

FOREST SERVICE SOUTHERN CALIFORNIA MAPPING PROJECT
SANTA MONICA MOUNTAINS NATIONAL RECREATION AREA

Task 11 Description and Results

FINAL REPORT

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Introduction

The vegetation of the Santa Monica Mountains National Recreation Area (SMMNRA) was mapped in cooperation with the National Park Service (NPS) as a part of the US Forest Service Southern California Mapping Project currently underway at the department of Geography, San Diego State University. Vegetation types were mapped using 1) unsupervised classification of Landsat Thematic Mapper imagery, 2) image segmentation to define mapping polygons corresponding to vegetation stands or mapping units, and 3) manual editing of the mapping units using aerial photo interpretation. Following the completion of the map, an accuracy assessment was conducted.

The mapping area extends beyond the Santa Monica Mountains "zone" by a half-mile buffer and encompasses the entire 7.5' USGS quadrangles of Newbury Park, Thousand Oaks, and Calabasas that lay north of the National Recreation Area (NRA). The satellite image utilized in the mapping process was acquired in spring 1993 in order to map vegetation before the widespread fires of fall 1993. The NRA was mapped with a minimum mapping unit of 5 acres, corresponding approximately to a scale of 1:24,000.

Data and Equipment

The hardware and software utilized in this project are housed within CESAR (Center for Earth Systems Analysis Research) at San Diego State University. All processing was conducted on Sun Sparc stations. The image processing was completed using Image Processing Workbench (IPW), a public domain software package available over the internet. Arc-Info was used for all other geographic information systems processes.

The data used in this project was in both digital and analogue form. The Landsat Thematic Mapper (TM) Image of the area (Path 41 Row 36, acquired 8/26/93) was geocoded and terrain corrected. Geographic digital layers that were obtained from the National Park Service (NPS) consisted of USGS Digital Elevation Models (DEMs), coverages of roads, streams, the NRA boundary, and land-use.

Non-digital data provided by the NPS consisted of the following items that extend over the entire mapped area: 1:24,000 Orthophoto quads and USGS topographic quadrangles, and aerial photos (1988 color prints 1:12,000, 1994 color 1:12,000, 1994 color IR 1:24,000, and 1984 1:12000 color IR).

Mapping Procedures

Field work and reconnaissance was conducted for two weeks in the summer of 1994. Data were collected on the vegetation type distribution for the NRA. These data, recorded on data sheets and digital orthophotos, were used in mapping the vegetation during the photo interpretation and editing portion of the project, and provided terrain rules for the planned geographic modeling of non-spectrally distinguishable vegetation types.

Using the USGS 30-m DEMs, illuminated and shaded areas were masked out or separated from each other in preparation for separate per-pixel classifications. Areas primarily urban in composition were masked out, or removed, using the land cover data from NPS (original source was SCAG) in order to isolate natural vegetation as the target object. Four bands were utilized in the per-pixel classification of the image: band 3--red, band 4--near-infrared, band 5--mid-infrared, and a texture band as measure of local spatial variance. The classification was unsupervised and iterative in nature and conducted with IPW software. Clusters, or pixels that were classified similarly, were given general vegetation labels, or "lifeform" labels using air photo interpretation and the field data collected in the summer of 1994. Using a segmentation or region-growing algorithm in IPW, the entire mapping area was separated into similar "stands" or segments based upon spectral similarities and spatial characteristics. The maximum number of 30 by 30 meter pixels that may occur in each stand or segment is 50 (4.5 hectares or 11.12 acres), with a minimum of 20-25 pixels or a minimum mapping unit of 2.2 hectares or 5.5 acres. These segments were then overlaid with the per-pixel map in order to acquire vegetation labels. The resulting geographic layer consisted of these segments with labels of vegetation type resulting from the per-pixel classification. This was the geographic layer that was edited manually by aerial photo interpretation.

