

Chapter 13

Klamath Mountains Ecoregion

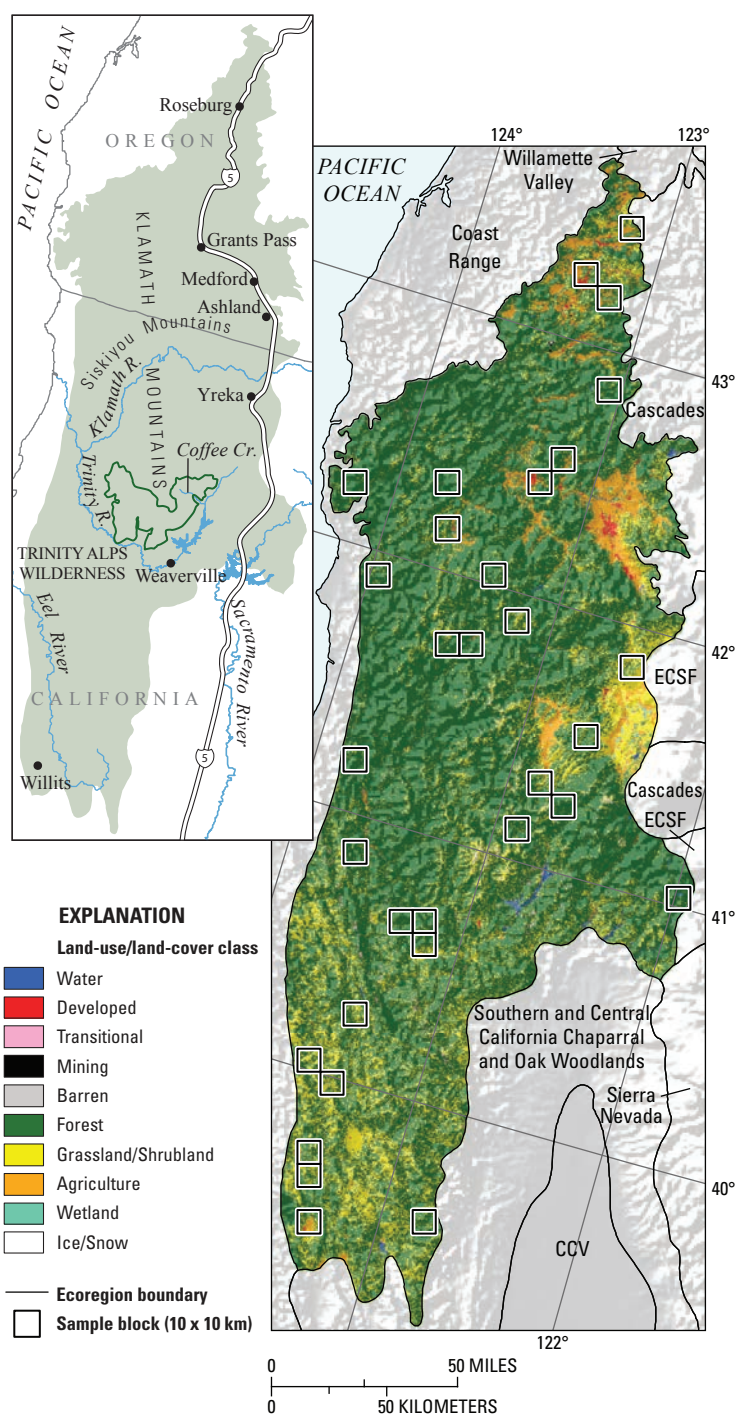
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Ecoregion Description

