in parentheses is the group name (defined by the first vegetation plot number in each group). These can be further aggregated up to the 11 final mesoclusters. Because the final mesocluster groupings were derived from the Twinspan analysis, which does not display well, this graphic does not show the final ordered arrangement defined in the report.



We suspect that closer to 500 plots of classification data would have been necessary to accurately and comprehensively complete the association-level classification. The predetermined minimum sample size of 3, required to author a new association definition used in this project, was used to strategize the number of plots we could afford to sample should have been increased to a minimum of five with a goal of ten plots. Ten 'training' plots is NatureServe's current recommendation for plant community classification projects.

Because the majority of the descriptions are based on the mapping area, and not beyond, we had a difficult time determining their range and conservation status. As noted in the descriptions (Appendix B), the range, species composition, and environment of these associations globally are currently impossible to define. It is likely that with further investigation we will discover that some of the minor associations defined in this study will be subsumed into more broadly defined associations.

Thus, as with all early classifications, these descriptions should be thought of as initial and subject to review following the collection of more data from similar vegetation elsewhere in coastal California. One interesting result of this study included the definition of at least five new alliances (Table 3).

Table 3. Some noteworthy new plant communities (alliances and associations) described for this study area.

Alliance	**Associations**
Coffeeberry (*Rhamnus californica*),	*Rhamnus californica/Baccharis pilularis/Scrophularia californica*
California wax myrtle (*Morilla californica*),	None defined
Sensitive manzanita (*Arctostaphylos nummularia*),	*A. nummularia/Vaccinium ovatum/Chrysolepis chrysophylla*
Hazel (*Corylus cornuta*),	*Corylus cornuta/Polystichum munitum*
Slough sedge (*Carex obnupta*),	*Carex obnupta/Juncus patens*
Rush (*Juncus effusus* var. *brunneus*)	None defined
Mt. Tamalpais manzanita (*Arctostaphylos hookeri* var. *montana*)	None defined

A much clearer understanding of the ecological relationships between the dune scrub, coastal terrace prairie, coastal scrub, and coastal forest and woodland communities was developed as a result of this study. In particular, many examples of the seral relationships between coastal grasslands and *Baccharis pilularis* alliance stands, their transition to more mature stands dominated by coffeeberry (*Rhamnus*), and the invasion of coastal scrub by Douglas-fir were documented during this project. Many grassland and shrub (*B. pilularis*) plots were difficult to key out to life-form (training and accuracy assessment) due to relatively high cover of *B. pilularis* in what was determined to be a grassland. Many sites within the study area are in this ecotonal or transitional state between the herbaceous and shrub life-forms. Similarly, Douglas-fir occurs at close to the cut-off level in many shrub plots presenting another common ecotone. The abundance and importance of these ecotonal areas is one of the reasons we developed a custom plant community classification, in addition to the NVCS, hierarchy during the accuracy assessment phase of this project. This allowed us to place more importance on ecological

similarity than on life-form when clustering plots to define group membership. The role of *Baccharis pilularis* alliance and related "northern coastal scrub" alliances in the central and north coast ranges of California has been shown to be complex. Some stands are clearly long lived and are products of long and relatively disturbance-free periods (this includes the local representative associations of the coffeeberry, blue blossom, holly-leafed cherry, and poison - oak alliances). Others are clearly shorter-lived and more transitional to forests (*Pseudotsuga* - *Baccharis* association), herbaceous wetlands and moist grasslands (*Baccharis pilularis / Carex obnupta* - *Juncus patens* Association, *Baccharis pilularis / Danthonia californica* Association, *Baccharis pilularis / Deschampsia cespitosa* Association), or drier grasslands (*Baccharis pilularis /* Annual grass Association, *Baccharis pilularis / Nassella pulchra* Association, *Baccharis pilularis* - *Rubus ursinus* / weedy herb Association).

The stability of chaparral and woodland / forest interfaces resulting from exposure and soil differences also became evident. Such examples stress the relative stability of these vegetation patterns and suggest moisture and soil permeability differences in the substrates or in their exposure allow these patterns to persist for relatively long intervals between disturbance such as fire.

The study area contains some of the best remaining patches of native coastal grasslands and graminoids in the state. These also have a complex history, and research would be required to fully understand the relationship between these plant's communities and the range of disturbance regimes they may experience.

Some of the most useful results of this study were the conclusions from the initial accuracy assessment. These enabled us to re-think the logic behind accuracy assessments and prompted us to develop the superalliance, mesocluster, and supercluster ecological groupings. We believe these techniques will be valuable for many additional vegetation mapping projects and will shed further light on the proper botanical and spatial resolutions to expect for mapping vegetation throughout the United States and the world.

Future Direction

During the accuracy assessment phase of the project, field crews sampled vegetation at more than 1600 plots throughout the study area. More than 100 of these plots were not keyable; many of them likely represent discrete plant community types that were not sampled during the training data collection phase of the project and therefore remain undescribed. In addition, the wetlands mapping program at PRNS and GGNRA have collected vegetation plot data at more than 500 sites; many of these plots were also not keyable using our current plant community key. Many of these un-keyable plots have been proposed by NPS staff as possible undescribed plant community types. Furthermore, most of the described types are only based on three plots. Therefore, the next phase and future direction of this work is to refine and update the plant community classification.

Within the next year and a half, we intend to run an ordination analysis that includes the more than 2,100 additional vegetation plot samples that were collected since the plant community classification presented in this report was conducted. This will solidify many of the existing types and will likely result in describing several new associations (and

possibly alliances) for our study area and a significant update to the plant community key.

Monitoring plant community change was ranked as one of the most important ecosystem indicators to monitor as part of the NPS's San Francisco Bay Area Network's Inventory and Monitoring Program. This future work will set the stage for the long term monitoring of plant community composition and will make it possible to detect plant community type changes in one of the most biologically diverse ecological sub-regions in North America.

Photo Interpretation

The first two parks mapped under the USGS-NPS vegetation mapping program- Assateague Island National Seashore and Tuzigoot National Monument utilized a vegetation layer mapping approach. Layer mapping consists of photo interpretation of multiple canopies of vegetation that are visible on the aerial photography. Canopies are normally defined by the structure of the vegetation (trees, shrubs, or herbaceous growth). Where possible, individual plant species were interpreted for each layer of vegetation. These data layers were then aggregated up into the appropriate alliance or community as defined by NatureServe. Subsequent parks, including the Nebraska grassland parks, Isle Royale National Park, Congaree Swamp National Monument, and Rock Creek Park elected to use another approach by mapping an initial photo signature type describing multiple vegetation canopies. These photo signature types were then translated into a NatureServe community type or alliance. Height, density and pattern attributes were also assigned to each polygon. Photo interpretation signature types are retained to further describe at a more detailed level the attributes visible on the aerial photography for each polygon.

PRNS & GGNRA - Initial Meeting

A one-day meeting was held on October 24, 1996 to bring together project team members from the National Park Service, ESRI, and NatureServe. This meeting focused primarily on discussing the Vegetation Inventory and Mapping Program, existing park data, and specific interests and issues of the park.

During the meeting, imagery, basemaps, and other pertinent collateral materials were reviewed and evaluated. Included in this inventory were the following data that were not used:

- Fire management plots
- EarthWatch plots (450 total) conducted from 1990 - 1996
- Range management data
- Wildlife surveys and habitat monitoring efforts (Tule Elk, Monarch Butterfly and 180 points with vegetation data showing neotropical migratory bird sites)
- Habitat restoration plots in alien species habitat
- Rare plant plots (300 sites)
- Digital ortho-photo quads

Park specific issues were also discussed. These issues are addressed below in the General Mapping Criteria.

Development of Photo Interpretation Mapping Procedures

The normal process to conduct plant community mapping using aerial photo interpretation is 1) conduct an initial field reconnaissance, 2) map the vegetation units through photo interpretation (PI), and 3) conduct a field based accuracy assessment. The field reconnaissance visit serves two major functions. First, the photo interpreter keys the signature on the aerial photos to the vegetation on the ground at each signature site.

Second, the photo interpreter becomes familiar with the flora, vegetation communities, and local ecology that occur in the study area. Park and/or NatureServe field biologists familiar with the local vegetation and ecology of the park were present to help the photo interpreter understand these elements and their relationship with the geography of the park.

Upon completion of the field reconnaissance, photo interpreters delineated vegetation units on mylar sheets that overlay the 9x9 aerial photos. This effort is conducted in accordance with the NatureServe vegetation classification and criteria for defining each community or alliance. The initial mapping is then followed by a field verification session. The purpose of the field verification trip was to verify that the vegetation units were mapped correctly. Any PI-related questions are also addressed during the visit.

The vegetation mapping at PRNS/GGNRA in general followed the normal mapping procedure as described in the above paragraphs with one major exception:

The photo interpretation team performed two revision efforts to the initial delineations and PI calls. The first set of changes reflected notes taken from field ecologists onto hard copies of the photo overlays during their sampling effort. The second set of changes reflected information gathered during the subsequent accuracy assessment efforts.

Development of Photo Interpretation Mapping Criteria

From the onset of the USGS-NPS Vegetation Inventory and Mapping Program, a standardized program-wide mapping criteria has been used. The mapping criteria contains a set of documented working decision rules used to facilitate the maintenance of accuracy and consistency of the photo interpretation. These criteria assist the user in understanding the characteristics, definition, and context for each vegetation community.

The mapping criteria for PRNS / GGNRA were composed of four parts:

- The standardized program-wide general mapping criteria
- A park specific mapping criteria
- A working photo signature key (see Appendix D)
- The NatureServe classification, key, and descriptions

General Mapping Criteria / Aerial Photography

The mapping criterion at PRNS/GGNRA conformed to the standards set for parks greater than 100,000 acres. The Minimum Mapping Unit (MMU) was 0.5 hectare. Photo interpreters mapped to the highest botanical resolution possible. This is normally to the alliance level in the NatureServe classification; however, during this project we attempted to interpret to the association level in most cases. Interpretation to the alliance or multiple-alliance mapping unit was done when association level mapping is not possible.

Upon completion of accuracy assessment, photo interpreters were required to scale back from an 86-class map to a more general 24-class map at the superalliance level in order to come close to meeting the 80% user accuracy standard suggested by the USGS-NPS vegetation mapping program.

Difficulties were incurred mainly due to the scale of available aerial photography. The photos used for this project had a larger (coarser) scale (1:24,000) than previously mapped parks. Large parks currently in progress have acquired photography at smaller (finer) scales. For example, Joshua Tree National Park with more than 800,000 acres is currently using 1:12,000 natural color photography. Yosemite National Park and environs with more than 1,000,000 acres is using photography at 1:15,800. Both parks also provided a set of diapositives which provide a higher resolution than the prints used for the PRNS / GGNRA effort. The USGS-NPS Vegetation Mapping Program specifies 1:12,000 as the scale of aerial photos for plant community mapping outside of the Alaskan parks.

Alliance / Community Associations

The assignment of alliance and community association to the vegetation is based on criteria formulated by NatureServe. In the case of PRNS/GGNRA, NatureServe provided AIS with a preliminary community classification in March 1997. A second draft of the vegetation classification, supported by plots, was delivered in February of 1999. Associated keys and descriptions of each alliance and association were completed in August 2003, after the photo-interpretation and accuracy assessment efforts were complete.

Park-Specific Mapping Criteria

The Vision Fire

The Vision Fire burned approximately 12,000 acres of federal, state and private land in October of 1995. Over 90% of the burned area was within the PRNS boundaries. Aerial photography was subsequently flown eight months after the fire for use in post-burn mapping and analysis but was not used for plant community assignment. A photo interpretation-based burned verses unburned GIS layer was created using these photographs. There are several limitations to the burn vs. unburned GIS data due to the date of the post-burn photography:

- The photography was flown too late (eight months later) to reliably determine which herbaceous polygons were affected by the Vision Fire. The subsequent rainy season and resultant herbaceous growth masked any reliable burn signature to herbaceous polygons.
- Shrub communities that became dominated by herbaceous growth (native and non - native grasses) after the fire have been assigned burn modifiers, but the vegetation map units were not split based on portions of polygons being affected by fire. The aerial photography did not yield a reliable enough signature to enable splitting of these polygons.
- Forested and woodland polygons were split in cases where only portions of these polygons were affected. The minimum mapping unit (approximately 5 - 10 hectares) rules for splitting the polygon was greater than the standard set for the plant community map.
- The aerial photography was flown too soon after the burn to detect the extensive regeneration of blue blossom (*Ceanothus thyrsiflorus*).

Because it was not possible to accurately delineate the burn within herbaceous and shrub polygons with a strong herbaceous component, a fire boundary should not be construed from this GIS layer. The burn modifiers are, however, especially useful in depicting forested and wooded areas within the Vision Fire burn that were not killed at the time the photography was flown. Many of these unburned areas were riparian areas, consisting of red alder (*Alnus rubra*).

