

Chapter 30

Sonoran Basin and Range Ecoregion

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Ecoregion Description

The Sonoran Basin and Range Ecoregion covers approximately 116,364 km² (44,928 mi²) of desert landscape in southeastern California and southwestern Arizona (fig. 1) (Omernik, 1987; U.S. Environmental Protection Agency, 1997). This ecoregion is bounded on the west by the Southern and Central California Chaparral and Oak Woodlands and the Southern California Mountains Ecoregions; on the north by the Mojave Basin and Range, the Arizona/New Mexico

Plateaus, and the Arizona/New Mexico Mountains Ecoregions; and on the east by the Madrean Archipelago Ecoregion (fig. 1). The Sonoran Basin and Range Ecoregion extends far southward into both mainland Mexico and northeastern Baja California peninsula; however, those international parts were not included in the present study. The largest concentrations of population in the ecoregion include the Palm Springs–Coachella Valley area (population 332,485 in 2000) in California’s Riverside County, as well as the Phoenix and Tucson metropolitan areas (metropolitan populations of approximately 4.2 million and 1 million, respectively) in Arizona (U.S. Census Bureau, 2011).

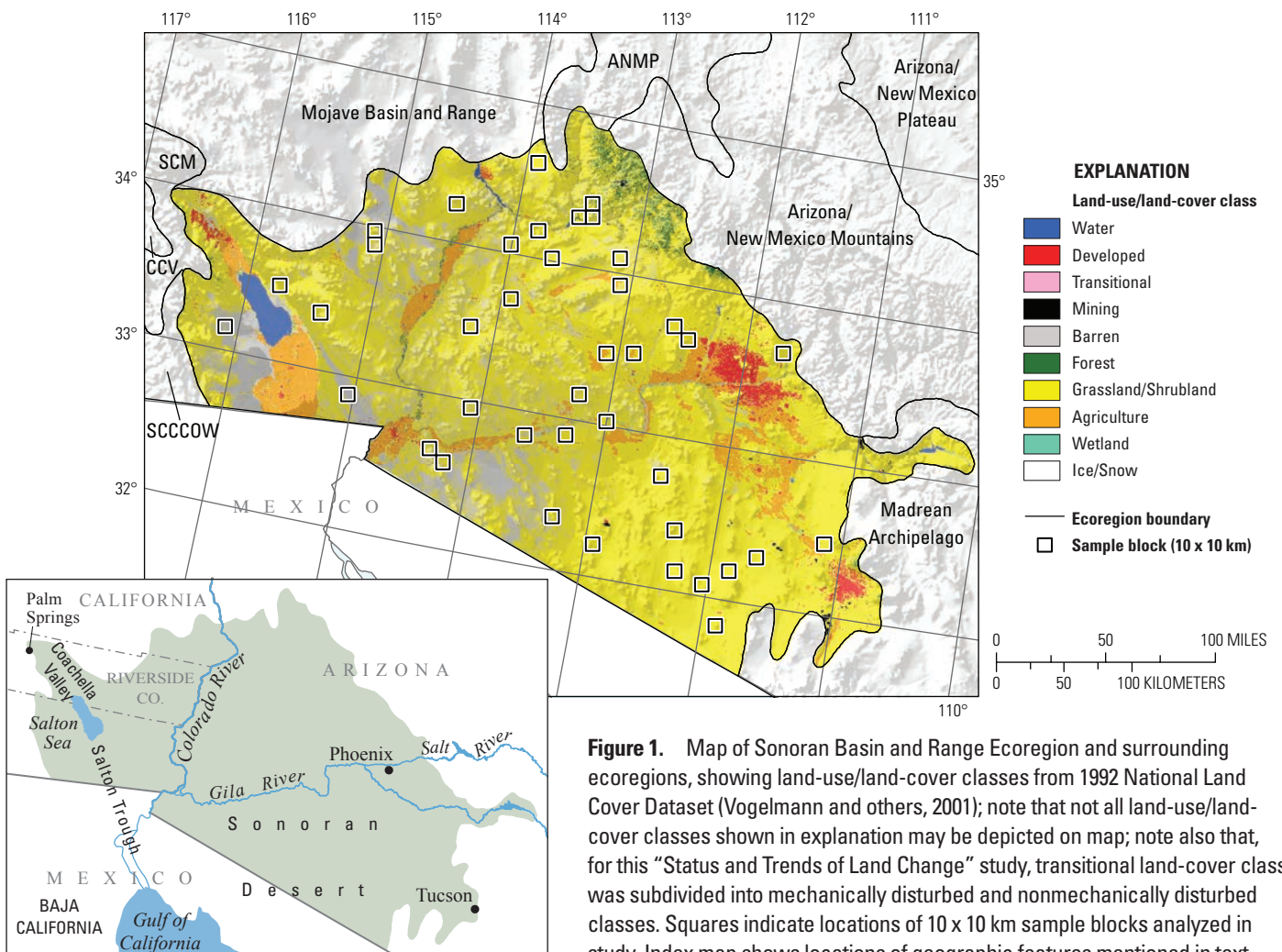


Figure 1. Map of Sonoran Basin and Range Ecoregion and surrounding ecoregions, showing land-use/land-cover classes from 1992 National Land Cover Dataset (Vogelmann and others, 2001); note that not all land-use/land-cover classes shown in explanation may be depicted on map; note also that, for this “Status 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 geography of the Sonoran Basin and Range Ecoregion is characterized by discontinuous mountain ranges separated by wide alluvial plains. The mountains are composed of igneous, sedimentary, and metamorphic rocks that vary in age from Precambrian to Tertiary (Jennings, 1977; Arizona Geological Survey and Bureau of Land Management, 1993). Elevations range from 20 to 1,830 m. The largest rivers include the Colorado River along the boundary between California and Arizona, as well as the Gila and Salt Rivers in Arizona. The Salton Sea at the northern end of the Salton Trough is located near the ecoregion's western border.