At this juncture it was planned to implement geographic modeling of terrain variables to predictively map classes that were not spectrally discernible from each other (e.g., thick-stipuled *Ceanothus* and thin-stipuled *Ceanothus*). Unfortunately, the data taken from the field exhibited no consistent or clear relationship between terrain (elevation, slope, and aspect) and these closely related vegetation types. The map of segments with vegetation labels was then manually edited with aerial photo interpretation. The 1994 1:12,000 color

print aerial photos were used wherever possible due to their high quality, and the 1988 1:12,000 color print photos were used in areas of the 1993 burn in order to map "potential" vegetation. During the editing process, 39 percent of all segments were edited or changed to new vegetation categories from the categories originally assigned by the per-pixel classification. These changes were made to correct errors of the per-pixel classification, and more significantly, to map the vegetation in far more detail than the per-pixel lifeform map which mapped only sub-shrub, chaparral, hardwood, water and urban categories. In the past, much larger national forest areas mapped by this SDSU project had only 20 percent of the segments changed or edited.

Vegetation/Land Cover Types Mapped

In contract with the other mapping performed by SDSU for the Forest Service, based on the Calveg classification (Forest Service 1981), types of vegetation mapped in this project correspond to vegetation classes at approximately the series level as defined by the Holland (or NDDB) classification system (Holland 1986). [Note: The Holland classification has now been superseded by the Manual of California Vegetation (Sawyer and Keeler-Wolf 1995), published by the California Native Plant Society (CNPS), which contains an index relating the series of the CNPS classification to Holland/NDDB (p. 431)]. The following list and description of vegetation types was an initial evaluation of the mappable types of the Santa Monica Mountains. The types actually mapped are labeled with numeric "map labels".

A. GUIDE TO "LIFE FORMS" OR SUBFORMATIONS, AND LAND COVER TYPES:

NOTE: Cover values for defining forest/woodland vs. shrub/subshrub vs. grassland/herbaceous are modified from Forest Service life form definitions (FIA Handbook 1994). Neither Holland (1986) nor Sawyer and Keeler-Wolf (1995) provide decision rules for separating life forms (they say dominated by [trees, shrubs...], with no definition of dominance).

I. Tree cover >10-%; pick one of the following forest/woodland classes:

Mapped TypeMap Label Types and Subtypes

Valley Oak	11	71130 Valley Oak Woodland
Coast Live Oak	12	71160 Coast Live Oak Woodland
California Walnut	13	71210 California Walnut Woodland
Riparian Woodland	15	several Holland classes; see below

I. Not as above but shrub or subshrub ground cover >10%, pick one of the following soft or hard chaparral types:

Coastal Dunes	1	21230 Southern Foredunes
and Bluff Scrub		21330 Southern Dune Scrub

		31200 Southern Coastal Bluff Scrub
Coastal Sage Scrub	2	32300 Venturan Coastal Sage Scrub
CSS-Chap Transition	3	37G00 Coastal Sage-Chaparral transition
N. Mixed Chap	4	37110 Northern Mixed Chaparral
		37810 <i>Ceanothus cuneatus</i> chaparral
		37830 <i>C. crassifolius</i> chaparral
		37840 <i>C. megacarpus</i> chaparral
		<i>C. spinosus</i> , <i>C. oliganthus</i> , <i>C. leucodermus</i>
Redshank	5	37300 Redshank Chaparral
Chamise	6	37200 Chamise Chaparral
Scrub oak		37900 Scrub Oak Chaparral

III. Not as above and cover of graminaceous plants, forbs, herbs >10%:

Grassland	8	(42110 Valley Needlegrass) (42140 Valley Wildrye) 42200 Non-native grassland
Salt Marsh	10	52120 Southern Coastal Salt Marsh

IV. Cover of natural or seminatural vegetation <10% (areas graded for development are better labeled urban):

Barren	16	rocky outcrops
	9	coastal strand

V. Surface water; lakes, ponds, reservoirs, ocean:

Water	17	N/A
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VI. All types of urban development including residential, industrial and other, both within the intensively developed urban areas bordering the NRA and scattered within the NRA on private lands:

Development	18	N/A
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VII. Agricultural fields, vegetable crops, flowers, etc. (pasture of annual grasses used for grazing are better labeled "grassland"):

Agriculture	19	N/A
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B. DESCRIPTION OF HOLLAND VEGETATION TYPES

* -- type occurs in SMMNRA but could not be mapped using our methods.

Map

Label Type

Holland Label

1 Coastal Bluff Scrub 31200 Southern Coastal Bluff Scrub

Scrub up to 2 m. tall, exposed to constant winds/salt spray (but not on dunes; on bluffs or cliffs). *Coriopsis gigantea*, *C. maritima*, *Encelia californica*, *Erigeron glaucus*, *Atriplex* sp., *Rhus integrifolia*.