Non-Native Vegetation

Invasive exotics are of particular concern in the study area. Every effort was made to map many of these types including broom, European beach grass, and blue gum eucalyptus below the MMU.

Native California Grasslands

Sensitive stands of native California grasslands for the most part cannot be mapped to the alliance or mapping unit level. Generally, it is not possible to detect the different native grasses apart on the photography, and tying these different species to unique environmental constraints was not attempted during this project. Therefore, a mapping unit, which used environmental parameters to detect grasslands with a significant native component, was created to aid field ecologists in further studying the distribution of native grasses in the region. Our assumptions in applying environmental parameters to the relative abundance of native grasses in a grassland polygon were only partially successful. The focus was mainly on "teasing" out the xeric species of natives such as *Nasella pulchra*. We applied the following abiotic factors:

- Steepness of the slope: steeper rockier slopes tended to have higher relative native component.
- Proximity to the coast: areas closer to the coast seemed to have higher native components.
- Lack of color variability in the signature: more color patterns especially in wetter areas (a splotchy signature) indicated higher forb component - probably not native.
- Direction of the slope: South and west slopes seemed to support more native grasses.
- *Nasella* with a non-native component was generally sparser.

Zero Value Data

Several polygons within the San Francisco Presidio, Alcatraz and Angel Island have values of zero. These three areas were not visited during either the reconnaissance or verification efforts, nor were any plot samples taken. Additional efforts to label these polygons will be required.

Working Photo Signature Key

A photo signature key is an important tool for maintaining consistency in interpretation. It correlates the physical descriptions of the photo signature with the appropriate vegetation community. A key may also describe other useful information that would be helpful in the interpretation.

For PRNS/GGNRA, a working photo signature key (see Appendix D) was developed during the initial mapping phase. The key was used to label the mapped units with a initial PI call, which guided the stratification for collecting training data. Field data collected during the reconnaissance effort were analyzed and compared with the aerial photos and any consistent correlation between the photo signatures and plant community types were noted. Each photo signature was then assigned a generalized vegetation type. This signature key was later modified to accommodate the final classification and further knowledge gained on the field verification trip and NatureServe/AIS follow-up meeting.

The final signature key (Appendix D) contains the photo signature characteristics, geographic settings, specific park example locations, and the associated NatureServe plant community.

NatureServe-TNC Classification, Key, and Descriptions

In February 1999, NatureServe delivered to AIS the PRNS/GGNRA classification supported by plots, which conformed to the National Vegetation Classification System. The Nature Conservancy, in partnership with the network of Natural Heritage Programs, developed this classification of vegetation of the United States as the National Vegetation Classification standard.

This classification, in addition to the field ecologists' notes and the working photo signature key (Appendix D), enables the photo interpreter to delineate, refine, and label the vegetation units interpreted of the aerial photography.

Project Set - Up

Several sets of aerial photography were provided for the project. The specifications for the aerial photography are listed below:

- NOAA 1:24,000 March 1994 Natural Color Prints covering PRNS, the northern portion and southern coastal portions of GGNRA, and the western two thirds of Mt. Tamalpais State Park
- Pacific Aerial Survey 1:24,000 August 1995 Natural Color Prints covering the southern portions of GGNRA and the San Francisco Watershed district
- Pacific Aerial Survey 1:24,000 November 1995 Natural Color Prints (Leaf Change) covering Samuel P. Taylor State Park and portions of the GGNRA
- 1:36,000 August 1991 Natural Color Prints (Leaf On) covering the eastern portion of Mt. Tamalpais State Park
- 1:12,000 August 1990 Natural Color Prints (Leaf On) covering Samuel P. Taylor State Park. (Supplemental data set - not interpreted off of)
- 1:12,000 June 1993 Natural Color Prints (Leaf On) covering coastal portions of Mt. Tamalpais State Park (Supplemental data set - not interpreted off of)
- Hammon - Jensen - Wallen 1:12,000 August 1996 CIR Prints and Diapositives (Leaf On) covering the Vision Fire Burn Area

- 1:12,000 April 1984 CIR Prints were provided to fill in small gaps in the Drakes Bay area
- Radman Aerial Surveys 1:12,000 April 1993 Natural Color Prints covering Angel Island
- Only the Black and White Digital Ortho Photography Quarter Quadrangles (DOQQ) (San Francisco NE) was available for Alcatraz Island
- During the latter part of the accuracy assessment phase of the project, multi-spectral $1m^2$ aerial imagery acquired in October of 2001 became available. This imagery was used to re-interpret specific plant communities that were difficult (low accuracy) on the 1:24,000 true color aerial photos. See the accuracy assessment section of this report for details.

Every effort was made to delineate beyond the study area boundary. A comprehensive administrative boundary map was not provided to use as a study area boundary, therefore, the vegetation map should not be used to determine administrative units.

Photo interpretation of non-vegetated intertidal zones that include, but are not limited to, sandy beaches, rocky shorelines, and mudflats have not been conducted for this study effort. A best approximation of the interface between the mean high water line and upland vegetation types denotes the boundary used in this study. This boundary was originally interpreted from the 1:24,000 base photography and later refined by using the DOQQ's during the rectification process of the polygons.

A general flight line index was created on an 8 ½" by 11" sheet of paper to show the principle sets of aerial photos used in the project. This index was used for quick reference to photo locations and as a status tool showing work completed on various portions of the project.

Preliminary Photo Signature Delineations

A total of 80 aerial photographs were needed to provide full photo coverage of the study area. Because of adequate control and sufficient overlap between flight lines and photos, it was determined that interpretation would be done on every other photograph.

Each photo was prepared with a 9" x 9" frosted mylar overlay for the photo signature delineations. Photo overlays were then pin - registered to the photos; project labels were affixed to each overlay identifying the photo number, status of work (Initial PI, QC), and photo interpreters responsible for that task. Study area boundaries were drafted onto each photo overlay, defining the area within the photograph to be interpreted. The study area boundaries were edge matched to adjacent photos to ensure full coverage.

Using a mirror stereoscope, with a 3X0 lens, photo signature units were delineated onto the mylar overlays. These initial photo delineations were based on a number of signature characteristics including color, tone, texture, relative height and density. The signature units were then edge matched to the adjoining photo before it was to be interpreted. Initial attribute codes (photo interpretation signatures) were assigned to the polygons along with the height and density values.

Photo interpretation did not begin until the initial field reconnaissance visit. Photo interpreters used the reconnaissance trip to train on the signatures that pertain to differentiating the plant communities. Without this fundamental knowledge, photo interpreters will either miss what is suppose to be a meaningful distinction between two communities or delineate areas which may be of no significant ecological interest, but may yield a difference in signature on the photos. One obvious example is a signature difference reflecting the varying health (greenness) of vegetation within the same community.

Field Reconnaissance Effort

A five-day photo interpretation field reconnaissance effort was conducted in March 1997. Initial descriptions of the units were soon after formulated into a working interim signature key to be used in labeling the polygons. The field crew consisted of Todd Keeler-Wolf - Vegetation Ecologist (CDFG), Sarah Allen - Science Advisor - Project Manager NPS, Randy Vaughn - ESRI Project Manager, Michael Schindel - NatureServe ecologist, Laura Nelson and Marcia Semenoff - Irving - GGNRA, Kim Cooper - field ecologist NPS, Dennis Odion - Marin County Water District, Lisa Cotterman and John Menke - AIS photo interpreters.

Prior to the field reconnaissance, several in-house preparations were performed in order to facilitate a more organized trip. Each photo was prepared with a separate field overlay. Registration and navigation features (roads, buildings, etc) were drafted onto the overlays. Each photo was reviewed, and field visit sites were chosen representing different signatures types, geographic variables (% slope, aspect, shape of the slope, elevation), and other abiotic variables noted on the photography. These sites were drafted onto the field overlays with notations to each site as needed. Multiple sites were chosen to provide alternatives if one or more sites proved inaccessible.

During the field visit, the photo interpreters worked with the field biologists to identify the plant species, preliminary vegetation communities, and their photo signature throughout the park. Field site numbers were annotated directly onto the photo field overlay, thereby correlating the field site to a specific location and photo signature. A field notebook was used to record pertinent information (canopy dominance, understory species present, abiotic features, disturbance history) for each site visited. Numerous ground photos were taken at selected locations that were later tied back to the aerial photographs and the field sites. Sites not previously identified on the aerial photos were also visited. These sites included areas between initially selected sites, areas of noteworthy or unusual significance as determined by park personnel, and areas the photo interpreter deemed important in transit from site to site.

Photo Interpretation of Vegetation

Photo interpretation is the process of identifying map units based on their photo signature. All land cover features have a photo signature. These signatures are defined by the color, texture, tone and pattern they represent on the aerial photography. By observing the context and extent of the photo signatures associated with specific vegetation types, the photo interpreter is able to identify and delineate the boundaries between plant communities, mapping units, or signature units. Additional collateral

sources (existing vegetation maps, supplemental photography, soil data, etc.) can be of great utility to the photo interpreter. Understanding the relationship between the vegetation and the context in which it appear is useful in the interpretation process. Familiarity with regional differences also aids interpretation by establishing a context for a specific area.

Initial photo interpretation of vegetation normally takes place after an interim plant community classification has been developed. After the draft linework is complete, a second field effort is undertaken in order to verify the accuracy of the preliminary linework and to verify initial PI signature calls. Because a plant community classification did not exist for PRNS or GGNRA, a rudimentary mapping classification was not in place at the time the photo interpretation started. A working mapping classification was completed soon after the reconnaissance visit, and copies were sent to the PRNS and NatureServe ecologists. Each polygon was then labeled with a preliminary photo interpretation (PI) signature code that reflected the preliminary mapping classification. Photos were edge matched to assure consistency of linework and labels across photo boundaries.

At PRNS / GGNRA, the initial vegetation map unit delineations along with their preliminary photo interpretation calls were used by the field ecologists to guide the sampling strategy for training data collection. The delineations proved extremely useful in the plot sampling effort. In addition, field ecologists were able to comment on polygons that were both sampled and visited for a number of areas. Cross-walking the data points and field comments from the southern portions of the GGNRA proved extremely difficult, however, because there were no field ID numbers on the working photocopies.

Collateral Source Vegetation Maps

Several collateral vegetation maps existed for various studies within the mapping area and are noted below:

- Angel Island vegetation map on 8½” by 11” sheet based on 1978 aerial photography.
- 1993 vegetation map of Tomales Point based on June 1974 aerial photography
- GAP vegetation map of the central coastal region
- UC Berkeley vegetation map of Muir Woods National Monument
- Marin Municipal Watershed vegetation map

Unfortunately, a vegetation map, which was believed to exist for the San Francisco Watershed District, was not made available for use in this project.

Photo Interpretation Field Verification

A three-day photo interpretation field verification trip was held in February 1999. This effort focused primarily on verifying and/or refining photo signature units and substantiating the associations attached to each polygon.

Preparation for the field verification involved three steps: 1) Locating the NatureServe sample plots on the photo overlays, 2) Choosing representative areas for each community type to review in the field, and 3) Compiling photo interpretation question forms in order to plan a strategy for the three-day effort. Although AIS chose specific areas of focus, other portions of the study were checked for both line and label accuracy.

While in the field, notes were made directly onto the PI overlays using a red Pentel. This helped in establishing which polygons were actually visited during field verification and assisted in refinements of the codes and line-work back at the office.

A satisfactory correlation between the photo interpretation calls and field visits were established for many plant community types. Important limitations to the mapping project were noted, however; several important examples are listed below. Refer to the Accuracy Assessment section of this report and the photo interpretation key (Appendix D) of this report for a set of comments regarding mapping limitations by type.

- Aerial Photography used was flown after the Vision Fire.
- Environmental parameters that were assumed to differentiate native grassland alliances or associations were not reliable.
- A significant reduction in the total area of yellow bush lupine (*Lupinus arboreus*) has occurred since the time the photography was flown.
- A reliable photo signature could not be established for several plant communities previously thought possible to separate out. They include:
    1. Canyon live oak
    2. Manzanita species other than sensitive manzanita (*A. nummularia*)
- Several associations and or alliances needed to be combined due to heterogeneity or small size. They include:
    1. Coast buckwheat alliance - Polygon units were too small and will be included in with a coyote brush - California sagebrush association.
    2. Dune sagebrush alliance and dune lupine - goldenbush alliance both occur on coastal dunes too small to separate out on the photography. Individual communities of each type are often only a few square meters in size.
    3. Several willow communities were merged into the willow mapping unit due to heterogeneity between very similar communities. These are often discernable on the ground but not on the 1:24K photos.

Photo interpretation is performed to the highest level deemed possible at the time. Subsequent accuracy assessment (AA) efforts resulted in dissolving some line - work and community labeling up to a more general level. See the accuracy assessment section of this report. It is usually desirable to map at the most detailed level possible in that it is much easier to dissolve out erroneous line-work than to split existing polygons in the database based on too general a mapping classification.

Final Photo Interpretation

After the field verification effort, AIS proceeded with the next revisions to the photo interpretation line-work and community calls. Each polygon was reviewed in conjunction with the notes taken during the field reconnaissance effort and data from the plot sampling effort.

