Status and Trends of Land Change in the Western United States—1973 to 2000
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Chapter 18

Southern California Mountains Ecoregion

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Ecoregion Description

The Southern California Mountains Ecoregion (Omernik, 1987; U.S. Environmental Protection Agency, 1997) encompasses approximately 17,871 km² (6,900 mi²) of land located entirely within California. The ecoregion is bounded on the far north by the Sierra Nevada Ecoregion, on the east by the Mojave Basin and Range Ecoregion, on the southeast by the Sonoran Basin and Range Ecoregion, and on the west and north by Southern and Central California Chaparral and Oak Woodlands Ecoregion. In addition, the northern part of the ecoregion is separated from the Central California Valley Ecoregion by a narrow strip of the Southern and Central California Chaparral and Oak Woodlands Ecoregion (fig. 1).

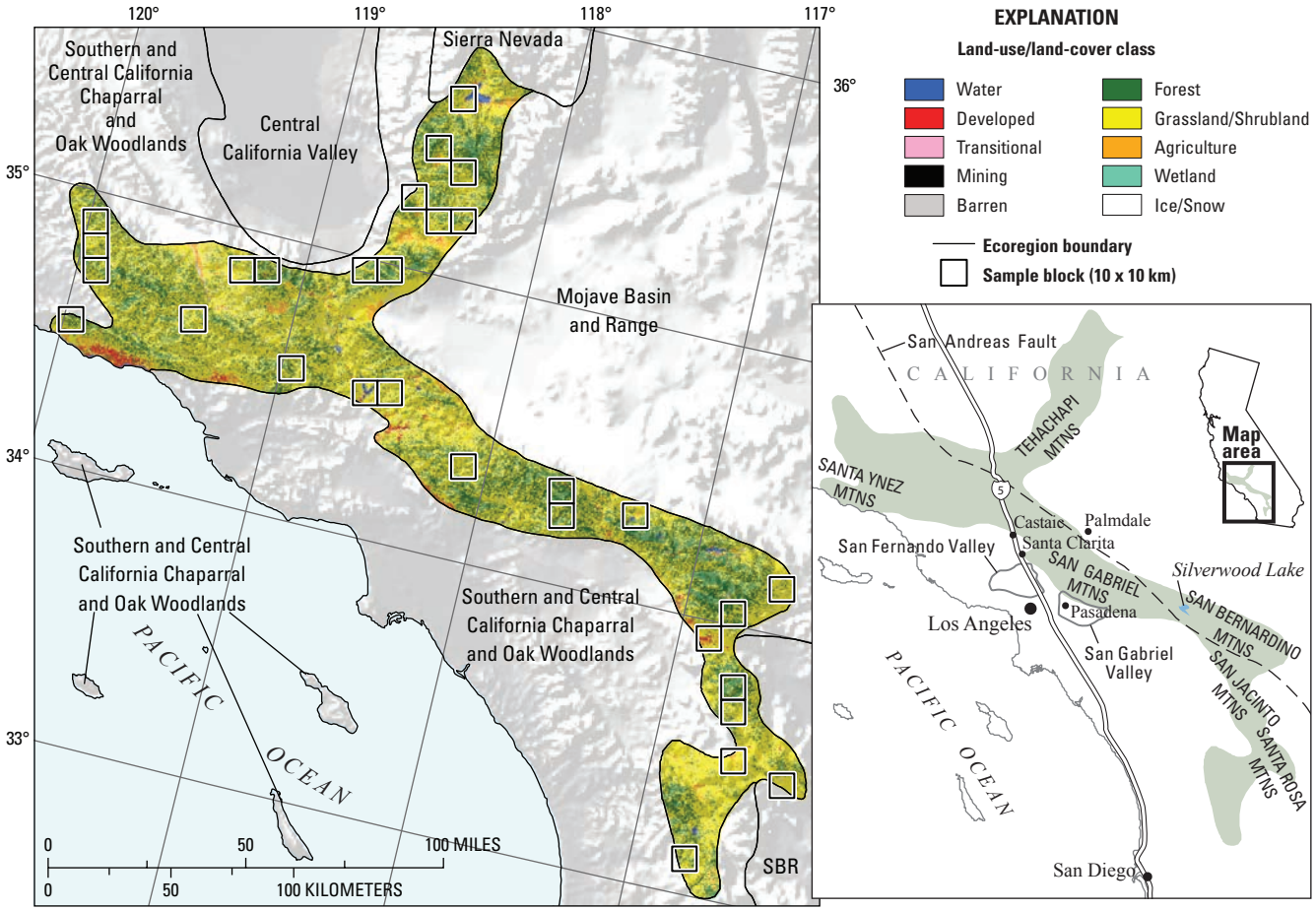

Figure 1. Map of Southern California Mountains Ecoregion and surrounding ecoregions, showing land-use/land-cover classes from 1992 National Land Cover Dataset (Vogelmann and others, 2001); note that not all land-use/land-cover classes shown in explanation may be depicted on map; note also that, for this "Status and Trends of Land Change" study, transitional land-cover class was subdivided into mechanically disturbed and nonmechanically disturbed classes. Squares indicate locations of 10 x 10 km sample blocks analyzed in study. Index map shows locations of geographic features mentioned in text. Abbreviations for Western United States ecoregions are listed in appendix 2. See appendix 3 for definitions of land-use/land-cover classifications.

The Southern California Mountains Ecoregion includes several Pacific Coast mountain ranges. From northwest to southeast, these are the Santa Ynez Mountains, the Tehachapi Mountains, the San Gabriel Mountains, the San Bernardino Mountains, the San Jacinto Mountains, and the Santa Rosa Mountains. These mountain ranges are composed primarily of Mesozoic granitic and metamorphic rocks, in addition to Tertiary sedimentary rocks. The mountains are fractured and discontinuous, owing to movement on the San Andreas Fault and also the associated thrust faults that underlie the region. Additionally, the Santa Ynez Mountains, San Gabriel Mountains, and San Bernardino Mountains make up part of the geologic province known informally as the "Transverse Ranges Province," so-named because of its atypical east-west orientation, which differs from the more typical northwest-southeast orientation (roughly parallel to the San Andreas Fault) of most mountain ranges and valleys elsewhere in California.