The Klamath Mountains Ecoregion covers approximately 47,791 km² (18,452 mi²) of the Klamath and Siskiyou Mountains of northern California and southern Oregon (fig. 1) (Omernik, 1987; U.S. Environmental Protection Agency, 1997). The ecoregion is flanked by the Coast Range Ecoregion to the west, the Southern and Central California Chaparral and Oak Woodlands Ecoregion to the south, the Cascades and the Eastern Cascades Slopes and Foothills Ecoregions to the east, and the Willamette Valley Ecoregion to the north. The mild Mediterranean climate of the ecoregion is characterized by hot, dry summers and wet winters; the amount of winter moisture varies within the ecoregion, decreasing from west to east. The Klamath–Siskiyou Mountains region is widely recognized as an important biodiversity hotspot (Whittaker, 1960; Kruckeberg, 1984; Wagner, 1997; DellaSala and others, 1999), containing more than 3,500 plant species, more than 200 of which are endemic (Sawyer, 2007). A biological assessment by DellaSala and others (1999) ranked the Klamath–Siskiyou Mountains region as the fifth richest coniferous forest in terms of species diversity. In addition, the International Union for the Conservation of Nature considers the region an area of notable botanical importance (Wagner, 1997). Twenty-nine different species of conifers can be found in the Klamath Mountains Ecoregion (Sawyer, 1996).

This ecoregion is underlain by belts of Paleozoic to Mesozoic metasedimentary and metavolcanic rocks separated by linear belts of serpentinite. Most of these serpentinite

Figure 1. Map of Klamath 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.



belts are intruded by Mesozoic granitic rocks and (or) overlain by late Mesozoic sedimentary rocks. All of these rocks are overlain by gravel and alluvial deposits of Cenozoic age (Irwin, 1966; Snoke and Barnes, 2006). Soils developed on serpentinite, which are toxic and nutrient poor, are characterized by high levels of magnesium, nickel, and chromium and low levels of calcium. Seventy endemic species of plants are associated only with serpentinite extrusions in the Siskiyou Mountains, outnumbering those associated with any other serpentinite outcrop in North America (Coleman and Kruckeberg, 1999; Sawyer, 2007).

Forests, which cover approximately three-quarters of the Klamath Mountains Ecoregion, are generally organized along elevation and longitudinal gradients, whereas grasslands and shrubs account for approximately 15 percent of the ecoregion (Homer and others, 2007). Redwood (*Sequoia sempervirens*) forests that dominate the coastal parts of the ecoregion give way to Douglas-fir (*Pseudotsuga menziesii*), tanoak (*Lithocarpus densiflorus*), Pacific madrone (*Arbutus menziesii*), and canyon live oak (*Quercus chrysolepis*) further inland, as well as Douglas-fir and ponderosa pine (*Pinus ponderosa*) in the eastern parts of the ecoregion (Sawyer, 1996). White fir (*Abies concolor*) and Shasta fir (*Abies magnifica*) can be found at higher elevations, and Mountain hemlock (*Tsuga mertensiana*) is common at subalpine elevations (Sawyer, 1996). Oak