Photo overlays were then edge matched to the adjacent photo to ensure a seamless coverage in the database. Delineations and codes were compared, and discrepancies between photos were resolved and corrected on mylar overlays. Any uncertain interpretations were flagged on the mylar overlays for review during the quality control task.

Quality Control of the Photo Interpretation

A senior photo interpreter on staff reviewed each photo for line-work accuracy and accuracy regarding the PI signature and NatureServe community codes. The photo overlays were also checked for completeness, consistency, and adherence to the mapping criteria and guidelines. For those polygons flagged by the photo interpreter, the quality control reviewer either assigned the appropriate vegetation code and/or discussed the change with the interpreter.

Data Conversion

Converting the vegetation delineations to a digital format involved four main procedures:

- Geo-referencing (rectifying) photo overlay line-work to the DOQQ's.
- Creating manuscript (digital quality) overlays and related attribute files.
- Input of spatial data into digital format (scanning).
- Linking the spatial data with the fields from the attribute files.

Basemap Production

In order to begin the data conversion process, a hardcopy version of the base was needed. The designated base was the USGS digital orthophoto quarter quads (DOQQ's) series for all or portions of fourteen USGS 1:24,000 topographic quads.

Creation of the DOQQ hardcopy base required having the image plotted onto clear mylar at the mapping input scale, approximately 1:24,000. To facilitate the geo-referencing of the polygons, it was determined that the average (nominal) scale of the aerial photography was also approximately 1:24,000. Forty-three plots were generated at the normal scale on mylar overlays to cover the entire study and its environs.

Manual Rectification - Heads Up Digitizing

The first step in geo-referencing the vegetation polygons delineated on the photo overlays involves manually fitting the line-work to hard copies of the DOQQ's. This was a highly labor intensive procedure that adjusts for distortion in the aerial photography caused by topography and distance from the photo's nadir.

Manual rectification was conducted by attaching a new mylar overlay to the hard copy DOQQ. The photo signature delineations were transferred to the overlays through local

registration of the photos with the attached photo signature delineation overlay. A small area of the photo was registered to the base at a time. By matching photo image to orthophoto image, the delineations were transferred to the base overlay. Because the parallax of the photo differs from that of the orthophoto base, care was required in transfer. Inconsistent stretching or shortening of the images was common from the photo to the base. When one area was completed, the photo was shifted to register to another small area. The process continued until the manual rectification and transfer of polygons was complete. Three code attributes were placed on the overlays: 1) Values containing alliance (series) / association codes, 2) Height, and 3) Density attributes. These codes were transferred from the corresponding photo overlays.

A quality control step was performed in order to assure accuracy of the rectification and delineation and transfer of the codes. A senior interpreter reviewed the overlays for accuracy and completeness of transfer and made the appropriate changes where needed.

This procedure was performed for approximately half of the more complicated portions of the study. The remaining modules had line-work directly transferred from the photo overlays to the DOQQ's in an ArcView environment. This heads up digitizing procedure eliminated several interim steps including attribute assignments, manuscript map preparation, sequence number assignments, polygon encoding and scanning.

DOQQ Edge Problems

Several minor inconsistencies were noted between DOQQ's. These problems were evident along some of the quad boundary edges, however; all discrepancies were below 10 meters.

Manuscript Map Preparation

Approximately twenty manuscript maps (roughly half the study area) were created to input the spatial component of the vegetation mapping units. The manuscripts were produced by pin-registering a clean sheet of mylar to the base. The vegetation delineations from the manually rectified overlays were transferred to the new overlays using black P2 Pentel lead suitable for scanning. The manuscript maps were carefully edited to ensure completeness and correctness. The editing included comparing the manuscripts with the original delineations on the aerial photos.

Quality Assurance of the Manuscript Maps

The final manuscript maps underwent a quality assurance review. The manuscript maps were compared to geo-referenced (rectified) overlays to ensure that all line-work was transferred correctly. Particular attention was given to the quality of the line delineations with respect to gaps and other irregularities.

Sequence Number Assignment

Sequential identification number overlays were produced for the manuscript maps. A clean sheet of mylar was pin-registered to each manuscript, and each polygon was labeled with a unique sequence number. These sequence numbers were used to relate the spatial files to the tabular attribute files.

Polygon Attribute Encoding

To expedite the encoding of the vegetation attributes for each polygon, a Quattro Pro spreadsheet file was created for each sheet. A separate field was created for the polygon sequence number, PI code, height code, density code, and Vision fire burn attributes. The manuscript maps, sequence number overlays, and attribute overlays were pin - registered together on a light table. The coder, following the numbers on the sequence number overlays, entered the vegetation attributes for each polygon. During this task, the coder verified the accuracy of the sequence number labels. Any errors found on the sequence number overlay were corrected to ensure that each polygon had a unique identifier.

Spatial Data Input / Scanning

The manuscript maps were scanned and converted into ARC/INFO coverages at ESRI. Prior to any production scanning, test scans of small areas of the data map were conducted to determine the optimum raster to vector conversion settings. The critical settings that determine the output resolution and completeness are the TOLERANCE and THRESHOLD. The TOLERANCE, which governs the output resolution and is comparable to fuzzy tolerance, would be set to .01 inches (10 feet at 1:12,000 scale). The THRESHOLD is a reflectance measure. It is dependent on the physical characteristics of the data maps and their contents and is determined through testing. Once the THRESHOLD was derived, production scanning of manuscript maps began.

Assigning Polygon Identifiers

In an earlier step, the vegetation polygons were assigned a unique identifier. The numbers were sequenced 1 through "n" (4 - digit item width) and were drawn on the sequence number overlays. The manuscript maps and the sequence number overlays were registered together on the digitizing board. The polygon identifiers were sequentially input as label points. To ensure that all labels points were entered, the processor marked off each label as it was digitized.

Creation of Topology

Topology is the mathematical procedure for explicitly defining spatial relationships. In the case of maps, topology defines connections between features and identifies adjacent polygons. Once the manuscript map's polygon boundaries and label points had been input into the computer, the ARC / INFO software CLEAN command was used to create the "coverage topology." The CLEAN fuzzy tolerance was set to .002 inches to preserve the required data resolution. When other coordinate edits were made to a coverage after the CLEAN command was run, topology was recreated utilizing the BUILD command.

Label Entry Error Processing

Missing labels were identified by using the LABELERRORS command in ARC. Using ARCEDIT, any label errors identified were corrected by entering the missing label number and placing it within the correct polygon. Once all the errors were corrected, the coverages were joined with the tabular attribute data.

Joining of Attribute and Spatial Data

The Quattro Pro code file was converted into an INFO file. Once converted it was related to the feature attribute table by the sequence number found in both files. An INFO item, named "SEQNO" was added to the feature attribute table. The sequence number for each polygon was calculated to equal its coverage I.D. number. The ARC/INFO command JOINITEM was used to join the code file to the feature attribute table. The spreadsheet file was joined with its corresponding coverage. Each variable interpreted from the aerial photography was provided with a unique field (item).

Code Verification and Edit Plot Quality Assurance

Code verification involved running each coverage attribute file through a series of ARC / INFO commands that checked for invalid codes. These commands produced listings that aided in identifying abnormal codes. The errors were checked against the vegetation delineation and attribute overlays. Corrections were made to the listings and input into the database.

ESRI produced a plot of the converted spatial data and sequence numbers (label I.D.s) for each manuscript. The plot was checked by AIS for cartographic quality of the arcs defining the polygon features and the accuracy of the label I.D. assignments. The plots was overlaid to the manuscript maps to verify that the scanned data was not distorted beyond .02 map inches. Other problems were noted on the plots, including line overshoots and undershoots, missing lines, premature convergence of polygon boundary lines that intersected arcs at acute angles, and incorrect sequence number assignments.

ESRI also produced code verification plots of the PI codes, height codes, and density codes. The plots were checked by AIS for coding errors that may have occurred during the polygon attribute encoding step. The plots were overlaid on the corresponding manual rectification code attribute overlay. Code changes were noted on the plot.

Final Quality Assurance of the Vegetation Map

Once the rectifying of the polygon data was completed and the attribute items populated, a final on screen review of line - work and community designations was performed in an ArcView session. Any final corrections to the community association assignments were then made to the database. Revised coverages were mapjoined to create a single coverage.

Accuracy Assessment

Introduction

Accuracy assessments (AA) of the 86 vegetative mapping units was initiated after a first draft of the vegetation map was delivered to the NPS. The number of sites visited for each mapping unit was determined based on the number of occurrences of each type which ranged from one to over 1,000 (Table 4). Fieldwork for the assessment occurred during the growing season of 1999, 2000, and 2001.

Methods

Accuracy Assessment Sample Allocation

Following the training plot sampling, analysis, development of the draft plant community key, and GIS plant community map, ecologists and air photo interpreters convened to discuss the allocation of accuracy assessment points. The lead aerial photo interpreter provided an accuracy estimate for each plant community or mapping unit delineated on the map. Based on the photo interpreter's estimation of their accuracy, the heritage ecologist derived the sample sizes required for an accuracy assessment of each map type. The USGS -- NPS vegetation mapping program suggests that accuracy assessment point sample size be adequate to provide a significance level of 0.01 (90% confidence level) on the accuracy assessment results.

The formula for the suggested sample size was calculated using the normal approximation from the binomial distribution based on Cochran (1977).

- $n = (t^2pq) / d^2$
- n = number of samples
- t = abscissa of a normal curve that cuts off an area of a (alpha)
- p = estimated variance, proportion correct
- q = 1 - p
- d = discrepancy.

For this sampling exercise, the following parameters were set for all classes: alpha = .05, t = 1.96, d = .15, p is estimated for each class in the table below, under the column Estimated Proportion correct.

For the first class, the number of samples, n, is calculated by:

- $n = (1.96^2 * .95 * .05) / .2^2$
- n = (3.8416 * 0.0475) / .04
- n = 4.5, or rounded up, 5 samples

In brief, the two primary considerations for selecting sample size are 1) the "p" level, an estimate of how accurately the photo interpreters labeled a particular vegetation type in the mapping effort and 2) the "d," or margin of error in the estimate of how well we guessed the accuracy of a given vegetation type to be based on the actual accuracy of the vegetation type (known as upper case "P") and the estimated accuracy (lower case "p" as

described above). In general, as certainty in the "p" value increases, the number of samples required for accuracy assessment goes down. As the allowable discrepancy ("d") between the actual accuracy ("P") of a mapping type and its predicted accuracy ("p") increases (e.g., you are more lenient about the margin of error), the fewer samples required. These concepts are further discussed in Cochran (1977) and Congalton and Green (1999). In most cases, we set the margin of error between the actual and predicted accuracy to be 15% (a generally used estimate in accuracy assessment). In some cases where there are not enough polygons of a certain type to make the calculated sample size, we have dropped the margin of error to allow for fewer samples. Accuracy assessment points sample size allocation is displayed in Table 4.

The assessment was initiated as a producer accuracy oriented approach (for a given plant community type on the map, how well did it match what was on the ground) because accuracy assessment field data was not collected at the same time as the training data. Accuracy assessment points were stratified based on the map's polygons rather than the plant community type on the ground. Therefore, the producer accuracy oriented approach in selecting the sample size for each type was the only option. The producer accuracy approach is advantageous because fewer accuracy assessment points will be thrown out for not be in representative portions of the assessment polygon. (The user accuracy approach usually relies on collecting field data prior to the delineation of plant community polygons, and, therefore some points are likely to be either too close to the polygon edge or in unrepresentative portions of the photo-interpreted polygons). The producer accuracy approach's primary limitation is that certain plant communities may be under sampled during the accuracy assessment if they were consistently confused with other types by the photo interpreters. Managers and researchers are more interested in user accuracy (for given plant community type on the ground how many were correctly labeled on the map). Therefore, user accuracy is emphasized in this report. The results of the accuracy assessment, a series of confusion matrices reporting user and producer accuracy are available in Appendix C.

Selection Criteria for Accuracy Assessment Polygons

Initially, the photo interpreters desired field crews to completely assess the accuracy assessment polygon. However, covering each assessment polygon in its entirety was deemed impossible due to the nature of the terrain, the number of samples required (1,600), and the budget. Therefore, a point (0.5 Ha plot) assessment approach was adopted.

Because only a portion of the approximately 12,000 polygons could be field checked due to time and budget constraints, a random selection was desired, so that the results of the sample selected could be an indicator for map accuracy. The sample selection was constrained to public properties, and selected private properties for which access was granted. Accuracy assessment polygons were selected using the following guidelines:

1) Select all polygons in the sample frame of properties accessible. Eighty percent of all polygons sampled were chosen to be within 300 meters of roads and trails.
2) Remove as candidates for selection any polygon that had been visited during training data collection.