The mountains of the Southern California Mountains Ecoregion act as a barrier between a coastal Mediterranean climate to the west and a dry desert climate to the east. This physiographic-barrier effect, along with the topographic gradient of rolling hills to mountains, plays a large role in dictating regional land-use patterns. For example, most urban and agricultural development (for example, irrigated pasture, hay fields, orchards) occurs at lower elevations in the more temperate parts of the ecoregion. Much of this land use is also connected to the suburban growth occurring in adjacent ecoregions; population pressure from cities along the periphery of the Southern California Mountains ecoregion—specifically, the San Fernando and San Gabriel Valleys in the greater Los Angeles, California, area, as well as the cities of Pasadena, Santa Clarita, and Palmdale, California —has caused a spillover in development into the Southern California Mountains Ecoregion's foothills. At higher elevations, development is less dense and is primarily associated with recreational activities and their supporting infrastructure (for example, campgrounds, vacation homes, ski resorts).

The physiographic barrier between the coastal and desert climates also sets the stage for the annual fire season, which occurs from late summer to early fall. Dry conditions on the ground, coupled with the seasonal strong, offshore Santa Ana winds (created from steep pressure gradients that develop between the desert and the coast), have fueled frequent major wildfires throughout the region for more than 500 years (Mensing and others, 1999). The increase in contemporary development, coupled with the long fire history, makes human populations in the region susceptible to fire hazards on a regular basis.

Contemporary Land-Cover Change (1973 to 2000)

Between 1973 and 2000, the footprint (overall areal extent) of land-use/land-cover change in the Southern California Mountains Ecoregion was 5.1 percent, or 906 km². The footprint of change can be interpreted as the area that experienced land-cover change during at least one of the four multiyear time periods that make up the 27-year study period. Of the total change, 518 km² changed during one period, 268 km² changed during two periods, 107 km² changed during three periods, and less than 1 km² changed during all four periods (table 1). Compared to other western United States ecoregions, overall change was low (fig. 2).