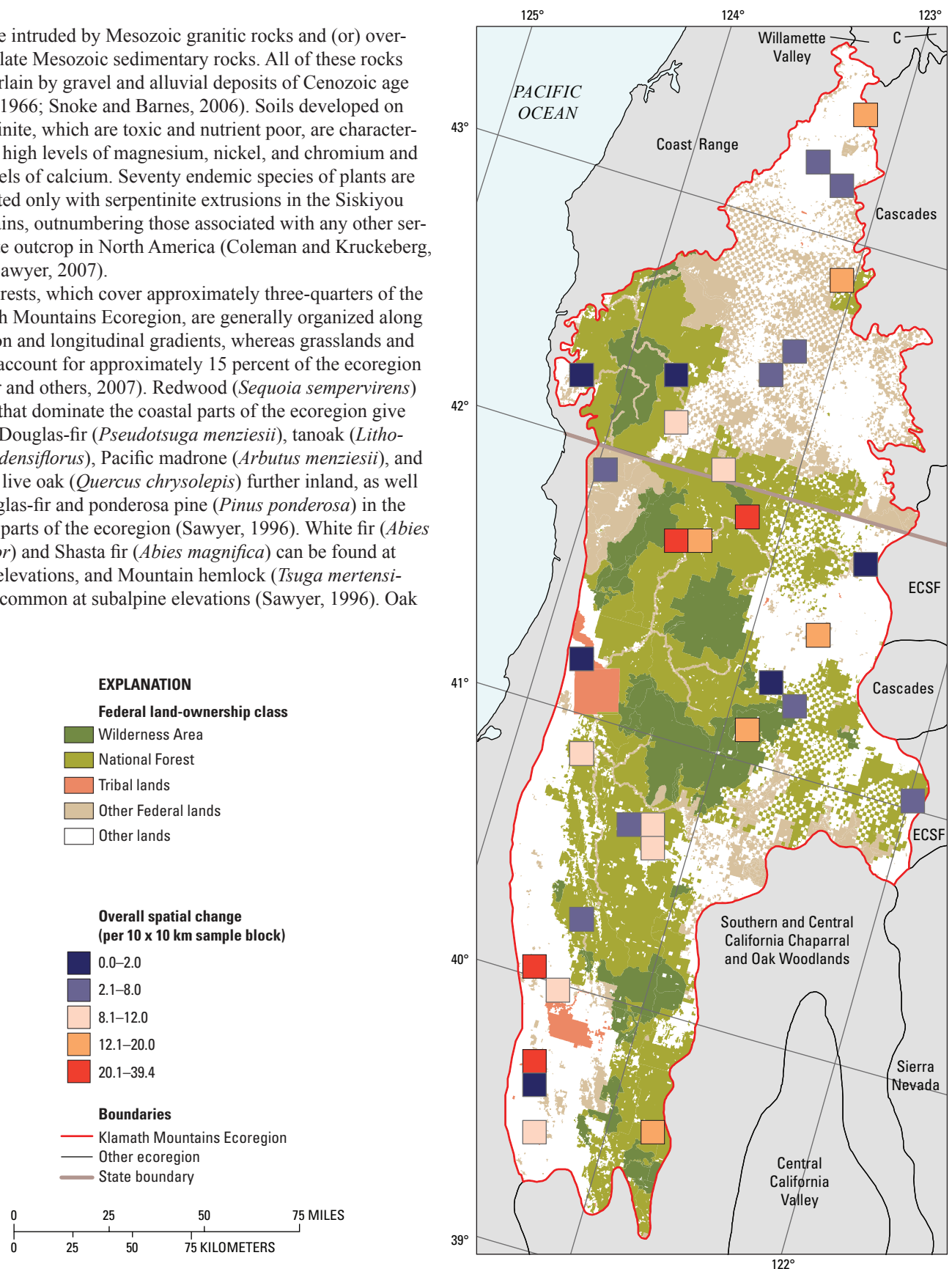


Figure 2. Federal land ownership and cumulative land-use/land-cover change (as percent of sample-block area) from 1973 to 2000 in Klamath Mountains Ecoregion. Land-ownership data from National Atlas of the United States (2006). See appendix 2 for abbreviations for Western United States ecoregions.



Figure 3. White-water rafting along Klamath River in Klamath Mountains Ecoregion.

(*Quercus* spp.) woodlands are common in foothills of the Eel, Trinity, and Sacramento Rivers' watersheds.

Agriculture and developed landscapes make up much of the remainder of the Klamath Mountains Ecoregion. The major land uses within the ecoregion include forestry, farming, grazing, tourism, and mining. Approximately 83 percent of the ecoregion is managed by the Federal Government, mostly for public use and recreation (figs. 2,3). The U.S. Forest Service manages 12 wilderness areas and 8 national forests, accounting for the majority of public lands in the ecoregion. Other federal landholders include the Bureau of Land Management, National Park Service, and Bureau of Reclamation. In addition, several tribal lands are located across the ecoregion. Protected lands (Conservation Biology Institute, 2003), which limit permanent anthropogenic conversion and are managed for natural ecosystem values,¹ make up 17.3 percent of the ecoregion.

Farming is limited and is generally confined to the larger alluvial valleys. One of the more productive agricultural locations in the ecoregion exists in a corridor between Ashland, Medford, and Grants Pass, Oregon. Developed land uses are sparse. Medford and Grants Pass in Oregon are the two largest urban areas, with 2000 population estimates of 63,154 and 23,003, respectively (U.S. Census Bureau, 2008). Other urban areas include Roseburg and Ashland in Oregon and Willits and Yreka in California.

