

# *Monterey Pine Forest Conservation Strategy Report*



*Prepared for:*



California Native  
Plant Society

and



California Department  
of Fish and Game  
Natural Heritage Division

*Prepared by:*



Jones & Stokes Associates, Inc.

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*FINAL*

**MONTEREY PINE FOREST  
CONSERVATION  
STRATEGY REPORT**

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## Section 1. Introduction

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### BACKGROUND AND PURPOSE

Monterey pine forest is a biological community of limited extent that faces continued threats from urban growth and development in California. Indigenous stands of Monterey pine forest are restricted to five locations, three in coastal California and two on islands off the coast of Baja California (Figure 1). The California forests are much larger than the Mexican forests, with the Monterey pine forest at Monterey comprising an area greater than all other stands combined (Table 1). Though Monterey pine (*Pinus radiata*) is of limited distribution in its native habitat and is of little economic importance for lumber production in the United States, it is the most widely planted pine tree in the world and of great economic importance in other countries including New Zealand, Chile, Australia, Spain, South Africa, Argentina, Uruguay, and Kenya. Monterey pine is an important ornamental tree in California. Indigenous Californian and Mexican native stands of Monterey pine constitute the exclusive repository of raw material for developing genetic innovations in commercial Monterey pine. Because of the unique nature of the Monterey pine forest ecosystem and the economic importance of Monterey pine as a species, identification of a long-term conservation strategy is crucial to the protection of this valuable resource.

The purpose of this report is to identify conservation priorities and conservation tools that can be used in achieving the long-term conservation of the indigenous Monterey pine forest ecosystem. The focus of this study is the forest of the Monterey area (Figure 2). Specifically, the Monterey forest has suffered the greatest reduction in extent and faces the greatest development pressures of any of the Monterey pine forests (Table 2). Natural habitats (including Monterey pine forest) and developed areas (including urban areas with Monterey pine canopy) in the Monterey study area are depicted in Figure 3 and classified in Table 3.

Several important reports have been prepared in recent years that pertain directly to and have contributed to the conservation strategy. These reports are Jones & Stokes Associates (1994a) ecological assessment report on Monterey pine forest, Jones & Stokes Associates (1994b) description of the Monterey ecological staircase, Huffman & Associates (1994) evaluation of Monterey pine populations, EIP Associates (1995) revised draft environmental impact report on the Pebble Beach lot program, and Jones & Stokes Associates (1996) recovery strategy report for six rare plant species of the Monterey Peninsula.



Table 1. Historical and Present Extent of the Five Populations of Monterey Pine Forest (in acres)

Location	Historic Forest Extent	Present Forest Extent
Monterey	18,324 <sup>a</sup>	9,405 <sup>a</sup>
Año Nuevo	1,500 <sup>b</sup>	1,500 <sup>b</sup>
Cambria	3,500 <sup>b</sup>	2,300 <sup>b</sup>
Cedros	370 <sup>c</sup>	370 <sup>c</sup>
Guadalupe	(400 trees in 1964) <sup>c</sup>	(45 trees in 1988) <sup>d</sup>
Commercial plantings worldwide	0	~ 8 million <sup>e</sup>

Sources: <sup>a</sup>Jones & Stokes Associates, Inc. 1994a.

<sup>b</sup>Huffman & Associates 1994.

<sup>c</sup>Libby et al. 1968.

<sup>d</sup>Libby 1990.

<sup>e</sup>Ciesla 1995.

Table 2. Historical, Present, and Protected Extent of Monterey Pine Forest  
by Geomorphic Surface

Geomorphic Surface	Historical Forest (acres) <sup>c</sup>	Present Forest (acres) <sup>a</sup>	Protected Present Forest (acres) <sup>e</sup>	Percentage of Historical Extent Remaining	Percentage of Present Forest Protected
Marine terrace 1	<sup>f</sup>	43	41	--	95
Marine terrace 2	1,087	170	152	16	89
Marine terrace 3	1,339	161	13	12	8
Marine terrace 4	1,547	318 <sup>b</sup>	36	20	11
Marine terrace 5	1,277	457	118	37	26
Marine terrace 6	261	82	25	31	30
Undetermined marine terraces <sup>d</sup>	325	219	57	52	26
Youngest dunes	<sup>f</sup>	15	2	--	15
Middle-aged dunes	828	123	36	15	29
Oldest dunes	1,168	229	34	20	15
Monterey shale	5,965	4,722	833	79	16
Granitics	2,419	1,194	564	49	47
Other surfaces	1,553	1,430	160	92	11
Undetermined surfaces	<u>555</u>	<u>242</u>	<u>0</u>	<u>43</u>	<u>0</u>
Total	18,324	9,405	2,071	51	22

<sup>a</sup> Estimates based on the overlap between areas mapped by Jones & Stokes Associates as undeveloped Monterey pine forest (forest with natural understory) and geomorphic surfaces as mapped by Dupré (1990).

<sup>b</sup> Of this total, 80 acres are on granite-derived terraces and 238 are on shale-derived terraces.

<sup>c</sup> See Jones & Stokes Associates (1994a) for methodology for determining historical extent of Monterey pine forest.

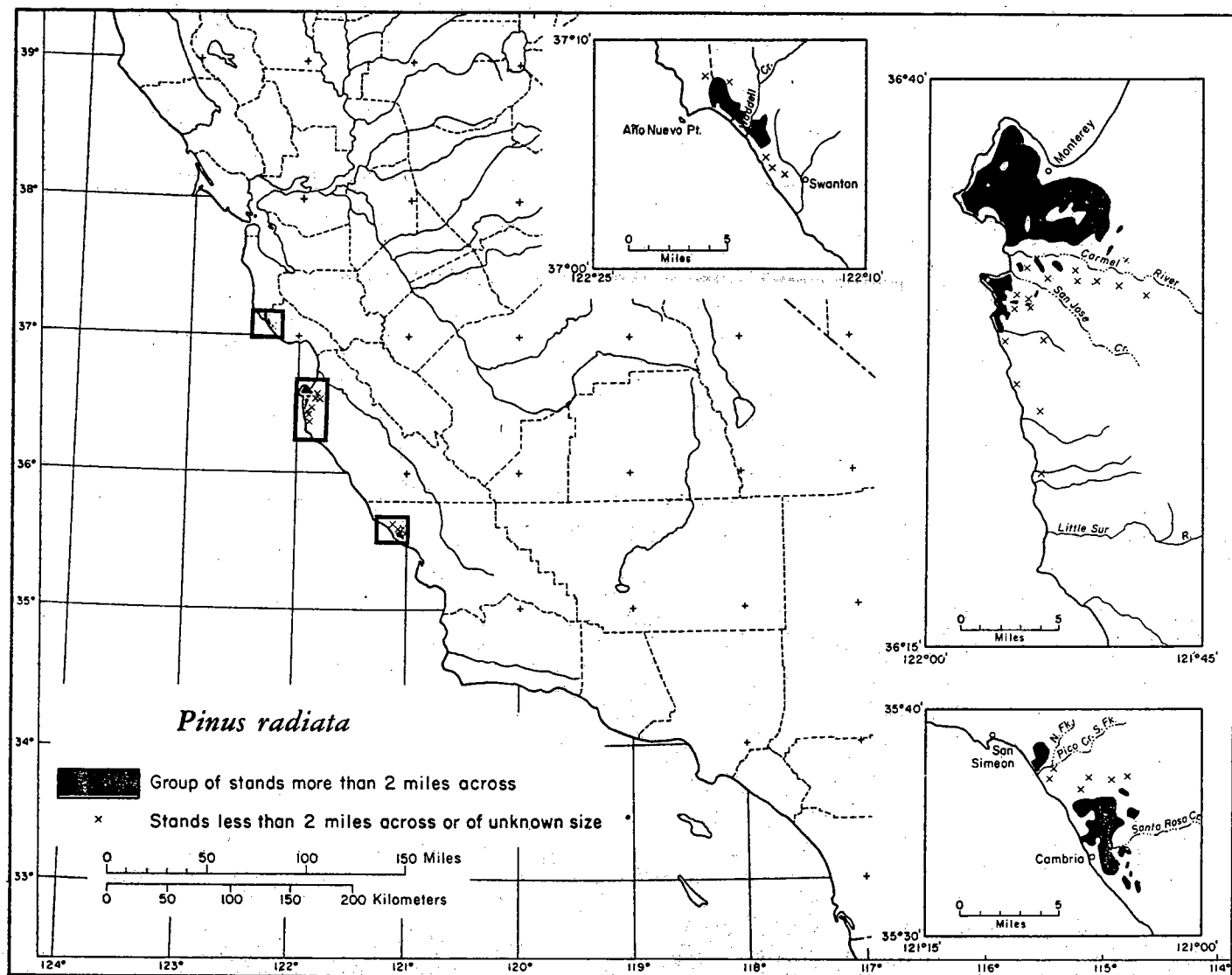
<sup>d</sup> Based on relative landscape positions, these undetermined terraces are most likely marine terraces 5 and 6.

<sup>e</sup> Undeveloped Monterey pine forest within existing parks, open space, and scenic easements.

<sup>f</sup> Historical extent of forest cannot be determined because Monterey pine forest only occasionally occurs naturally on Marine terrace 1 and youngest dunes.

Table 3. Habitat Mapping Classification System for Monterey Pine Forest Study

GIS Code	Habitat Type or Subtype
1.0	Monterey pine forest
1.1	Monterey pine in urban areas, sparse cover (<20% canopy cover)
1.2	Monterey pine in urban areas, dense cover (>20% canopy cover)
1.2.0	Urban development
1.2.1	Golf courses
1.2.2	Urban parks
1.3	Monterey pine in suburban developments (lots <1 acre)
1.4	Monterey pine in rural developments (lots >1 acre)
1.5	Monterey pine forest in undeveloped areas (natural understory)
1.5.0	Monterey pine dominates the canopy
1.5.1	Monterey pine/Bishop pine
1.5.2	Monterey pine in riparian setting
2.0	Monterey cypress forest
3.0	Pygmy forest (Gown cypress and/or Bishop pine with scattered Monterey pine)
4.0	Bishop pine forest (not pygmy)
5.0	Other forest types (redwood forest and Douglas fir forest may have scattered Monterey pine)
5.1	Other forests with Monterey pine as subdominant
6.0	Oak communities (oak forest, oak woodland, and oak savanna)
7.0	Riparian communities (except those that have significant amount of Monterey pine, see 1.5.2)
8.0	Chaparral and coastal scrub
9.0	Chaparral/grassland mosaic
10.0	Coastal dunes, bluffs, and development
11.0	Grasslands (sometimes with inclusions of coastal scrub)
12.0	Agriculture
13.0	Development (includes urban areas, landscaping and lawns, golf courses, and lakes)



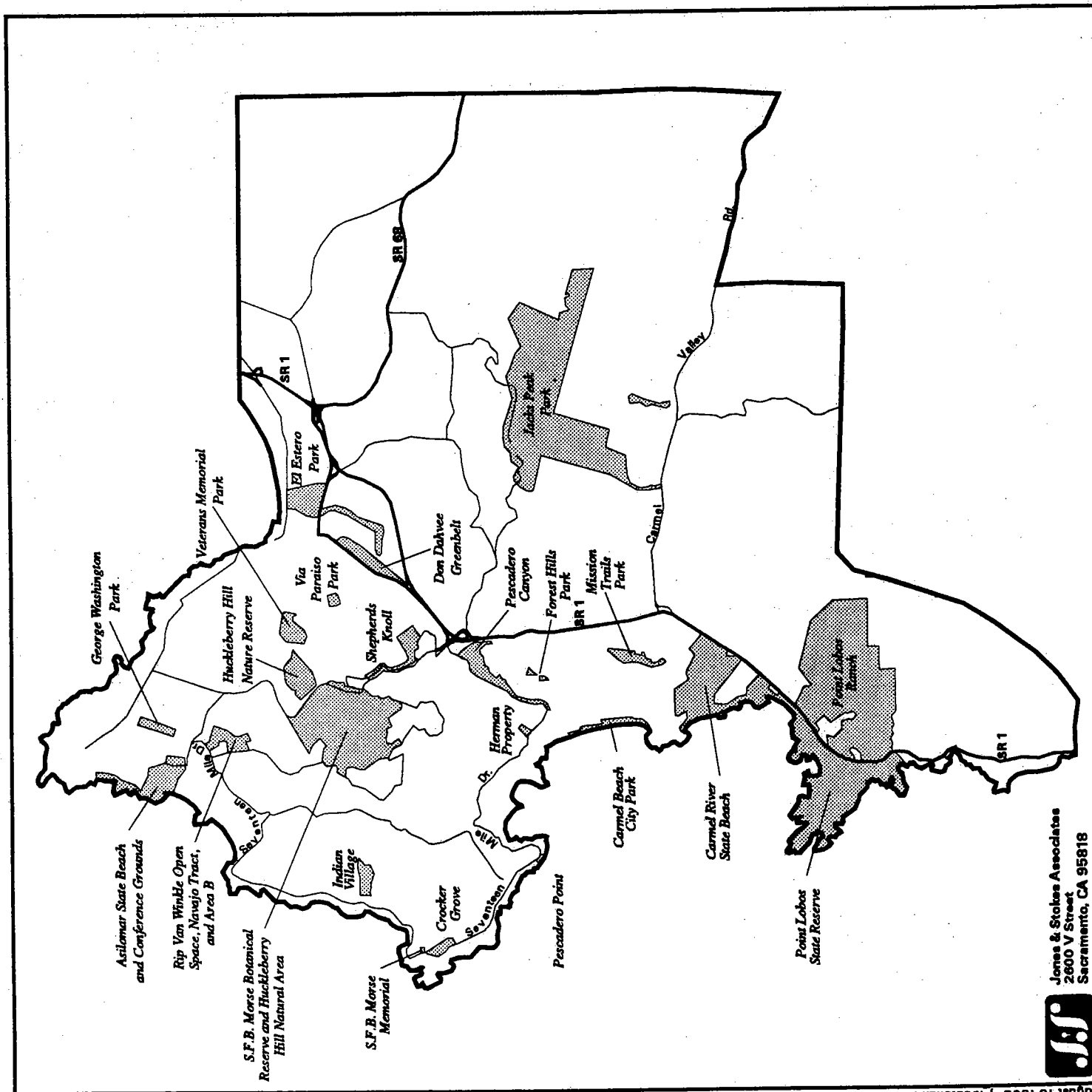
Source: Griffin and Critchfield 1972.



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**Figure 1**  
**Distribution of Monterey Pine Forest**  
**in California**

**Figure 2**  
**Locator Map**  
**for Monterey Pine**  
**Forest Study Area**

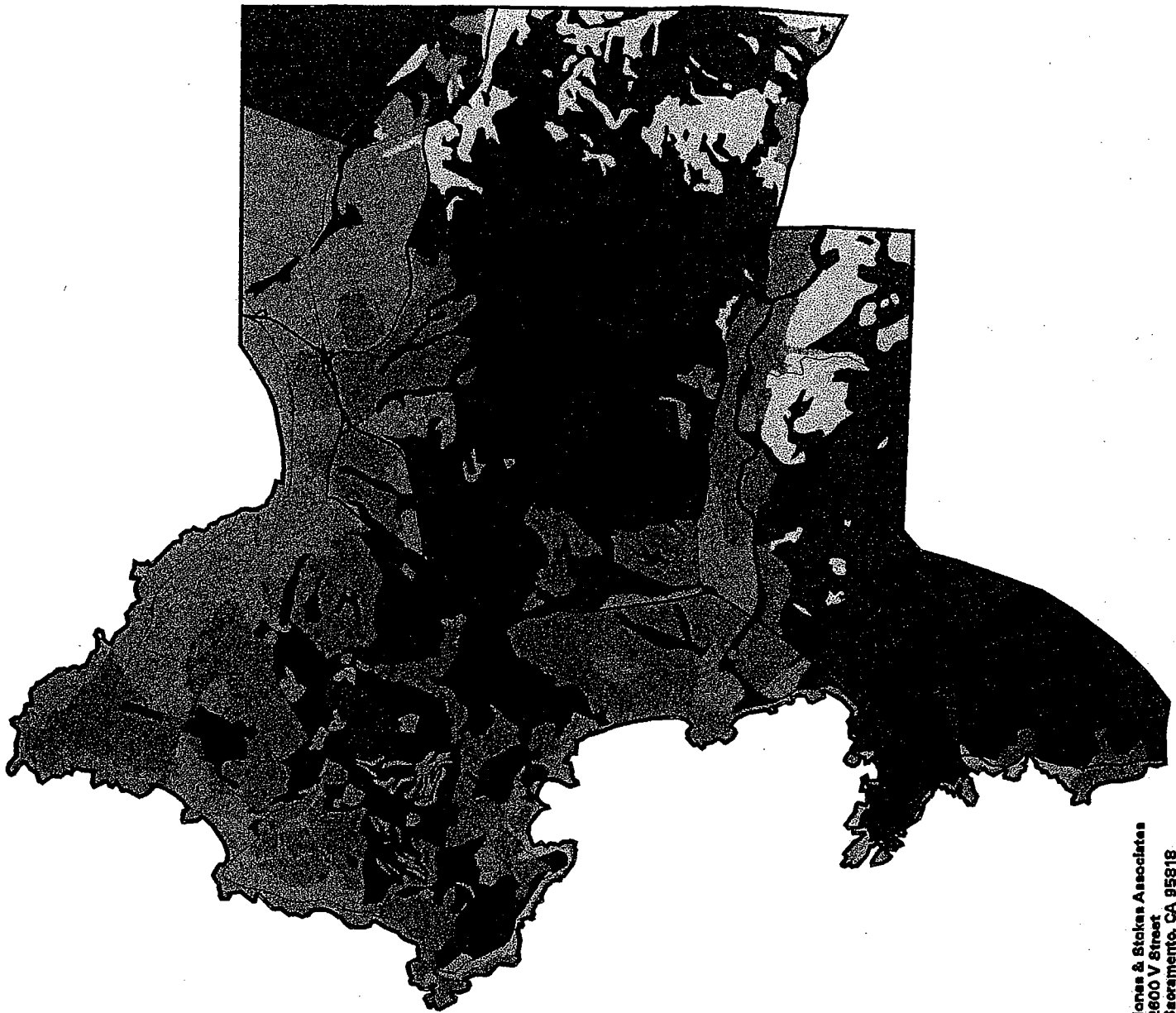


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**Legend**

-  Development - Scattered Monterey Pine as Street Trees
-  Monterey Pine Canopy over Urban and Suburban Development
-  Monterey Pine Forest in Rural Areas
-  Monterey Pine Forest in Undeveloped Areas
-  Monterey Cypress Forest
-  Pygmy Forest
-  Bishop Pine Forest
-  Other Forest Types
-  Oak Communities
-  Riparian Communities
-  Chaparral, Coastal Scrub, and Grassland
-  Coastal Dunes, Bluff, and Development
-  Agriculture



**Figure 3**  
**Habitats of**  
**the Monterey Area**

## Threats to Monterey Pine Forest

The health of the entire Monterey pine forest is threatened by several major factors: development, pitch canker, genetic contamination, fire suppression, and old age.

### Development

Residential and recreational development has been the main cause of the loss of Monterey pine forest (Table 2). Development projects continues to encroach upon the forests at Monterey and Cambria. The Pebble Beach Company's lot program as proposed would result in the removal of approximately 412 acres of Monterey pine forest on the Monterey Peninsula and impacts on remaining stands of forest from fragmentation and adjacent uses (EIP Associates 1995).