The average annual rate of land-cover change in the Southern California Mountains Ecoregion between 1973 and 2000 was roughly 0.3 percent per year. This measurement, which normalizes the results for each period to an annual scale, means that the ecoregion averaged roughly 0.3 percent (50 km²) of change each year in the 27-year study period. However, this annual change varied between each of the four time periods (fig. 3). Between 1973 and 1980, the annual rate of change in the Southern California Mountains Ecoregion

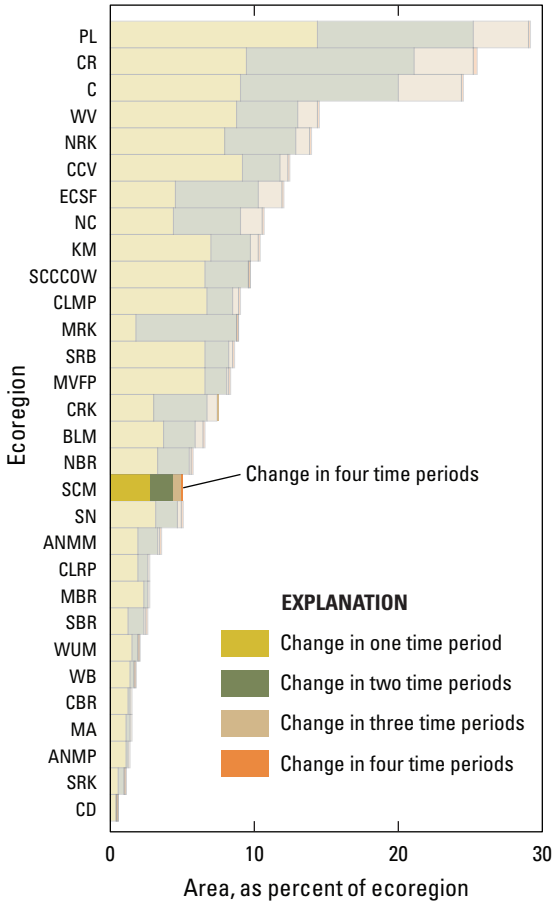

Figure 2. Overall spatial change in Southern California Mountains Ecoregion (SCM; darker bars) compared with that of all 30 Western United States ecoregions (lighter bars). Each horizontal set of bars shows proportions of ecoregion that changed during one, two, three, or four time periods; highest level of spatial change in Southern California Mountains Ecoregion (four time periods) labeled for clarity. See table 2 for years covered by each time period. See appendix 2 for key to ecoregion abbreviations.

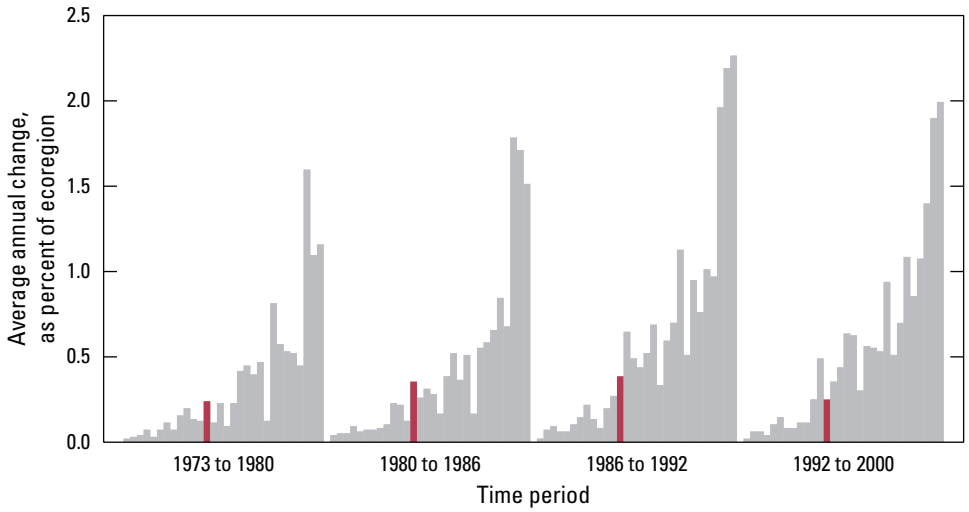

Figure 3. Estimates of land-cover change per time period, normalized to annual rates of change for all 30 Western United States ecoregions (gray bars). Estimates of change for Southern California Mountains Ecoregion are represented by red bars in each time period.