3) For each class to be assessed, use a random number generation to select *n* polygons. A standard ArcView script was used to do this. The random selection process is based on record number, giving equal probability to both small and large polygons.
4) Centroids of all polygons were inspected in a GIS with a DOQ backdrop. In cases where centroids did not fall within a representative portion of the polygon, the point was manually moved to a representative location within the polygon. Some polygons were rejected due to inaccessibility.

Field Data Collection for Accuracy Assessment

Field crews navigated to the plot centers that were selected using GIS in the office (described above). This often required hiking off trail through dense vegetation. The field crews were provided with maps delineating the assessment polygon and centroid. Although centroids were placed in representative areas of the polygon based on DOQs, as crews navigated to the plot they made a determination whether or not the centroid was actually representative of the entire polygon. After field crew members agreed on a sampling location, they assessed an area of 0.5 Ha. surrounding the plot center. The dimensions were often square, however, crews were permitted to use a shape that best represented the polygon as long as the area was 0.5 Ha. Crews collected plant composition as absolute percent cover for all species with at least 1% cover and percent cover and height information for each life form. Crews then keyed out the plant community and recorded a level of confidence they had in the determination. If the polygon obviously contained more than one plant community, this was also noted. Crews recorded detailed comments describing the plot, the polygon and how well the draft plant community key worked for the vegetation at the site. GPS coordinates were recorded and a digital photo was taken.

Accuracy assessment field data was entered into an MS Access database that automated the comparisons of field data plant community determination with the photo interpreters plant community label and generated confusion matrices. Any accuracy assessment point where the field staff's plant community call did not match the photo-interpreter's call was flagged for review. These flagged accuracy assessment plot data were then reviewed for several factors: 1) does the plant composition data lead the reviewer to the same plant community call as the field crew? 2) is the plot within 10 meters of the polygon' edge (GPS error is +/- 10m for the PLGR+ that was used on this project) ? and 3) is the plot in a representative portion of the polygon (based on viewing it in a GIS with aerial imagery)? If the reviewer answered 'no' to any one of these questions, the plot was removed from the set of field plots that was used for the next accuracy assessment and set of confusion matrices. The final distribution of accuracy assessment plots is displayed in Figure 4.

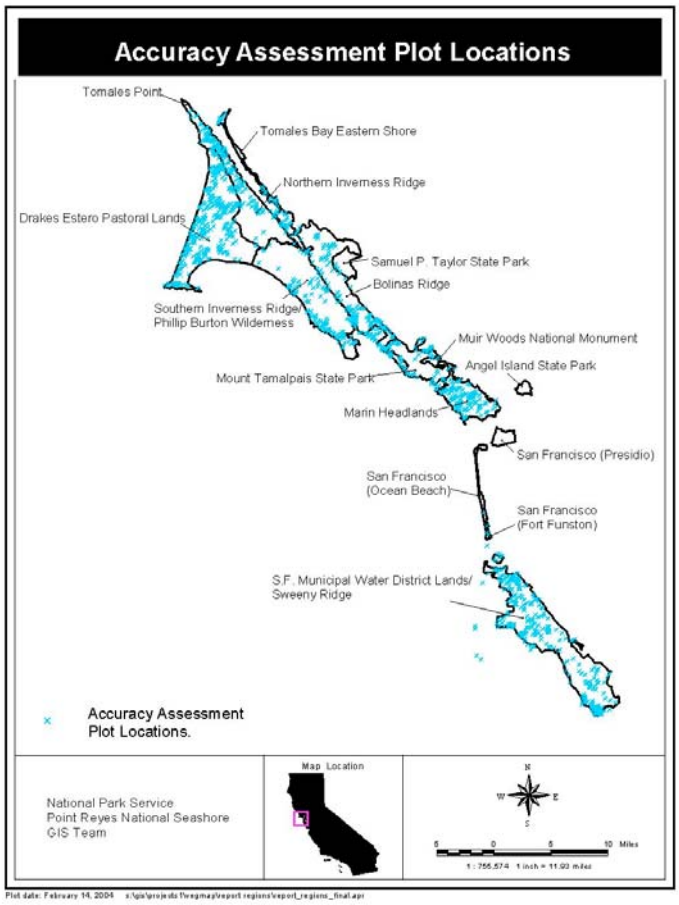
After running this set of confusion matrices, another round of accuracy assessment plot data review occurred at a meeting during July of 2002 at the offices of Aerial Information Systems (AIS) in Redlands, CA. Staff from PRNS along with staff from AIS, the Heritage Ecologist, and ESRI reviewed more than 200 plots that the photo-interpreters had questions about. Between these two accuracy assessment plot review sessions, about

400 out of the 1,600 plots were removed from the set that was used to generate the final set of confusion matrices presented in Appendix C.

Table 4. The suggested sample size for accuracy assessment points for each plant community type along with the actual number of samples of that type collected on the ground. Included for reference are the total number of polygons for each mapped plant community type , and land area of each mapped plant community type. The suggested sample size was based on the number of mapped polygons of each type and therefore appropriate for assessing producer accuracy. However, not all of the mapped polygons were correctly labeled. Therefore, the actual sample size is listed because this was the sample size used to assess user accuracy.

Mapped Vegetation type	PI Code	Predicted Accuracy	Suggested Sample Size	Percent selected of total	Total Number Polygons	Percent Polygons	Acres	Percent Area	Plots Used for User Accuracy	Percent of AA Plots
California Bay	1010			60%	45	0.40%	243	0.18%	27	2.21%
California Bay/ Tanoak	1011	75	100%	9%	23	0.21%	356	0.26%	2	0.16%
California Bay/ Sword fern	1012	70	13%	8%	271	2.43%	3705	2.70%	21	1.72%
California Bay/ Coast Live Oak/ Poison Oak	1014	70	10%	5%	350	3.13%	3829	2.79%	18	1.47%
Eucalyptus	1030	90	9%	3%	180	1.61%	998	0.73%	5	0.41%
Tanoak	1070	80	100%	70%	20	0.18%	221	0.16%	14	1.15%
Giant Chinquapin	1090	85	96%	17%	23	0.21%	69	0.05%	4	0.33%
Douglas fir	2010	90	3%	6%	468	4.19%	9076	6.62%	27	2.21%
Douglas fir/ California Bay/ Sword fern	2011	90	4%	3%	376	3.37%	8321	6.07%	10	0.82%
Douglas fir/ Coyote Brush	2012	90	7%	11%	215	1.93%	1151	0.84%	24	1.97%
Douglas fir/ Coast live oak	2013	80	17%	8%	165	1.48%	2745	2.00%	13	1.06%
Douglas fir/ California Bay/ Coffeeberry	2015	90	11%	6%	141	1.26%	1229	0.90%	8	0.66%
Douglas fir/ Tanoak / Coffeeberry (preliminary)	2020	70	100%	8%	26	0.23%	256	0.19%	2	0.16%
Coast Redwood	2050	90	12%	28%	129	1.16%	1354	0.99%	36	2.95%
Coast Redwood/ Tanoak/ Huckleberry	2051	85	47%	36%	47	0.42%	1528	1.12%	17	1.39%
Coast Redwood/ Douglas fir/ California Bay	2052	90	15%	5%	108	0.97%	2076	1.52%	5	0.41%
Bishop pine	3030	90	7%	5%	227	2.03%	2730	1.99%	12	0.98%
Bishop pine/ Madrone/ Huckleberry	3031	80	70%	25%	40	0.36%	854	0.62%	10	0.82%
Monterey Cypress or Monterey Pine	3120	90	9%	8%	185	1.66%	1114	0.81%	15	1.23%
Mixed Willow "Super Alliance" Mapping Unit	7060	70	55%	3%	66	0.59%	328	0.24%	2	0.16%
Red Alder	7070	90	100%	100%	3	0.03%	4	0.00%	16	1.31%
Red Alder/ Salmonberry/ Red Elderberry	7071	70	54%	13%	67	0.60%	1005	0.73%	9	0.74%
Red Alder/ Arroyo Willow	7072	70	55%	20%	66	0.59%	751	0.55%	13	1.06%
Coast Live Oak	12020			33%	24	0.21%	140	0.10%	8	0.66%
Coast Live Oak/ (Madrone)/ California Bay	12021	80	6%	5%	489	4.38%	4670	3.41%	23	1.88%
Coast Live Oak/ Poison Oak	12022	85	8%	5%	282	2.53%	2959	2.16%	13	1.06%
California Buckeye	14020	70	100%	42%	12	0.11%	72	0.05%	5	0.41%
Yellow Bush Lupine	19010	80	74%	32%	38	0.34%	278	0.20%	12	0.98%
California Wax Myrtle	20010	70	31%	24%	42	0.38%	116	0.08%	10	0.82%
Blue-blossom	20020	75	72%	22%	46	0.41%	287	0.21%	10	0.82%
Hazel	30010	85	48%	9%	46	0.41%	176	0.13%	4	0.33%
Chamise	21110	90	15%	15%	104	0.93%	1053	0.77%	16	1.31%
Chamise/ Eastwood Manzanita/ Interior Live Oak	21140	75	53%	10%	62	0.56%	232	0.17%	6	0.49%
Coffeeberry	21460	80	15%	5%	184	1.65%	2003	1.46%	9	0.74%
Mixed Manzanita Mapping Unit	21470	75	79%	10%	42	0.38%	263	0.19%	4	0.33%
Sensitive Manzanita	21480	90	100%	33%	15	0.13%	75	0.05%	5	0.41%
Mixed Broom	24040	80	35%	26%	81	0.73%	252	0.18%	21	1.72%
Coyote Brush/ California Sagebrush/ Poison Oak/ Coyote Mint	24051	75	12%	12%	275	2.46%	3232	2.36%	34	2.78%
Coyote Brush/ Yellow Bush Lupine	24052	70	14%	3%	258	2.31%	2038	1.49%	8	0.66%
Coyote Brush/ Sword fern	24053	70	52%	20%	25	0.22%	371	0.27%	5	0.41%
Coyote Brush/ Blue-blossom/ Purple Needlegrass	24054	80	64%	11%	44	0.39%	504	0.37%	5	0.41%
Coyote Brush/ Coffeeberry/ Thimbleberry	24055	80	8%	3%	365	3.27%	4478	3.27%	11	0.90%
Coyote Brush/ Purple Needlegrass	24056	70	75%	54%	48	0.43%	276	0.20%	26	2.13%
Coyote Brush/ Native Grassland Component	24058	80	16%	6%	176		1756	1.28%	10	0.82%
Coyote Brush/ Poison Oak	24059	85	2%	4%	1165		12517	9.14%	46	3.77%
Coyote Brush/ Lizardtail	24060	80	41%	15%	68		550	0.40%	10	0.82%
Coyote Brush/ Slough Sedge/ Rush (J. patens)	24063	75	29%	15%	113		575	0.42%	17	1.39%
Coyote Brush/ California Blackberry/ Weedy Association	24064	75	13%	6%	248		2635	1.92%	15	1.23%
Coyote Brush/ Non-native Grasslands Mapping Unit **	24065	80	2%	6%	432		4813	3.51%	24	1.97%
Coyote Brush/ Hazel	24066	70		73%	11		103	0.08%	8	0.66%
Coyote Brush/ Holly-leaf Cherry	24067	75	100%	8%	12		82	0.06%	1	0.08%
California Sagebrush	24080	75	100%	100%	12		147	0.11%	12	0.98%
Salmonberry	30050	75	75%	38%	16		63	0.05%	6	0.49%
Arroyo Willow (shrub form)	32080	70	12%	8%	301		1236	0.90%	24	1.97%
Pacific Reedgrass/ Coyote Brush	46021	70	37%	11%	35		142	0.10%	4	0.33%
Pacific Reedgrass/ Sedge/ Rush	46022	70	72%	46%	50		497	0.36%	23	1.88%
European Dunegrass	47010	95	11%	12%	82		822	0.60%	10	0.82%
Introduced Perennial Grasslands Mapping Unit	47030	80	17%	29%	161		1636	1.19%	46	3.77%
Saltgrass	51010	85	34%	23%	64		252	0.18%	15	1.23%
Rush	52030	90	6%	10%	268		1354	0.99%	27	2.21%
Tufted Hairgrass	52040	70	45%	17%	29		417	0.30%	5	0.41%
Unit	55020	90	29%	4%	55		256	0.19%	2	0.16%
Cordgrass	56010	80	59%	18%	17		84	0.06%	3	0.25%
Iceplant	62040	90	17%	18%	92		656	0.48%	17	1.39%
Dune Sagebrush/ Goldenbush Alliance Complex Mapping Unit**	62060	80	27%	7%	105		705	0.51%	7	0.57%

Figure 4. Location of accuracy assessment plots.



RESULTS

Development of "Fuzzy Logic" for Accuracy Assessment

As this was the first map produced using the new USGS and NatureServe specifications for vegetation mapping in National Parks that was done in California, it was taken to be an experiment in photo interpreters' ability to discern vegetation patterns at different levels of botanical resolution in the USNVC (see the photo interpretation section of this report). The philosophy of this mapping effort was to strive for the most accurate and botanically detailed photo-interpretation-based plant community map possible, with the understanding that there would likely be a need to "back-off" to less detailed levels of classification hierarchy to achieve the desired user accuracy of 80%.