### Forest Diseases and Pests

Over 120 pathogens and insect pests are known to attack Monterey pine (Jones & Stokes Associates 1994b). Important fungal diseases include pine pitch canker, western gall rust, coast gall rust, annosus root rot, shoestring fungus, and velvet top fungus. Coastal dwarf mistletoe is a common stem parasite. The most damaging insect pests are red turpentine beetle, California five-spined ips, California four-spined ips, Monterey pine ips, and Monterey pine weevil.

Monterey pine has evolved in the presence of all these diseases and pests except pitch canker, a fungal disease, described in more detail below, that has recently entered California and quickly decimated planted and indigenous stands of Monterey pine. This disease is found in all three California populations of Monterey pine and will likely change the character of Monterey pine forests if it cannot be controlled or if its effects on the forest are not properly managed.

### Genetic Contamination

Genetic contamination refers to the introduction of non-local genes, gene frequencies, or gene combinations into local populations. Genetic contamination results when nursery stock trees originating from breeding programs or from other parts of the species range are planted within or near indigenous Monterey pine stands. Pollen and seeds distributed from these trees of non-local origin can spread their genes into the local population and, over generations, change the genetic make-up of the local stand. Genetic contamination introduces an artificial mixing among the three genetically-isolated pine populations that results in the loss of their genetic uniqueness. Also, planted trees, genetically selected for ornamental or commercial traits, mix with indigenous trees. Genetic contamination could affect adaptations and fitness of local trees to local environments. Although no direct studies have been conducted of the effects of genetic contamination, genetic theory supports the potential for adverse effects (Huffman & Associates 1994, Libby pers. comm.).

## **Fire Suppression and Aging Forest**

The successful suppression of fire in Monterey pine forest in the 20th century has changed the character of the forest. The forest has become uniformly of old age and lacks a diversity of succession stages and structure. Old stands are more susceptible to pests and disease, and fuel loads have built to unnaturally high levels, increasing the risk of catastrophic fire.

### **Goals and Objectives**

The goals of the long-term conservation strategy for the Monterey pine forest are to:

- protect sufficient numbers of trees and stands to ensure survival of indigenous Monterey pine forest,
- promote sufficient natural regeneration for self-sustaining populations of Monterey pine,
- conserve and recover rare, threatened, and endangered plant and wildlife species associated with Monterey pine forest,
- control diseases and pests and promote general health and vigor of Monterey pine stands,
- promote genotypic diversity in Monterey pine as a species by preserving a wide range of ecotypes,
- promote ecological (species) diversity by preserving a wide range of Monterey pine forest community subtypes (associations),
- identify Monterey pine forest management techniques compatible with existing and projected land uses, and
- identify planning tools and policies that will promote Monterey pine forest conservation.

To achieve these goals the conservation strategy has three main objectives:

- to rank remaining stands of Monterey pine forest at Monterey in terms of priority for conservation based on the conservation goals;
- to describe how laws, regulations, policies, and planning tools can be used to conserve the Monterey pine forest resource; and
- to describe appropriate forest management tools for maintaining the health of Monterey pine forest.



This report addresses the biological and logistical issues concerning conservation of Monterey pine forest. No attempt was made to conduct land use planning, assess conservation constraints imposed by such factors as land ownership or property values, or analyze the affects of proposed development projects.

## **Key Forest Conservation Elements**

In this section, background information is provided on elements given primary consideration in developing the conservation strategy for Monterey pine forest. Methods for assigning conservation priority are discussed in "Approach to Identifying Conservation Area Priorities" in Section 2.

### **Geomorphic Surfaces and Soil-Vegetation Relationships**

In 1994, Jones & Stokes Associates (1994b) soil scientists and botanists described a general relationship between soil development and vegetation on the geomorphic surfaces of the Monterey area called the "Monterey ecological staircase". The results of that study indicate that each geomorphic surface supports different combinations of soils and vegetation. Monterey pine forest develops different characteristics as a result of soil and climatic conditions found on geomorphic surfaces of different ages, origins, and location.

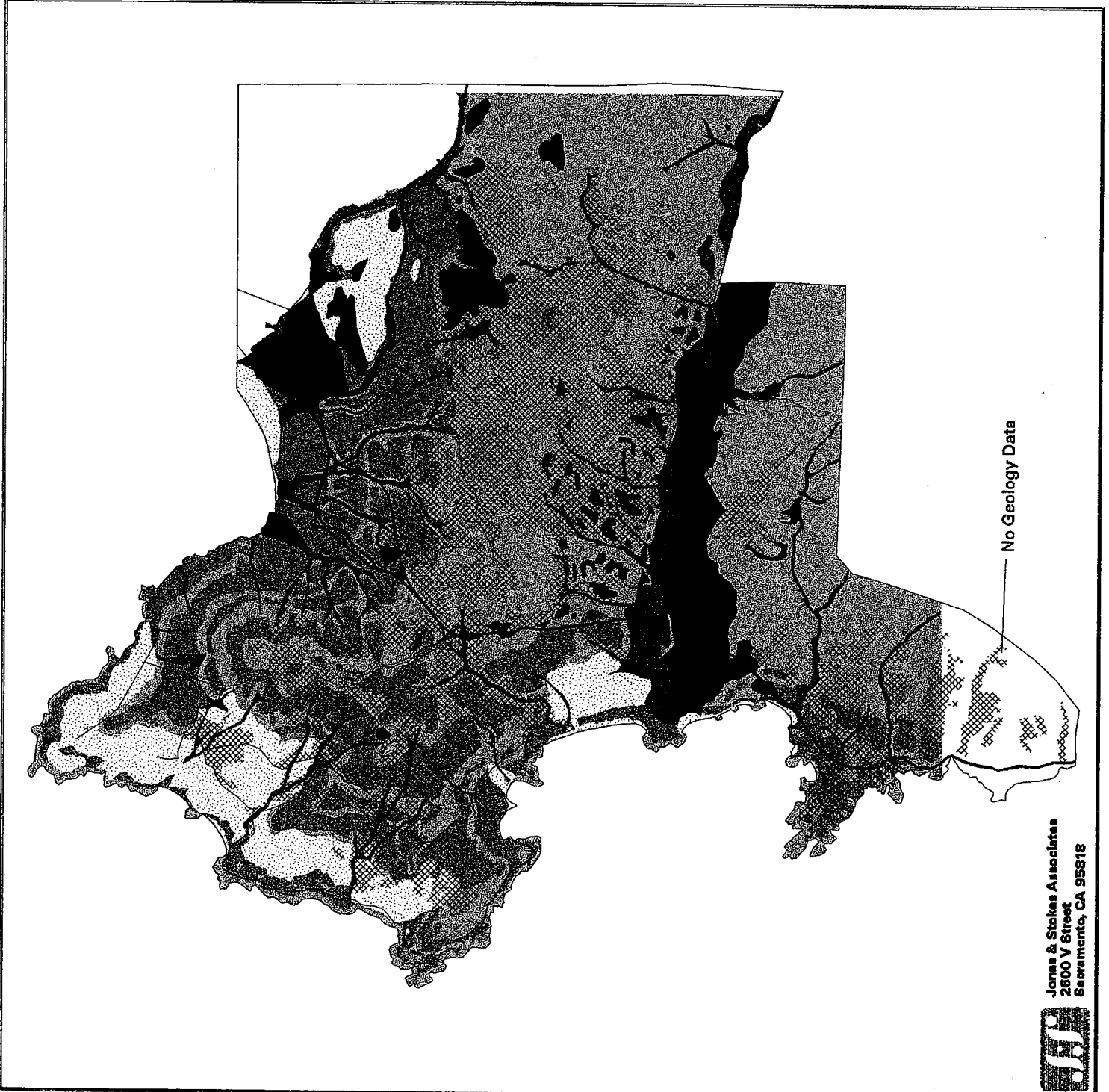
Four major types of geomorphic surfaces that support Monterey pine forest are defined: marine terraces, dunes, alluvial deposits, and pre-Quaternary shales and granites (Table 4 and Figure 4). The extreme soil conditions found on older marine terraces (terraces 4, 5, and 6) result in Monterey pine forests of reduced stature, few oaks, and an understory of manzanita and huckleberry shrubs (Figure 5). Stabilized dunes of Pleistocene origin support full-sized Monterey pine, coast live oak, and an understory of grass and soft-leaved shrubs (monkeyflower, poison-oak, snowberry) (Figure 6). Soils on inland pre-Quaternary shale bedrock support Monterey pine forest of full stature in multi-storied forests with coast live oak and an understory of mostly grass with some areas dominated by low shrubs. On inland shale, Monterey pine forest intergrades with grassland, oak woodland, coastal scrub, and chaparral, transitioning to these communities at more inland locations presumably where summer moisture is insufficient to support Monterey pine. Inland pre-Quaternary granitics support Monterey pine forest of full stature and an understory of chaparral shrubs. On alluvial deposits, Monterey pine forest supports a diverse assemblage of mesic shrubs and herbs. Some inland alluvial deposits support coast redwood (*Sequoia sempervirens*), other riparian species, and Monterey pine.

The geomorphic surfaces of the Monterey area are a good indicator of the nature of Monterey pine forest that exists or that has existed historically on a given site. Regardless of the present condition of a forest stand at a specific site, the soil conditions and climate at the site influence

Table 4. Geomorphic Surfaces Classification System for Monterey Pine Forest Study

GIS Code	Geomorphic Surface <sup>a</sup>
1.0.0	Dunes
1.1.0	Holocene dunes, "youngest dunes"
1.1.1	Beach and sand (Qbs)
1.1.2	Flandrian dune (Qfd, Qd)
1.2.0	Pleistocene dunes (Qod)
1.2.1	Late Pleistocene (Qod1), "middle-aged dunes"
1.2.2	Middle Pleistocene (Qod2), "oldest dunes"
1.2.3	Early Pleistocene, Aromas Formation (Qoe), "oldest dunes"
2.0.0	Coastal marine terraces (Qct)
2.1.0	Marine terrace 1, Lighthouse (Qct1)
2.2.0	Marine terrace 2, Ocean view (Qcto)
2.3.0	Marine terrace 3, Peninsula College (Qctp)
2.4.0	Marine terrace 4, Silvan (Qcts)
2.5.0	Marine terrace 5, Monte Vista (Qctm)
2.6.0	Marine terrace 6, Huckleberry (Qcth)
3.0.0	Other terraces (Qt) mostly fluvial deposits
4.0.0	Pre-Quaternary bedrock (pQ) and Quaternary landslides (Qls)
4.1.0	Monterey shale (pQg, Qlss)
4.2.0	Granitic (pQg, Qlsg)
5.0.0	Alluvial deposits (Qal)
6.0.0	Other surfaces (Qb, QTc, Qc)
7.0.0	Carmel River floodplain deposits (Qb, Qof, Qyf, Qyf(a), Qcf within the Carmel Valley)

<sup>a</sup> Follows Dupré 1990.



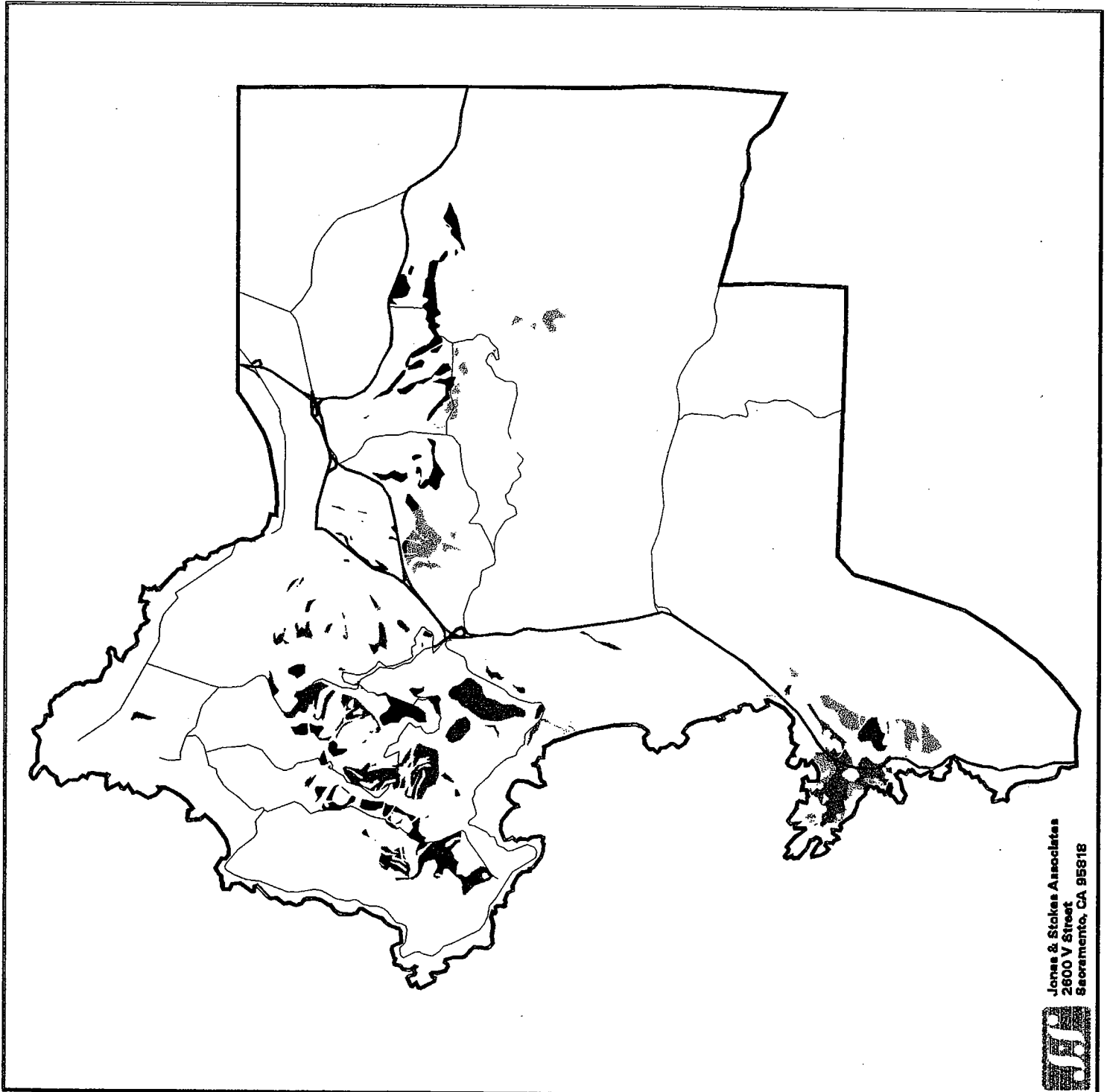
**Legend**

- Dunes (Holocene and Pleistocene)
- Coastal Marine Terraces
- Fluvial Terraces
- Pre-Quaternary Shale and Granite
- Alluvial Deposits
- Other Surfaces
- Carmel River Floodplain Deposits
- Undeveloped Monterey Pine Forest

**Figure 4**  
**Major Geomorphic Features**  
**of the Monterey Area and**  
**Undeveloped Monterey Pine Forest**

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**Legend**

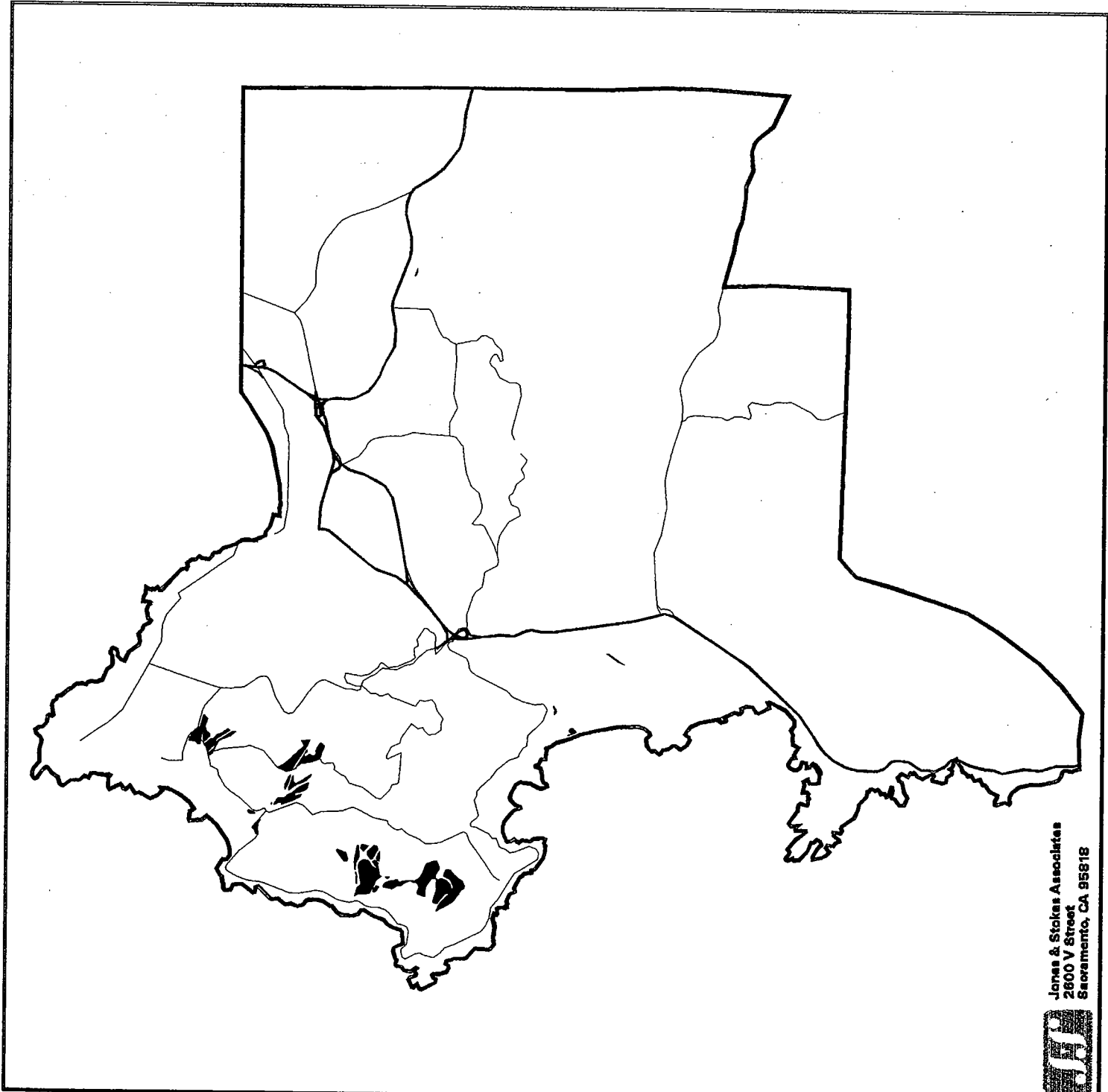
- Undeveloped Forest on Terrace 1
- Undeveloped Forest on Terrace 2
- Undeveloped Forest on Terrace 3
- Undeveloped Forest on Terrace 4
- Undeveloped Forest on Terrace 5
- Undeveloped Forest on Terrace 6
- Undeveloped Forest on Undetermined Terrace



**Figure 5**  
**Undeveloped Monterey**  
**Pine Forest on Marine**  
**Terraces in the Monterey Area**

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**Legend**

- Undeveloped Forest on Youngest Dunes
- Undeveloped Forest on Middle-Aged Dunes
- Undeveloped Forest on Oldest Dunes
- ▨ Undeveloped Forest on Undetermined Dune



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**Figure 6**  
**Undeveloped Monterey**  
**Pine Forest on Dunes**  
**in the Monterey Area**

specific successional sequence and ultimate mature forest subtype that could occur there. In this sense, the ecological potential of a site to support a specific type of Monterey pine forest is of greater importance to conservation planning than the present condition and health of the forest stand. Forest stands can be managed to improve their condition and health, but native soils and climates cannot be recreated. The unusual soil conditions of upper marine terraces and the limited extent of remaining forest on marine terraces and dunes make these forest types of greatest priority for the conservation of habitat, species, and genetic diversity in the Monterey pine forest ecosystem.