The Sonoran Basin and Range Ecoregion is characterized by a warm, arid climate. During winter months, daytime temperatures can average 21°C, and overnight temperatures can drop to below freezing in some low-lying desert valleys (Climate Assessment for the Southwest, 2010). In summer months, temperatures often climb above 38°C during the day. Daily temperature variation can exceed 15°C (Climate Assessment for the Southwest, 2010). Annual precipitation varies from 7.5 to 43 cm, with slightly more rainfall at higher elevations (Arizona Fish and Game Department, 2006; McGinnies, 1976) and a gradient of increasing precipitation from west to east. The western Sonoran Desert receives most of its precipitation in winter, whereas summer precipitation totals farther east are greater because of the influence of monsoon rains fed by higher temperatures and moisture pumped in from the Gulf of California and the Gulf of Mexico (Comrie and Glenn, 1998).

The bimodal precipitation pattern contributes to the surprisingly diverse range of vegetation within the Sonoran Basin and Range Ecoregion. More than 2,500 species, including both annual and perennial trees and shrubs, as well as succulents and cacti (Turner and others, 1995), are found here. Vast expanses of cholla (*Opuntia* spp.) cactus in California are joined by the giant saguaro (*Carnegie gigantea*) cactus in Arizona. The saguaro is cold-intolerant and highly susceptible to winter freeze mortality; it cannot survive in the California part of the ecoregion (Steenbergh and Lowe, 1977). Creosote (*Larrea tridentata*), white bursage (*Ambrosia dumosa*), ocotillo (*Fouquieria splendens*), and brittlebush (*Encelia farinosa*) shrubs dominate plant communities in the hottest, driest areas; palo verde (*Parkinsonia* spp.), mesquite (*Prosopis* spp.), and ironwood (*Olneya tesota*) trees are common on slopes and near the heads of alluvial fans.

Land ownership in the ecoregion is primarily Federal, managed by the Bureau of Land Management, Department of Defense, and National Park Service, and some of the remainder is occupied by tribal lands. Major land uses include urban and rural settlement, agriculture and livestock grazing, mining, and military training. Agriculture was established where water was available, but in recent years it has given way to urban growth. The dry climate makes this ecoregion a favored destination for relocation and retirement (Arizona Fish and Game, 2006).