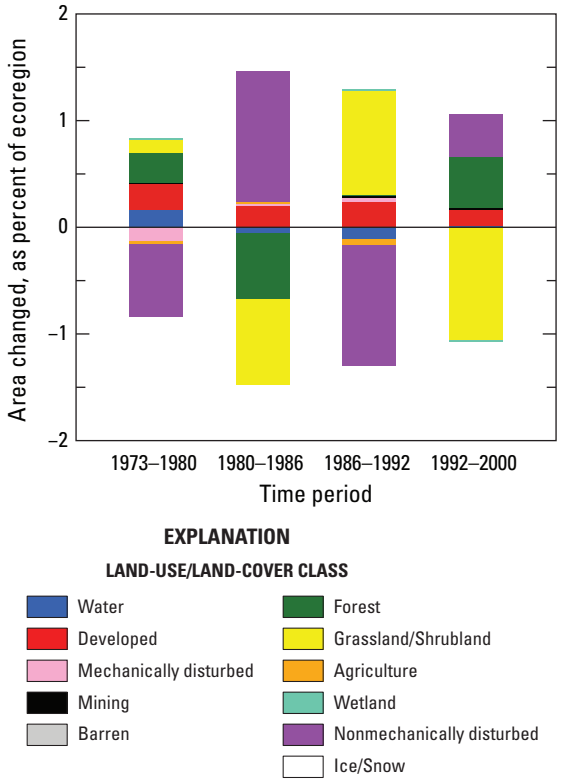

Figure 4. Normalized average net change in Southern California Mountains Ecoregion by time period for each land-cover class. Bars above zero axis represent net gain, whereas bars below zero represent net loss. Note that not all land-cover classes shown in explanation may be represented in figure. See appendix 3 for definitions of land-use/land-cover classifications.

was 0.2 percent per year, increasing to 0.3 percent per year between 1980 and 1986 and 0.4 percent per year between 1986 and 1992. The normalized annual rate dropped to 0.2 percent per year between 1992 and 2000 (table 2).

In 2000, 4 of the 11 land-cover classes occupied most of the Southern California Mountains Ecoregion: grassland/shrubland (65.9 percent), forest (27.5 percent), developed (2.6 percent), and agriculture (1.5 percent). Six other land-cover classes cumulatively made up the remaining 2.5 percent of the ecoregion in 2000, each making up less than 1.0 percent of the ecoregion (table 3).

Between 1973 and 2000, the land-cover classes that experienced a measurable net change in relation to the total Southern California Mountains Ecoregion area were, in descending order, developed (44.6 percent increase) and grassland/shrubland (1.1 percent decrease) (fig. 4). However, net change may not necessarily be the best indicator of change for individual land-cover classes as it can mask more complex land-use/land-cover dynamics. Analysis of gross change (that is, area gained or lost) by individual land-cover classes by time period shows that classes have fluctuated throughout the 27-year study period to a greater degree than net change values may indicate (fig. 5). Figure 5 illustrates how land-cover classes may experience gains and losses in area both within and between time periods. For example, the water class had no significant net change but experienced a gross change of nearly half its 1973 value. The nonmechanically disturbed class, which fluctuated greatly over the study period. underwent gross change totaling more than four times its original value.

The “from class–to class” information afforded by a postclassification comparison allows the identification of land-use/land-cover class conversions and the ranking of these conversions according to their magnitude. Table 4 illustrates the most frequent conversions between 1973 and 2000 in the Southern California Mountains Ecoregion. Five of the top ten