The association between geomorphic surfaces and Monterey pine forest is used in this study as an indicator of forest diversity. High priority is given to conservation of representative and sustainable stands of Monterey pine forest on each of the geomorphic surfaces. The assumption is that preservation of the greatest diversity of Monterey pine forest across geomorphic surfaces will ensure the greatest diversity of forest subtypes, species, and genetic variation within species.

### Associated Rare Species

Eleven special-status wildlife species and 14 special-status plant species are associated with Monterey pine forest at Monterey (Tables 5 and 6). These species are not evenly distributed within Monterey pine forest but are associated with soils, climate, and vegetation that are correlated with geomorphic surfaces. Species endemic to the central coastal area are of particular concern in conservation planning for the forest (Table 7). These central coast endemics are considered the "priority" species for the forest conservation strategy. The association of priority species with Monterey pine forest on different geomorphic surfaces was used as a measure of the ecological uniqueness and habitat specialization of the forest on different surfaces.

Known distributions of rare plant and animal species were taken into consideration in identifying the conservation priority of forest stands with special attention given to locally endemic priority species (Table 7). Data on the location of special status species occurrences were obtained from the California Department of Fish and Games natural diversity database (NDDDB 1996), Jones & Stokes Associates (1996; 1995a; 1995b), and EIP Associates (1995).

### Pitch Canker

Pine pitch canker, caused by the fungus *Fusarium subgutinans* f. sp. *pini*, has become a serious disease of indigenous and planted stands of Monterey pine throughout coastal California. Pitch canker was first discovered in California in 1986 at New Brighton State Beach in Santa Cruz County (Storer et al. 1994). It spread rapidly and by 1996 was found in 17 counties from Mendocino to San Diego (Pine Pitch Canker Task Force 1996) (Figure 7). Pitch canker is present in all three of the indigenous Monterey pine populations. No cure exists for the pitch canker disease. The pitch canker disease in Monterey pine is characterized by:

- surface of infected shoots, branches, roots, and trunks exhibiting a resinous exudation;

Table 5. Special-Status Plant Species Known to Occur in Monterey Pine Forest at Monterey, California

Common and Scientific Name	Listing Status <sup>a</sup>		Habitat	Distribution
	Federal/State/CNPS			
Hickman's onion <i>Allium hickmanii</i>	--/--/1B		Closed-cone conifer forest, chaparral, and grasslands	Monterey Peninsula, Ford Ord, Monterey Airport, and coastal San Luis Obispo County
Sandmat manzanita <i>Arctostaphylos pumila</i>	--/--/1B		Closed-cone conifer forest, coastal scrub, and coastal dunes	Extensive areas of Ford Ord; scattered occurrences in the Monterey Peninsula, in Seaside, and at Monterey Airport
Hooker's manzanita <i>Arctostaphylos hookeri</i> ssp. <i>hookeri</i>	--/--/1B		Chaparral, closed-cone conifer forest, and coastal scrub	Extensive areas of Ford Ord; Prunedale Hills; Larkin Valley; scattered sites on Monterey Peninsula
Monterey ceanothus <i>Ceanothus cuneatus</i> var. <i>rigidus</i>	--/--/4		Maritime chaparral; closed-cone conifer forest on sandy hills and flats	North coastal Monterey County
Seaside bird's-beak <i>Cordylanthus rigidus</i> var. <i>littoralis</i>	--/E/1B		Coastal scrub, closed-cone conifer forest, oak woodland, and chaparral on dry, sandy soils below 3,000 feet	Coastal Monterey and Santa Barbara Counties, areas include Ford Ord, Monterey Airport, and Elkhorn Slough in Monterey County; Burton Mesa in Santa Barbara County
Gowen cypress <i>Cupressus goveniana</i> ssp. <i>goveniana</i>	PT/--/1B		Pygmy conifer forest	Known from only two occurrences on Monterey Peninsula and Lobos Ranch in Monterey County
Monterey cypress <i>Cupressus macrocarpa</i>	--/--/1B		Closed-cone conifer forest	Immediate coast on Monterey Peninsula and Point Lobos
Eastwood's ericameria <i>Ericameria fasciculata</i>	--/--/1B		Closed-cone conifer forest, maritime chaparral, and coastal scrub	Most occurrences at Ford Ord; also at Monterey Airport, Monterey Peninsula, Toro Regional Park, and Prunedale Hills
Wedge-leaved horkelia <i>Horkelia cuneata</i> ssp. <i>sericea</i>	--/--/1B		Sandy and gravelly places in coastal scrub and closed-cone conifer forest	Along the coast from Sonoma County to Santa Barbara County
Small-leaved lomatum <i>Lomatium parvifolium</i>	--/--/4		Pine forests, chaparral, and serpentine outcrops	Monterey, Santa Cruz, and San Luis Obispo Counties

Table 5. Continued

Common and Scientific Name	Listing Status*		Habitat	Distribution
	Federal/State/CNPS			
Hickman's potentilla <i>Potentilla hickmanii</i>	PE/E/1B		Grassy openings in closed-cone forest on vernal mesic sites	Known from two occurrences, one small population on the Monterey Peninsula and a large population near Devil's Slide in San Mateo County
Monterey pine <i>Pinus radiata</i>	--/1B		Closed-cone conifer forest on poor soils in summer fog zone	Coastal areas near Monterey, Año Nuevo, and Cambria; two Mexican islands near Baja California
Yadon's piperia <i>Piperia yadoni</i>	PE/--/1B		Chaparral; coastal scrub; and closed-cone conifer forest	Northern coastal Monterey County
Monterey clover <i>Trifolium trichocalyx</i>	PE/E/1B		Closed-cone conifer forest in recently burned sites	Known from the Monterey Peninsula
Pacific Grove clover <i>Trifolium polyodon</i>	--/R/1B		Closed-cone conifer forest, coastal prairie, and meadow on mesic sites	Known from the Monterey Peninsula and Point Lobos

\* Status definitions:

**Federal**

- = No designation  
 PE = Proposed for federal listing as endangered under the federal Endangered Species Act.  
 PT = Proposed for federal listing as threatened under the federal Endangered Species Act.

**State**

- E = Listed as endangered under the California Endangered Species Act.  
 R = Listed as rare under the California Endangered Species Act. This category is no longer used for newly listed plants, but some plants previously listed as rare retain this designation.

**California Native Plant Society**

- 1B = List 1B species: rare, threatened or endangered in California and elsewhere.  
 4 = List 4 species: plants of limited distribution that may be considered rare under CEQA.



Table 6. Special-Status Wildlife Species Known or with Potential to Occur in Monterey Pine Forest at Monterey, California

Common and Scientific Name	Listing Status <sup>a</sup>		Habitat	Distribution
	Federal/State			
Monterey ornate shrew <i>Sorex ornatus salarius</i>	--/--		Found in a variety of riparian, woodland, and upland communities where thick duff or downed logs are present	Restricted to the Monterey Bay region; historical occurrences at the mouth of the Salinas River and Moss Landing in Monterey County
Monterey dusky-footed woodrat <i>Neotoma fuscipes luciana</i>	--/--		Uses habitats with moderate to dense cover and abundant dead wood for nest construction (marine chaparral and woodlands)	Restricted to Monterey County and northern San Luis Obispo County
American badger <i>Taxidea taxus</i>	--/SSC		Uses open, grassy areas with scattered shrubs or trees for cover and loose soil for digging	Found throughout California except in parts of Del Norte, Humboldt, and Siskiyou Counties; widespread throughout the United States west of the Mississippi River
Sharp-shinned hawk <i>Accipiter striatus</i>	--/SSC		Found in riparian forests, conifer forests, and oak woodlands	Permanent resident in the Sierra Nevada, Cascade, Klamath, and north Coast Ranges, as well as along the coast in Marin, San Francisco, San Mateo, Santa Cruz, and Monterey Counties; winters over the rest of the state except at high elevations; breeds and winters throughout North America
Cooper's hawk <i>Accipiter cooperi</i>	--/SSC		Nests in riparian forests and dense canopy oak woodlands; forages in open woodlands	Found in all parts of California except high altitudes in the Sierra Nevada; winters in the Central Valley, southeastern desert regions, and the plains east of the Cascade Range; permanent resident throughout the lower 48 states
Ringtail <i>Bassariscus astutus</i>	--/FP		Prefers riparian forests, chaparral, and rocky hillsides	Found in the Sierra Nevada and Coast Ranges and the Sacramento Valley; potentially occurs in riparian woodlands in the Chico area; nearest occurrences are on the Sacramento River, Feather River, and Bobelaine Sanctuary
Pallid bat <i>Antrozous pallidus</i>	--/SSC		Rocky outcrops, cliffs, and crevices for roosting; access to open habitats required for foraging	Low elevations throughout California
California horned lizard <i>Phrynosoma coronatum frontale</i>	--/SSC		Occurs in areas with sandy soils and moderate cover	Occurs in Central Valley from Tehama County south to Tulare County and Coast Ranges from Sonoma County south to San Diego County

Common and Scientific Name	Listing Status <sup>a</sup>		Habitat	Distribution
	Federal/State			
California black legless lizard <i>Anniella pulchra nigra</i>	PE/SSC		Requires moist, warm habitats with loose soil for burrowing, prostrate plant cover, and abundant invertebrate populations; may be found on beaches, in chaparral, scrub, or woodland areas, with appropriate microhabitat conditions	Restricted to small populations along the coast in Monterey and northern San Luis Obispo Counties; one recorded population in Contra Costa County
Silvery legless lizard <i>Anniella pulchra pulchra</i>	--/SSC		Requires similar habitat conditions as the black legless lizard	Where habitat is appropriate in the south Coast, Transverse, and Peninsular Ranges from Contra Costa County to San Diego County and the southern Sierra Nevada in Kern County and Tulare County
Monarch butterfly <i>Danans plexippus</i>	--/SSR		Roosts in trees, such as eucalyptus, Monterey pine, and Monterey cypress	Overwinters (September-February) in colonies along the California coast from Mendocino County in the north, to San Diego County in the south

<sup>a</sup> Status definitions:

**Federal**

-- = No designation.

PE = Proposed for federal listing as endangered under the federal Endangered Species Act.

**State**

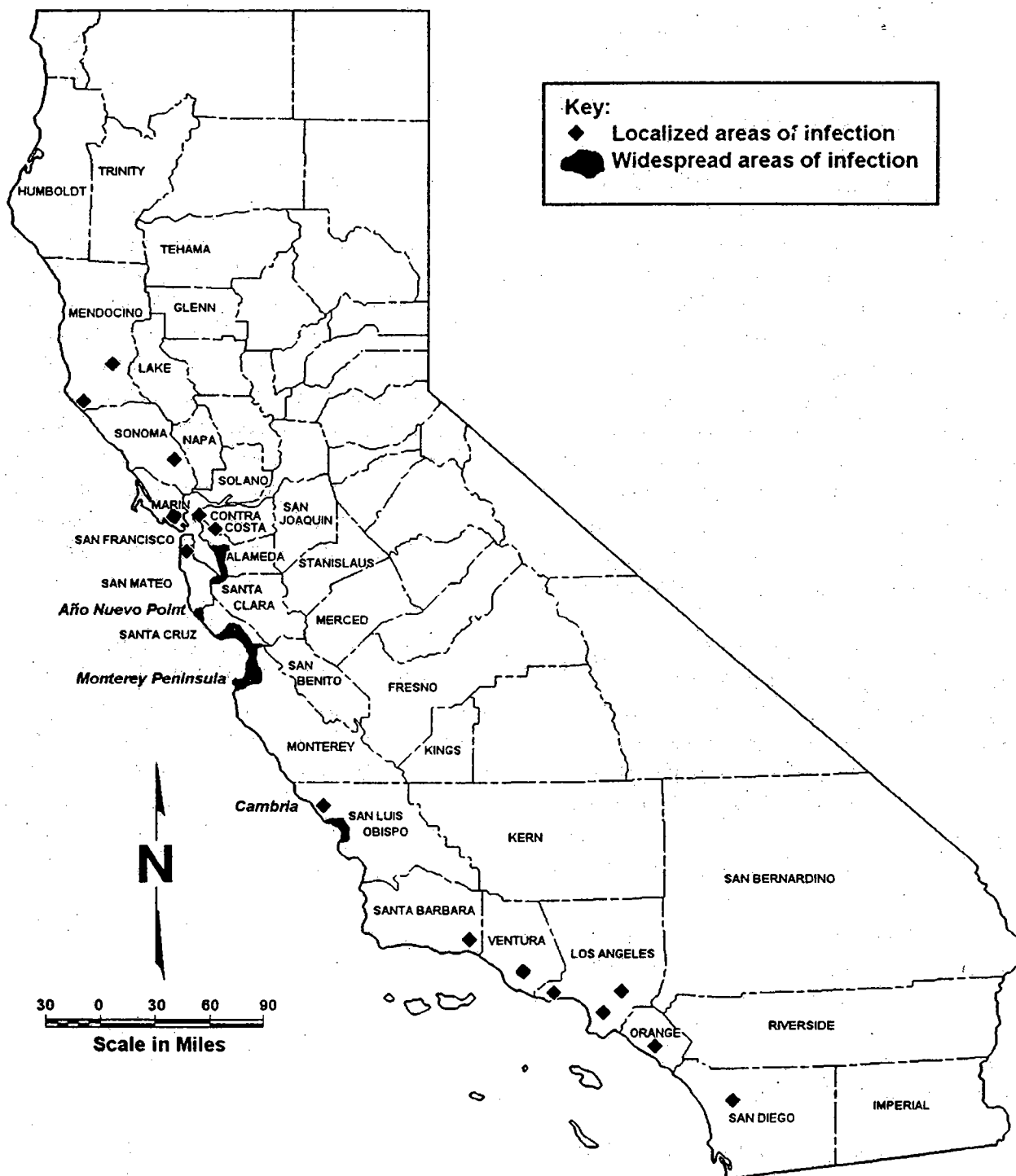
FP = Fully protected under the California Fish and Game code.

SSC = California Department of Fish and Game species of special concern.

SSR = State special resource

Table 7. Priority Species: Special-Status Species Locally Endemic to Central Coastal California that Occur in Monterey Pine Forest at Monterey

Species	Geomorphic Surface Typically Associated with Species within Monterey Pine Forest
black legless lizard	recent and Pleistocene dunes
Monterey ornate shrew	potentially all geomorphic surfaces
Monterey dusky-footed woodrat	potentially all geomorphic surfaces
Hooker's manzanita	marine terraces 3, 4, 5 and 6; Pre-Quaternary shale and granitics; oldest Pleistocene dunes (Aromas Formation)
sandmat manzanita	Pleistocene dunes; marine terrace 4, 5, and 6; Pre-Quaternary granitics
Monterey ceanothus	older marine terraces; granitics
Gowen cypress	marine terrace 5
Monterey cypress	coastal edge of marine terrace 2
Eastwood's ericameria	marine terraces 4 and 5
Yadon's piperia	marine terraces 2-6; Pleistocene dunes; Pre-Quaternary shales and granitics
Hickman's potentilla	marine terrace 2
Pacific Grove clover	marine terraces 1-4; Pleistocene fluvial terrace; swales in recent dunes
Monterey clover	marine terraces 5 and 6
Hickman's onion	marine terraces 3-5, Pleistocene fluvial terrace



Source: Dallara et al. 1995.



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**Figure 7**  
**Distribution of Pitch Canker in California**

- infected wood becoming honey-colored, resin soaked;
- needles at ends of infected branches turning yellow then light reddish-brown and eventually falling off; and
- tree crown exhibiting evidence of die-back (Storer et al. 1994).

Pitch canker disease often leads to the death of the entire tree. Pitch canker fungus has been isolated from a variety of beetles that likely serve as vectors of the pathogen. These species include twig beetles (*Pityophthorus nitidulus*, *P. pulchellus tuberculatus*, *P. carmeli*, *P. setosus*), cone beetle (*Conophthorus radiatae*), dry twig and cone beetle (*Ernobius punctulatus*), California five-spined ips (*Ips paraconfusus*), Monterey pine ips (*I. mexicanus*), and California four-spined ips (*I. plastographus*) (Storer et al. 1994). The fungus has been found to be borne in the seeds of infected trees and passed to the seedling; even asymptomatic branches on infected trees have produced infected seeds (Wood pers. comm.). Recent field observation indicate the spittlebugs (*Aphrophora* spp.) may be a vector of pitch canker among Monterey pine seedlings and saplings (Pine Pitch Canker Task Force 1996). If they are not disease vectors, spittlebugs may provide a wound or habitat for the fungus to enter (Owen pers. comm.). The fungus also survives in the soil and may infect seedlings at the soil level (Owen pers. comm.).

A wide range of native and nonnative pines and Douglas-fir (*Pseudotsuga menziesii*) have been found to be susceptible to pitch canker infection (Storer et al. 1994). California tree species have not coevolved with pine pitch canker, but variation in susceptibility to pitch canker has been found in Monterey pine, indicating that genetically-based resistance may exist (Wood pers. comm.). About 15% of trees in ornamental plantings appear to be resistant and, in addition, some trees survive infection but are not completely resistant (Owen pers. comm.). These infection-tolerant trees appear to be able to survive in the long term with the fungal infection, but the disease has not been present long enough in California to evaluate the survivorship of these trees.

The control of pitch canker is of vital importance to successful conservation of Monterey pine forest. Recommended forest management practices take into consideration the control of pitch canker.

## Fire Management

Monterey pine forest is a fire-adapted community. Most of the species growing in the forest respond well to periodic fires. Fire causes Monterey pine cones to open, clears overstory and understory cover, and returns nutrients to the soil. Following fire, thousands to hundreds of thousands of pine seedlings per acre often establish simultaneously. Forest shrub and herb diversity is greatest in the early successional stage following a fire event. Forest shrubs recover by stump sprouting and seeding. Seeds from many herbaceous species, including the rare Monterey clover, invade or germinate from the seed bank and appear at forest sites only following fire. More detail

on successional patterns following fire for forests on different geomorphic surfaces is provided in a report prepared by Jones & Stokes Associates (1994b).

As a fire adapted community, Monterey pine forest is best managed by fire. Urban development, however, restricts the use of fire in many areas of the forest. The city of Monterey prohibits and the city of Carmel discourages the use of fire for vegetation and fuel load management. The conservation strategy takes into account the limitations posed by fire hazards and identifies a different set of suitable management techniques for forest conservation areas in urban settings and for forest conservation areas in wildland locations.

## **Section 2. Forest Conservation Areas**

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This section describes the approach and results of the assessment of conservation priorities for Monterey pine forest at Monterey. Rather than specifying the location of specific conservation areas for Monterey pine forest, this report identifies the relative conservation priority for forest stands based on defined ecological criteria.

### **APPROACH TO IDENTIFYING CONSERVATION AREA PRIORITIES**

Only stands of indigenous Monterey pine forest with natural understory at Monterey and outside of existing protected properties were assigned conservation priority values. These stands were originally defined and their locations mapped in the Jones & Stokes Associates (1994a) ecological assessment report for Monterey pine forest.