Contemporary Land-Cover Change (1973 to 2000)

The overall spatial change of land cover in the Sonoran Basin and Range Ecoregion between 1973 and 2000 was estimated at 2.6 percent (table 1). Although the overall change is small when compared to other ecoregions in the western United States, the amount of change is high relative to the adjacent Chihuahuan Deserts (0.5 percent; CD, on fig. 2) and Madrean Archipelago (1.4 percent; MA, on fig. 2) Ecoregions. Our estimates indicate that between 1973 and 2000, 1.3 percent of the ecoregion changed at least once, and 1.1 percent changed at least two times (table 1).

The normalized annual rates of land-cover change, which account for varying lengths of time between imagery dates (table 2), show that the rate of land-cover change in the

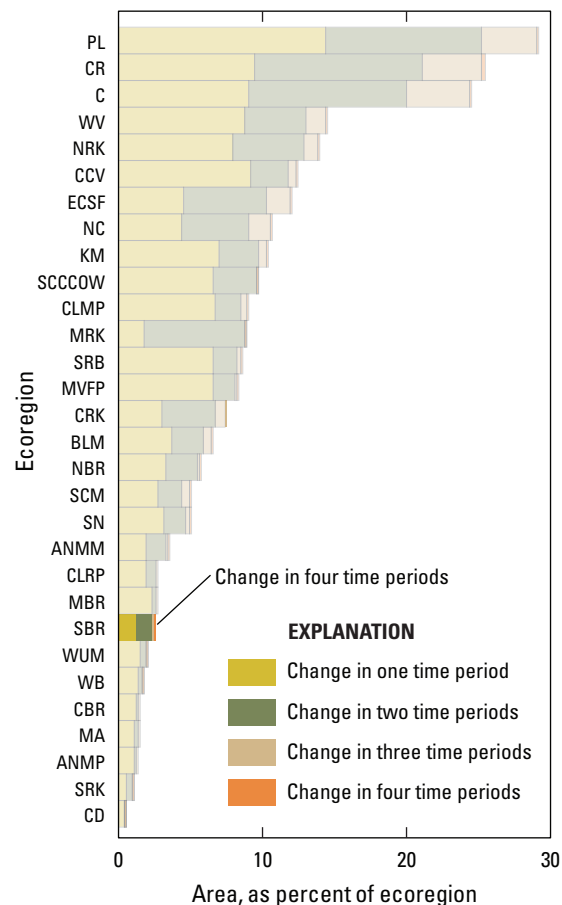


Figure 2. Overall spatial change in Sonoran Basin and Range Ecoregion (SBR; darker bars) compared with that of all 30 Western United States ecoregions (lighter bars). Each horizontal set of bars shows proportions of ecoregion that changed during one, two, three, or four time periods; highest level of spatial change in Sonoran Basin and Range 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.