¹ Protected lands, which are classified as having either GAP protection status code 1 or 2, are lands managed for different levels of biodiversity protection (Scott and others, 1993; DellaSala and others, 2001). GAP protection status codes are defined as follows: status code 1 is an area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management; status code 2 is an area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but it may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.

Contemporary Land-Cover Change (1973 to 2000)

The overall spatial change in the Klamath Mountains Ecoregion (that is, the amount of area that changed at least one time between 1973 and 2000) was 8.5 percent (4,929 km²) (table 1). Compared to other western United States ecoregions, the Klamath Mountains Ecoregion experienced a modest amount of change, although the rate was substantially lower than other forested ecoregions in the Pacific Northwest (fig. 4). An estimated 5.2 percent of the ecoregion experienced change in more than one time period, indicating a cyclic pattern that is consistent with the changes associated with forestry. Change within the four individual time periods ranged from a low of 3.0 percent between 1980 and 1986 to a high of 4.2 percent between 1986 and 1992 and between 1992 and 2000 (table 2). When the change estimates are normalized to an average

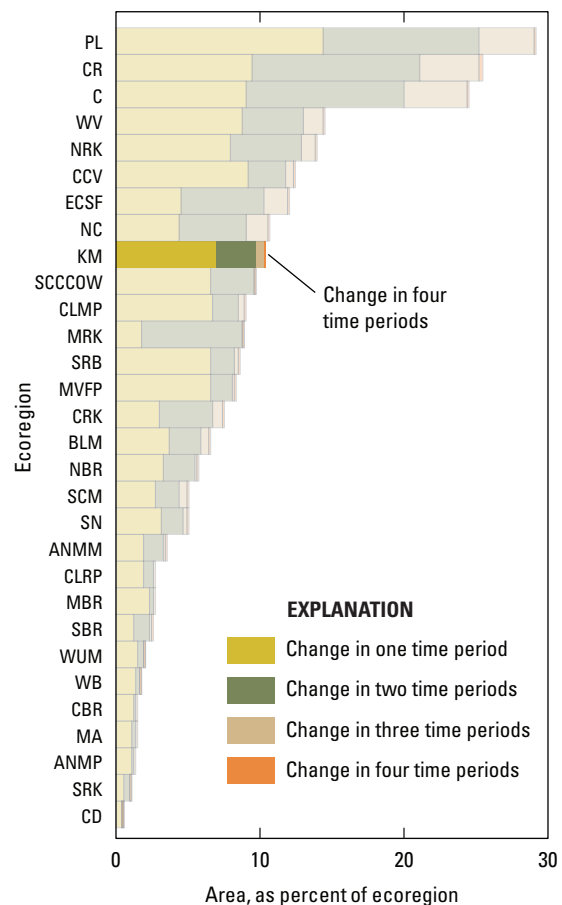
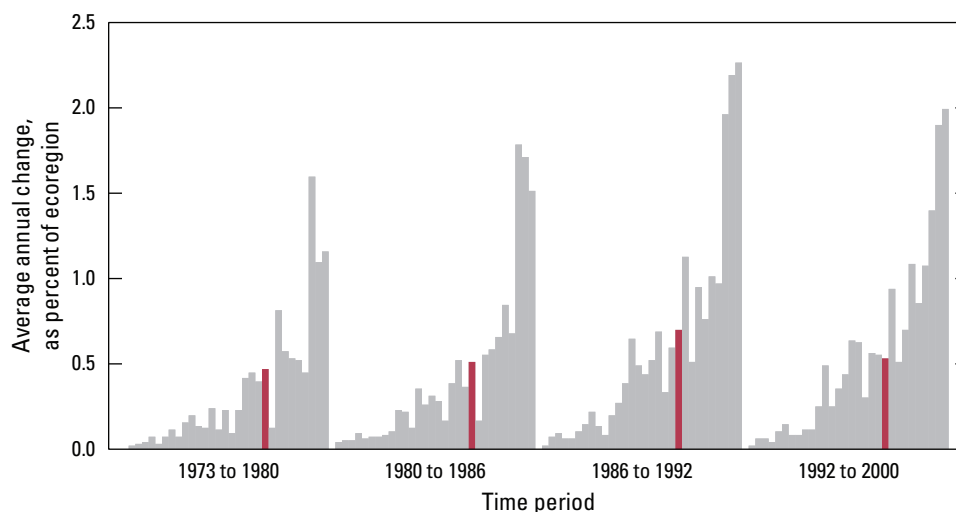