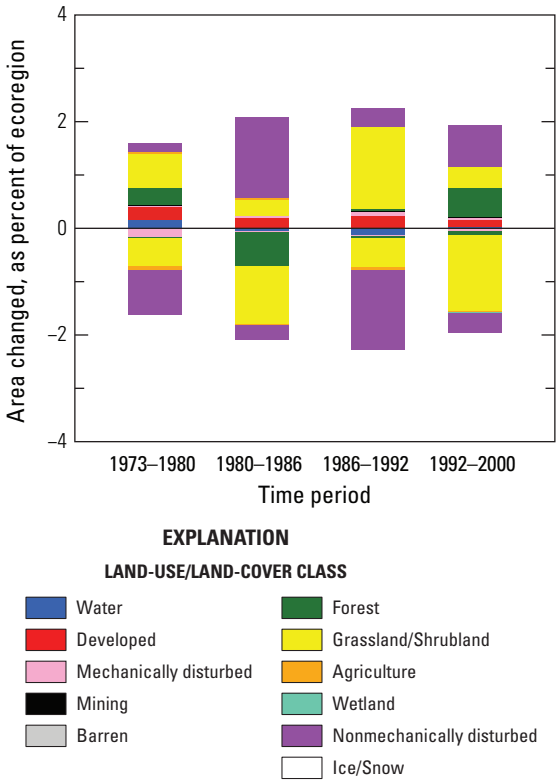

Figure 5. Gross change (area gained and lost) in Southern California Mountains Ecoregion by time period for each land-cover class. Bars above zero axis represent net gain, whereas bars below zero represent net loss. Note that not all land-cover classes shown in explanation may be represented in figure. See appendix 3 for definitions of land-use/land-cover classifications. Diagram illustrates that net change can mask within-class fluctuations within each time period and during entire 27-year study period.

Figure 6. Photograph taken in April 2005 of Silverwood Lake, California, and its surroundings, showing area undergoing regeneration following fire. Although grasses and shrubs tend to reestablish themselves quite soon after fire, trees take much longer to recover. Land-cover classes shown are grassland/shrubland and water.

most prominent conversions are connected to the nonmechanical disturbance of land cover by fire. Cumulatively, the effect of nonmechanical disturbance on grassland/shrubland and forest resulted in an estimated 501 km² of vegetated land-cover loss. However, much of this land experienced ecological succession, or regrowth, after each disturbance event (fig. 6). Regrowth accounted for 531 km² of vegetated land-cover gain; areas that were disturbed in consecutive periods account for an additional 21 km².

Conversions to the developed class also were common in the Southern California Mountains Ecoregion during the study period (146 km²) (fig. 7). The ecoregion is a geographically unique place, surrounded at lower elevations by human development and having few natural corridors that link its multiple mountain ranges. In the past, natural ignition sources such as lightning and wind dictated fire behavior in the Southern California Mountains Ecoregion, but today most of the fires are human-caused and are located at or near the interface between human development and wildlands (U.S. Department of Agriculture, 2005). These anthropogenic changes make predictions of future ecosystem health difficult as threats and outcomes

Figure 7. Photograph taken in April 2005 of new homes in Castaic, California, an unincorporated community in Los Angeles County located alongside Interstate 5. Land-use/land-cover classes shown are grassland/shrubland, forest, developed, and water.

cannot be measured against historical conditions. Topographic isolation, coupled with increased fragmentation of habitat by fire, poses significant threats to existing diversity and may ultimately drive species turnover in Southern California Mountains Ecoregion (Center for Biological Diversity, 2007). Protection of this designated biodiversity hotspot will become increasingly difficult given current land-use/land-cover trends (Myers and others, 2000). The consequences of land-use/land-cover change caused by nonmechanical disturbance and development, as well as the general loss of grassland/shrubland, do not necessarily follow managerial boundaries. On Federal lands, many agencies have adopted multiscale, integrated planning and management activities in an attempt to deal with these ecological processes within and across management units (Hann and Bunnell, 2001).

Table 1. Percentage of Southern California Mountains Ecoregion land cover that changed at least one time during study period (1973–2000) and associated statistical error.

[Most sample pixels remained unchanged (94.9 percent), whereas 5.1 percent changed at least once throughout study period]

Number of changes	Percent of ecoregion	Margin of error (+/– %)	Lower bound (%)	Upper bound (%)	Standard error (%)	Relative error (%)
1	2.4	1.3	1.5	4.2	0.9	31.6
2	1.1	1.6	0.0	3.1	1.1	68.8
3	0.6	0.7	−0.1	1.4	0.5	78.1
4	0.0	0.0	0.0	0.0	0.0	52.2
Overall spatial change	5.1	2.5	2.6	7.5	1.7	32.8

Table 2. Raw estimates of change in Southern California Mountains Ecoregion land cover, computed for each of four time periods, and associated error at 85-percent confidence level.

[Estimates of change per period normalized to annual rate of change for each period]

Period	Total change (% of ecoregion)	Margin of error (+/– %)	Lower bound (%)	Upper bound (%)	Standard error (%)	Relative error (%)	Average rate (% per year)
Estimate of change, in percent stratum							
1973–1980	1.6	1.0	0.6	2.6	0.7	41.6	0.2
1980–1986	2.1	1.5	0.6	3.5	1.0	47.4	0.3
1986–1992	2.3	1.6	0.6	3.9	1.1	48.4	0.4
1992–2000	1.9	1.1	0.8	3.0	0.7	38.4	0.2
Estimate of change, in square kilometers							
1973–1980	289	178	111	467	120	41.6	41
1980–1986	371	260	111	632	176	47.4	62
1986–1992	407	291	116	698	197	48.4	68
1992–2000	346	196	149	542	133	38.4	43

Table 3. Estimated area (and margin of error) of each land-cover class in Southern California Mountains Ecoregion, calculated five times between 1973 and 2000. See appendix 3 for definitions of land-cover classifications.