Geomorphic surfaces serve as an excellent summary of key features concerning Monterey pine forest qualities. Different geomorphic surfaces are associated with soils, elevation, and relationships to the coast that result in the occurrence of varied canopy and understory structure and species composition in Monterey pine forest (Jones & Stokes Associates 1994b). Many special-status plant and wildlife species are associated with Monterey pine forest on specific geomorphic surfaces (Table 8) (Jones & Stokes Associates 1996). The following summary parameters were used to determine the relative conservation priority of stands of Monterey pine forest:

- total amount of existing Monterey pine forest on each geomorphic surface;
- the percentage of existing Monterey pine forest on each geomorphic surface relative to the historical extent of forest on that surface;
- the percentage of existing undeveloped Monterey pine forest protected in parks, open space, and scenic easements;
- the known occurrences of special-status species populations and areas of suitable habitat for special-status species based on geomorphic surfaces;
- the size of a forest stand relative to the size of other stands of forest; and
- the spatial relationship of the forest stand to adjacent habitats and the quality of adjacent habitats.

Table 8. Relationship of Priority Species of Monterey Pine Forest with Different Geomorphic Surfaces

	Monterey														Total (14)
	Black Legless Lizard	Monterey Ornate Shrew	Dusky- Footed Woodrat	Hooker's Manzanita	Sandmat Manzanita	Monterey Ceanothus	Gowen Cypress	Monterey Cypress	Eastwood's Ericameria	Yadon's Piperia	Hickman's Potentilla	Pacific Grove Clover	Monterey Clover	Hickman's Onion	
Marine terrace 1		X	X									X			3
Marine terrace 2		X	X					X		X	X	X			6
Marine terrace 3		X	X	X		X				X		X		X	7
Marine terrace 4		X	X	X	X	X			X	X		X		X	9
Marine terrace 5		X	X	X	X	X	X		X	X			X	X	10
Marine terrace 6		X	X	X	X	X				X			X	X	8
Undetermined terrace <sup>a</sup>		X	X	X	X	X	X		X	X			X	X	10
Youngest dune	X	X	X									X			4
Middle-aged dune	X	X	X		X					X					5
Oldest dune	X	X	X	X	X					X					6
Monterey shale		X	X	X						X					4
Granite		X	X	X	X	X				X					6
Other		X	X									X		X	4

<sup>a</sup> Includes terraces 5 and 6.

<sup>a</sup> Includes terraces 5 and 6.



## Assigning Priority to Forest Found on Different Geomorphic Surfaces

Monterey pine forest on different geomorphic surfaces was assigned ranks of high, moderate or low priority for conservation based on:

- existing extent of forest,
- percent loss of forest from historic extent,
- percent of forest in protected status, and
- number or target species with potential to inhabit the area.

Geomorphic surfaces with small existing extent (less than 100 acres) of Monterey pine forest are youngest dunes, marine terrace 1, and marine terrace 6 (Table 9). Geomorphic surfaces with greatly reduced extent (80% or more loss) of Monterey pine forest from historical distribution are middle-aged dunes, oldest dunes, marine terrace 2, marine terrace 3, and marine terrace 4 (Table 9). Geomorphic surfaces with a small percentage (less than 20%) of Monterey pine forest in protected status are youngest dunes, oldest dunes, marine terrace 3, marine terrace 4, inland shale, and other surfaces (Table 9). The distribution of undeveloped Monterey pine forest in relation to existing protected properties (parks, open space, and scenic easements) is depicted in Figure 8. Geomorphic surfaces supporting Monterey pine forest with potential habitat for a large number (7 or more species) of priority species are marine terrace 3, marine terrace 4, marine terrace 5, marine terrace 6, and undetermined marine terraces (terraces 5 and 6) (Table 8).

The rationale for priority ranks for each surface is provided in Table 10. Based on the four criteria, Monterey pine forest on the following geomorphic surfaces was determined to be of high conservation priority:

- youngest dunes,
- middle-aged dunes,
- oldest dunes,
- marine terrace 3,
- marine terrace 4,
- marine terrace 5,
- marine terrace 6, and
- undetermined marine terraces (includes marine terraces 5 and 6).

Based on the four criteria, Monterey pine forest on the following geomorphic surfaces was determined to be of moderate conservation priority:

- marine terrace 2, and
- marine terrace 1.

Based on the four criteria, Monterey pine forest on the following geomorphic surfaces was determined to be of low conservation priority:

Table 9. Conservation Priority Evaluation Data by Geomorphic Surface

Geomorphic Surface	Present Forest (acres)	Percent of Historical Remaining	Percent of Present Forest Protected	Number of Priority Species
Youngest dunes	15.5	<sup>b</sup>	15.4	4
Middle-aged dunes	123.3	15	28.9	5
Oldest dunes	230.5	20	15.0	6
Undetermined marine terrace <sup>a</sup>	219.4	52	26.1	10
Marine terrace 1	42.8	<sup>b</sup>	95.1	3
Marine terrace 2	170.0	16	89.3	6
Marine terrace 3	160.9	12	8.2	7
Marine terrace 4	318.5	20	11.3	9
Marine terrace 5	457.6	37	25.8	10
Marine terrace 6	81.6	31	30.1	8
Monterey shale (410)	5,095.6	79	16.3	4
Granitic (420)	1,204.3	49	46.8	6
All other surfaces	1,043.3	92	15.3	4
Undetermined surfaces <sup>c</sup>	<u>242.0</u>	43	0.0	Unknown
Total	9,405.1	51%	22.0%	14

<sup>a</sup> Includes marine terraces 5 and 6.

<sup>b</sup> Percent historical remaining cannot be calculated because Monterey pine forest only occurs sporadically on the youngest dune and marine terrace 1 surfaces.

<sup>c</sup> 242 acres of undeveloped Monterey pine forest occur south of the area mapped by Dupré (1990) for geomorphic surfaces.

Table 10. Rationale for Determining Conservation Priority for Monterey Pine Forest on Different Geomorphic Surfaces

Geomorphic Surface	Conservation Priority	Rationale
Marine terrace 1	moderate	Only 43 acres of forest on this surface remain, which amounts to 16% of the historical extent; however, 95% of this forest is in protected status.
Marine terrace 2	moderate	Only 12% of the historical extent of this forest remains; however, 89% of this forest is in protected status.
Marine terrace 3	high	This forest has been reduced to 12% of its historical extent with only 8% in protected status; 7 priority species are associated with this forest.
Marine terrace 4	high	Only 20% of the historical extent of this forest remains, with only 11% in protected status; 9 priority species are associated with this forest.
Marine terrace 5	high	Ten priority species are associated with this forest.
Marine terrace 6	high	Eight priority species are associated with this forest.
Undetermined marine terrace (terraces 5 and 6)	high	Ten priority species are associated with this forest.
Youngest dunes	high	Only 15 acres of this forest remain, with only 15% in protected status.
Middle-aged dunes	high	Only 15% of the historical extent of this forest remains.
Oldest dunes	high	Only 20% of the historical extent of this forest remains, with only 15% in protected status.
Pre-Quaternary shale	low	This forest is the largest of all types with an extent of 5,096 acres, representing 79% of the historical extent of this forest; a large extent of forest, 833 acres, is in protected status.
Pre-Quaternary granitic	low	A large amount, 1,204 acres, of this forest remains, representing 49% of the historical extent; 47% is in protected status.
Other surfaces	low	A large amount, 1,043 acres, of this forest remains, representing 92% of the historical extent; 160 acres are in protected status.

- pre-Quaternary shale,
- pre-Quaternary granitics, and
- other surfaces.

The distribution of forest stands of high, moderate, and low conservation priority, based on the ranking of geomorphic surfaces, is presented in Figure 9. This ranking was used as one parameter in the assessment of conservation priority for forest management units, described below in the section "Criteria for Assigning Priority to Management Units."

### **Criteria for Assigning Priority to Management Units**

Following the conservation priority ranking of forest stands by geomorphic surface, the stands were grouped into larger management units based on continuity of forest stands and protection status (Figure 10). These management units were evaluated for:

- degree of fragmentation,
- management potential, and
- presence of priority species.

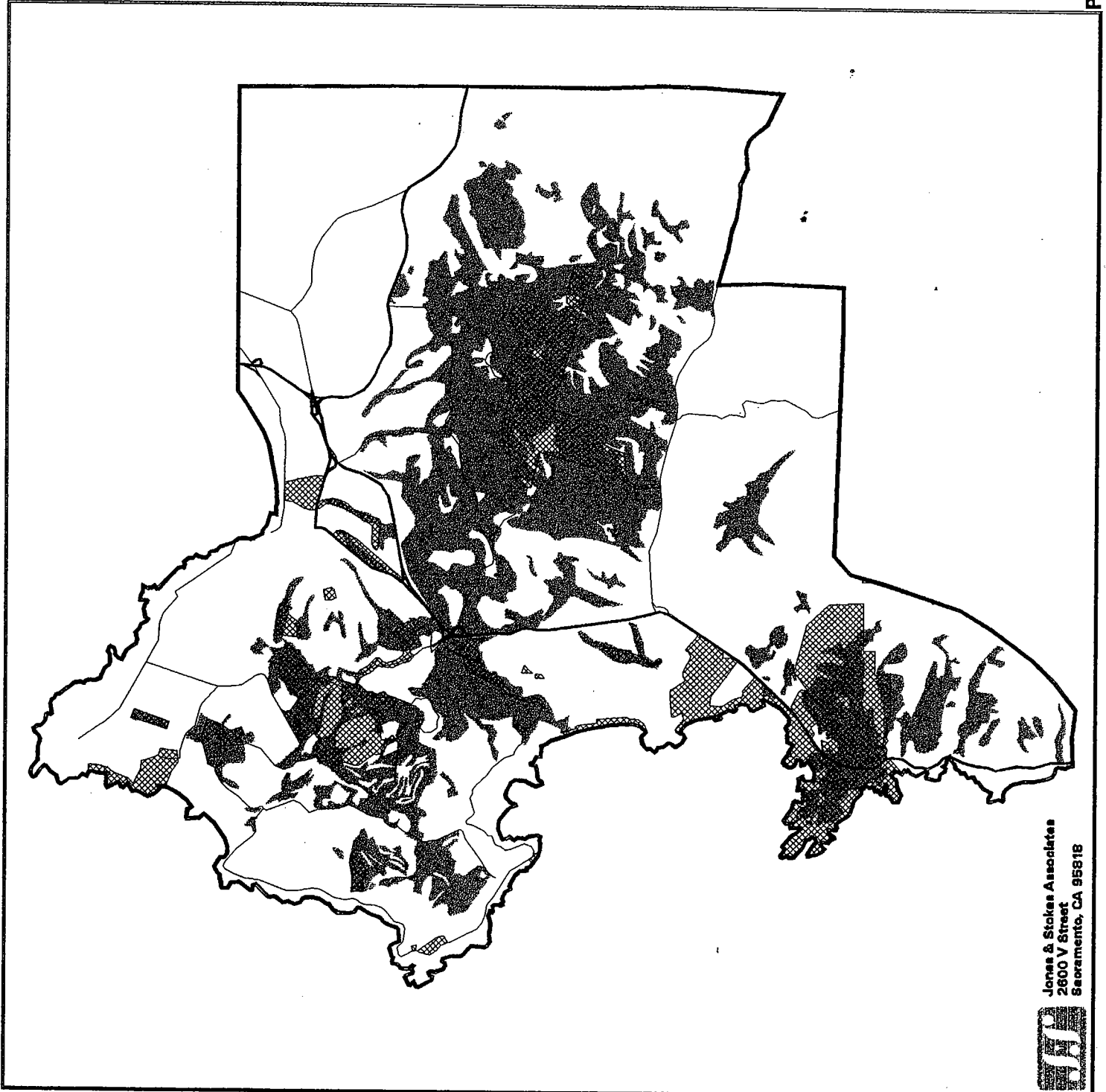
#### **Degree of Fragmentation**

Forest stands within management units appear as continuous, large patches with low edge-to-area ratio or as fragmented, smaller patches with high edge-to-area ratio. Portions of the forest with geometric shapes and greater than 40 acres in extent were considered to be large and continuous. Isolated stands smaller than 40 acres and portions of forest with interspersed development or other habitats were considered to be fragmented. The 40-acre threshold was chosen based on the size of several of the large continuous stands of forest on the Monterey Peninsula and does not reflect any ecologically determined minimum stand size. Stands smaller than 40 acres can be of high value. The 40-acre threshold was used only as a means of assessing the fragmentation parameter.

Fragmented portions of forest within management units are considered to be of lower conservation priority than continuous, large forest stands.

#### **Management Potential**

Proper ecosystem management is important to the maintenance of healthy Monterey pine forest. Management tools include controlled fire, mechanical vegetation maintenance, and manual vegetation maintenance. The management potential is an estimation of the flexibility for use of the



**Legend**

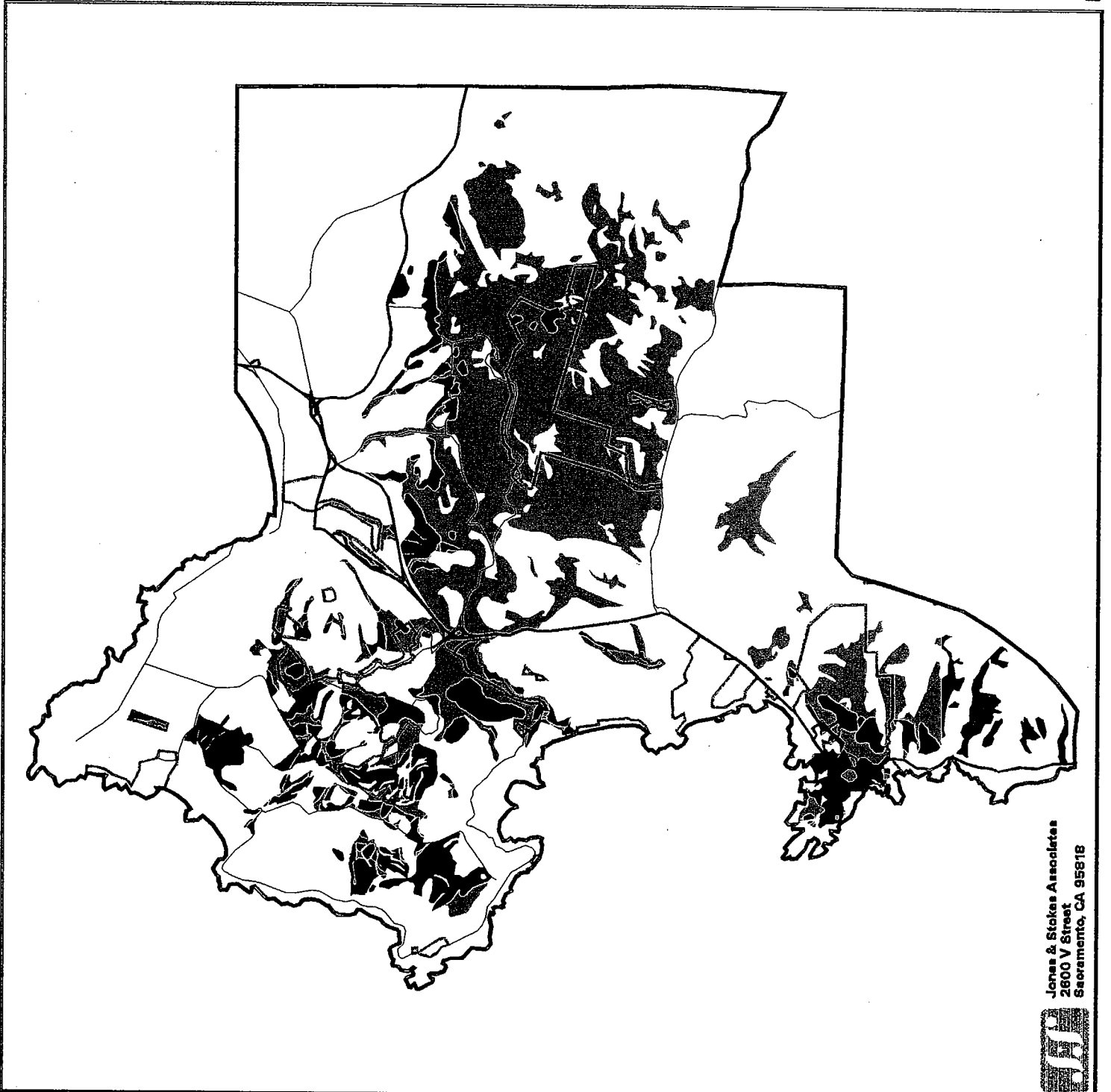
-  Undeveloped Monterey Pine Forest
-  Parks, Open Space, Scenic Easements

**Figure 8**  
**Distribution of Undeveloped**  
**Monterey Pine Forest and Existing**  
**Protected Areas in the Monterey Area**

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**Legend**

- High Conservation Priority
- Moderate Conservation Priority
- Low Conservation Priority
- Not Rated
- ▣ Parks, Open Space, Scenic Easements

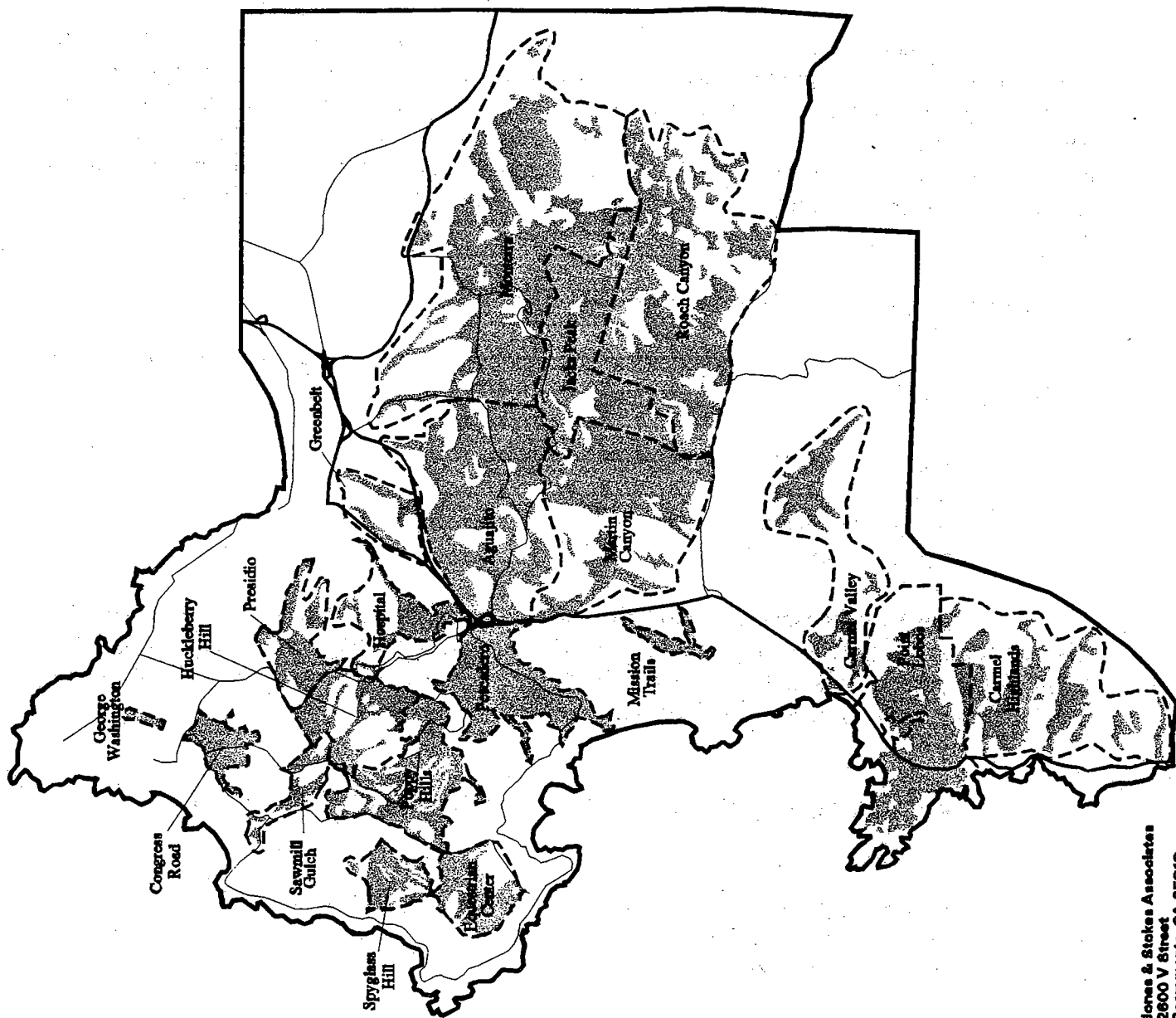


**Figure 9**  
**Conservation Priorities of**  
**Geomorphic Surfaces Supporting**  
**Undeveloped Monterey Pine Forest**

**Legend**

 Undeveloped Monterey Pine Forest

 Management Unit Boundary



**Figure 10**  
**Management Units for**  
**Undeveloped Monterey Pine Forest**

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full range of ecosystem management tools in a given management unit. Management potential is determined by factors including:

- size of the forest patch,
- nearness of the patch to development, and
- adjacent land use and habitat.