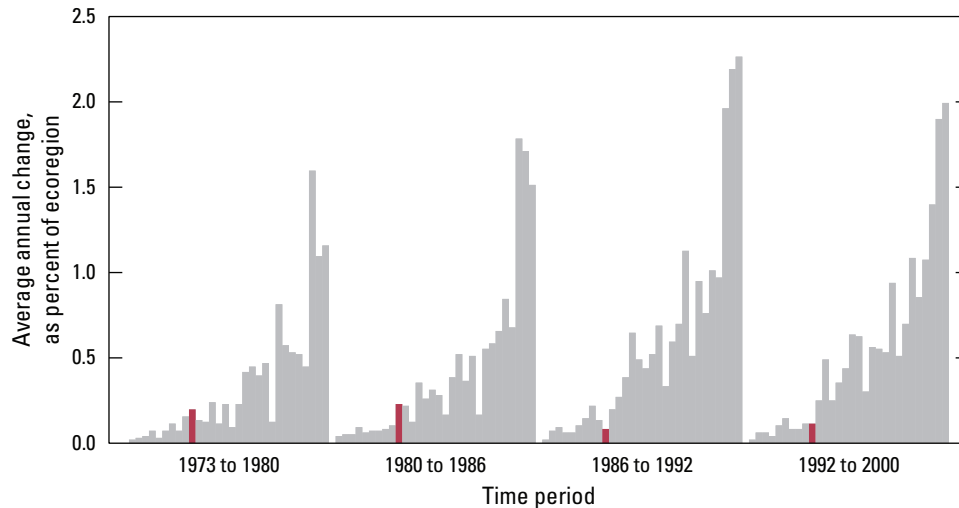


Figure 3. Estimates of land-cover change per time period, normalized to annual rates of change for all 30 Western United States ecoregions (gray bars). Estimates of change for Sonoran Basin and Range Ecoregion are represented by red bars in each time period.

Sonoran Basin and Range Ecoregion was very low compared to that in other ecoregions in the western United States (fig. 2). Within the Sonoran Basin and Range Ecoregion itself, the fastest rate of land-cover change occurred between 1980 and 1986, when approximately 264 km² changed land-cover classes per year, followed closely by 221 km² annually between 1973 and 1980. These rates were nearly twice as fast as between 1986 and 1992 and were approximately 50 percent faster than the rate of change between 1992 and 2000. It is worth noting that, because considerable error is associated with these rates, they may not be significantly different (table 2).

Net change in land-cover classes per time period is presented in figure 4. Between 1973 and 1980, a large net increase in water coupled with a large net decrease in grassland/shrubland was observed, whereas between 1980 and 1986 this trend reversed, with a large increase in grassland/shrubland and wetland coupled with a large decrease in water. These changes in land cover were in response to short-term climate fluctuations that resulted in widely varied reservoir levels. Grassland/shrubland changes were also influenced by an increase in developed land, which expanded by 173 percent over the study period, from 278 to 759 km².

Grassland/shrubland dominates the Sonoran Basin and Range Ecoregion, followed distantly by agriculture. In 2000 the grassland/shrubland class covered 92.9 percent (108,139 km²) of the ecoregion, while agriculture covered 3.2 percent of the ecoregion (3,698 km²) (table 3). Between 1973 and 1980, 617 km² of grassland/shrubland and 264 km² of wetland were converted to water, and another 257 km² of grassland/shrubland was converted to agriculture (table 4). Nearly the same area of water changed back to grassland/shrubland and wetland between 1980 and 1986. In addition, 147 km² of grassland/shrubland was converted to agriculture, and 96 km² was

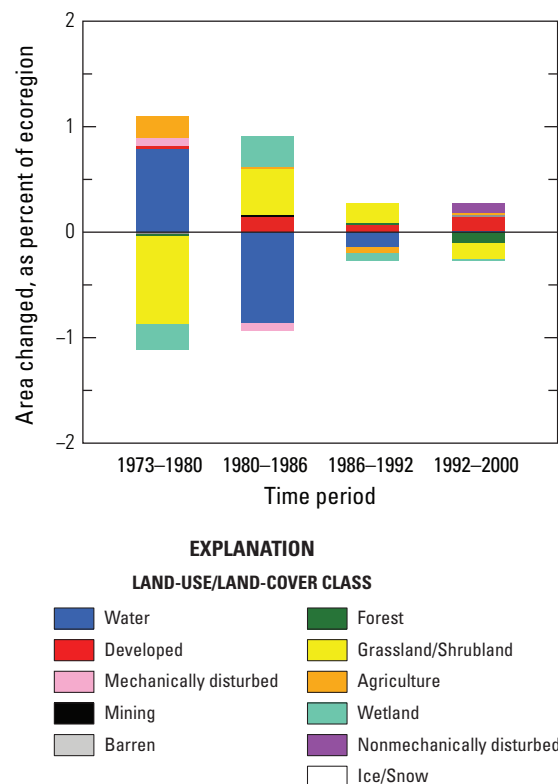


Figure 4. Normalized average net change in Sonoran Basin and Range Ecoregion by time period for each land-cover class. Bars above zero axis represent net gain, whereas bars below zero represent net loss. Note that not all land-cover classes shown in explanation may be represented in figure. See appendix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

reclassified as developed. These changes continued between 1986 and 2000, during which time the Sonoran Basin and Range Ecoregion experienced net losses of 461 km² of grassland/shrubland and 245 km² of water, as well as net gains of 244 km² of agricultural land and 481 km² of developed land (fig. 4).