Due to the high probability of year to year variation of vegetation, the relatively low resolution (1:24,000) of the original aerial photographs, the March date of the aerial photography (the ideal timing for aerial photo acquisition in the study area is late June), and the high physical similarity of many vegetation types within the mapping area, we suspected that a simple "yes" or "no" for accuracy would yield disappointing and un-meaningful results. Many of the vegetation types are so physically similar that it takes a

detailed field-based estimate of cover of the component species to determine if a type is a member of one association or another. Many of these associations and alliances are ecologically similar as well. Thus, the aerial photo-identification of these visually and ecologically similar vegetation types was expected to be relatively imprecise.

A common accuracy assessment procedure compares the label assigned of a polygon in the map (map label) with the 'field call' of the same polygon using a field evaluation (ground truth) sites. Using a traditional method, only one possible answer (considered to be the best answer by an 'expert' in the field) is compared to the map label. However, vegetation map classes do not always lend themselves to unambiguous measurements. While a map label of *Pseudotsuga menziesii / Umbellularia californica / Polystichum* association may be considered absolutely correct for a particular site, a user might consider acceptable a map label of *Pseudotsuga menziesii* Alliance. An alternative method for evaluating map accuracy, and the one chosen for use in this assessment, is based on the use of fuzzy sets, first developed by Gopal and Woodcock (1994). The use of fuzzy sets to evaluate vegetation maps has now occurred on vegetation maps of the Stanislaus National Forest (Woodcock and Gopal 1992) the Modoc and Lassen National Forests (Milliken et al 1997) the four southern California National Forests, (Franklin et al. 1999), Suisun marsh (Keeler-Wolf et al. 2000) and others. We used a modified fuzzy logic approach based on the plant community classification hierarchy.

Instead of developing different levels of "correctness" for all the various combinations of field-assessed versus photo-interpreted plant community types possible (the usual approach for a fuzzy assessment), we assessed the accuracy at different hierarchical levels within the USNVC and within the customized plant community hierarchy developed specifically for this study area during the accuracy assessment phase of the project. This method allows the user to choose a level that best suits their requirements for botanical resolution versus thematic accuracy. If we could not achieve an acceptable level of accuracy at the most detailed 'association' level of the hierarchy, we could move up to the alliance level. Initially, the hierarchy within the USNVCS was used to 'roll up' the plant community classification and determine overall accuracy values for the plant community map. However, this approach did not yield satisfactory results; the desired 80% accuracy was not reached even at the 'Group' level (within the USNVCS), which contained only eight plant community types. This problem drove us to develop the custom, ecologically-based hierarchical, three-level, classification. The three levels in this classification hierarchy named (beginning with the most detailed) superalliance, mesocluster, and supercluster were based on ecological similarity and the results of the initial TWINSPAN clustering that was used to create the initial classification. The full plant community classification displaying both the USNVC and the custom one created for this project is available in Appendix C. Although the custom classification developed for this project occurred during the accuracy assessment phase of the work, it is discussed in the plant community classification section of this report above.

Table 4. The overall accuracy for the levels in the USNVCS and custom plant community hierarchies.

Level	**Primary Basis For Classification**	**Number of Classes**	**Number of Classes with ≥ 80% user accuracy**	**Number of Classes with upper confidence interval (95%) ≥ 80% user accuracy**	**Overall Accuracy**
Group	Leaf types, corresponding to climate	8	2 (25%)	5 (63%)	77.6%
Formation	Additional physiognomic and environmental factors, including hydrology	21	2 (10%)	15 (71%)	71.1%
Alliance	Dominant/diagnostic species of uppermost or dominant stratum	49	9 (18%)	35 (71%)	64.3%
Association	Additional dominant/diagnostic species from any strata	86	8 (9%)	35 (41%)	44.7%
Superalliance (Microcluster)*	Groups vegetative associations based on shared dominant species and other shared floristic, physiognomic and ecological properties. This grouping provides an ecological perspective, emphasizing the shared geographic, site, and disturbance factors that shape vegetation patterns. These are narrower than the formation level of the USNVC.	24	10 (42%)	17 (71%)	71.7%
Mesocluster*	Groups vegetative associations based on broadly shared ecological processes and floristics. This groupings provide a ecological perspective emphasizing the shared geographic, site, and disturbance factors that shape vegetation patterns. These are broad vegetation types within a biogeographic region that share similar habitats (e.g., ecological processes, abiotic factors, and environmental gradients) and that have broadly similar species composition. Mesoclusters are similar to the USNCV formation level.	11	7 (64%)	10 (91%)	76.3%
Supercluster*	Groupings of mesoclusters sharing similar physiognomy and ecological context. These superclusters are aggregations of vegetation associations that are similar to the sub-class level in the USNVC.	6	5 (83%)	6 (100%)	80.1%
Community	Plant community grouping similar to Mesocluster but designed for vegetation management (ie fire management) purposes	8	3 (38%)	5 (63%)	73.9%

Photo Interpretation Notes on Accuracy Assessment

General Observations

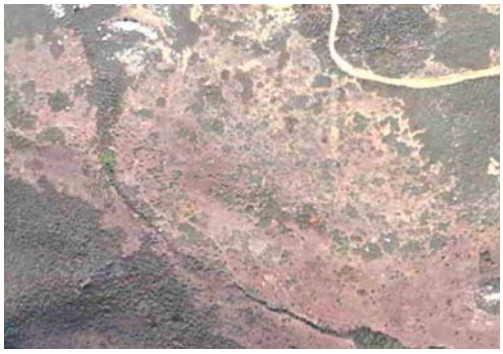
- Aerial Photo Scale: The photo interpreters worked with 1:24,000 scale photography. This is slightly coarser than aerial photography used by the USFS in many of their efforts to establish dominant and co - dominant tree species in forest mapping. In general, this scale is adequate to distinguish most tree species that form dominant stands over areas greater than 1 hectare. Where more than one species co-dominate an area, it becomes difficult to establish a reliable signature as to which species has a higher relative cover. 1:24,000 photography is adequate to distinguish several species of shrubs only if they form extensive stands yielding an overall signature pattern. Individual species at the shrub layer cannot for the most part be distinguished on 1:24,000 photography. Separation of species below the shrub layer (sub-shrubs and herbaceous) is possible only where the species or co - dominance of species covers extensive areas that form an overall tone and texture identifiable to the photo interpreter. The USGS-NPS vegetation mapping protocols suggest the use of 1:12,000 aerial photos which have 4 times the resolution of the 1:24,000 photography used in this project. This was probably the most significant cause of the low thematic accuracy of the plant community at the association (most botanically detailed) level (see the accuracy assessment section of this report).
- Aerial Photo Media: Photos were produced on print media - Negative images were not available for interpretation. In general, print media yields a coarser and somewhat grainier resolution although it is hard to quantify the difference. Diapositives images are considered the standard for detailed aerial photo interpretation work.
- Temporal Change: Several areas have undergone a type-change from when the aerial photography was flown in 1994 and when the accuracy assessment plots were assessed 4-5 years later. Most noticeable is the decrease in yellow bush lupine and increase in Douglas-fir.
- Seasonality: As a rule, flying during different seasons yields differing results depending on the growth characteristics of the vegetation that is being interpreted. The NPS photography was flown in early spring in conditions where growth of the herbaceous layer is in flush conditions between 20 and 50% of the total “biomass”. Unfortunately, this is the least desirable time to identify out low shrub layers that at the time would not stand out from the adjacent grasslands. Other herbaceous species, particularly non-native perennials which often form nearly pure stands, are more noticeable in the summer, when non-native annual grasses have already senesced, than in early spring (Figure 5).

Figure 5
Harding Grass (September Imagery
1 meter resolution Natural Color)

Harding Grass (March 1:24,000
Natural Color Photography)

Below is an example showing difficulties with the existing aerial photography flown in early spring in distinguishing sparse coyote brush from the adjacent annual grasslands (figure 6).

Figure 6
Sparse Coyote Brush (Fall Imagery
1 meter resolution Natural Color



Sparse Coyote Brush (March
1:24000 Natural Color)

Although the sparse coyote brush is visible on the March aerial photography, relative shrub cover is generally estimated lower than actually exists; therefore, many coyote brush stands were misinterpreted as grasslands resulting in a “life - form” level error.

Specific Observations at the Superalliance Level

Several vegetation units listed below depict vegetation interpreted at an alliance level or sub - alliance level. Problem types (mapped below 80% accuracy) are noted below

Note: * Denotes Alliance Level Mapping, * Denotes Sub - alliance Level Mapping

- California Bay - Coast Live Oak - Highest error emanating from stands where a sparse emergent canopy of Douglas-fir of around 10% relative cover was incorrectly mapped into the hardwood community
- *Red Alder - Confusion with other riparian type (Mixed Willow) especially when tree - form willows dominate
- *Open grassy coyote brush - yellow bush lupine - Confusion with the more coastal type of dune - lupine - dune sagewort - dunegrass - coyote brush is often a component in both types
- Wax myrtle - salmonberry - Stands generally too small to extrapolate an adequate signature from the 1:24,000 aerial photography
- Coyote brush – blue blossom - Confusion with other dense coyote brush especially ones containing California coffeeberry, which is easily confused with blue blossom
- Holly-leaf cherry - coyote brush - Confusion with coyote brush with coffeeberry - a very similar signature. This type was not extensive enough to establish a PI signature although it appears to be more common south of the study area
- *Mature coyote brush - coffeeberry - poison oak - General confusion with other coyote brush stands which are drier and more open
- *Sensitive manzanita - Confusion with other species of manzanita normally occupying more xeric settings
- Coyote brush - California sagebrush - Confusion with other dry open coyote brush especially open grassy coyote brush - lupine.
- Pacific reedgrass - Carex – Juncus - Some confusion with introduced perennial grasses and open coyote brush; an especially difficult type to separate out using early spring photography
- Introduced perennial grasses - Early spring photography yields substantial confusion with open sparse coyote brush stands and wet meadow types.
- *Cordgrass - Sample size is small, but later established that this type was not visible on the photography.
- Native weedy grassland - Early spring photography yields substantial confusion with open sparse coyote brush.

Additional Photo Interpretation to Improve the Maps Thematic Accuracy

We attempted to further improve the accuracy of the plant community map be re-interpreting several plant community types that exhibited low accuracy and that the photo-interpreters suggested could be improved by utilizing the DAIS imagery that was acquired in the fall of 2001 (Table 5).We recognize the problems associated with using imagery acquired 7 years apart, but decided it may provide a small improvement in accuracy. Users can easily tell which source imagery was used for any polygon through a

simple query. A total of 183 (1.5% of the total) polygons were re-interpreted post accuracy assessment. During this step, photo-interpreters did not know which polygons contained accuracy assessment points.

Table 5. List of plant communities that were re-photo-interpreted using the 2001 DAIS imagery. OLD alliance-association is the original photo-interpreter call.

OLD Alliance-Association	**NEW** Alliance-Association	**Number Polygons Changed**
Arroyo Willow - NA	California Bay - NA	2
Arroyo Willow - NA	Coast Live Oak - NA	1
Arroyo Willow - NA	Coast Live Oak -(Arbutus menziesii)/Umbellularia	2
Arroyo Willow - NA	Coyote Brush-Toxicodendron	2
Arroyo Willow - NA	Willow Mapping Unit - NA	1
Bishop Pine -Arbutus menziesii/Vaccinium ovatum	Coast Live Oak - NA	3
Blue Blossom - NA	California Wax Myrtle - NA	1
Blue Blossom - NA	Coast Live Oak - NA	1
Blue Blossom - NA	Coffeeberry - NA	1
Blue Blossom - NA	Coyote Brush-Toxicodendron	4
Blue Blossom - NA	Poison Oak - NA	1
Blue Blossom - NA	Salmonberry - NA	1
California Bay-Lithocarpus densiflorus	Coast Live Oak - NA	1
California Buckeye - NA	California Bay - NA	3
California Buckeye - NA	Coast Live Oak - NA	1
California Buckeye - NA	Coast Live Oak - (Arbutus menziesii)/Umbellularia	1
Chamise - NA	Coast Live Oak - NA	5
Chamise - NA	Coast Live Oak -Toxicodendron/(Corylus cornuta)	4
Chamise - NA	Coffeeberry - NA	2
Chamise - NA	Coyote Brush-Toxicodendron	6
Coast Live Oak -(Arbutus menziesii)/Umbellularia	California Bay - NA	2
Coast Live Oak -(Arbutus menziesii)/Umbellularia	Douglas-fir - NA	1
Coast Live Oak -(Arbutus menziesii)/Umbellularia	Douglas-fir - Quercus agrifolia	1
Coast Redwood - NA	California Bay - NA	5
Coast Redwood -Lithocarpus/Vaccinium ovatum	California Bay - NA	1
Coast Redwood -Pseudotsuga/Umbellularia	Coast Live Oak -(Arbutus menziesii)/Umbellularia	1
Coffeeberry - NA	Coast Live Oak - NA	4
Cordgrass - NA	Beaches or Mudflats - NA	1
Cordgrass - NA	Pickleweed - NA	14
Coyote Brush-Ceanothus thyrsiflorus	Coyote Brush –Artemisia/Toxicodendron/Monardella	2
Coyote Brush-Ceanothus thyrsiflorus	Coyote Brush -Rhamnus californicus/Rubus parviflorus	2
Coyote Brush-Ceanothus thyrsiflorus	Coyote Brush-Toxicodendron	13
Coyote Brush-Ceanothus thyrsiflorus	Salmonberry - NA	1