Large patches surrounded by compatible uses are considered to be of higher conservation priority than small patches with surrounding urban development that could be put at risk by fire.

### **Presence of Priority Species**

Known occurrences of priority species in management units were used to determine the conservation priority for all or portions of the management unit. A high number of priority species results in greater conservation priority for a site. Where a population of a priority species is important to the survival of the species, such as populations that form a large percentage of the entire known population of the species, the site was given a high conservation priority. Where populations are unique, such as at the limit of the species range, the site was given a higher priority.

### **Conservation Priority for Management Units**

Each of the management units or sub-areas within the unit was assigned a conservation priority based on:

- conservation priority of geomorphic surfaces,
- degree of fragmentation,
- management potential, and
- presence of priority species.

The analysis of conservation priority was qualitative and was conducted through the review of maps, reports, and aerial photographs containing information on habitat, geology, priority species, and development (Jones & Stokes Associates 1994a, 1994b, 1995a, 1995b, and 1996; EIP Associates 1995; Huffman and Associates 1994; and Dupré 1990).

## **RESULTS OF CONSERVATION AREA PRIORITIES ANALYSIS**

The resources present in each management unit and the conservation priority of the unit are discussed in this section. The conservation priority rankings of management units and a summary of the rationale for conservation priority decisions are provided in Table 11.



Table 11. Conservation Priority and Decision Rationale for Monterey Pine Forest Management Units

Management Unit/Portion of Unit	Conservation Priority	Decision Rationale
<b>Equestrian Center</b>		
On oldest dunes and marine terraces 3 and 4	High	Large stands on high priority surfaces with priority species populations
On other surfaces	Low	Low priority surface, no priority
<b>Spyglass Hill</b>	High	Important remaining stands on high priority geomorphic surfaces
<b>Poppy Hills</b>		
Large stands on marine terraces 4, 5, and 6	High	High priority surfaces, large, contiguous with other stands, priority species
Fragmented stands on Poppy Hills Golf Course	Moderate	Fragmented stands on high priority surfaces
<b>Huckleberry Hill</b>	Not assigned	Existing protected status
<b>Pescadero</b>	High	Large, unfragmented forest; large extent of high priority surfaces; large number of priority species occurrences
<b>Congress Road</b>	High	Large, unfragmented, important remaining stands of high priority surfaces
<b>Presidio</b>	Low	Mostly low priority surfaces; portions are fragmented; important resources on protected properties
<b>Hospital</b>	Low	Low priority geomorphic surfaces; fragmented portions; portion on protected properties; and no priority species
<b>Agujito</b>		
West portion	Low	Partly fragmented stands; does not support high priority surfaces; no priority species
East portion	Moderate	Large; contiguous with other large stands; some high priority surfaces and priority species on north edge
<b>Jacks Peak</b>	Not assigned	Existing protected status

Table 11. Continued

Management Unit/Portion of Unit	Conservation Priority	Decision Rationale
<b>Monterra</b>		
On marine terrace 4 and easternmost stands	High	High priority surface; priority species; easternmost extent of Monterey pine forest
Linear stands in developed area	Low	Fragmented; surrounded by development; no priority species; low and high priority surfaces
Remainder of unit	Moderate	Large, unfragmented; mostly low priority surfaces; some priority species
<b>Martin Canyon</b>		
West portion	Low	Low priority surfaces; no priority species; fragmented
East portion	Moderate	Large, unfragmented; low priority surfaces; contiguous with other large stands
<b>Roach Canyon</b>		
East portion	High	Easternmost extent of Monterey pine forest
West portion	Moderate	Large, unfragmented; low priority surfaces
Carmel Valley	Low	Fragmented; mostly low priority geomorphic surfaces; no priority species
Point Lobos	Not assigned	Existing protected status
<b>Carmel Highlands</b>		
On inland granite surface	Low	Low priority surfaces; parts fragmented by development
On marine terraces 5 and 6	High	High priority surfaces
At Malpas Creek	High	Southernmost extent of Monterey pine forest
George Washington	Not assigned	Existing protected status
Sawmill Gulch	Low	High priority surfaces present, but forest stands are small, fragmented and surrounded by development; no priority species
Mission Trails	Low	Small, fragmented; much of stand, including priority species, in existing protected areas

## **Equestrian Center Management Unit**

The Equestrian Center unit supports a large, unfragmented patch of Monterey pine forest, mostly on the high priority oldest dunes and marine terrace 3 and low priority granitic slopes. It supports the largest remaining stands of Monterey pine forest on marine terrace 3 and oldest dunes.

This unit includes approximately 14,600 individuals of Yadon's piperia, which represent 26% of the entire known population of this species (Jones & Stokes Associates 1996). This unit and the Pescadero unit support the largest and least fragmented known occurrences of Yadon's piperia. A population of Pacific Grove clover appears in disturbed habitat on marine terrace 3 in the Equestrian Center parking lot and near the grandstands adjacent to the forest. This site supports approximately 10,000 plants, or 22% of the entire known population of this species (Jones & Stokes Associates 1996). A small stand of Hooker's manzanita is found in this unit on the granitic slopes between marine terraces 3 and 4 (EIP Associates 1995).

The Equestrian Center unit is bordered by residential and recreational (golf courses and the Equestrian Center) development and native dune habitat. Forest of the Equestrian Center unit is tenuously connected to the forests of the Spyglass Hill and Poppy Hills units (Figure 10).

The forest on oldest dunes and marine terraces 3 and 4 at the Equestrian Center is of high conservation priority. These stands are large and support several priority species. Populations of Yadon's piperia and Pacific Grove clover in this unit are likely vital to the continued existence of these species.

## **Spyglass Hill Management Unit**

The Spyglass Hill unit supports Monterey pine forest on youngest dunes, oldest dunes, marine terrace 2, marine terrace 3, granitic slopes, and alluvial deposits. Most of the forest in this unit is on high priority geomorphic surfaces. The forest is fragmented by the fairways of the Spyglass Hill Golf Course. The largest stand of forest is found in the northwest portion of the unit, and much of this stand is in protected status at the Indian Village site under the ownership of the Del Monte Forest Foundation.

Approximately 6,119 individuals of Yadon's piperia (11% of the entire known population) grow in scattered locations within this unit. A population of Pacific Grove clover with approximately 4,100 individuals and a population of Hickman's potentilla with approximately 14 individuals is found in the protected Indian Village site.

The Spyglass Hill unit is surrounded by golf course and residential development and native dune habitat.

The forest at the Spyglass Hill unit is of high conservation priority because it represents important remaining stands on high priority geomorphic surfaces: youngest dunes, oldest dunes, and marine terrace 3.

### **Poppy Hills Management Unit**

The Poppy Hills unit supports Monterey pine forest mainly on marine terraces 4, 5, and 6; granitic slopes between terraces; and a smaller extent of forest on alluvial deposits and marine terrace 3. The central portion of this unit is fragmented by the fairways of Poppy Hills Golf Course, residential development, and Forest Lake reservoir. Large, contiguous stands of forest remain on the east and west portions of this unit. A small part of the Bishop pine-Gowen cypress pygmy forest is found at the north edge of the unit. This unit also supports the uncommon Monterey pine-Bishop pine forest associated with marine terraces 4 and 5.

Approximately 8,700 individuals of Yadon's piperia (15% of the known population) grow at scattered sites within this unit. The largest sites are in unbroken forest in the east and west portions of the unit. Monterey clover is known to grow in Monterey pine forest on marine terrace 6 at the easternmost portion of the unit. This site supported the largest population of Monterey clover in 1988, the year after the Huckleberry Hill fire, and a small population in a grassy opening in spring 1996 (Jones & Stokes Associates 1996). Three sites in this unit are known to support Hickman's onion (EIP Associates 1995). Hooker's manzanita is found throughout this unit (EIP Associates 1995). Sandmat manzanita was identified at one site, (EIP Associates 1995), and scattered individuals of Gowen cypress grow within this unit where the Poppy Hills unit borders the Bishop pine-Gowen cypress pygmy forest of the Huckleberry Hill unit.

The Poppy Hills unit is bordered by residential and golf course development on three sides but shares its northern border with the Monterey pine and pygmy forests of the Huckleberry Hill.

Large stands of Monterey pine forest and Monterey pine-Bishop pine forest on marine terraces 4, 5, and 6 in the Poppy Hills unit are of high conservation priority. These forest stands are contiguous with other stands, support populations of several priority species, and represent significant portions of the remaining habitat on high priority marine terraces. Forest stands fragmented by the Poppy Hills Golf Course are of moderate conservation priority because, although the stands are fragmented, they support forest on high priority geomorphic surfaces.

### **Huckleberry Hill Management Unit**

The Huckleberry Hill unit is a protected area that encompasses the S.F.B. Morse Botanical Reserve and the Huckleberry Hill Natural Area. This unit supports large, continuous stands of Monterey pine forest on marine terrace 5 and granitic slopes and smaller extent of forest on marine

terraces 3, 4, and 6, and alluvial deposits. The Huckleberry Hill unit supports the largest area of Bishop pine-Gowen cypress pygmy forest, the uncommon Monterey pine-Bishop pine forest, and the only stand of Bishop pine forest (not pygmy) in the region.

Approximately 7,600 individuals (13% of the known population) of Yadon's piperia are found in this unit, with the largest stand at the southern edge. Monterey clover populations have been found at scattered locations within this unit in the early 1980's, 1988, 1990, and 1995 (Jones & Stokes Associates 1996). Gowen cypress is abundant in this unit as a codominant tree in the pygmy forest. Hooker's manzanita is common in this unit. Individuals of Eastwood's ericameria and Monterey ceanothus are found at scattered locations.

The Huckleberry Hill unit shares its borders with Monterey pine forest and residential development in approximately equal amounts.

This unit supports a wide range of unique resources including unusual habitats and rare species. The entire unit is in protected status under the ownership of the Del Monte Forest Foundation (S.F.B. Morse Reserve) and as a scenic easement from the Pebble Beach Company to the Del Monte Forest Foundation (Huckleberry Hill Natural Area). The unit is not assigned a conservation priority rank because it is already in protected status; if it were not protected, it would have a high conservation priority.

### **Pescadero Management Unit**

The Pescadero unit supports Monterey pine forest mainly on marine terrace 5, granitic slopes, Monterey shale, and alluvial deposits. A smaller extent of forest is found on marine terraces 1, 2, 3, and 6 and on middle-aged dunes. The forest in this entire unit is large and unfragmented. The eastern portion of this unit, the 63.5-acre Pescadero Canyon, and the southwest corner, the 4.5-acre Herman Property, are in protected status under the ownership of the Del Monte Forest Foundation.

Approximately 15,995 Yadon's piperia plants (29% of the known population of this species) are found in this unit, the majority associated with marine terraces 5 and 6. The two largest stands of Yadon's piperia in the unit support 12,544 and 2,834 individuals. This unit and the Equestrian Center unit support the largest and least fragmented known occurrences of Yadon's piperia. A population of Hickman's onion supporting tens of thousands of individuals grows in meadows and clearings within the Monterey pine forest in the western portion of the unit and is mostly associated with marine terrace 5 (EIP Associates 1995). Hooker's manzanita and sandmat manzanita are found in this unit, mostly associated with marine terraces 5 and 6. A Monterey dusky-footed woodrat nest was found in this unit in Pescadero Canyon (EIP Associates 1995).

The Pescadero unit is mostly surrounded by residential development. The forest of the Pescadero unit shares a border along State Route 1 with the forest of the Aguajito unit.

The Pescadero unit is of high conservation priority because of its large, unfragmented forest; large extent of high priority marine terrace 3, 5, and 6 habitat; large number of priority species occurrences, including a population of Yadon's piperia that is likely vital to this species' survival; and connectivity to the forests of inland areas of Monterey pine found east of State Route 1. Forest of highest priority within this unit is found in stands on marine terraces 5 and 6.

### **Congress Road Management Unit**

The Congress Road unit supports Monterey pine forests mostly on high priority middle-aged and oldest dunes, with a smaller extent of forest on alluvial deposits. The stand is large and unfragmented. The forest on middle-aged dunes is the largest remaining unfragmented stand on this geomorphic surface. About one-third of the unit is in protected status in the Rip Van Winkle Open Space and the Navajo Tract and Area B under the ownership of the Del Monte Forest Foundation.

Three small populations (totaling 182 plants) of Yadon's piperia are found in the unit.

The Congress Road unit is entirely surrounded by residential and recreational development. The Monterey pine forest in this unit is of high conservation priority because it represents important remaining stands of high priority surfaces (middle-aged and oldest dunes) and because of the large, unfragmented condition of the forest.

### **Presidio Management Unit**

The Presidio unit supports Monterey pine forest mostly on low priority granitic slopes and alluvial deposits with small extent of forest on high priority marine terraces 3, 4, 5, and 6. The unit supports a large, unfragmented stand of forest at the south end of the Presidio of Monterey. The other stands in the unit are small and linear in shape. Much of the forest in this unit, including all of the forest on marine terrace 6, is in protected status in the Huckleberry Hill Nature Preserve and Veterans Memorial Park.

Three small populations of Yadon's piperia (totaling 53 plants) appear at scattered locations in this unit, all within protected areas.

The Presidio unit is mostly surrounded by residential development. The forest of the Presidio unit shares a border along State Route 68 with the forest of the Huckleberry Hill unit.

The Presidio unit is of low conservation priority because important resources in the unit are in protected status, most of the forest in the unit is on low priority geomorphic surfaces, and portions of the forest are fragmented by development.

## **Hospital Management Unit**

The Hospital unit supports Monterey pine forest mostly on low priority Monterey shale and alluvial deposits with smaller extent of forest on marine terraces 4, 5, and 6. A large, unfragmented stand of forest is found in this unit, but development has fragmented much of the forest into a long linear shape. A portion of this unit is in protected status as a scenic easement in the Shepard's Knoll property.

No priority species have been identified in this unit.

The Hospital unit is surrounded by residential development. The unit shares a border along State Route 1 with the Aguajito unit. This unit is of low conservation priority because it supports forest on low priority geomorphic surfaces, much of the forest is fragmented, a portion is already in protected status, and no priority species have been identified.

## **Aguajito Management Unit**

The Aguajito unit supports a large extent of Monterey pine forest on low priority Monterey shale and high priority undetermined marine terraces (marine terraces 5 or 6) and a smaller extent of forest on alluvial deposits, marine terrace 4, and fluvial terrace. The forest in this unit is very large and contiguous. Some large-lot development is taking place within the unit that supports an indigenous forest canopy with partially intact understory.

Approximately 2,472 Yadon's piperia plants (4% of the known population of this species) grow at the north edge of this unit, mostly associated with marine terraces 4, 5, and 6. No other priority species are known from the unit, but the unit has not been as extensively surveyed as units on the Monterey Peninsula.

The Aguajito unit is surrounded by residential development and other stands of forest. The forest on this unit is contiguous with forest of the Monterra, Jack's Peak, Martin Canyon, Pescadero, and Hospital units.

The large and contiguous forest in this unit increases the unit's conservation value; however, few unique, high priority resources are present. Overall, the Aguajito unit is of moderate conservation priority. Partly fragmented stands of forest in the west portion of the unit could be considered to be of low conservation priority because adjacent and interspersed development may limit management approaches, and this area does not support high priority forest types or species. Large, unfragmented stands of forest on the east side of the unit could be considered of moderate or high priority because of their large extent and connection with other large management units.

## **Jacks Peak Management Unit**

Jacks Peak unit is an entirely protected management unit comprised of Jacks Peak Park. The majority of the forest is on low priority Monterey shale and fluvial terraces, with a smaller extent on alluvial deposits and undetermined marine terraces (terraces 5 or 6). The forest is extensive and contiguous.

No priority species are known to grow in the unit, but extensive surveys have not been conducted.

This unit is bordered by Monterey pine forest and other natural habitats.

Jacks Peak is not assigned a conservation priority because it is already in protected status.

## **Monterra Management Unit**

The Monterra unit supports a large extent of Monterey pine forest on Monterey shale, marine terrace 4, and other surfaces (mostly Paso Robles Formation), with a smaller extent on undetermined marine terrace (terrace 5 or 6) and alluvial deposits. The forest is very large and contiguous. Some linear patches associated with streams are fragmented by development. The stands at the east portion of this unit represent the easternmost extent of Monterey pine. Inland of this unit, summer moisture is not sufficient to support Monterey pine, and the Monterey pine forest is replaced by oak woodland, grassland, chaparral, and coastal scrub habitats.

Yadon's piperia is known from three small populations (totaling 158 plants) along Jack's Peak Road. These populations are significant because they represent the easternmost known extent of the species. A large population of Pacific Grove clover associated with marine terrace 4 is found in grasslands between the stands of Monterey pine forest at Monterra Ranch on the north edge of the management unit. Over 8,500 Pacific Grove clover plants (19% of the known population) grow at this site. Hooker's manzanita is found in this unit in patches of chaparral habitat within the Monterey pine forest.

The Monterra unit is bordered by Monterey pine forest on the west and south, development on the north, and natural habitats on the east.

The forest in the Monterra unit is mostly large, unfragmented, and contiguous with other large stands. Most of the unit is low priority forest type on common geomorphic surfaces with no priority species. High priority forest types and species are found in the north portion of the unit. Forest stands associated with priority species and marine terrace 4 and forest stands at the easternmost sites could be considered of high conservation priority. Long linear stands surrounded by development in the northwest portion of the unit could be considered of low conservation priority.



The stands at the east portion of the unit that represent the easternmost extent of Monterey pine could be considered of moderate to high conservation priority because of their location and potentially unique ecological conditions. The remaining portions of the unit are large, unfragmented stands, contiguous with other large stands, and could be considered of moderate priority.

### **Martin Canyon Management Unit**

The Martin Canyon unit supports Monterey pine forest on low priority Monterey shale, fluvial terrace, and alluvial deposits. The forest stand in the east portion of the unit is large and contiguous. The forest stands in the west portion of the unit are fragmented by development.

No priority species are known from this unit, but extensive surveys have not been conducted.

The Martin Canyon unit is bordered by development on the west and south and by Monterey pine forest on the east and north. It is contiguous with the Jacks Peak and Aguajito units.