Estimates suggest that, between 1973 and 2000, land-cover change in the Sonoran Basin and Range Ecoregion was small, and it also occurred at a slow rate relative to other ecoregions in the western United States. However, as in the Mojave Basin and Range Ecoregion to the north, a seemingly small, yet significant change was occurring in developed land (fig. 5). Although development is sparse, all three major metropolitan regions in the Sonoran Basin and Range Ecoregion experienced unprecedented rates of population growth both during and since the study period. Between 1990 and 2000 alone, the population of the Coachella Valley grew at more than twice the rate of any other region in California. This growth has continued since the end of the study: between 2000 and 2005, the population of the Coachella Valley grew to 410,974 (an increase of 23.6 percent) (U.S. Census Bureau, 2011); by 2008, the Phoenix metropolitan area added nearly a million more people, a 31.7 percent increase since 2000. The greater Tucson region grew from 531,443 residents in



Figure 5. Changing landscape of Sonoran Basin and Range Ecoregion. *A*, Typical grassland/shrubland land cover within ecoregion. *B*, Result of change from grassland/shrubland to developed land-cover classes.



Figure 6. Increased use of water (*A*), coupled with decreasing water supplies (*B*), has controlled, and will continue to control, rate of land-cover change in Sonoran Basin and Range Ecoregion.

1980 to 666,880 in 1990 (a 25.5 percent increase) and to an estimated 843,746 people in 2000 (a 26.5 percent increase since 1990) (U.S. Census, 2011). In 1990, the Sonoran Basin and Range Ecoregion included 6.9 million residents; by 2020, the population is expected to reach 12 million (U.S. Census Bureau, 2011). Land-cover data suggest that urbanization of the Sonoran Basin and Range Ecoregion comes primarily at the expense of grassland/shrubland. As the population grows, water resources may become limited as human uses draw down regional water tables by groundwater pumping and also tax the Colorado River's finite water resources and its long-distance water delivery systems (for example, the Central Arizona Project canal) (fig. 6).

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

[Most sample pixels remained unchanged (97.4 percent), whereas 2.6 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	1.3	0.7	0.6	2.0	0.5	35.4
2	1.1	0.8	0.2	1.9	0.6	53.1
3	0.2	0.2	0.0	0.4	0.1	84.0
4	0.0	0.0	0.0	0.0	0.0	85.9
Overall spatial change	2.6	1.4	1.2	3.9	0.9	36.4

Table 2. Raw estimates of change in Sonoran Basin and Range 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 time 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	1.3	0.9	0.4	2.2	0.6	45.4	0.2
1980–1986	1.4	1.1	0.3	2.5	0.7	55.0	0.2
1986–1992	0.5	0.4	0.1	0.8	0.2	50.2	0.1
1992–2000	0.8	0.5	0.4	1.3	0.3	38.8	0.1
Estimate of change, in square kilometers							
1973–1980	1,544	1,029	515	2,574	701	45.4	221
1980–1986	1,583	1,277	306	2,861	870	55.0	264
1986–1992	558	411	147	969	280	50.2	93
1992–2000	985	560	424	1,545	382	38.8	123