OLD Alliance-Association	**NEW** Alliance-Association	**Number Polygons Changed**
Coyote Brush-Ceanothus thyrsiflorus	Willow Mapping Unit - NA	1
Coyote Brush-Non-native grassland	Coast Live Oak - NA	2
Coyote Brush-Non-native grassland	Coyote Brush-/Toxicodendron	1
Coyote Brush -Rhamnus californicus/Rubus parviflorus	Coast Live Oak - NA	1
Coyote Brush -Rhamnus californicus/Rubus parviflorus	Coast Live Oak -Toxicodendron/(Corylus cornuta)	1
Coyote Brush -Rhamnus californicus/Rubus parviflorus	Coyote Brush -Toxicodendron diversilobum	1
Coyote Brush -Toxicodendron diversilobum	California Bay - NA	1
Coyote Brush -Toxicodendron diversilobum	Chamise - NA	2
Coyote Brush -Toxicodendron diversilobum	Coast Live Oak - NA	1
Coyote Brush -Toxicodendron diversilobum	Unable to Key - NA	1
Douglas-fir - NA	California Bay - NA	1
Douglas-fir - NA	Coast Live Oak -Toxicodendron/(Corylus cornuta)	1
Douglas-fir-Baccharis pilularis	Coast Live Oak - NA	2
Douglas-fir-Baccharis pilularis	Coast Live Oak -(Arbutus menziesii)/Umbellularia	1
Douglas-fir -Lithocarpus densiflorus/Rhamnus	California Bay - NA	1
Douglas-fir-Quercus agrifolia	Bishop Pine - NA	1
Douglas-fir-Quercus agrifolia	California Buckeye - NA	1
Douglas-fir-Quercus agrifolia	Coast Live Oak -(Arbutus menziesii)/Umbellularia	1
Douglas-fir -Umbellularia californica/Polystichum	California Bay - NA	11
Douglas-fir -Umbellularia californica/Polystichum	Coast Live Oak -(Arbutus menziesii)/Umbellularia	2
Eastwood Manzanita-Quercus wislizenii	California Bay - NA	8
Giant Chinquapin - NA	California Bay - NA	3
Giant Chinquapin - NA	California Bay -Quercus agrifolia/Toxicodendron	1
Giant Chinquapin - NA	Coast Live Oak -(Arbutus menziesii)/Umbellularia	3
Giant Chinquapin - NA	Coast Redwood - NA	1
Pickleweed -Distichlis spicata/Jaumea carnosa	Pickleweed - NA	3
Red Alder-Rubus spectabilis/Sambucus	Bulrush - Cattail – Spikerush Marsh Mapping Unit - NA	1
Red Alder-Rubus spectabilis/Sambucus	California Bay - NA	2
Red Alder-Rubus spectabilis/Sambucus	Willow Mapping Unit - NA	3
Red Alder-Salix lasiolepis	Arroyo Willow - NA	1
Red Alder-Salix lasiolepis	Coast Live Oak - NA	1
Red Alder-Salix lasiolepis	Coyote Brush - NA	1
Red Alder-Salix lasiolepis	Willow Mapping Unit - NA	17
Red Alder - NA	California Bay - NA	2

OLD Alliance-Association	**NEW** Alliance-Association	**Number Polygons Changed**
Red Alder - NA	California Bay / Polystichum	1
Red Alder - NA	California Buckeye - NA	1
Red Alder - NA	Willow Mapping Unit - NA	4
Tanoak - NA	California Bay - NA	2
Willow Mapping Unit - NA	Coast Live Oak - NA	1
Willow Mapping Unit - NA	Coast Live Oak -(Arbutus menziesii)/Umbellularia	1
Willow Mapping Unit - NA	Douglas-fir -Umbellularia californica/Polystichum	1
Total		**183**

Data Dictionary for associated GIS Data

I. Data Format Outline:

Coverage related variables:

Area	8	18	F
Perimeter	8	18	F
Poreveg#	4	5	B
Poreveg - id	4	5	B

Defined variables:

PI	4	5	B
Height	4	2	B
Density	4	2	B
Burn	1	1	B

II. Preliminary Data Dictionary:

PI (Defines the NatureServe Alliance (Series), Association or Mapping Unit)
(See the following Preliminary Classification of Vegetation Types for numeric values)

HEIGHT - Defines average height of the alliance or association type (Tree - Shrub - Herbaceous)

1 = <0.5 meters
2 = 0.5 - 2 meters
3 = 2.01 - 5 meters
4 = 5.01 - 15 meters
5 = 15.01 - 35 meters
6 = 35.01 - 50 meters
7 = >50 meters
9 = Not Applicable

ABSOLUTE CROWN DENSITY - Defines average density of the life form of the alliance or association type (Tree - Shrub - Herbaceous)

1 = Closed / Continuous: >60%
2 = Discontinuous: 40% - 60%
3 = Dispersed: 25% - 39%
4 = Sparse: 10% - 24%
5 = Rare: 2% - 9%
9 = Not Applicable

BURN MODIFIER - Defines polygons (shrub and tree types) that were burned in the Vision fire area.

1 = Burned
2 = Not Burned
3 = Not Known (Herbaceous and & 9000 code polygons)

FGDC Metadata for the associated GIS data:

Identification_Information:
Citation:
Citation_Information:
Originator: PRNS
Publication_Date: Unpublished Material
Publication_Time: Unknown
Title: Vegetation Map - PRNS and Golden Gate National Recreation Area - 1994 Aerial Photos
Geospatial_Data_Presentation_Form: map
Other_Citation_Details: Classification of the vegetation of PRNS, Golden Gate National Recreation Area, Samuel P. Taylor, Mount Tamalpais, and Tomales State Parks in Marin, San Francisco, and San Mateo Counties, California
Description:
Abstract: The National Park Service (NPS), in conjunction with the Biological Resources Division (BRD) of the U.S. Geological Survey (USGS), has implemented a program to develop a uniform hierarchical vegetation mapping methodology and classification at a national level and apply it to National Parks. The purpose of the data is to document the state of vegetation within PRNS, Golden Gate National Recreation Area and the surrounding wildlands during 1994, thereby providing reference data for further analysis at the Regional or Service-wide level. The vegetation units of this map were determined through stereoscopic interpretation of aerial photographs supported by field sampling and ecological analysis. The vegetation boundaries were identified on the photographs by means of the photographic signatures and collateral information on slope, hydrology, geography, and vegetation in accordance with the Standardized National Vegetation Classification System (October 1995). The mapped vegetation primarily reflects conditions that existed during 1994 and 1995. Several sets of aerial photography were utilized for this project: 1) NOAA 1:24,000 March 1994 Natural Color Prints (Leaf Off) covering Point Reyes NS, the northern portion and southern coastal portions of Golden Gate NRA, and the western two thirds of Mt. Tamalpais State Park; 2) Pacific Aerial Survey 1:24,000 August 1995 Natural Color Prints (Leaf On) covering the southern portions of Golden Gate NRA and the San Francisco Watershed district; 3) Pacific Aerial Survey 1:24,000 November 1995 Natural Color Prints (Leaf Change) covering Samuel P. Taylor State Park and portions of the GGNRA; 4) 1:36,000 August 1991 Natural Color Prints (Leaf On) covering the eastern portion of Mt. Tamalpais State Park; 5) 1:12,000 August 1990 Natural Color Prints (Leaf On) covering Samuel P. Taylor State Park. (Supplemental data set - not interpreted off of); 6) 1:12,000 June 1993 Natural Color Prints (Leaf On) covering coastal portions of Mt. Tamalpais State Park (Supplemental data set - not interpreted off of); 7) Hammon-Jensen-Wallen 1:12,000 August 1996 CIR Prints and Diapositives (Leaf On) covering the Vision Fire Burn Area; 8) 1:12,000 April 1984 CIR Prints were provided to fill in small gaps in the Drakes Bay area; 9) Radman Aerial Surveys 1:12,000 April 1993 Natural Color Prints covering Angel Island; 10) Only the Black and White DOQQ (San Francisco NE) was available for Alcatraz Island. Additionally, suplemental DAIS imagery for October 2001 was

acquired after the project was started, which was then used to re-interpret some of the original work. There is an inherent margin of error in the use of aerial photography for vegetation delineation and classification.

Purpose: The purpose of this spatial data is to provide the National Park Service the necessary tools to wisely manage the natural resources within this park system. Several parks, representing different regions, environmental conditions, and vegetation types, were chosen by BRD to be part of the prototype phase of the program. The initial goal of the prototype phase is to "develop, test, refine, and finalize the standards and protocols" to be used during the production phase of the project. This includes the development of a standardized vegetation classification system for each park and the establishment of photo interpretation, field, and accuracy assessment procedures. PRNS and Golden Gate National Recreation Area were initially identified as one of the prototype projects within the National Park System for the USGS-NPS Vegetation Mapping Program.

Supplemental_Information: PRNS (PRNS) was established in September of 1962 and encompasses approximately 71,000 acres of diverse habitats, including grasslands, coastal scrub, broadleaved evergreen woodlands and coniferous forests. Within the general vicinity of the PRNS there are a number of public and private land holdings that have also been interpreted and mapped for the project. They include the following areas: 1) PRNS 2) Phillip Burton Wilderness Area and Research Natural Area (part of PRNS); 3) Privately owned land including portions of the town of Inverness, Olema, and Bolinas, land east of the Bear Valley Trail to Olema Creek, Audubon Canyon Ranch, and a narrow band along State Highway 1 north to Preston Point; 4) Samuel P. Taylor State Park; 5) Tomales Bay State Park; 6) Stinson Beach. Areas in the general vicinity of PRNS that were not part of the mapping effort include: 1) The Marin Municipal Water District (Kent Lake Area); 2) Portions of the towns of Bolinas, Inverness Park, Stinson Beach and Inverness; 3) Duxbury Reef Reserve and Point Reyes Headlands Reserve (below the mean high water); 4) Farallone Islands National Marine Sanctuary. Golden Gate National Recreation Area (GGNRA), established in 1983, covers over 76,000 acres of land, including extensive stands of chaparral, coastal scrub, grasslands, broadleaved woodlands and old growth redwood forests. Within the general vicinity of the GGNRA there are a number of public and private land holdings that have been interpreted and mapped for the project. They include the following areas: 1) GGNRA; 2) Muir Woods National Monument; 3) Mount Tamalpais State Park; 4) Marine Headlands; 5) The Presidio of San Francisco; 6) Angel Island State Park; 7) Fort Funston; 8) Sweeny Ridge; 9) The San Francisco Watershed Lands. Areas in the general vicinity of the GGNRA that were not part of the mapping effort include: 1) Adjacent Mid Peninsula Regional Open Space lands; 2) Edgewood County Park; 3) Portions of Montara State Beach and San Pedro Valley County Park.