The western portion of the Martin Canyon unit is of low priority because of its lack of high priority geomorphic surfaces or species, fragmented condition, and proximity to developed properties. The eastern portion of the Martin Canyon unit could be considered of moderate conservation priority because, although it lacks high priority geomorphic surfaces and species, it is large and unfragmented and is connected to the large stands of the Aguajito and Jacks Peak units.

### **Roach Canyon Management Unit**

The Roach Canyon unit supports Monterey pine forest on low priority Monterey shale, fluvial terrace, and alluvial deposits. The forest stand in the west portion of the unit is large and contiguous. The forest stands in the east portion of the unit, representing the easternmost extent of Monterey pine, are fragmented by other natural habitats. Inland of this unit, summer moisture is not sufficient to support Monterey pine, and the Monterey pine forest is replaced by oak woodland, grassland, chaparral, and coastal scrub habitats.

A population of Pacific Grove clover is found in grassland on a fluvial terrace adjacent to Monterey pine forest in the southeast corner of the unit (Jones & Stokes Associates 1996). This population supports only about 100 plants, less than 0.1 % of the known population of this species. No other priority species are known from this unit, but extensive surveys have not been conducted.

The Roach Canyon unit is bordered by development on the south; by Monterey pine forest, of the Jacks Peak unit, on the west and north; and by natural habitats on the east.

The western portion of the Roach Canyon unit could be considered of moderate conservation priority because, although it lacks high priority geomorphic surfaces and species, it is large and unfragmented and is connected to the large stands of the Jacks Peak unit. The stands at the east portion of the unit, which represent the easternmost extent of Monterey pine, could be considered of moderate to high conservation priority because of their location and potentially unique ecological conditions.

### **Carmel Valley Management Unit**

The Carmel Valley unit supports Monterey pine forest mainly on low priority Monterey shale, with a small extent on marine terrace 2, granitic slopes, undetermined marine terrace, and alluvial deposits. One large, isolated stand is found at the east portion of the unit. All other stands in the unit are small and fragmented. Less than 2 acres of the forest in this unit is protected at Carmel River State Beach.

No priority species have been identified in this unit, but extensive surveys have not been conducted.

The forest stands in this unit are surrounded by grassland, coastal scrub, chaparral, and oak woodland habitats.

The Carmel Valley unit is of low conservation priority because it supports mostly low priority geomorphic surfaces, is not known to support priority species, is not contiguous with other forest stands, and consists of mostly small fragmented stands.

### **Point Lobos Management Unit**

The Point Lobos unit supports Monterey pine forest on a diversity of geomorphic surfaces within the protected Point Lobos State Reserve and Point Lobos Ranch. Geomorphic surfaces supporting forest in this unit are marine terraces 1, 2, and 5, granitics, and alluvial deposits. The forests are large and unfragmented. Monterey pine forest grades into Monterey cypress forest on marine terrace 2 of the coastal bluffs. Gowen cypress pygmy forest appears on marine terrace 5 above Gibson Creek.

Priority species identified in this unit are Monterey cypress, Pacific Grove clover, Monterey ceanothus, sandmat manzanita, and Hooker's manzanita. Monterey cypress is found on marine terrace 2 at Point Lobos State Reserve. Pacific Grove clover appears in grasslands associated with Monterey pine forest on marine terrace 2 at Point Lobos Ranch. Gowen cypress is found in pygmy forest associated with Monterey pine forest on marine terrace 5 at Point Lobos Ranch. Monterey

ceanothus, sandmat manzanita, and Hooker's manzanita are found in chaparral associated with Monterey pine forest on granitics of Point Lobos Ranch.

The Point Lobos unit is surrounded by natural habitats, including coastal prairie, coastal scrub, grasslands, chaparral, and Douglas-fir-coast redwood forest.

The Point Lobos unit supports a wide range of unique resources including unusual habitats and rare species. The entire unit is in protected status under the ownership of the California Department of Parks and Recreation (Point Lobos State Reserve) and Big Sur Land Trust (Point Lobos Ranch). The unit is not assigned a conservation priority rank because it is already in protected status.

### **Carmel Highlands Management Unit**

The Carmel Highlands unit supports the southernmost extent of Monterey pine forest at Monterey, with the last stand appearing along Malpas Creek. Geomorphic surfaces have not been mapped for most of this unit, but most of the forest is likely found on granitics with a lesser extent on undetermined marine terraces and alluvial deposits. The forest stands are fragmented by other natural habitats and residential development.

Priority species found in this unit are Monterey ceanothus, sandmat manzanita, Hooker's manzanita associated with inland granitics, and Monterey cypress associated with marine terrace 2.

This unit is surrounded by natural habitats and development. The northernmost stand is contiguous with forests of the Point Lobos unit.

Monterey pine forests on inland granitics in this unit are of low conservation priority because this forest type is abundant and much of it is in protected areas. Forests in this unit on undetermined marine terraces, which are likely marine terrace 5 or 6, are of moderate to high priority because of the unique ecological conditions found on these surfaces. More information is needed on the soils and vegetation of the terraces in this unit. The stand of Monterey pine at Mal Paso Creek is of high conservation priority because it represents the southernmost extent of the Monterey population of Monterey pine.

### **George Washington Management Unit**

The George Washington unit is a small, isolated management unit entirely in protected status with George Washington Park. Although this is an urban park, much of the natural understory is present.

One Yadon's piperia plant has been found in the George Washington unit. Because the unit is in protected status, it has not been assigned a conservation priority rank.

### **Sawmill Gulch Management Unit**

The Sawmill Gulch unit supports Monterey pine forest mostly on high priority oldest dunes and low priority alluvial deposits, with a lesser extent of forest on middle-aged dunes and marine terrace 3. The forests are in small, linear stands and are fragmented by residential and golf course development.

No priority species have been identified in this unit.

The Sawmill Gulch unit is surrounded by residential and recreational development. The eastern stand in this unit is contiguous through two narrow connections with forests of the Huckleberry Hill unit.

The Sawmill Gulch unit is of low conservation priority because, although high priority geomorphic surfaces are found, the forest stands are small, fragmented, and surrounded by development, and no priority species are known to be present.

### **Mission Trails Management Unit**

The Mission Trails unit supports Monterey pine forest on Monterey shale, fluvial terrace, alluvial deposits, marine terrace 5, and oldest dunes. About half of the unit is in protected areas of Mission Trails Park owned by the City of Carmel. The forest is small, linear in shape, and fragmented by development.

A population of Hickman's onion supporting 100-150 individuals is found in coastal prairie associated with the Monterey pine forest in the unit (Jones & Stokes Associates 1995b). Two Monterey dusky-footed woodrat nests have been identified in the forest within Mission Trails Park (Jones & Stokes Associates 1995b).

The Mission Trails unit is surrounded by urban development. It is not connected to other stands of Monterey pine forest. The unit is of low conservation priority because it is small and fragmented and about half the forest and the known priority species occurrences are already in protected areas.

## **Greenbelt Management Unit**

The Greenbelt unit supports Monterey pine forest mostly on alluvial deposits and Monterey shale, with smaller extent on marine terraces 3 and 4. Most of the forest in the unit is in protected areas of the Don Dahvee Greenbelt and Iris Canyon Greenbelt, owned by the city of Monterey. The two forest stands are small, linear in shape, and fragmented by development.

No priority species have been identified in this unit.

The Greenbelt unit is surrounded by urban development. It is not connected to other stands of Monterey pine forest and is of low conservation priority because it is small and fragmented and most the forest is already in protected areas.

## **Section 3. Recommended Strategies for Preserving Forest**

This section presents a strategy by which important remaining sites supporting Monterey pine forest can be preserved in the Monterey area. A range of regulatory, planning, and voluntary tools applicable to Monterey pine forest conservation and selected tools that are recommended for the Monterey area are discussed in this section.

A regional conservation planning approach is recommended and discussed in this section. The best methods and tools for preserving important stands of Monterey pine forest vary across the Monterey study area. The Monterey Peninsula differs in many respects from inland and southern portions of the study area in that its land values are highest, development proposals are most imminent, and forest conservation priorities are highest because the stands represent the last remnants of unique geomorphic surfaces and priority species populations. The recommended approach to forest preservation on the Monterey Peninsula is discussed separately from the inland and southern portions of the study area. This section also contains a discussion of potential funding mechanisms for the Monterey pine forest conservation effort.

### **DEVELOPMENT OF A REGIONAL CONSERVATION PLAN**

The Monterey pine forest at Monterey is located within several jurisdictions and is owned by many public and private entities. Major jurisdictions and landowners of pine forest at Monterey are:

- County of Monterey,
- City of Monterey,
- City of Pacific Grove,
- City of Carmel-by-the-Sea,
- California Department of Parks and Recreation,
- Pebble Beach Company,
- Del Monte Forest Foundation,
- Big Sur Land Trust,
- U.S. Army, and
- U.S. Navy.

Monterey pine forest has steadily declined as development has expanded in the Monterey area. Efforts to protect the forest on a project-by-project basis have not slowed the decline or taken into account the varied ecological conditions across the forest. Effective conservation of Monterey

pine forest in the Monterey area would best be accomplished through a comprehensive regional conservation planning effort that brings together:

- all major landowners within the forest,
- local planning agencies,
- federal and state resource agencies,
- other stakeholders,
- scientific experts, and
- the local public.

A natural community conservation plan (NCCP) for Monterey pine forest under the Natural Community Conservation Planning Act is an appropriate mechanism for this type of effort (see discussion below). A management plan developed using the coordinated resource management and planning (CRMP) process is also an appropriate comprehensive approach (see discussion below). In a region as biologically and politically complex as Monterey, a comprehensive and public approach to conservation planning is essential. The NCCP and CRMP processes are well suited for the Monterey area because both are proactive planning processes that address habitat and species conservation issues before species reach a point where they could become listed as threatened or endangered under the federal or California Endangered Species Acts. The U.S. Fish and Wildlife Service will likely make a decision by spring 1997 on whether to list five priority species (black legless lizard, Yaden's piperia, Monterey clover, Hickman's potentilla, and Gowen cypress) as threatened or endangered under the federal Endangered Species Act.

Ideally, the conservation plan would encompass Monterey pine forest and habitats associated with Monterey pine forest. Additional habitats that should be included are Gowen cypress-Bishop pine pygmy forest, Monterey cypress forest, coastal dune scrub and strand, coastal terrace prairie and scrub, and chaparral. Incorporating these habitats into the planning process would result in the inclusion of additional associated priority species that are not found in Monterey pine forest.

### **Natural Community Conservation Planning Act**

A natural community conservation plan (NCCP) developed under the California Natural Community Conservation Planning Act (California Fish and Game Code, Section 2800) is a type of conservation plan that focuses on a biological community rather than an individual species. NCCPs provide for regional protection and perpetuation of natural communities while allowing compatible and appropriate development and growth. The goal of natural community conservation planning is to protect species of plants and animals and their habitats before they decline to the point where designation as threatened or endangered under the California Endangered Species Act becomes necessary. NCCPs are expected to:

- promote coordination and cooperation among public agencies, landowners, and other private interests;

- provide a mechanism by which landowners and development proponents can effectively participate in the resource planning process;
- provide a regional planning focus that can effectively address cumulative impact concerns and minimize wildlife habitat fragmentation;
- promote multi-species management and conservation;
- provide an option for identifying and ensuring appropriate mitigation for impacts on fish and wildlife; and
- promote the conservation of broad-based natural communities and species diversity (California Fish and Game Code, Section 2800).

One or more NCCPs for Monterey pine forest could be developed by the counties of Monterey, San Mateo, Santa Cruz, and San Luis Obispo; the cities of Monterey, Carmel, and Pacific Grove; the California Department of Parks and Recreation; and private landowners. An NCCP would be an effective tool for these agencies and landowners to use in planning the pattern of future development to avoid significant conflicts with the Monterey pine forest resource. Such an NCCP would be more effective if it also included other habitats associated with Monterey pine forest, such as Monterey cypress forest, pygmy forest, maritime chaparral, Bishop pine forest, and coastal dune habitats.

### **Coordinated Resource Management and Planning**

The Coordinated Resource Management and Planning (CRMP) process is an established process by which many local landowners and agencies can conduct cooperative resource conservation. The California CRMP memorandum of understanding has been signed by 14 federal and state agencies including California Department of Parks and Recreation, California Department of Forestry and Fire Protection, California Department of Fish and Game, and U.S. Fish and Wildlife Service. CRMP is a resource planning, problem solving, and management process that allows for direct participation of all parties concerned with natural resource management in a given planning area. The CRMP process is specifically designed to address local resource issues that involve lands under more than one ownership or jurisdiction, and issues involving existing or potential conflicts among land and resource uses. The ultimate goal of the CRMP process is to conserve natural resources, but the practical objective is to develop and implement a unified program that minimizes conflict, is consistent with land capabilities, and is supported by all people whose interests are affected (California CRMP Handbook 1990).

The CRMP process includes the following steps:

- identifying the resource,



- defining the planning area,
- defining the planning group,
- gathering information on the planning area,
- conducting planning group meetings,
- identifying major resource issues and planning objectives,
- listing actions to accomplish objectives,
- developing a draft management plan,
- planning group review of the draft plan,
- developing an implementation strategy and funding,
- signing the plan, and
- periodically reviewing the plan implementation.

The CRMP process results in a coordinated resource management plan signed by all members of the planning group.

Monterey pine forest is a resource that could benefit from the CRMP process because of multiple land ownership and the conflicts between land and resource use. Large landowners and jurisdictions in the Monterey forest include the Pebble Beach Company, California Department of Parks and Recreation, County of Monterey, City of Monterey, City of Pacific Grove, City of Carmel-by-the-Sea, Del Monte Forest Foundations, Big Sur Land Trust, U.S. Army and U.S. Navy.

## **PRESERVING FORESTS OF THE MONTEREY PENINSULA**

Proposed development in most of the remaining large stands of Monterey pine forest on the Monterey Peninsula is presently in the environmental review process. The Pebble Beach lot program revised draft environmental impact report (EIR) was released to the public in November 1995 (EIP Associates 1995), and the final EIR is expected to be released in fall 1996 (Rose pers. comm.). The lot program includes plans for residential and recreational development that would remove approximately 412 acres of Monterey pine forest and fragment large remaining stands of forest in the Equestrian Center, Spyglass Hill, Poppy Hills, Pescadero, and Congress Road management units. These management units contain stands identified as high priority for the conservation of the Monterey pine forest ecosystem. See Section 2 for a discussion of these management units and the conservation priority ranking methods.

The recommended approach to forest preservation on the Monterey Peninsula involves land acquisition and land use regulations. These tools for forest preservation are discussed separately below.

## **Local Land Use Regulations**

Monterey County could require developers to set aside as open space the highest priority forest stands as a condition of approval for development that removes portions of the Monterey pine forest. Alternatively, developers could be required to pay an impact fee that would be used for the acquisition of forest stands. The County could allow higher development densities that would cluster development on a site, or the transfer of development rights between sites in exchange for the preservation of larger stands of forest. As proposed, the Pebble Beach lot program would result in the fragmenting of stands of Monterey pine forest and populations of priority species. Monterey County should, through the planning process, encourage project proponents to concentrate development in areas where forest stands are of low or moderate conservation priority and avoid fragmenting the forest or priority species populations wherever feasible.

## **Land Acquisition**

Because a large extent of the high-conservation-priority forest stands on the Monterey Peninsula are on privately owned land that is proposed for development, the most effective preservation tool for these areas is the acquisition of property. Property could be acquired by purchase of fee title ownership or by open space or conservation easements. Land purchase could be made through an existing land trust such as the Del Monte Forest Foundation, Big Sur Land Trust, Trust for Public Land, or The Nature Conservancy or through a newly created Monterey pine forest land trust.

Land in conservation areas of high priority could also be acquired through land exchanges. Sites held by public agencies supporting low-conservation-priority stands of Monterey pine forest or other less-sensitive habitats could be exchanged for private property supporting forest stands of high conservation priority. Public exchange lands that are local and offer the potential for an equivalent economic return on development would be more acceptable to private land owners. Obviously, any attempt to exchange public open space lands would be controversial. A program to transfer ownership of lands in these public properties must be conducted with a substantial public awareness program that describes the purpose and benefits of the proposed transfer.

## **Fee Title Ownership**

Fee title ownership, the most comprehensive form of land ownership, includes the entire package of property rights. Acquisition of fee title land can be accomplished through fee simple purchase, dedication (exaction), complete donation, exchange, or transfer from one agency to another. Fee title ownership provides complete control over land use and avoids any problems associated with partial ownership of rights to access, water, or minerals, or with other reservations or exclusions. Fee title ownership, however, is the most expensive form of property ownership.

## **Open Space and Conservation Easements**

Open space and conservation easements provide a method to acquire specific property rights needed to conserve biological values while offering the landowner the economic incentive of reduced property taxes. Acquiring easements is usually much less expensive than fee title purchase.

Cities, counties, or nonprofit organizations may accept an open space easement that relinquishes the right to construct improvements on private property. An easement may be granted forever or for a specified period of at least 20 years, subject to renewal.

Open space easements may be used to prohibit activities that may destroy physical or scenic characteristics of the land. To acquire an easement, an agency or organization must determine that preservation of the land as open space is consistent with the local general plan; in the best interest of state or local government; and important to the public for specific scenic, natural, and biological resource or open space characteristics.

Conservation easements are deed limitations that require successive landowners to retain the land in its natural condition. Easements, which must be granted voluntarily, may be acquired by state or local governmental entities or by nonprofit organizations whose primary purpose is to preserve and protect land in its natural condition. Many easements, however, can permit compatible uses of land, including grazing, agricultural use, or timber harvesting.

## **PRESERVING FORESTS IN INLAND AND SOUTHERN PORTIONS OF THE MONTEREY AREA**

In the Aguajito, Martin Canyon, Monterra, Roach Canyon, and Carmel Valley management units of inland and southern portions of the Monterey study area, most of the Monterey pine forest is of low or moderate conservation priority, and development proposals do not comprise a large proportion of these forests at this time. As these areas are developed further, the forests could be lost and fragmented to such an extent that the remaining stands would become a high conservation priority. Recommended tools for the preservation of Monterey pine forest stands in these areas include the land use planning process, tax incentives, and land acquisition. Each of the tools is discussed separately below.

### **Local Land Use Planning Process**

Monterey County can use the full range of planning tools at their disposal in these inland and southern areas. The general plan process, specific plans, conditions of approval, and zoning regulations could all be used to encourage preservation of Monterey pine forest as these areas are developed. Emphasis should be placed on maintaining large stands of forest that can continue to be

managed using controlled fire after the area is developed. The County could encourage cluster development and allow for increased development densities where Monterey pine forest would benefit. The County could use impact analyses conducted according to the California Environmental Quality Act (CEQA) to address mitigation measures necessary to reduce cumulative impacts on Monterey pine forest. The conservation priority information provided in Section 2 of this report could be used for the assessment of cumulative impacts.

## **General Plans**

City and county governments exercise control over land use by preparing and implementing general plans. Cities and counties in California are mandated to prepare long-range plans. The California legislature has declared the following:

Decisions involving the future growth of the state, most of which are made and will continue to be made at the local level, should be guided by an effective planning process, including the local general plan, and should proceed within the framework of officially approved statewide goals and policies directed to land use, population growth and distribution, development, open space, resource preservation and utilization, air and water quality and other related physical, social and economic development factors (Government Code, Section 65030.1).

The general plan conservation element, which typically emphasizes the use and the preservation of natural resources, is usually the most appropriate location for addressing natural resource issues. When provisions of the conservation element overlap with those of the open space and land use elements, development and resource protection can be considered simultaneously during preparation of the general plan (Office of Planning and Research 1990).