	Water		Developed		Mechanically disturbed		Mining		Barren		Forest		Grassland/ Shrubland		Agriculture		Wetland		Non-mechanically disturbed	
	%	+/–	%	+/–	%	+/–	%	+/–	%	+/–	%	+/–	%	+/–	%	+/–	%	+/–	%	+/–
Area, in percent stratum																				
1973	0.8	0.6	1.8	0.8	0.1	0.2	0.1	0.0	0.5	0.2	27.4	5.3	66.6	5.0	1.6	1.2	0.2	0.2	0.9	0.8
1980	1.0	0.7	2.1	0.9	0.0	0.0	0.1	0.1	0.5	0.2	27.7	5.3	66.7	5.0	1.5	1.2	0.2	0.2	0.3	0.2
1986	0.9	0.7	2.3	0.9	0.0	0.0	0.1	0.1	0.5	0.2	27.0	5.0	65.9	4.9	1.5	1.2	0.2	0.2	1.5	1.3
1992	0.8	0.6	2.5	1.0	0.1	0.1	0.1	0.1	0.5	0.2	27.0	5.0	66.9	4.8	1.5	1.2	0.2	0.2	0.4	0.4
2000	0.8	0.6	2.6	1.1	0.1	0.1	0.1	0.1	0.5	0.2	27.5	5.3	65.9	5.0	1.5	1.2	0.2	0.2	0.8	0.6
Net change	0.0	0.2	0.8	0.3	−0.1	0.2	0.0	0.0	0.0	0.0	0.1	0.3	−0.7	0.8	−0.1	0.2	0.0	0.0	−0.2	1.0
Gross change	0.4	0.3	0.8	0.3	0.3	0.2	0.0	0.0	0.0	0.0	1.6	1.5	4.6	2.4	0.2	0.2	0.0	0.0	4.1	2.4
Area, in square kilometers																				
1973	143	100	327	146	26	28	11	7	92	44	4,893	940	11,902	897	279	214	30	29	169	143
1980	175	120	368	159	3	4	13	10	92	44	4,943	941	11,924	892	274	210	30	29	49	43
1986	167	119	404	167	7	5	14	10	92	44	4,830	886	11,781	884	276	209	31	29	269	234
1992	147	101	448	185	14	13	17	12	92	44	4,831	888	11,958	849	267	207	31	30	66	80
2000	151	102	473	194	16	14	19	14	92	44	4,916	939	11,769	892	265	207	31	29	139	106
Net change	8	32	146	62	−10	31	8	7	0	0	24	58	−133	148	−13	30	1	1	−30	172
Gross change	70	46	146	62	55	36	8	7	0	0	291	266	814	426	32	29	2	2	741	431

Table 4. Principal land-cover conversions in Southern California Mountains Ecoregion, showing amount of area changed (and margin of error, calculated at 85-percent confidence level) for each conversion during each of four time periods and also during overall study period. See appendix 3 for definitions of land-cover classifications.

[Values given for "other" class are combined totals of values for other land-cover classes not listed in that time period. Abbreviations: n/a, not applicable]