*** Coastal Dunes 21230 Southern Foredunes 21330 Southern Dune Scrub**

Located on foredunes and stabilized backdunes; dominated by low +/- succulent perennial herbs: *Abronia*, *Cakile*, *Ambrosia*; grading into coastal scrub community of scattered shrubs, subshrubs and herbs: *Atriplex* sp., *Ericameria* sp., *Haplopappus* sp., *Lupinus* sp., *Rhus integrifolia*, *Carpobrotus edulis* [ice plant].

7 Coastal Cactus Scrub (no equivalent Holland class)

Overwhelmingly dominated (over 60 percent of relative cover) by coastal prickly pear (*Opuntia littoralis*). Occurs in the far western portion of the mountains on southwest facing slopes.

2 Coastal Sage Scrub 32300 Venturan Coastal Sage Scrub

0.5-2 m tall with crowns mostly touching and bare ground beneath. Mainly below 3000 ft. south of Pt. Conception to Baja. *Artemisia californica*, *Eriogonum fasciculatum*, *Eriophyllum confertiflorum*, *Rhus integrifolia*, *Salvia leucophylla*, *S. mellifera*, *Yucca whipplei*.

3 CSS-Chap 37G00 Coastal Sage-Chaparral Transition

Greater than 70 percent cover of both coastal sage scrub and chaparral species. With less than or equal to 40 percent relative cover of coastal sage scrub species, or less than or equal to 60 percent relative cover; where both types are admixed. (From the mapping rules for vegetation and land cover types on Miramar Naval Air Station, O'Leary et al. 1994).

- 4 N. Mixed Chap 37110 Northern Mixed Chaparral**
37810 *Ceanothus cuneatus* chaparral
37830 *C. crassifolius* chaparral
37840 *C. megacarpus* chaparral
C. spinosus, *C. oliganthus*, *C. leucodermus*

Northern Mixed Chaparral is defined by Holland as occurring from the "Klamath mountains to...Transverse and Peninsular ranges on slopes facing away from deserts...dominated by chamise, scrub oak, or one of several species of manzanita or ceanothus." This describes the associations where chamise is present and codominant (0-60% relative cover, typically 40%) with one of the following: cupleaf ceanothus, bigberry manzanita, eastwood manzanita, whitethorn, buckbrush, scrub oak, etc.

Although there may be stands that would qualify as ceanothus chaparral (> 60% relative cover by *C. crassifolius*, *C. megacarpus*, *C. spinosus*, *C. leucodermus*, etc.), manzanita chaparral, etc. in Holland, they can not be identified by our methods are lumped with Northern Mixed Chaparral.

5 Redshank 37300 Redshank Chaparral

Redshank Chaparral is defined in Holland as "often forming pure stands. . . on granitic soils...at higher elevations, with greater precipitation and colder winters than chamise chaparral" characteristic species are chamise, red shank, manzanita spp., *Ceanothus* spp., scrub oak, *Rhus ovata*. 60-100% relative cover of red shank.

6 Chamise 37200 Chamise Chaparral

Chamise chaparral defined in Holland as "overwhelmingly dominated by chamise...associated species contribute little to cover...similar [site factors] to Upper Sonoran Mixed Chaparrals but on shallower drier soils, at somewhat lower elevations."

Based on the Forest Service's ecological type classification definitions for single species chaparral series in southern California (Gordon and White 1994), >60% relative cover of chamise would be chamise-dominated. However, our mapping criteria were more stringent (>80% relative cover chamise). Stands with 60-80% chamise could be members of either Chamise or Northern Mixed Chaparral.

*** Scrub oak 37900 Scrub Oak Chaparral**

Scrub Oak Chaparral defined in Holland as "dominated by scrub oak, with considerable Mountain Mahogany...more mesic [site] than other chaparrals, occurring up to 5000'." From the Gordon and White (1994) ecosystem classification plot data, associations and series that fall within Holland's scrub oak type consist of scrub oak

dominant (60-90% ground cover), or codominant (28-60% ground cover) with mountain mahogany, chamise, and/or ceanothus.