Figure 4. Overall spatial change in Klamath Mountains Ecoregion (KM; darker bars) compared with that of all Western United States Ecoregions (lighter bars). Each horizontal set of bars shows proportion of ecoregion that changed during one, two, three, or four time periods; highest level of spatial change in Klamath 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 5. 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 Klamath Mountains Ecoregion are represented by red bars in each time period.



annual rate to compensate for the varying lengths of time periods, the time period between 1986 and 1992 experienced the highest rate of change, at 0.7 percent per year (fig. 5). The other three time periods were fairly stable, at approximately 0.5 percent per year (table 2). Staus and others (2002) found similar rates of forest disturbance between 1972 and 1992 in the Klamath–Siskiyou Mountains region. The fact that land-cover change in the Klamath Mountains Ecoregion was substantially lower than that of the adjacent Coast Range Ecoregion is explained, in part, by the Klamath Mountains Ecoregion's larger percentage of public lands, particularly areas of high protection (for example, wilderness areas; fig. 6), that either minimize, or severely restrict, timber harvest. Table 3 provides estimates of net forest change, public land ownership, and protected lands for forest-dominated ecoregions in the western United States. The Klamath Mountains Ecoregion had the lowest net loss of forest land cover in the Pacific Northwest over the 27-year study period (594 km²), with the exception of the Cascades Ecoregion (tables 3,4; fig. 7), and it ranked behind only the Sierra Nevada Ecoregion in terms of the proportion of public lands found within the ecoregion.



Figure 6. Wilderness area along Coffee Creek in Trinity Alps Wilderness, Klamath Mountains, California.

Forest covered an estimated 76.6 percent of the ecoregion in 1973 and declined to 75.3 percent by 2000, a loss of 1.6 percent (fig. 8). The only time period to experience a net increase in forest was between 1980 and 1986, with an increase of 73 km². Grassland/shrubland, which accounted for an estimated 14.3 percent of the ecoregion in 1973, increased

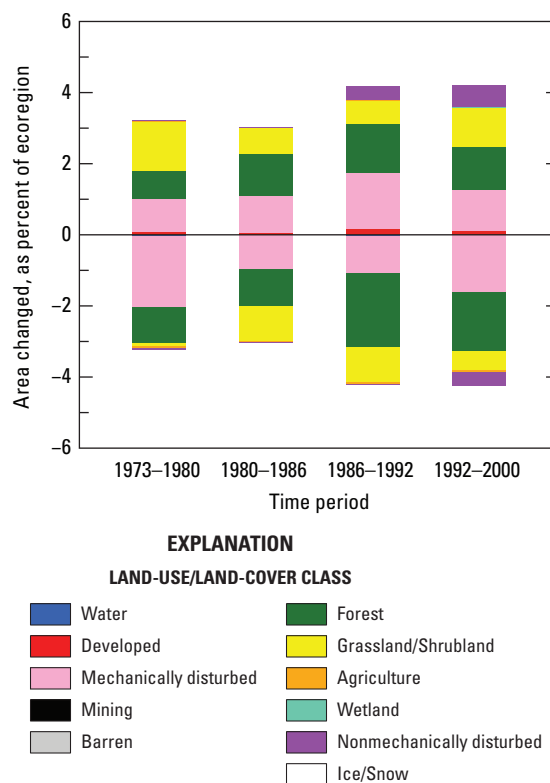


Figure 7. Gross change (area gained and lost) in Klamath Mountains Ecoregion by time period for each land-cover class. Bars above zero axis represent net gain, whereas bars below zero represent net loss. Note that not all land-cover classes shown in explanation may be represented in figure. See appendix 3 for definitions of land-use/land-cover classifications.