Period	From class	To class	Area changed (km^2)	Margin of error (+/– km^2)	Standard error (km^2)	Percent of ecoregion	Percent of all changes
1973–1980	Nonmechanically disturbed	Grassland/Shrubland	98	89	60	0.5	33.7
	Nonmechanically disturbed	Forest	53	51	34	0.3	18.2
	Grassland/Shrubland	Nonmechanically disturbed	31	37	25	0.2	10.7
	Grassland/Shrubland	Developed	31	19	13	0.2	10.7
	Grassland/Shrubland	Water	24	20	13	0.1	8.4
	Other	Other	53	n/a	n/a	0.3	18.3
		Totals	289			1.6	100.0
1980–1986	Grassland/Shrubland	Nonmechanically disturbed	166	183	124	0.9	44.7
	Forest	Nonmechanically disturbed	103	132	89	0.6	27.9
	Nonmechanically disturbed	Grassland/Shrubland	48	43	29	0.3	12.8
	Grassland/Shrubland	Developed	21	9	6	0.1	5.8
	Forest	Developed	10	11	7	0.1	2.8
	Other	Other	23	n/a	n/a	0.1	6.1
		Totals	371			2.1	100.0
1986–1992	Nonmechanically disturbed	Grassland/Shrubland	262	232	157	1.5	64.3
	Grassland/Shrubland	Nonmechanically disturbed	62	76	51	0.3	15.3
	Grassland/Shrubland	Developed	30	14	9	0.2	7.3
	Water	Grassland/Shrubland	11	14	9	0.1	2.8
	Agriculture	Developed	10	13	9	0.1	2.3
	Other	Other	32	n/a	n/a	0.2	7.9
		Totals	407			2.3	100.0
1992–2000	Grassland/Shrubland	Nonmechanically disturbed	122	93	63	0.7	35.4
	Grassland/Shrubland	Forest	98	132	90	0.5	28.4
	Nonmechanically disturbed	Grassland/Shrubland	64	79	53	0.4	18.5
	Grassland/Shrubland	Developed	22	10	7	0.1	6.5
	Forest	Nonmechanically disturbed	14	19	13	0.1	4.1
	Other	Other	24	n/a	n/a	0.1	7.0
		Totals	346			1.9	100.0
1973–2000 (overall)	Nonmechanically disturbed	Grassland/Shrubland	471	377	255	2.6	33.3
	Grassland/Shrubland	Nonmechanically disturbed	382	344	233	2.1	27.0
	Forest	Nonmechanically disturbed	119	133	90	0.7	8.4
	Grassland/Shrubland	Developed	104	41	28	0.6	7.4
	Grassland/Shrubland	Forest	101	132	89	0.6	7.2
	Other	Other	236	n/a	n/a	1.3	16.7
		Totals	1,413			7.9	100.0

References Cited

Center for Biological Diversity, 2007, Impacts of the 2003 Southern California wildfires on four species listed as threatened or endangered under the Federal Endangered Species Act—Quino checkerspot butterfly, Mountain yellow-legged frog, Coastal California gnatcatcher, Least Bell's vireo: Tucson, Ariz., Center for Biological Diversity, 46 p., last accessed June 18, 2007, at www.biologicaldiversity.org/publications/papers/report-2003.pdf.

Hann, W.J., and Bunnell, D.L., 2001, Fire and land management planning and implementation across multiple scales: International Journal of Wildland Fire, v. 10, p. 389–403.

Mensing, S.A., Michaelson, J., and Byrne, R., 1999, A 560-year record of Santa Ana fires reconstructed from charcoal deposited in the Santa Barbara Basin, California: Quaternary Research, v. 51, p. 295–305.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., and Kent, J., 2000, Biodiversity hotspots for conservation priorities: Nature, v. 403, p. 853–858.

Omernik, J.M., 1987, Ecoregions of the conterminous United States: Annals of the Association of American Geographers, v. 77, no. 1, p. 118–125.

Soulard, C.E., Raumann, C.G., and Wilson, T.S., 2007, Land-cover trends of the Southern California Mountains ecoregion: U.S. Geological Survey Scientific Investigations Report 2007–5235, 22 p., available at http://pubs.usgs.gov/sir/2007/5235/.

U.S. Department of Agriculture, 2005, Final environmental impact statement, volume 1, Land management plans—Angeles National Forest, Cleveland National Forest, Los Padres National Forest, San Bernardino National Forest: United States Department of Agriculture, Forest Service, Pacific Southwest Region, R5-MB-074-A.

U.S. Environmental Protection Agency, 1997, Descriptions of level III ecological regions for the CEC report on ecological regions of North America: U.S. Environmental Protection Agency database, accessed April 12, 2006, at http://www.epa.gov/wed/pages/ecoregions/na_eco.htm#Downloads.

Vogelmann, J.E., Howard, S.M., Yang, L., Larson, C.R., Wylie, B.K., and van Driel, N., 2001, Completion of the 1990s National Land Cover Data Set for the conterminous United States from Landsat Thematic Mapper data and ancillary data sources: Photogrammetric Engineering and Remote Sensing, v. 67, p. 650–662.