Time_Period_of_Content:
  Time_Period_Information:
    Multiple_Dates/Times:
      Single_Date/Time:
        Calendar_Date: 19940300
        Time_of_Day: Unknown
      Single_Date/Time:

Calendar_Date: 199508
Single_Date/Time:
Calendar_Date: 199511
Single_Date/Time:
Calendar_Date: 199108
Single_Date/Time:
Calendar_Date: 199008
Single_Date/Time:
Calendar_Date: 199306
Single_Date/Time:
Calendar_Date: 199608
Single_Date/Time:
Calendar_Date: 198404
Single_Date/Time:
Calendar_Date: 199304
Single_Date/Time:
Calendar_Date: 200110
Currentness_Reference: ground condition - Nine different dates of aerial photography were utilized to photo interpret the ground conditions.
Status:
Progress: Complete
Maintenance_and_Update_Frequency: None planned
Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: -123.03641
East_Bounding_Coordinate: -122.26584
North_Bounding_Coordinate: 38.24762
South_Bounding_Coordinate: 37.43177
Keywords:
Theme:
Theme_Keyword_Thesaurus: Natural Resources
Theme_Keyword: Inventory
Theme_Keyword: Wetlands
Theme_Keyword: Plant Communities
Theme_Keyword: Aerial Photo Interpretation
Theme_Keyword: Vegetation
Theme_Keyword: Land-cover
Place:
Place_Keyword_Thesaurus: PRNS
Place_Keyword: PRNS
Place_Keyword: California
Place_Keyword: Golden Gate Biosphere Reserve
Place_Keyword: National Park Service Area
Place_Keyword: Golden Gate National Recreation Area
Place_Keyword: National Seashore

Place_Keyword: North America
Place_Keyword: San Francisco Bay Area
Stratum:
Stratum_Keyword_Thesaurus: Natural Resources
Stratum_Keyword: Ground-surface
Access_Constraints: None
Use_Constraints: Any person using the information presented here should fully understand the data collection and compilation procedures, as described in these metadata, before beginning analysis. The burden for determining fitness for use lies entirely with the user. For purposes of publication or dissemination, citations should be given to the National Park Service and the U.S. Geological Survey.
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dave Schirokauer
Contact_Organization: PRNS
Contact_Position: GIS Biologist
Contact_Address:
Address_Type: physical address
Address: PRNS
City: Point Reyes
State_or_Province: CA
Postal_Code: 94956
Country: USA
Contact_Voice_Telephone: 415-464-5199
Contact_Facsimile_Telephone: 415-464-5183
Contact_Electronic_Mail_Address: dave_schirokauer@nps.gov
Data_Set_Credit: Project Leader: Dave Schirokauer - NPS, Vegetation Ecolotgists: Todd Keeler Wolf - CA Dept of Fish and Game and Pam van der Leeden - NPS, Photo Interprter: John Meinke - Aerial Information Systems, Contract Coordinator: Doug Cribbs - ESRI
Security_Information:
Security_Classification_System: None
Security_Classification: None
Security_Handling_Description: None
Native_Data_Set_Environment: ArcInfo
Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
Code verification involved running each coverage attribute file through a series of ARC/INFO commands that checked for invalid codes. These commands produced listings and frequencies that aided in identifying abnormal codes. The errors were checked against the vegetation delineation and attribute overlays. Corrections were made to the listings and input into the database. ESRI produced a plot of the converted spatial data and sequence numbers (label I.Ds) for quality control review. These plots were

checked for cartographic quality of the arcs defining the polygon features and the accuracy of the label I.D. assignments. Other edits were also noted on the plots, such as overshoots and undershoots, missing lines, premature convergence of polygon boundary lines that intersected arcs at acute angles, and incorrect sequence number assignments. Code verification plots of the community association/alliance codes, height codes, density codes, land use codes, and burn modifier codes were created and checked for coding attribute errors that may have occurred during the polygon attribute encoding step. These plots were checked against the original aerial photograph delineations and attributing. Code changes were noted on the plots. Processors conducted interactive ARCEDIT sessions to make the necessary corrections to the coverages. Accuracy Assessment field data was captured by park staff to analyze the accuracy of the vegetation community polygons.

Accuracy Assessmnt confusion matrices were developed to analyze the data within several levels of the vegetation classification hierarchy including:1) Assocaition = 42.5%; Alliance = 62.3%; Superalliance 71.4%; Mesocluster = 76.1%, Supercluster = 82.4%; Lifeform = 83.8%.

A hierarchical vegetation classification system, outside of the National Vegetation Classification System, was developed for this project to improve usability of the data. Alliances were merged hierarchically into Superalliances, Mesoclusters, and Superclusters based on ecological similarities that were discerned during the ordination (TwinSpan) analysis that originally was used to describe plant associations. Each successive level in this hierarchy had fewer, broader, vegetative communities. Therefore, the thematic accuracy (user and producer) improves at each successive level. This is the fuzzy logic approach that was used to improve the usability of these data. The superalliance level was selected as the primary classification to be used because important ecological differences between plant communities are preserved while the accuracy of the product is improved to 71.4%. However, all of the levels in the hierarchy are available for the end-user. Please refer to the final report associated with this project to view the confusion matrices associated with the other levels in the classification hierarchy.

The accuracy of each plant community mapping unit at every level in the classification heirarchy is available in the attribute table. See the Entity and Attribute section of this metadata record.

Logical_Consistency_Report: All polygon features are checked for topology using the ARC/INFO software. Each polygon begins and ends at the same point with the node feature. All nodes are checked for error so that there are no dangling features. There are no duplicate lines or polygons. All nodes will snap together and close polygons based on a specific tolerance. If the node is not within the tolerance, it is adjusted manually. The test for logical consistency are performed in ARC/INFO.

Completeness_Report: All data that can be photointerpreted is also digitized. This includes association / community and superalliance classes, surface water, and unvegetated/landuse.

Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report: +/- 12 meters National Map Standards for 24000 Scale Data
Vertical_Positional_Accuracy:
Vertical_Positional_Accuracy_Report: NA
Lineage:
Source_Information:
Source_Citation:
Citation_Information:
Originator: PRNS
Publication_Date: Unpublished Material
Publication_Time: Unknown
Title: Vegetation Map - PRNS and Golden Gate National Recreation Area - 1994 Aerial Photos
Geospatial_Data_Presentation_Form: map
Other_Citation_Details: Classification of the vegetation of PRNS, Golden Gate National Recreation Area, Samuel P. Taylor, Mount Tamalpais, and Tomales State Parks in Marin, San Francisco, and San Mateo Counties, California
Source_Scale_Denominator: 24000
Type_of_Source_Media: CD-ROM
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 19940401
Time_of_Day: Unknown
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: PORE-GOGA Veg Map
Source_Contribution: All information from Final Report associated with this project:
Process_Step:
Process_Description: Please see the final report associated with this project.
Process_Date: Unknown
Process_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dave Schirokauer
Contact_Organization: PRNS
Contact_Position: GIS Biologist
Contact_Address:
Address_Type: physical address
Address: PRNS
City: Point Reyes
State_or_Province: CA
Postal_Code: 94956
Country: USA

```
        Contact_Voice_Telephone: 415-464-5199
        Contact_Facsimile_Telephone: 415-464-5183
        Contact_Electronic_Mail_Address: dave_schirokauer@nps.gov
  Cloud_Cover: 0
Spatial_Data_Organization_Information:
  Direct_Spatial_Reference_Method: Vector
  Point_and_Vector_Object_Information:
    SDTS_Terms_Description:
      SDTS_Point_and_Vector_Object_Type: G-polygon
      Point_and_Vector_Object_Count: 11167
Spatial_Reference_Information:
  Horizontal_Coordinate_System_Definition:
    Planar:
      Grid_Coordinate_System:
        Grid_Coordinate_System_Name: Universal Transverse Mercator 1983
        Universal_Transverse_Mercator:
          UTM_Zone_Number: 10
          Transverse_Mercator:
            Scale_Factor_at_Central_Meridian: 0.9996
            Longitude_of_Central_Meridian: -123
            Latitude_of_Projection_Origin: 0
            False_Easting: 500000
            False_Northing: 0
      Planar_Coordinate_Information:
        Planar_Coordinate_Encoding_Method: Coordinate Pair
        Coordinate_Representation:
          Abscissa_Resolution: 1
          Ordinate_Resolution: 1
        Planar_Distance_Units: m
    Geodetic_Model:
      Horizontal_Datum_Name: North American Datum of 1983
      Ellipsoid_Name: Geodetic Reference System 80
      Semi-major_Axis: 6378137
      Denominator_of_Flattening_Ratio: 298.257
Entity_and_Attribute_Information:
  Detailed_Description:
    Entity_Type:
      Entity_Type_Label: Attributes
      Entity_Type_Definition: NA
      Entity_Type_Definition_Source: NPS
    Attribute:
      Attribute_Label: ALLIANC_AC
      Attribute_Definition: Vegetative Alliance User Accuracy
      Attribute_Definition_Source: NA
      Attribute_Domain_Values:
```

Range_Domain:
Range_Domain_Minimum: 0
Range_Domain_Maximum: 100
Attribute_Units_of_Measure: Percent
Attribute_Measurement_Resolution: 0.1
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy: 80
Attribute_Value_Accuracy_Explanation: The percentage of polygons for the current record's alliance where the alliance on the ground matched the alliance on the vegetation map. This value can also be considered the probabily that the vegetative alliance on the ground matched the alliance on the vegetation map.
Attribute:
Attribute_Label: ALLIANCE
Attribute_Definition: A grouping of associations with a characteristic physiognomy and habitat and which share one or more diagnostic species typically found in the upper most or dominant stratum of the vegetation. Synonymous with series. Part of the national vegetation classification system.
Attribute_Definition_Source:
Proposed Standards for Association and Alliances of the U.S. National Vegetation Classification
ESA Panel on Vegetation Classification, 2003
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: Detailed disciptions of each vegetative associations and alliance contained in this data set are available in the final report that is assicatiated with this data. 'Classification of the vegetation of PRNS, Golden Gate National Recreation Area, Samuel P. Taylor, Mt.Tamalpais, and Tomales State Parks in Marin, San Francisco, and San Mateo counties California.'
Attribute:
Attribute_Label: AREA
Attribute_Definition: The area of the current records polygon in square meters.
Attribute_Definition_Source: NA
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA

Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: NA
Attribute:
Attribute_Label: ASSOC
Attribute_Definition: Association: A plant community based on dominant and up to several associated species. A recurring plant community with a characteristic range in species composition, specific diagnostic species, and a defined range in habitat conditions and physiognomy or structure. The most detailed floristic level of the national vegetation classification system
Attribute_Definition_Source:
Proposed Standards for Association and Alliances of the U.S. National Vegetation Classification
ESA Panel on Vegetation Classification, 2003
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: Detailed disciptions of each vegetative associations and alliance contained in this data set are available in the final report that is assicatiated with this data. 'Classification of the vegetation of PRNS, Golden Gate National Recreation Area, Samuel P. Taylor, Mt.Tamalpais, and Tomales State Parks in Marin, San Francisco, and San Mateo counties California.'
Attribute:
Attribute_Label: ASSOC_AC
Attribute_Definition: Vegetative associations user accuracy.
Attribute_Definition_Source: NA
Attribute_Domain_Values:
Range_Domain:
Range_Domain_Minimum: 0
Range_Domain_Maximum: 100
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: The percentage of polygons for the current record's association where the alliance on the ground matched the alliance on the vegetation map. This value can also be considered the probabily that the vegetative association on the ground matched the association on the vegetation map.
Attribute:
Attribute_Label: COMMUNI_AC
Attribute_Definition: Community user accuracy
Attribute_Definition_Source: NA

Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: The percentage of polygons for the current record's where the communityon the ground matched the communityon the vegetation map. This value can also be considered the probabily that the vegetative communityon the ground matched the communityon the vegetation map.
Attribute:
Attribute_Label: COMMUNITY
Attribute_Definition: Community: A grouping of vegetation alliances by physiognomy, floristics and distinctive ecological habitat for management purposes.
Attribute_Definition_Source: NPS
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: NA
Attribute:
Attribute_Label: CWHR_AC
Attribute_Definition: California While Habitat Relations user accuracy
Attribute_Definition_Source: NA
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: na
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: The percentage of polygons for the current record's CWHR type where the CWHR type on the ground matched the CWHR type on the vegetation map. This value can also be considered the probabily that the CWHR type on the ground matched the CWHR type on the vegetation map.
Attribute:
Attribute_Label: CWHR_code
Attribute_Definition: The land cover type code used by the California Wildlife Habitat Relations classification.
Attribute_Definition_Source: http://www.dfg.ca.gov/biogeodata/cwhr/wildlife_habitats.asp
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA

Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: NA
Attribute:
Attribute_Label: CWHR_Type
Attribute_Definition: California Wildlife Habitat Relations land cover types. The crosswalk between the California Wildlife Habitat Relationships vegetation types is available at: http://www.dfg.ca.gov/biogeodata/cwhr/wildlife_habitats.asp.
Attribute_Definition_Source:
A Guide to Wildlife Habitats of California. 1988.
Edited by Kenneth E. Mayer and William F. Laudenslayer, Jr.
State of California,
Resources Agency,
Department of Fish and Game,
Sacramento, CA. 166 pp
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: NA
Attribute:
Attribute_Label: DENSITY
Attribute_Definition: The percent cover (absolute) class of the dominant vegetative life form in the current records polygon.
Attribute_Definition_Source: Vegetation Map Final Report
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: 1
Enumerated_Domain_Value_Definition: Closed / continuous: > 60%. Accuracy: Trees-86.9%, Shrubs-71.7, Herbs-63.7%
Enumerated_Domain_Value_Definition_Source: Vegetation Map Final Report.
Enumerated_Domain:
Enumerated_Domain_Value: 2
Enumerated_Domain_Value_Definition: Discontinuous: 40% -- 60% Accuracy: Trees-11.0%, Shrubs-9.1, Herbs-11.1%
Enumerated_Domain_Value_Definition_Source: Vegetation Map Final Report
Enumerated_Domain:
Enumerated_Domain_Value: 3
Enumerated_Domain_Value_Definition: Disbursed: 25% -- 40% Accuracy: Trees-14.7%, Shrubs-35.8, Herbs-40.0%
Enumerated_Domain_Value_Definition_Source: Vegetation Map Final Report
Enumerated_Domain:
Enumerated_Domain_Value: 4
Enumerated_Domain_Value_Definition: Sparse: 10% -- 25% Accuracy: Trees-8.0%, Shrubs-12.1, Herbs-0%
Enumerated_Domain_Value_Definition_Source: Vegetation Map Final Report
Enumerated_Domain:

Enumerated_Domain_Value: 5
Enumerated_Domain_Value_Definition: Rare: 2% -- 10% Accuracy: Trees-0%, Shrubs-0, Herbs-NA
Enumerated_Domain_Value_Definition_Source: Vegetation Map Final Report
Enumerated_Domain:
Enumerated_Domain_Value: 9
Enumerated_Domain_Value_Definition: Not applicable
Enumerated_Domain_Value_Definition_Source: Vegetation Map Final Report
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: Please see the Final Report for more detail on the accuracy of this attribute
Attribute:
Attribute_Label: FIELD_ID
Attribute_Definition: The identifier that links the vegetation map's data to the tabular database containing vegetation plot field data.
Attribute_Definition_Source: NPS
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute:
Attribute_Label: FUEL_MODEL
Attribute_Definition: The Anderson fuel model number
Attribute_Definition_Source: Anderson, Hal E. 1982. Aids to determining fuel models for estimating fire behavior. General Technical Report INT-122. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 22 p.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute:
Attribute_Label: GROUP
Attribute_Definition: Physiognomic Group: The level in the classification hierarchy below subclass based on leaf characters and identified and named in conjunction with broadly defined macroclimatic types to provide a structural-geographic orientation (Grossman et al. 1998).
Attribute_Definition_Source: VegBank
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA

Attribute:
Attribute_Label: GROUP_AC
Attribute_Definition: Group use your accuracy
Attribute_Definition_Source: na
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: The percentage of polygons for the current record's group where the group on the ground matched the group on the vegetation map. This value can also be considered the probabily that the vegetative group on the ground matched the group on the vegetation map.
Attribute:
Attribute_Label: HEIGHT
Attribute_Definition: The average height of the dominant life form of current records alliance or association type
Attribute_Definition_Source: Vegetation Map Final Report
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: 1
Enumerated_Domain_Value_Definition: < 0.5 m Accuracy: Trees-NA, Shrubs-36.6%, Herb-81.4%
Enumerated_Domain_Value_Definition_Source: Final Report
Enumerated_Domain:
Enumerated_Domain_Value: 2
Enumerated_Domain_Value_Definition: 0.5-2 meters Accuracy: Trees-50%, Shrubs-74.2%, Herb-72.6%
Enumerated_Domain_Value_Definition_Source: Final Report
Enumerated_Domain:
Enumerated_Domain_Value: 3
Enumerated_Domain_Value_Definition: 2-5 meters Accuracy: Trees-37.5%, Shrubs-17.8%, Herb-0%
Enumerated_Domain_Value_Definition_Source: Final Report
Enumerated_Domain:
Enumerated_Domain_Value: 4
Enumerated_Domain_Value_Definition: 5-15 meters Accuracy: Trees-68.3%, Shrubs-33.3%, Herb-NA%
Enumerated_Domain_Value_Definition_Source: Final Report
Enumerated_Domain:
Enumerated_Domain_Value: 5
Enumerated_Domain_Value_Definition: 15-35 m Accuracy: Trees-17.1%, Shrubs-NA%, Herb-NA
Enumerated_Domain_Value_Definition_Source: Final Report

Enumerated_Domain:
Enumerated_Domain_Value: 6
Enumerated_Domain_Value_Definition: 35-50 meters Accuracy: Trees-13.6%, Shrubs-NA%, Herb-NA
Enumerated_Domain_Value_Definition_Source: Final Report
Enumerated_Domain:
Enumerated_Domain_Value: 7
Enumerated_Domain_Value_Definition: > 50 m Accuracy: Trees-0%, Shrubs-NA%, Herb-NA
Enumerated_Domain_Value_Definition_Source: Final Report
Enumerated_Domain:
Enumerated_Domain_Value: 9
Enumerated_Domain_Value_Definition: Not applicable
Enumerated_Domain_Value_Definition_Source: NA
Attribute:
Attribute_Label: LEGEND_ORD
Attribute_Definition: the numeric order for a maps legend to be displayed in an ecologically meaningful way grouped by mesocluster.
Attribute_Definition_Source: NA
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute:
Attribute_Label: LIFE_FO_AC
Attribute_Definition: Life form user accuracy
Attribute_Definition_Source: NA
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute:
Attribute_Label: LIFE_FORM
Attribute_Definition: Life Form
Attribute_Definition_Source: Vegetation Map Final Report
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute:
Attribute_Label: MESOCLU_AC
Attribute_Definition: Mesocluster user accuracy

Attribute_Definition_Source: NA
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: The percentage of polygons for the current record's mesocluster where the mesoclusteron the ground matched the mesocluster on the vegetation map. This value can also be considered the probabily that the vegetative mesocluster on the ground matched the mesocluster on the vegetation map.
Attribute:
Attribute_Label: MESOCLUSTE
Attribute_Definition: Mesocluster: The mesocluster level (in our vegetation classification hierarchy) groups vegetative associations based on broadly shared ecological processes and vegetation, rather than on the National vegetation classification hierarchy alone. Such groupings provide a more ecological perspective on associations and alliances, emphasizing the shared geographic, site, and disturbance factors that shape vegetation patterns. These mesoclusters may be considered as broad vegetation types within a biogeographic region that share similar habitats (e.g., ecological processes, abiotic factors, and environmental gradients) and that have broadly similar species composition. These mesoclusters are aggregations of vegetation associations that are broader than the standard National Vegetation Classification Alliance and Association definitions, but narrower, typically than the formation level. They are defined by floristic and environmental similarity. These mesoclusters were determined by analyzing the TWINSPAN and cluster analysis diagrams of the vegetation plots. Mesocluster groups were typically defined by the mid - level breaks in TWINSPAN and Cluster Analysis algorithms, we call them meso clusters indicating their mid - level position in the numerical classification of the plots.
Attribute_Definition_Source: Vegetation Map Final Report
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute:
Attribute_Label: PERIMETER
Attribute_Definition: The current records perimeter in meters.
Attribute_Definition_Source: NA
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute:

Attribute_Label: PI
Attribute_Definition: The code that corresponds to a specific land cover type assigned by the photo interpreters. The other attributes in this dataset describe design cover and vegetation types.
Attribute_Definition_Source: Vegetation Map Final Report
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: Detailed disciptions of each vegetative associations and alliance contained in this data set are available in the final report that is assicatiated with this data. 'Classification of the vegetation of PRNS, Golden Gate National Recreation Area, Samuel P. Taylor, Mt.Tamalpais, and Tomales State Parks in Marin, San Francisco, and San Mateo counties California.'
Attribute:
Attribute_Label: SUPERAL
Attribute_Definition: Superalliance: The superalliance level (in our vegetation classification hierarchy) groups vegetative associations and/or alliances based on shared dominant species or other shared floristic or physiognomic properties, rather than on the national vegetation classification hierarchy alone. Such groupings provide an ecological perspective on associations and alliances, emphasizing the shared geographic, site, and disturbance factors that shape vegetation patterns. These superalliance are aggregations of vegetation associations and alliances that are usually broader than the standard national vegetation classification Alliance and Association definitions, but narrower, typically than the formation (or mesocluster) level. These superalliance were determined by analyzing the TWINSPAN and cluster analysis diagrams of the vegetation plots. Superalliance groups were typically defined by the low - level breaks in TWINSPAN and Cluster Analysis algorithms, we also call them microclusters indicating their low - level position in the numerical classification of the plots.
Attribute_Definition_Source: Vegetation Map Final Report
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute:
Attribute_Label: SUPERAL_AC
Attribute_Definition: Superalliance user accuracy
Attribute_Definition_Source: NA
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA

Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: The percentage of polygons for the current record's superalliance where the pathoson the ground matched the superalliance on the vegetation map. This value can also be considered the probability that the vegetative superalliance on the ground matched the mesocluster on the vegetation map.
Attribute:
Attribute_Label: SUPERCL_AC
Attribute_Definition: Supercluster user accuracy
Attribute_Definition_Source: NA
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy_Explanation: The percentage of polygons for the current record's supercluster where the supercluster on the ground matched the supercluster on the vegetation map. This value can also be considered the probability that the vegetative supercluster on the ground matched the mesocluster on the vegetation map.
Attribute:
Attribute_Label: SUPERCLUST
Attribute_Definition: Supercluster: Groupings of mesoclusters sharing similar physiognomy. These superclusters are aggregations of vegetation associations that are broader than the meoscluster and the superalliance levels in our classification hierarchy and broader then the standard National Vegetation Classification Alliance and Association definitions, but narrower the life form level. They are defined by floristic and environmental similarity. These superclusters were determined by analyzing the TWINSPAN and cluster analysis diagrams of the vegetation plots. Supercluster groups were typically defined by the coarse - level breaks in TWINSPAN and Cluster Analysis algorithms, we call them superclusters indicating their coarse (broadest) - level position in the numerical classification of the plots.
Attribute_Definition_Source: Vegetation Map Final Report
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute:
Attribute_Label: WETLAND
Attribute_Definition: All upland types are called 'upland' in this attribute while the wetlands are described by their alliance. Use to help map areas likely to contain wetlands.
Attribute_Definition_Source: NPS
Attribute_Domain_Values:
Enumerated_Domain:

Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute:
Attribute_Label: X_COORD
Attribute_Definition: The x-coordinate of the current polygons centroid.
Attribute_Definition_Source: NA
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Attribute:
Attribute_Label: Y_COORD
Attribute_Definition: The Y coordinate other current record polygons centroid.
Attribute_Definition_Source: NA
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NA
Enumerated_Domain_Value_Definition: NA
Enumerated_Domain_Value_Definition_Source: NA
Overview_Description:
Entity_and_Attribute_Overview: The system is organized hierarchically to support conservation and resource stewardship application across multiple scales. The upper levels of the hierarchy (life form and supercluster)are based on the physical form or structure of the vegetation (physiognomy) and have been refined from the international standards developed by the United Nations Educational Scientific, and Cultural Organization (UNESCO). The two most detailed levels of the hierarchy (association and alliance) are based on the species composition of the existing vegetation (floristics) and reflect the phyto-sociological standards that were originally developed by European ecologists. The middle levels of the classification (superalliance and mesocluster) were developed specifically for this project and are based on the ecological similarity between plant alliances. The superalliance, mesocluster, and supercluster membership was determined by clustering of vegetation plots evident in an ordination analyses conducted as part of this project and expert knowledge of the plant communities in the study area. The vegetation classification is continually advanced through the collection and analysis of new field data and will be greatly strengthened during the course of future NPS mapping efforts. Please refer to the final report for detailed descriptions of the plant communities classified and mapped during this project.
Entity_and_Attribute_Detail_Citation: NA
Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dave Schirokauer

Contact_Organization: PRNS
Contact_Position: GIS Biologist
Contact_Address:
Address_Type: physical address
Address: PRNS
City: Point Reyes
State_or_Province: CA
Postal_Code: 94956
Country: USA
Contact_Voice_Telephone: 415-464-5199
Contact_Facsimile_Telephone: 415-464-5183
Contact_Electronic_Mail_Address: dave_schirokauer@nps.gov
Distribution_Liability:
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The information contained in these data is dynamic and may change over time. The data are not better than the original sources from which they were derived. It is the responsibility of the data user to use the data appropriately and consistent within the limitations of geospatial data in general and these data in particular. The related graphics are intended to aid the data user in acquiring relevant data; it is not appropriate to use the related graphics as data.

The National Park Service gives no warranty, expressed or implied, as to the accuracy, reliability, or completeness of these data. It is strongly recommended that these data are directly acquired from an NPS server and not indirectly through other sources which may have changed the data in some way. Although these data have been processed successfully on computer systems at the National Park Service, no warranty expressed or implied is made regarding the utility of the data on other systems for general or scientific purposes, nor shall the act of distribution constitute any such warranty. This disclaimer applies both to individual use of the data and aggregate use with other data.
Standard_Order_Process:
Fees: None
Ordering_Instructions: Download from website, phone call or send email to request FTP download.
Available_Time_Period:
Time_Period_Information:
Single_Date/Time:
Time_of_Day: Unknown
Metadata_Reference_Information:
Metadata_Date: 20031010
Metadata_Review_Date: 20031010
Metadata_Future_Review_Date: 20091010
Metadata_Contact:

Contact_Information:
Contact_Person_Primary:
Contact_Person: Dave Schirokauer
Contact_Organization: PRNS
Contact_Position: GIS Biologist
Contact_Address:
Address_Type: physical address
Address: PRNS
City: Point Reyes
State_or_Province: CA
Postal_Code: 94956
Country: USA
Contact_Voice_Telephone: 415-464-5199
Contact_Facsimile_Telephone: 415-464-5183
Contact_Electronic_Mail_Address: dave_schirokauer@nps.gov
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

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