Monterey pine forest conservation can be addressed in the general plan by mapping the resource, describing its habitat value, and developing conservation goals, policies, and action or implementation programs. Conservation of Monterey pine forest can also be addressed in a general plan programmatic environmental impact report (EIR). Such an EIR assesses impacts on Monterey pine forest resources and includes mitigation measures and monitoring programs for losses of forest.

## **Specific Plans**

Specific plans are tools for systematic implementation of the general plan. Typically, they are applied to portions of the general plan where more detailed planning is needed to facilitate development. At a minimum, a specific plan must state its relationship to the general plan and include the following:

- the distribution, location, and extent of uses of land, including open space, within the area covered by the plan;

- the proposed distribution, location, extent, and intensity of major components of public and private transportation, sewage, water, drainage, solid waste disposal, energy, and other essential facilities proposed to be located within the area covered by the plan and needed to support the land uses described in the plan;
- standards and criteria by which development will proceed and standards for the conservation, development, and use of natural resources, where applicable; and
- a program of implementation measures, including regulations, programs, public works projects, and financing measures necessary to carry out the provisions of the preceding three items. (Government Code, Section 65451[a].)

Specific plans are a mechanism for linking resource preservation and management to development. Phasing programs, adopted as part of specific plans, can tie the dedication of resource lands, establishment of buffers, initiation of management programs, and other conservation concepts to development permit approvals.

Though smaller than the areas covered by general plans, land areas covered by a specific plan are typically large enough to offer flexibility in the location and intensity of land uses. Specific plans are also a means of establishing open space and conserving Monterey pine forest while planning for development. Stands of Monterey pine forest within a specific plan area can be designated as preserves with plan guidelines to maintain these resources in areas separate from development. The ownership of these resource areas can be conveyed to the local agency that has jurisdiction, a private resource conservation organization, or a special district that has the funding necessary to carry out long-term conservation management.

## **Zoning Regulations**

Zoning regulations for Monterey pine forest protection can take the form of written criteria establishing buffers and other preservation features or mapped districts where Monterey pine forest is designated as having a defined and protected use. Regulations may be adopted as separate ordinances designed solely to protect Monterey pine forest values or as part of a more comprehensive program regulating several activities and areas in addition to the forest and adjacent buffer zones. Forest protection through zoning districts can include specific forest protection districts and more general natural resource protection districts. The use of zoning overlays can also be an effective means of providing forest protection if the forest resource can coexist with other uses, such as, grazing, parks, and open space.

Zoning ordinances and mapped districts typically receive the greatest enforcement of the local planning programs referenced in this report. Some of the key sections of a Monterey pine forest preservation ordinance are:

- **findings of fact and purpose**, which help the public and courts understand the rationale for protecting Monterey pine forest;
- **descriptions of the lands to which this ordinance applies**, which allow for the incorporation of forest maps into the zoning ordinance;
- **discussion of permit requirements and enforcement**, which specifies permit requirements for activities conducted in a forest stand and within a specified distance from a forest stand;
- **discussion of uses by right and special permit uses in a forest stand**, which establishes permit requirements and identifies which uses are allowed outright; and
- **discussion of standards and procedures for special permit uses**, which specifies the information necessary for permit application and the agency's regulatory review process.

### **Transfer of Development Rights Programs**

The transfer of development rights recognizes that parcels of land can be assigned the right to develop. This right can be established by a local agency's general plan or zoning ordinance. The transfer of development rights allows an agency to consider development rights as a commodity that can be transferred from one location to another. A transfer of development rights program would identify parcels transferring rights as "sending sites" and parcels receiving the transferred development as "receiving sites". The sending property is preserved in an undeveloped state or developed at a lower density, and its owner is compensated for the lost development rights through sale of these rights to a receiving property. The receiving site can then be developed more intensely than would otherwise be permitted under the existing zoning. Preservation of natural resource areas, such as Monterey pine forest, is one of the benefits that can be realized by having a transfer of development rights program in place.

Many California cities and counties, including San Luis Obispo County, have proposed or initiated transfer of development rights (TDR) programs. Lack of specific state regulations for TDR programs allows flexibility in designing these programs but makes the legal status of specific approaches uncertain. Concerns by potential users center on fears of inverse condemnation and on potential conflicts in the government's role of assigning credits, brokering transactions, and influencing the price of credits through its regulatory powers. TDRs can effectively protect biological resources, especially when they are supported by local agencies to achieve conservation goals identified in general plans. This protection, however, need not always exclude compatible commercial land uses.

## **Mitigation Banking Programs**

Mitigation banking involves acquiring biologically valuable land to be preserved, restored, or enhanced as compensation for future loss of similar biological resources elsewhere. Mitigation banking is an attractive alternative to project-by-project onsite mitigation when the resulting small, isolated mitigation projects may be costly and difficult to implement, of low biological quality, and difficult to manage and monitor. Mitigation banking assures regulatory agencies that well-conceived mitigation is produced and assures developers that a predictable, equitable, and cost-effective program is available to mitigate project impacts.

Mitigation banking can consolidate compensation for many small projects into a single area of higher biological value than small, scattered mitigation sites. Other advantages are:

- mitigation can be completed before habitat loss occurs,
- monitoring is easier, and
- costs and project approval times are reduced.

Potential disadvantages are:

- losses of specific components of natural communities might not be replaceable in mitigation bank areas,
- the bank habitats may not be as productive or diverse as the natural habitats that have been lost, and
- the landscape values of the original site (e.g., context with surrounding habitats) may not be reproduced in the bank.

## **Tax Incentives**

Many properties in inland areas are used for livestock grazing and, if maintained in agricultural use, could benefit from the tax breaks provided by the Williamson Act. Because of increasing land values and strong pressures for development, this tax incentive should be considered only a temporary tool for forest preservation. Land owners may be given an incentive to give up their development rights and preserve forest on their property if large property tax reductions result from acquisition of conservation easements.

## **Williamson Act Contracts**

The California Land Conservation Act of 1965 (commonly known as the Williamson Act) allows for reductions in property taxes for farmland designated as agricultural preserves. The act

provides an incentive to retain agricultural land (including grazed rangelands) that might otherwise be subject to increasing property taxes based on its development value. In return for lower tax rates, property owners contract with counties to maintain their land in agricultural uses for 10 years. Contracts are automatically extended each year.

More than 15 million acres, approximately half of the farm and grazing land in the state, are under Williamson Act contracts (California Department of Conservation 1987). The act has helped to maintain substantial biological values for species that can coexist with agricultural uses. Williamson Act contracts are also in effect in many grassland, shrubland, and oak woodland areas used for livestock grazing.

Williamson Act could apply to those portions of the Monterey pine forest that are used as rangelands.

### **Land Acquisition**

Fee title acquisition and conservation easements would be an effective tool in inland and southern management units. Conservation easements could allow the existing land uses, compatible with Monterey pine forest conservation, to continue. As described above for the Monterey Peninsula, an existing or new land trust could be used to acquire properties.

## **POTENTIAL FUNDING MECHANISMS**

Conservation planning and implementation (including long term management and maintenance) cannot proceed without adequate funding. To obtain sufficient funds and to spread the funding out in an equitable way, multiple funding sources should be included. This section lists a variety of potential funding sources.

### **Federal Agencies**

Funding for conservation planning and implementation could be obtained from federal agency sources. Potential federal contributors are U.S. Fish and Wildlife Service and Bureau of Land Management. Potential sources of federal funding through U.S. Forest Service are the Forest Stewardship Program and the Stewardship Incentive Program administered by the California Department of Forestry and Fire Protection. Another potential source of funding is the Land and Water Conservation Fund, a federal program for land acquisition using revenues derived from oil development royalties.



## **State Agencies and Programs**

The state of California could provide funding for conservation planning and implementation. Monterey County could apply for funding through programs such as the Mountain Lion Initiative (Prop 117 of 1990) or the Environmental Enhancement and Mitigation Program. Potential state agency contributors are the California Department of Fish and Game, California Department of Forestry and Fire Protection, California Department of Parks and Recreation, and California Department of Transportation.

## **Local Agencies**

Monterey County and the cities of Monterey, Pacific Grove, and Carmel could generate revenues in a variety of ways. A sales tax could be levied. Although often unpopular, sales taxes result in a shared burden of forest conservation costs among new residents and existing residents who have benefited from past forest removal activities. A conservation assessment special district could be established that generates revenue from parcels within the Monterey pine forest. Impact fees can be exacted by the county and cities as a condition of approval for new developments that remove Monterey pine forest.

## **Special Districts**

Special districts, state governmental agencies created by popular vote and governed by independently elected officials to provide a specific public purpose, are authorized to levy taxes and to acquire and manage land within their boundaries. Existing special resource management districts include those established for parks and recreation, regional open space, resource conservation, soil conservation, flood control, water supply, and air quality management. Special districts can actively protect and manage biological resources, such as Monterey pine forests, for conservation purposes as long as the activity is related to their established mandate.

## **Foundations and Land Trusts**

Private foundations and land trusts could provide funding for fee title acquisition or conservation easements on lands supporting Monterey pine forest.

Land trusts are private, nonprofit organizations created to acquire and protect land for conservation purposes by acquiring fee title or conservation easements to land or by transferring acquired land to public agencies. Trusts often acquire lands not simply to protect habitat, but also

to maintain productive land uses, such as grazing and agriculture. Such uses can be highly compatible with regional conservation efforts.

Land trusts vary from informal local groups to large regional groups, such as the Big Sur Land Trust and San Luis Obispo Land Conservancy, or national organizations, such as The Nature Conservancy and Trust for Public Land. Land trusts are usually governed by a board of directors that often relies on volunteers and private financial support to carry out its efforts. Lands are usually acquired by purchase on the open market, frequently at below market value or by donation. Land trusts can provide an important mechanism for developing local community support and involvement in the preservation of Monterey pine forest.

### **Land Exchanges**

Land exchanges could be an important mechanism for acquiring sites supporting Monterey pine forest of high conservation priority. Public agencies and land trusts that own property in the Monterey area could exchange portions of their lands that support Monterey pine forest of low conservation priority or other habitats of low value for private properties that support high-conservation-priority Monterey pine forest stands. Examples of entities that could participate in land exchanges at Monterey are:

- Bureau of Land Management,
- U.S. Forest Service,
- California Department of Parks and Recreation,
- Monterey County Department of Parks,
- Big Sur Land Trust,
- U.S. Army, and
- U.S. Navy.

The above list is intended to illustrate agencies that might be suitable for land exchanges that would benefit Monterey pine forest. The potential for any of these agencies to participate in a land exchange depends on each agency's specific policies and regulations that control the disposal, transfer, and acquisition of land. Land trusts can also be important as intermediaries in land exchanges between public agencies and private land owners.

### **Revenue Generation from Sale of Timber**

Monterey pine timber that is a product of ecosystem management practices could be sold to generate revenue for the management program or land acquisition. Production of usable timber would be a byproduct, not the purpose, of Monterey pine forest ecosystem management. However, if saleable timber can be produced without affecting the quality of ecosystem management, it could

be a means for generating revenue to support management practices. Boles could be removed from treatment sites if:

- cone-bearing limbs are removed and left on the ground at the point of the felled tree,
- no significant soil disturbance is created, and
- rare species are not disturbed.

The boles could be sold for commercial use. Commercial demand exists for Monterey pine; for example, Sierra Forest Industries in Tulare County mills Monterey pine lumber (Smith pers. comm.). The transport of material from pitch-canker-infected trees should be closely controlled to avoid spreading the pathogen to other forests with susceptible species.

## **Section 4. Recommended Forest Management Practices**

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This section provides recommendations for managing the Monterey pine forest ecosystem in the Monterey region. Forest on public and privately owned lands may require active management to ensure ecosystem health and public safety. Potential management practices are described for sites supporting remaining undeveloped Monterey pine forest ecosystem. Many of the management practices recommended in this report were developed based on information provided by individuals with experience and expertise in Monterey pine forest ecology and management (Owen, Washington, Parker, Staub, Smith, Reid, Kelly pers. comms.). A strong monitoring and research component is recommended for future management activities because the management practices described have not been tested in Monterey pine forest and there is a need to understand the effects on all components of the ecosystem before any management practices become widely implemented.

Management of the Monterey pine forest is required to achieve the following objectives:

- maintain a functional, sustainable ecosystem;
- reduce the impacts of pine pitch canker on the forest;
- improve the health of the Monterey pine population;
- improve the health and diversity of understory vegetation;
- improve habitat for priority species;
- avoid soil degradation; and
- avoid undue risk to human life and property.

These objectives can be achieved by employing ecosystem management practices that are based on the following underlying principles:

- allowing natural ecological processes to take place to the most feasible extent,
- applying ecosystem management techniques that mimic natural processes to the most feasible extent,
- establishing a mosaic of habitat patches at various successional stages with more early and middle successional habitat patches than occur in the present forest, and
- using ecosystem management techniques that are compatible with adjacent land use.

## LONG-TERM MANAGEMENT PROGRAM

A long-term management program should be developed that identifies the location, amount, and timing of forest management. The goals of such a program are to restore a healthy Monterey pine forest ecosystem in the Monterey area within the next human generation and to maintain ecosystem health in perpetuity. The program need not include specific details but rather should include guidelines from which a spatial and temporal pattern of disturbance patches can be developed that results in a patchwork of forest stands in various stages of ecological succession throughout the Monterey area. The first phase of the program would include the initial management actions to improve forest health in the existing aged, diseased, pest-infested, and declining stands; this phase would begin immediately at plan implementation and take place over the next 20-30 years. Because the natural return time for fire in a given patch of forest may be from 30 to over 100 years for Monterey pine forest, the long-term management program should address forest management in perpetuity and address long-term funding mechanisms for implementation.

All management techniques described in this report and other appropriate techniques should be included in the program, initially. Applying a wide variety of management approaches results in a greater diversity of forest stand structure and provides the opportunity to study the effectiveness of a wider range of management practices. A range of disturbance patch sizes should be included in the plan, from single tree-fall light gaps to cleared 15-acre forest patches. A variety of vegetation-clearing mechanisms should be used, including fire and mechanical methods. Management should address all ecosystem components including priority species, understory vegetation, canopy vegetation, wildlife use, soils, and watersheds. In addition, recreational use and viewsheds should be considered in management planning.

The management program should take into account the temporal and spatial distribution and overall population size of each priority species in such a way that each species is managed for long-term survival.

The management program should be opportunistic and take advantage of existing forest conditions, such as testing the methods of large patch clearing and burning at sites of heavy pest and disease infestation or where dead material is abundant. The program should also take advantage of land ownership; for example, testing new management techniques on tracts of land with large patches of forest away from developed lands to reduce risks to human life and property.

The program should be adaptive in that the initial management techniques and approach should be modified over time as various practices are tried, research is conducted, and the most successful methods are identified. See the section "Monitoring, Research, and Management" below.

## MONITORING, RESEARCH, AND ADAPTIVE MANAGEMENT

Ecosystem management practices recommended in this report have not been tested or proved effective. All Monterey pine forest management should be undertaken cautiously, with an experimental approach, and with the tight feedback loop provided by monitoring to guide future management. Monitoring of treatment sites is crucial to understanding the effectiveness of management practices and adopting the successful components of those practices. Focused research will be necessary to identify benefits or drawbacks of specific management techniques. Research should include all aspects of forest ecology, including ecological studies of priority and other rare species, understory vegetation, and canopy species; studies of forest dynamics, including disturbance, pest, and disease effects; and studies of abiotic factors such as soils, local climate, and watersheds. The combination of monitoring and research allows for an adaptive management process in which existing management practices are modified over time as more is learned about effective methods and resulting conditions.

It should be recognized that "no-management" is a management option, and that the no-management option will likely be the most common management on remaining patches of forest in the initial stages of the management program. More intensive management practices should be tested on a small scale and applied as we more fully understand the results of each method.

Examples of important ecological issues that should be studied to develop appropriate management techniques for the Monterey pine forest ecosystem include:

- interaction among diseases and pests native to the Monterey pine forest and introduced diseases such as pine pitch canker;
- mycorrhizal associates of Monterey pine forest plant species and the role of mycorrhizal associations during forest regeneration following fire and other disturbances;
- effects of the seasonal timing of fire on the post-fire regeneration of Monterey pine forest and priority species;
- relationship between the rate of dwarf mistletoe infestation and fire frequency, intensity (especially crown versus ground fire), and extent;
- ecological successional patterns following crown fires versus following ground fires;
- analysis of different kinds of disturbance and resulting forest regeneration, pests, and disease;
- analysis of disturbance patch size effects on forest regeneration, pests, and disease;

- analysis of fire intensity and remaining fuel loads on ecosystem regeneration and pest behavior;
- specific habitat requirements of priority species;
- ecology and best management practices for serious weeds, such as genista, pampas grass, and Ehrharta grass; and
- analysis of appropriate habitat buffers as they relate to human activities and the spread of diseases and pests.

The ecological issues listed above and other ecological issues not listed in this report require study before a ecosystem management can be implemented on a large scale in the Monterey pine forest.

### **POTENTIAL MANAGEMENT PRACTICES FOR CONSERVATION AREAS**

This section describes potential management practices for Monterey pine forest. All management practices described are untested and will need to be accompanied by monitoring and experimentation and modified using an adaptive management approach.

Wildland sites, which support Monterey pine forest in large stands that do not adjoin developed property, are the areas of least constraint for using the full range of tools, particularly fire, in managing the Monterey pine forest ecosystem. The following management units support Monterey pine forest in wildland settings: the southeastern portion of Aguajito, Monterra, and Jacks Peak and the eastern portion of Martin Canyon, Roach Canyon, Carmel Valley, and Point Lobos (Figure 10).

Many of the Monterey pine forest stands at Monterey are surrounded by urban development. The following management units are in urban settings: George Washington, Congress Road, Sawmill Gulch, Huckleberry Hill, Presidio, Hospital, Greenbelt, Spyglass Hill, Poppy Hills, Equestrian Center, Pescadero, Mission Trails, northwest portion of Monterra, western and northern portions of Aguajito, western half of Martin Canyon, and the western portion of Carmel Highlands. The adjacent land use may often preclude the use of fire as an ecosystem management tool. The management methods described in this report should be used at forest sites surrounded by urban development only where feasible, without increasing risk to human life and property. Techniques modified from those used in wildland settings may be necessary in using fire in urban settings. In some cases the risk of using fire may be too great, and mechanical or manual techniques should be used instead. Management of stands surrounded by development is crucial to reducing fuel loads

and hence the risk of wildfire starting in and escaping from these stands. In all cases, ecosystem management conducted in an urban setting should be preceded by a comprehensive public education and awareness program.

### **Fire and the Monterey Pine Forest Ecosystem**

Periodic crown fires and ground fires are important natural disturbances in the Monterey pine forest ecosystem. Monterey pine forest is a fire-adapted biological community; dominant species in the forest respond well to fire and regenerate rapidly. The size and frequency of fire events (the "fire regime") in the Monterey pine forest has changed over time because of natural and artificial factors. Greenlee and Langenheim (1990) identify five fire regimes for the Monterey Bay area extending from the natural lightning-start fire regime that existed prior to human settlement, through the Native American and the colonial periods when human-caused fire was frequent, to recent times. They conclude that fire frequencies in forested habitats in the Monterey Bay area have been lower since 1929 than in any past period, as a result of artificial fire suppression. As a result of fire suppression, most of the Monterey pine forest at Monterey is in late successional stages. A large proportion of the naturally occurring and horticultural Monterey pine trees are of advanced age and are not only susceptible to pathogens, insect pests, and wildfire, but also encourage the spread of these adverse conditions to other stands.