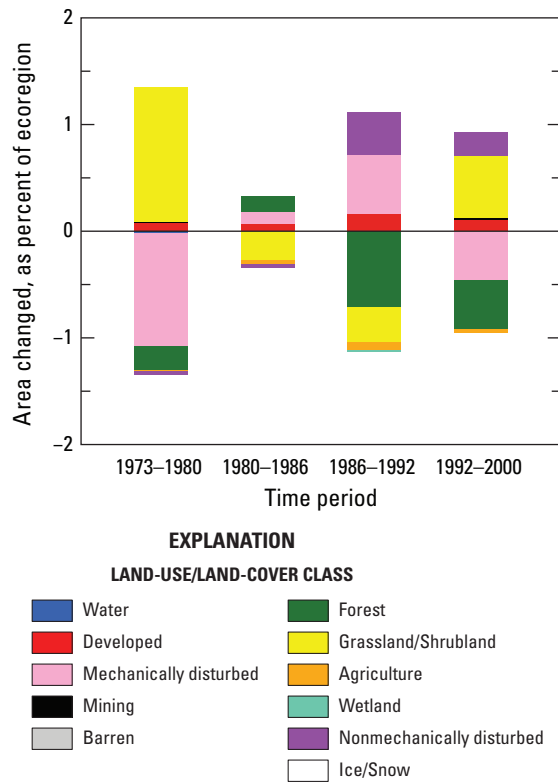


Figure 8. Normalized average net change in Klamath Mountains Ecoregion by time period for each land-cover class. Bars above zero axis represent net gain, whereas bars below zero represent net loss. Note that not all land-cover classes shown in explanation may be represented in figure. See appendix 3 for definitions of land-use/land-cover classifications.

to 15.5 percent in 2000, a net increase of 598 km² over 27 years. Furthermore, it is estimated that, between 1973 and 1980, regrowth of forest, often captured as grassland/shrubland in the earliest stages of regeneration (fig. 9), outpaced logging by approximately 74 km² per year. Logging accelerated in the 1980s and early 1990s (Daniels, 2005), resulting in a deficit of 43 km² per year between 1986 and 1992. The 1990s saw a shift back to trends witnessed during the 1970s when regrowth outpaced cutting at a rate of approximately 26 km² per year. These trends are consistent with findings from Cohen and others (2002), who investigated forest disturbance in western Oregon. Changes in land-cover classes over the four time periods can be found in table 4.

Agriculture, which was the third most common land cover in the Klamath Mountains Ecoregion, was generally confined to the eastern and northern parts of the ecoregion. Farmland remained stable throughout the study period, at approximately 4.5 percent of the ecoregion.

Changes associated with new development were relatively minor in the Klamath Mountains Ecoregion. It is estimated that developed land increased by 24 percent over the entire 27-year study, an increase of approximately 205 km². Developed land was estimated at 1.8 percent of the ecoregion in 1973, increasing to 2.2 percent by 2000. New development



Figure 9. Forested hillside regenerating after clearcut in Klamath Mountains Ecoregion.



Figure 10. New home construction and development in Grants Pass, Oregon.

focused around existing cities in Oregon such as Roseburg, as well as along the Interstate 5 corridor between Grants Pass and Medford (fig. 10). The ecoregion's only urban areas in California are Yreka, Weaverville, and Willits.

As expected, the leading land-cover conversions were associated with timber harvesting (table 5; fig. 11). Changes associated with logging accounted for most of the change in each time period, ranging from a high of nearly 95 percent between 1973 and 1980 to 72 percent between 1992 and 2000. Changes between forest, mechanically disturbed, and grassland/shrubland are closely linked and, when combined, represent the cyclical nature of logging. During the last two time periods, fire (classified as nonmechanical disturbance) took on a larger role as an agent for land change; nonmechanically disturbed land accounted for an estimated 189 km² between 1986 and 1992 and 206 km² between 1992 and 2000 (table 5).

Drivers of land-cover change in the Klamath Mountains Ecoregion were numerous and diverse. Private-forest-management policies controlled much of the change associated with logging; however, in later years, state and federal environmental policies have taken on increasing importance. The collapse of the Asian log-export market in the 1990s, the listing of the Northern Spotted Owl (*Strix occidentalis caurina*) on the endangered species list in 1990, and the



Figure 11. Lumber mill in Roseburg, Oregon.