Stands with >60% relative cover of scrub oak are Scrub Oak type. Stands with 30-60% scrub oak have fuzzy membership with both Scrub Oak and probably Northern Mixed Chaparral. No homogenous stands of this type over 5 acres were found in the Santa Monica Mountains during aerial photo interpretation or field work. ***Scrub oak does occur in the study area, yet could not be mapped with our methods.***

8 Grassland (42110 Valley Needlegrass)
(42140 Valley Wildrye)
42200 Non-native grassland

Dense to sparse cover of annual grasses, 0.2-0.5 m tall. Often with numerous species of annual forbs. On fine-textured soils. *Avena barbata*, *Bromus mollis*, *B. rigida*, *B. madritensis ssp. rubens*.

10 Salt Marsh 52120 Southern Coastal Salt Marsh

Herbaceous and suffrutescent salt-tolerant hydrophytes, moderate to dense cover up to 1 m tall. Sheltered inland margins of bays, estuaries, lagoons. *Salicornia*, *Sueda*, *Spartina*, *Distichlis*.

11 Valley Oak 71130 Valley Oak Woodland

Open woodland (usually <40% tree cover); *Q. lobata* usually the only tree present. On deep well-drained alluvial soils. Grass understory. Found on non-alluvial settings in South Coast and Transverse ranges.

12 Coast Live Oak 71160 Coast Live Oak Woodland

Forest form: dense overstory dominated by *Q. agrifolia*. Woodland form: Only one dominant tree (*Q. agrifolia*); shrub layer poorly developed but may include Toyon, *Malosma laurina*, Elderberry or poison oak; grass understory.

13 California Walnut 71210 California Walnut Woodland

Similar to and intergrading with Coast Live Oak Woodland but with canopy locally dominated by *Juglans californica*. Understory of introduced grassland; south side of San Gabriella mountains to the Santa Ana mountains, mostly 500-3000'.

15 Riparian Woodland

The following are riparian types in Holland:

- 61310 Southern Coast Live Oak Riparian Forest
- 61320 Southern Arroyo Willow Riparian Forest
- 61330 Southern Cottonwood-Willow Riparian Forest
- 61510 White Alder Riparian Forest
- 62400 Southern Sycamore/Alder Riparian Woodland
- 63300 Southern riparian scrub (mule fat; southern willow)

After the initial mapping was completed and the vegetation map reviewed, it was concluded by the NPS that further field work should be done in order to add an additional vegetation category. Coastal Cactus Scrub (7) was added to the map during two days of field work in November. Areas of Redshank Chaparral (5) were also added from this field work, as this type was difficult to distinguish spectrally.

Accuracy Assessment

An accuracy assessment was conducted for most classes of the vegetation map utilizing a "fuzzy" accuracy system developed by Gopal and Woodcock (1993). The evaluation of map accuracy with fuzzy sets allows for different levels of set membership for multiple map categories, as all map locations do not fit neatly into a single map category. The use of fuzzy sets provides much more information about the map accuracy than does a traditional confusion matrix.

The accuracy of the vegetation map was assessed by stands of vegetation as represented by the segments (5 acre minimum size). These sites or segments were randomly selected by using an AML script in the Grid module of Arc-Info. The segments selected for all vegetation classes were "anonymously" plotted on shaded relief maps without any information about vegetation classes and with the sequential individual segment number. Roads and streams were also plotted for navigation purposes. In the field, these segments were physically located and evaluated in fuzzy accuracy terms. The segments to be assessed were selected only within the park boundary in order that they could be easily and legally accessed.

The classes not evaluated for accuracy included:

- Redshank chaparral,
- salt marsh,
- walnut woodlands,
- riparian areas, and
- exotic conifer stands.

These classes were not assessed due to their very small sizes, with the exception of the riparian class, which the National Park Service is field mapping. The number of segments

chosen for each class reflects the assumed accuracy of the class (a priori, based on our experience with similar mapping methods) as well as its relative size. The more accurate a class was thought to be and the smaller relative area it contained, the less number of segments were necessary to evaluate it (from Rosenfield et al. 1982). The number of segments necessary was estimated per category and increased by five for each category to compensate for segments that would not be accessible in the field. The number of segments evaluated in the field per class is shown below:

Table 1. Relative area of each class (after classes listed above were excluded) and corresponding number of segments evaluated for accuracy.