Crown fires remove mature trees, understory vegetation, and duff, leaving an open site with nutrient-rich ash. Depending on the intensity of the fire, the amount of fuel remaining can vary greatly, but the forest canopy is mostly or totally removed. Crown fires cause all tree-born and fallen Monterey pine cones to open, and these cones release a huge amount of seed, much of which has been stored over many years in closed cones on the trees. Based on the maximum age that Monterey pines usually live, we can speculate that this species evolved under a fire regime in which fire returned to any given patch of forest at intervals of less than 150 years. For mixed evergreen forests of the Monterey Bay region, Greenlee and Langenheim (1990) estimate that return time intervals for fire, both crown and ground fires, is 30-135 years under a natural lightning-start fire regime.

Ground fires remove understory vegetation, duff, and small trees and often girdle and kill mature trees. Fire-scarred trunks on older trees and direct evidence from recent fires indicate that mature Monterey pine can survive ground fires. Unlike most of the close-coned pines and cypresses, which are of short stature and have limbs near the ground, large Monterey pine trees with their lowest limbs well above the ground are often able to survive ground fires. Vogl et al. (1988) speculate that ground fire is an important factor in the Monterey pine forest ecosystem.

Ecological succession following ground fire differs in several ways from succession following crown fire. Ground fires usually result in many small canopy gaps, while crown fires open large clearings in the forest. Early successional stages are abbreviated following a ground fire, relative to a crown fire. Small light gaps may not be large enough or last long enough to support populations of opportunistic, fire-following species. Ground fires sustain mature forests in uneven-



aged stands, whereas crown fires generally produce large, even-aged stands. In comparison to a crown fire, a ground fire results in a smaller release of Monterey pine seeds and less exposure of ground surface to full sun; hence, regeneration of pine is less prolific.

### Potential Management Practices

Taking into consideration the fire ecology of Monterey pine forest, the rapid spread of pitch canker, the spread of pests, and the advanced age of most stands of forest, the following ecosystem management practices are recommended and should be tested in Monterey pine forest:

- **No Active Management:** allow existing natural processes to proceed without active management of forest;
- **Gap Phasing without Fire:** cut only dead trees from stands and allow regeneration in light gaps;
- **Gap Phasing with Fire:** cut only dead trees from stands, burn the understory, and allow regeneration in light gaps;
- **Selective Cutting:** cut dying and dead trees from stands, burn the understory, and allow regeneration in patches and light gaps;
- **Patch Clearing:** cut all mature trees from a patch of forest, burn the site (mimics crown fire), and allow regeneration throughout the stand.

The use of "controlled burning" is discussed throughout this section and in other sections of this report. Controlled burning, also known as "prescribed fire," is defined by Franklin (1996) as "the application of fire to wildland fuels when conditions such as weather, fuels, and topography permit the specific objective to be accomplished safely." Controlled burning is considered to be the most environmentally sound and economical approach to managing large fire-prone habitat areas (Franklin 1996).

Specific recommendations to property owners from the Pine Pitch Canker Task Force for controlling pine pitch canker are provided in Appendix B.

### No Active Management

Under no active management, Monterey pine forests would continue to age and become more susceptible to disease and catastrophic wildfire. No active management may be appropriate for some sites, while at other sites the problems of diseases, pests, and fire hazard will need to be addressed

through appropriate ecosystem management techniques. In the absence of fire or other management techniques, forest pathogens and insect pests can be expected to increase over time.

With no active management, pine pitch canker, dwarf mistletoe, and bark beetles would be expected to continue to increase in the aging forests. Pitch canker has spread rapidly through all native populations and many ornamental plantings of Monterey pine in California in the past 5 years. An estimated 15% of Monterey pine trees exhibit resistance to pitch canker (Owen pers. comm.). Natural selection will favor resistant genotypes, and these genotypes can be expected to increase in frequency in future forests. In addition, some trees are "infection tolerant"; they become infected but are able to survive with the fungus (Owen pers. comm.). The percentage of trees that are infection tolerant is not known but may range from 25-35% (Owen pers. comm.). More than 50% of trees exhibit no resistance or ability to survive with the disease and could be expected to die within the next 10-20 years. The abundance of dead and weakened trees will result in larger populations of insect pests that can then weaken and kill the pitch canker resistant trees (Owen pers. comm.). The heavy fuel loads in these dying forests will result in a hazardous condition conducive to major wildfires (Washington pers. comm.). In the absence of fire or other methods of creating openings in the forest and controlling diseases and pests, forest structure and ecosystem processes are likely to change as Monterey pine trees succumb to disease and pest attack. Some experts speculate that coast live oak will increase in importance over time as the pine canopy becomes more open and understory composition could also change (Libby pers. comm.).

No active management may be the best technique to use at sites where disease and pest infestations are low. Vegetation management in Monterey pine forest stands that are free of pitch canker and pest infestations should only be conducted if needed for other ecosystem-enhancing purposes, because injuries to the bark from tree and brush cutting equipment or fire can create wounds that attract bark beetles and pitch moths and may lead to new pitch canker infections (Pine Pitch Canker Task Force 1996). In addition, these uninfected stands may, for unknown reasons, support unusually high numbers of trees with pitch canker resistance, unfavorable conditions for vectors of pitch canker, or some other ecological factor resulting in low infection rates. Studies of the ecology and genetics of these uninfected stands would be valuable in identifying causes for low infection rates and potential novel solutions to controlling pitch canker.

### **Gap Phasing without Fire**

Gap phasing without fire involves cutting only dead trees. Controlled fire is not used in this treatment. Light gaps created under this method would generally be small, approximately 0.1-0.5 acre. Regeneration of pine may be curtailed by canopy closure over gaps from expansion of adjacent mature trees. Establishment and maturation of Monterey pine can occur in light gaps. Because of competing grass and shrubs, establishment of Monterey pine in light gaps is expected to be infrequent and slow. Gap phasing without fire is a good method for maintaining forest health between planned controlled burns and is a good approach for stands where adjacent land use precludes the safe use of fire as a management tool.

## **Gap Phasing with Fire**

Gap phasing with fire involves removing only dead trees, followed by setting a ground fire. Light gaps created under this treatment would generally be small, typically 0.1-0.5 acre. Ecological succession would be expected to follow the pattern described above for ground fire.

The Pebble Beach lot program includes an ecosystem management plan that recommends a "gap phasing" program for Monterey pine forest enhancement and management (EIP Associates 1995). The recommended gap phasing in the Pebble Beach lot program plan involves clearing small patches, usually the light gap created by the felling of a single large tree and, in some cases, patches up to 1 acre, to allow pine regeneration. Active tree and understory vegetation planting is included in the Pebble Beach lot program management plan. In contrast to the Pebble Beach lot program management plan, we do not recommend planting Monterey pine or associated understory species in wildland settings or in urban settings where controlled burns can be conducted safely.

## **Selective Cutting**

The selective cutting approach involves cutting dead and dying trees. This approach can be similar to either patch clearing or gap phasing with the size of the opening created related to the number of dead and dying trees present in the treatment patch. If most of the trees in a stand are dead and dying, large patches of trees will be removed, and this method will resemble the patch clearing method; if the number of dead and infected trees is small, the similarity will be to gap phasing. The downed material and understory are burned following the cut. Ecological succession after the burn will follow either crown or ground fire pattern, depending on the size of the clearings created.

## **Patch Clearing**

The patch clearing method involves cutting all trees in a patch that is 5-15 acres in extent. The cut canopy material and understory are then burned on the ground, mimicking the effect of a small crown fire. Natural forest regeneration would be expected to follow the pattern described above for crown fire ecological succession.

Under a natural fire regime, crown fires may have covered hundreds of acres. Treatment patches of this size are not feasible in the Monterey area because of risk to life and property, air quality impacts, and visual landscape impacts. The cleared patch size of 5-15 acres was selected as being large enough to support effective forest management, minimize impacts on air quality from smoke, and minimize visual impacts (Washington pers. comm.).

Following cutting of a forest patch, a controlled burn would be conducted to clear the vegetative cover and duff, remove diseases and pests, add nutrients to the soil, and induce the release and germination of seeds of various plant species. To prepare the site for burning, fire height and

fuel loads can be controlled through mechanical chipping or crushing of understory vegetation. These actions, however, should only be conducted where significant soil disturbance does not result and rare species would not be adversely affected. The purpose of felling canopy trees and chipping or crushing understory shrubs is to allow for a fire that can be easily controlled, and provide the benefits of a crown fire (e.g., light penetration to the forest floor and release of seeds from closed cones on trees).

## ALLOWING NATURAL ECOSYSTEM REGENERATION

Except under special circumstances, we recommend that natural regeneration of Monterey pine forest ecosystem be allowed to take place following management actions described in the section "Potential Management Practices." Existing Monterey pine forests with natural understory vegetation should contain all the propagules necessary to regenerate a healthy forest following a disturbance. Evidence from sites of recent fires at Huckleberry Hill, Presidio of Monterey, and Point Lobos State Reserve indicate that regeneration of native trees, shrubs, and herbs is rapid and prolific. Exceptions, where more active management may be necessary following the disturbance event, include sites where:

- aggressive weeds threaten to dominate the understory or retard natural forest succession,
- rare plant or animal species require specific habitat enhancement measures,
- immediate revegetation is necessary to control erosion, or
- forest soils or other habitat factors are degraded and active forest restoration is necessary.

Each of these exceptions is described more fully below.

### Controlling Aggressive Weeds

Opportunistic weeds such as cut-leaved fireweed (*Erechtites glomerata*) and toothed fireweed (*Erechtites minima*) establish following fire. These and other non-native, weedy herbaceous species usually appear only in early successional stages and will be over-topped by native shrubs and trees in later years. On sites where these herbaceous weeds pose a threat to rare species populations, control measures would be needed. Soil disturbance promotes weeds such as genista (*Genista monspessulana*) and pampas grass (*Cortaderia jubata* and *Cortaderia selloana*). Active eradication measures are necessary where large aggressive weeds such as these and other species threaten to dominate the understory of Monterey pine forest or retard the establishment of Monterey pine or coast live oak seedlings.

## **Enhancing Rare Species Habitat**

Where rare plant or animal species are present or where efforts are taking place to establish new populations, habitat-enhancing measures specific to the target species may be necessary that require more intensive management of Monterey pine forest vegetation. For example, many rare species require conditions with canopy openings or large clearings, such as Hickman's onion, Pacific Grove clover, Yadon's piperia, Monterey clover, and black legless lizard. On sites suitable for these species, canopy thinning and other vegetation management methods may be necessary at various stages of forest succession to create and maintain suitable habitat. See additional discussion of rare species in the section "Special Management Practices for Priority Species."

## **Controlling Erosion**

Sites on steep slopes, adjacent to streams, or other sensitive areas may require erosion control measures following ecosystem management actions such as forest cutting and burning. These measures, for example, may include active revegetation with a native plant species seed mix, placement of erosion control materials, or felling trees parallel to slopes to minimize the amount of soil erosion and deposition.

## **Improving Degraded Habitat**

At sites where soils, hydrology, or other environmental factors have been altered and the Monterey pine forest exists in a degraded condition, artificial means to promote regeneration of vegetation may be required within existing forest stands or following a management cut and burn.

## **SPECIAL MANAGEMENT PRACTICES FOR PRIORITY SPECIES**

The recommended ecosystem management techniques of cutting and burning Monterey pine forest should benefit the common species of the forest. Special management practices and precautions, however, should be developed for priority species because of the rarity of these species and their local dependence on the Monterey pine forest ecosystem. Ecosystem management practices should be specifically tailored to priority species to accommodate specific microhabitat requirements of these species. At sites of priority species occurrences, ecosystem management should focus on a combination of techniques that promote a healthy ecosystem of common native species and also thriving populations of the priority species.

As discussed in the section "Allowing Natural Ecosystem Regeneration", many rare plant and animal species require specific microhabitat conditions within or adjacent to Monterey pine forest. Many of the priority species at Monterey require an open forest canopy or clearings within the forest to thrive. For example:

- early successional Monterey pine forest on specific geomorphic surfaces and soils appear to support much larger populations of Hooker's manzanita, sandmat manzanita, Eastwood's ericameria, and Monterey ceanothus than late successional forest (Jones & Stokes Associates 1994b);
- open-canopy Monterey pine forest with grassy understory is higher quality habitat for Yadon's piperia than closed-canopy forest or forest with dense shrub understory (Jones & Stokes Associates 1996); and
- large, mesic, grassy clearings are the highest quality habitat for Hickman's onion, Pacific Grove clover, and Hickman's potentilla at Monterey (Jones & Stokes Associates 1996).

Active forest thinning on a rotational basis within potential habitat for priority species may be necessary to maintain and enhance habitat for these species. Specific management practices should be developed for each priority species. Specific management and recovery strategies are provided by Jones & Stokes Associates (1996) for Pacific grove clover, Monterey clover, Hickman's potentilla, Yadon's piperia, and Gowen cypress.

## Section 5. Concluding Remarks

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This report outlines a broad strategy for Monterey pine forest conservation. Development of a regional Monterey pine forest conservation plan is recommended, with full involvement and consensus of all stakeholders, responsible agencies, and the public. The preferred approach for this plan is an NCCP for Monterey pine forest and associated habitats in the Monterey area.

The conservation strategy presented in this report identified:

- the location of stands of Monterey pine forest that are of highest conservation priority because of their unique ecological characteristics;
- regulatory, planning, and voluntary tools that are most appropriate for preserving Monterey pine forest in different parts of the Monterey study area; and
- ecosystem management practices that will promote forest health and are feasible.

Sites supporting undeveloped Monterey pine forest were ranked as being of high, moderate, or low conservation priority, and it is recommended that high priority stands be targeted for preservation where feasible. However, it is recognized that not all high priority stands can be preserved and that many low priority stands are already in protected status. No conclusions have been made as to how many or what extent of stands identified as high, moderate, and low conservation priority should be preserved. These decisions are best made after reviewing additional information on forest and priority species ecology and the contributions of all who are involved in a comprehensive Monterey pine forest conservation plan.

It would be speculative at this time to attempt to estimate how many of the 9,405 acres of remaining undeveloped Monterey pine forest should be retained to meet the conservation objectives, because the answer depends on the qualities of the stands that are preserved and how those stands are distributed. This decision would be an important element of a Monterey pine forest conservation planning effort.

It would not be appropriate to design a forest preserve system in this report, because the report was not prepared with the involvement of stakeholders, local agency review, or the public. The report includes a method for identifying the conservation priority of all sites supporting undeveloped Monterey pine forest and a map of those ranked sites (Figure 10 and Table 11). There are many different preserve designs that could meet the ecological objectives for conservation, but the preferred alternative should only be selected following a public planning process.

A variety of regulatory, planning, and voluntary tools for preserving forest stands are presented in this report. Because the planning process of the Pebble Beach lot program was in an advanced stage at the time this report was prepared, options for protecting forest in these areas of the Monterey Peninsula were considered to be limited. The primary tools recommended for forest preservation in these areas are land acquisition and conditions of approval. As proposed, the Pebble Beach lot program would result in fragmentation of the remaining large stands of forest growing on Pleistocene dunes and marine terraces 3, 4, 5, and 6. These geomorphic surfaces support unique soils, unusual forest composition and structure, and the greatest diversity and largest populations of priority species.

The existing forest in the Monterey area is mostly late successional, and Monterey pines are rapidly succumbing to old age, pitch canker, and other pests. The introduction and rapid spread of the pine pitch canker disease in Monterey pine in the past 10 years poses a major threat to Monterey pine as a species and the Monterey pine forest ecosystem. Over 50% of Monterey pine trees could succumb to this disease and concomitant insect pest infestations, resulting in changes in ecosystem structure and processes that are not yet known. Periodic controlled fire is recommended as a tool to improve and maintain ecosystem health and reduce the risk to human life and property posed by accumulating fuel loads. Appropriate monitoring and experimental studies, however, are necessary to determine the best ecosystem management techniques. A long-term management program is recommended that uses controlled fire as a management tool and results in a forest that is a patchwork of stands in various stages of ecological succession.



## Section 6. Citations

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## **Section 7. Report Preparation**

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<b>Staff</b>	<b>Area of Expertise</b>	<b>Project Role</b>
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Nick Dennis, Ph.D.	Forestry	Peer review
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Chris DiDio	Geographic Information System (GIS)	GIS maps and graphics preparation
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Susan Fujimoto	Editing	Editing, report production
Tony Rypich	Graphics	Graphics production
Mary Engbring	Graphics	Cover graphics preparation

## **Appendix A. Pine Pitch Canker Task Force Recommendations for Pitch Canker Control**

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The Pine Pitch Canker Task Force (1996), a statewide group working on the disease, recommends to property owners the following actions for control of pitch canker:

1. Arrange to have a qualified professional verify the presence of pitch canker. Ask what training or qualifications the person has that enables him or her to recognize pitch canker. Not all tree care workers may be qualified, and other diseases or insects can be responsible for your tree's poor or sickly appearance. Monterey pine is the tree species most likely to contract the disease.
2. If you live in an area where pitch canker is uncommon and your tree is only lightly infected, pruning infected branch tips may help reduce the spread of the disease to other trees, but this cannot be guaranteed. If you chose to prune infected branches, do so at a lateral branch that is at least one whorl below (i.e., closer to the trunk of the tree) any yellow or red needles and below any infestation of insects within the bark. Diseased and insect-infested branches must be promptly destroyed or disposed of. Studies have shown that pruning will not stop or reduce future infections in a tree that already has the disease.
3. In areas where pitch canker is common, pruning infected branch tips is not a practical means of reducing disease spread. Because Monterey pines vary in their susceptibility to pitch canker, it is best to wait and see how the disease affects your tree before taking action. Some trees will exhibit few or no symptoms of the disease, while others may become moderately to heavily infected. Highly susceptible trees experience rapid die-back and mortality. For trees that survive the disease, pruning may be needed to reduce hazard or for aesthetic reasons. Insist that tree care workers avoid use of climbing spurs or other equipment that injures the bark because this can create wounds that attract bark beetles and pitch moths and may lead to new infections.
4. A tree does not necessarily have to be removed because it has pitch canker. However, trees with large dead limbs, a dead top, and trunk cankers are likely to die from the disease. Such trees may present a hazard because dead material can break and fall from the tree, and eventually the entire tree could fall. Get expert advice. Hazardous situations need attention. Such trees may also contribute to the buildup of destructive beetles that can attack other trees. The timely removal and disposal of dying trees may help prevent this.
5. Tools and machinery that are used to prune, cut, or chip diseased trees should be cleaned and sterilized before use on uninfected trees or in uninfested areas. Lysol<sup>®</sup> or a 10% solution of bleach (1 part household bleach in 9 parts water) are effective sterilants.

6. Disposal of diseased material should be done so as not to spread the disease to uninfested areas. Limbs and small pieces of wood may be chipped and the mulch deposited on site, or they may be burned. Any material that is removed from the site should be tightly covered with a tarp during transit and taken to the nearest landfill or designated disposal facility for prompt burial, chipping and composting, or burning.

7. Logs may be split for firewood for local use, but the wood should be seasoned beneath a tightly sealed, clear plastic tarp to prevent the buildup of destructive insects. California Department of Forestry and Fire Protection Tree Note #3, Controlling Bark Beetles in Wood Residue and Firewood, provides specific guidelines for firewood tarping. Do not stack pine firewood next to living pine trees or transport it to uninfested areas.

Further information on pine pitch canker disease may be obtained by contacting your local Agricultural Commissioner's office, California Department of Forestry and Fire Protection forester, University of California Cooperative Extension office, or city forester (Pitch Canker Task Force 1996).