Northwest Forest Plan of 1994 (Espy and Babbitt, 1994) all are likely drivers of land-cover change in the ecoregion, the most direct result being a decrease of timber production to approximately 25 percent of 1980s levels (Daniels, 2005). Decades of fire suppression and climate change have likely contributed to the more recent emergence of fire as a major land-cover conversion. Fires over this period are typified by more frequent, high-intensity, stand-replacing burns in northern California (Westerling and others, 2006).

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

[Most sample pixels remained unchanged (91.5 percent), whereas 8.5 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	3.3	1.0	2.3	4.3	0.7	20.5
2	4.3	1.3	3.0	5.6	0.9	20.2
3	0.8	0.4	0.4	1.3	0.3	36.9
4	0.1	0.1	0.0	0.1	0.0	53.3
Overall spatial change	8.5	2.3	6.3	10.8	1.5	17.9

Table 2. Raw estimates of change in Klamath Mountains Ecoregion land cover, computed for each of four time periods between 1973 and 2000, 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	3.3	1.1	2.1	4.4	0.8	23.2	0.5
1980–1986	3.0	1.0	2.1	4.0	0.6	21.4	0.5
1986–1992	4.2	1.2	3.0	5.4	0.8	19.9	0.7
1992–2000	4.2	1.3	2.9	5.5	0.9	21.1	0.5
Estimate of change, in square kilometers							
1973–1980	1,554	533	1,022	2,087	361	23.2	222
1980–1986	1,449	457	992	1,906	310	21.4	242
1986–1992	2,011	592	1,419	2,603	401	19.9	335
1992–2000	2,017	627	1,390	2,644	425	21.1	252

Table 3. Comparison of areas of forest change, protected lands, and publicly held lands in Klamath Mountains Ecoregion with that of other forested ecoregions in western United States.

Ecoregion	Ecoregion area	Forest area in 2000	Change in forest area in 2000		Protected lands (GAP codes 1,2) ¹		Publicly held lands	
	(km ²)	(% of ecoregion)	(km ²)	(% of ecoregion)	(km ²)	(% of ecoregion)	(km ²)	(% of ecoregion)
Coast Range	53,986	72.4	-2,051	-5.2	6,531	12.1	13,359	24.7
Puget Lowland	16,454	48.4	-1,662	-20.8	83	0.5	567	3.4
Willamette Valley	14,883	33.5	-625	-12.5	156	1	561	3.8
Cascades	46,416	82.3	232	0.6	13,500	29.1	30,952	66.7
Sierra Nevada	52,872	70.1	-1,851	-4.9	15,143	28.6	42,166	79.8
Klamath Mountains	48,537	75.3	-594	-1.6	8,393	17.3	34,678	71.4

¹ Protected lands, classified as having either GAP protection status code 1 or 2, are lands managed for different levels of biodiversity protection (Scott and others, 1993; DellaSala and others, 2001). GAP protection status codes are defined as follows: status code 1 is area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management; status code 2 is area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain primarily natural state, but it may receive uses or management practices that degrade quality of existing natural communities, including suppression of natural disturbance.