Number	Vegetation Class Name	relative % of area	# segments evaluated
1	Coastal Bluff Scrub	0.68	13
2	Coastal Sage Scrub	21.36	26
3	CSS-NMC Transition	0.32	12
4	Northern Mixed Chaparral	32.24	28
6	Chamise	1.26	19
8	Grassland	3.72	13
11	Valley Oak	0.29	13
12	Coast Live Oak	1.71	22
16	Barren Areas	0.52	11
17	Inland water	1.44	11
18	Developed areas	33.16	11
19	Agriculture	3.30	10
Totals		100.00	189

Each segment was assessed in terms of its accuracy for every class on the vegetation map. Figure 1 shows an example of a data sheet used in this process, and includes a description of the ratings of 1 through 5 according to Gopal and Woodcock (1993). Figure 2 is the result of the fuzzy accuracy program and shows the results of the "MAX" and "RIGHT" operators. The MAX operator is an assessment of the percentage correct when a perfect match was found in the field (a rating of 5) which corresponded to the same category on the vegetation map. The RIGHT operator accounts for class fuzziness, and represents the percentage correct of the segments when they received a rating of 3 or above in the field for the category of vegetation that was on the map.

The values under the columns of "MAX", "RIGHT", and "Improvement" consist of the number of segments that fell into these categories followed by the percent of these segments which can be considered percent accuracy in the case of the MAX and RIGHT columns. The summary statistics at the bottom represent an unweighted accuracy ("Total") and an accuracy weighted by the relative area of each vegetation category ("Weighted"). Both summary statistics of the MAX and RIGHT operators should be taken and considered

together. The DIFFERENCE operator is described in Gopal and Woodcock (1993). Note that the overall area-weighted RIGHT accuracy is quite high (93%), while the per-class RIGHT accuracy ranges from 62% (Valley Oak) to 100%. The effect of using a fuzzy rather than traditional accuracy measure is evident when examining the Chamise class whose MAX accuracy is only 37% but whose RIGHT accuracy is 100%.

After this accuracy assessment was performed the map was edited further from the data gathered in the field during the assessment, from comments from the National Park Service's evaluation of a draft map, and from two final days in the field to add Coastal Cactus Scrub and Redshank Chaparral. The numbers provided by the accuracy assessment can therefore be regarded as a minimum accuracy, as the final vegetation map appears to be more accurate due to these edits.

Deliverables

It was discovered during the accuracy assessment that the vegetation map was misregistered slightly with the NPS roads and streams coverage. We determined that the TM image used was referenced to datum NAD83 while the SMMNRA database is all registered to NAD27. Subsequently the imagery and the final vegetation map were transformed to NAD27 and both were delivered to the National Park Service. One hard copy of transcriptions of the email detailing this correction have been submitted to the NPS. The aerial photos, and the digital orthophotos have been returned to the NPS.

REFERENCES

- Forest Service, R. 5. 1981. CALVEG" A classification of California vegetation. Regional Ecology Group, San Francisco, CA.
- . 1994. FIA User's Guide. USDA Forest Service Region 5 Remote Sensing Laboratory, Sacramento, CA.
- Gopal, S., and C. Woodcock. 1994. Theory and methods for accuracy assessment of thematic maps using fuzzy sets. Photogrammetric Engineering and Remote Sensing. 60(2):181-188.
- Holland, R. F. 1986. Preliminary Descriptions of the Terrestrial Natural Communities of California. The Resources Agency, Nongame Heritage Program, California Department of Fish and Game, Sacramento, CA.
- Ogden Environmental and Energy Services Co. Inc. 1991. Vegetation/mapping categories for the Multiple Species Conservation Program (MSCP) Vegetation Mapping Key. San Diego, CA.
- O'Leary, J.F., Hope, A.S., and R.D. Wright. 1994. Vegetation and Landcover Types, Naval Air Station Miramar. Report produced for the Department of the Navy Southwest Division Naval Facilities Engineering Command, Natural Resources Management Branch, by the Center for Earth Systems Analysis and Research (CESAR), Department of Geography, San Diego State University. 72 p.
- Rosenfield, G. H., Fitzpatrick-Lins, K., and H. S. Ling. 1982. Sampling for thematic map accuracy testing. Photogrammetric Engineering and Remote Sensing. 48(1): 131-137.
- Sawyer, J. O., and T. Keeler-Wolf. 1995. *A manual of California vegetation*. California Native Plant Society, Sacramento, CA.