Table 4. Estimated area (and margin of error) of each land-cover class in Klamath 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	0.3	0.1	1.8	1.3	2.0	0.9	0.1	0.1	0.2	0.1	76.6	4.2	14.3	3.7	4.5	1.9	0.1	0.1	0.1	0.1
1980	0.3	0.1	1.9	1.3	0.9	0.3	0.1	0.1	0.2	0.1	76.4	4.2	15.5	3.5	4.5	2.0	0.1	0.1	0.0	0.1
1986	0.3	0.1	1.9	1.4	1.1	0.4	0.1	0.1	0.2	0.1	76.5	4.3	15.2	3.6	4.5	2.0	0.1	0.1	0.0	0.0
1992	0.3	0.1	2.1	1.6	1.6	0.6	0.1	0.1	0.2	0.1	75.8	4.3	14.9	3.6	4.4	2.0	0.1	0.1	0.4	0.4
2000	0.3	0.1	2.2	1.6	1.2	0.4	0.1	0.1	0.2	0.1	75.3	4.3	15.5	3.5	4.4	2.0	0.1	0.1	0.6	0.5
Net change	0.0	0.0	0.4	0.4	-0.9	0.6	0.0	0.0	0.0	0.0	-1.2	1.0	1.3	0.9	-0.1	0.2	0.0	0.0	0.6	0.5
Gross change	0.0	0.0	0.4	0.4	4.3	1.3	0.0	0.0	0.0	0.0	4.4	1.1	4.3	1.3	0.3	0.2	0.0	0.0	1.1	0.8
Area, in square kilometers																				
1973	132	61	851	608	962	413	39	35	112	38	36,600	2,030	6,814	1,786	2,171	931	72	41	38	46
1980	128	57	892	639	449	164	42	37	112	38	36,499	2,009	7,417	1,691	2,162	935	70	39	19	27
1986	127	57	926	670	504	187	43	37	112	38	36,572	2,032	7,285	1,710	2,153	935	70	39	1	1
1992	133	61	1,001	741	764	277	43	37	113	38	36,229	2,039	7,131	1,724	2,115	933	69	38	193	211
2000	133	60	1,056	786	551	211	47	38	113	38	36,006	2,065	7,412	1,685	2,100	932	70	40	302	232
Net change	2	4	205	193	-412	305	7	6	0	1	-594	489	598	410	-70	106	-1	2	264	238
Gross change	17	16	205	193	2,071	633	10	8	0	1	2,111	543	2,045	638	134	103	4	5	510	386

Table 5. Principal land-cover conversions in Klamath 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	Mechanically disturbed	Grassland/Shrubland	631	267	181	1.3	40.6
	Forest	Mechanically disturbed	434	164	111	0.9	27.9
	Mechanically disturbed	Forest	323	240	162	0.7	20.8
	Grassland/Shrubland	Forest	30	25	17	0.1	1.9
	Agriculture	Developed	24	24	16	0.1	1.6
	Other	Other	113	n/a	n/a	0.2	7.3
	Totals		1,554			3.3	100.0
1980–1986	Forest	Mechanically disturbed	487	184	125	1.0	33.6
	Grassland/Shrubland	Forest	446	207	140	0.9	30.8
	Mechanically disturbed	Grassland/Shrubland	325	159	108	0.7	22.4
	Mechanically disturbed	Forest	115	49	33	0.2	7.9
	Agriculture	Developed	16	20	13	0.0	1.1
	Other	Other	61	n/a	n/a	0.1	4.2
	Totals		1,449			3.0	100.0
1986–1992	Forest	Mechanically disturbed	753	276	187	1.6	37.4
	Grassland/Shrubland	Forest	449	220	149	0.9	22.3
	Mechanically disturbed	Grassland/Shrubland	306	156	105	0.6	15.2
	Mechanically disturbed	Forest	190	102	69	0.4	9.5
	Forest	Nonmechanically disturbed	189	208	141	0.4	9.4
	Other	Other	124	n/a	n/a	0.3	6.2
	Totals		2,011			4.2	100.0
1992–2000	Forest	Mechanically disturbed	549	211	143	1.1	27.2
	Mechanically disturbed	Grassland/Shrubland	442	235	159	0.9	21.9
	Mechanically disturbed	Forest	313	157	107	0.7	15.5
	Forest	Nonmechanically disturbed	206	164	111	0.4	10.2
	Grassland/Shrubland	Forest	166	75	51	0.3	8.2
	Other	Other	341	n/a	n/a	0.7	16.9
	Totals		2,017			4.2	100.0
1973–2000 (overall)	Forest	Mechanically disturbed	2,222	687	466	4.6	31.6
	Mechanically disturbed	Grassland/Shrubland	1,704	656	444	3.6	24.2
	Grassland/Shrubland	Forest	1,091	430	291	2.3	15.5
	Mechanically disturbed	Forest	941	452	306	2.0	13.4
	Forest	Nonmechanically disturbed	415	373	253	0.9	5.9
	Other	Other	659	n/a	n/a	1.4	9.4
	Totals		7,032			14.7	100.0

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