Table 3. Estimated area (and margin of error) of each land-cover class in Sonoran Basin and Range 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	0.3	0.2	0.1	0.0	0.0	0.0	0.0	2.1	2.9	0.8	0.4	93.3	3.4	3.0	2.0	0.2	0.3	0.0	0.0
1980	1.1	1.1	0.3	0.1	0.1	0.1	0.0	0.0	2.1	2.9	0.8	0.4	92.5	3.6	3.2	2.1	0.0	0.0	0.0	0.0
1986	0.2	0.2	0.4	0.2	0.0	0.0	0.0	0.0	2.1	2.9	0.8	0.4	92.9	3.5	3.2	2.1	0.3	0.4	0.0	0.0
1992	0.0	0.0	0.5	0.3	0.0	0.0	0.0	0.0	2.1	2.9	0.9	0.4	93.1	3.4	3.2	2.0	0.2	0.3	0.0	0.0
2000	0.1	0.0	0.7	0.4	0.0	0.0	0.0	0.0	2.1	2.9	0.8	0.3	92.9	3.5	3.2	2.1	0.2	0.3	0.1	0.1
Net change	-0.2	0.3	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.1	-0.4	0.6	0.2	0.4	0.0	0.1	0.1	0.1
Gross change	1.9	1.9	0.4	0.3	0.1	0.2	0.0	0.0	0.0	0.0	0.2	0.2	2.3	1.4	0.8	0.5	0.7	0.9	0.1	0.1
Area, in square kilometers																				
1973	308	402	278	143	8	7	8	6	2,449	3,332	981	478	108,599	4,012	3,454	2,355	280	387	0	0
1980	1,224	1,321	328	172	88	90	9	6	2,428	3,326	962	489	107,615	4,175	3,696	2,398	14	13	0	0
1986	218	224	511	257	14	11	14	9	2,431	3,324	973	490	108,115	4,033	3,724	2,388	366	511	0	0
1992	43	42	604	313	15	13	14	10	2,435	3,323	995	495	108,315	4,010	3,674	2,381	269	368	0	0
2000	62	56	759	426	20	16	19	14	2,439	3,324	876	376	108,139	4,048	3,698	2,400	239	321	113	163
Net change	-245	396	481	310	12	11	11	13	-10	9	-104	130	-461	717	244	500	-42	67	113	163
Gross change	2,173	2,267	482	310	164	178	12	13	51	37	282	220	2,719	1,666	987	565	757	1,083	113	163

Table 4. Principal land-cover conversions in Sonoran Basin and Range 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	Grassland/Shrubland	Water	617	608	414	0.5	40.0
	Wetland	Water	264	381	260	0.2	17.1
	Grassland/Shrubland	Agriculture	257	188	128	0.2	16.6
	Grassland/Shrubland	Forest	90	120	82	0.1	5.8
	Grassland/Shrubland	Mechanically disturbed	80	90	61	0.1	5.2
	Other	Other	236	n/a	n/a	0.2	15.3
	Totals		1,544			1.3	100.0
1980–1986	Water	Grassland/Shrubland	657	738	503	0.6	41.5
	Water	Wetland	344	496	338	0.3	21.7
	Grassland/Shrubland	Agriculture	147	112	76	0.1	9.3
	Grassland/Shrubland	Developed	96	75	51	0.1	6.1
	Agriculture	Grassland/Shrubland	90	108	74	0.1	5.7
	Other	Other	249	n/a	n/a	0.2	15.7
	Totals		1,583			1.4	100.0
1986–1992	Wetland	Grassland/Shrubland	158	227	155	0.1	28.3
	Water	Grassland/Shrubland	147	160	109	0.1	26.4
	Grassland/Shrubland	Developed	91	63	43	0.1	16.3
	Agriculture	Grassland/Shrubland	49	44	30	0.0	8.7
	Grassland/Shrubland	Wetland	47	67	46	0.0	8.4
	Other	Other	67	n/a	n/a	0.1	12.0
	Totals		558			0.5	100.0
1992–2000	Grassland/Shrubland	Agriculture	245	264	180	0.2	24.9
	Agriculture	Grassland/Shrubland	207	161	110	0.2	21.0
	Grassland/Shrubland	Developed	135	99	68	0.1	13.7
	Forest	Nonmechanically disturbed	113	163	111	0.1	11.5
	Wetland	Grassland/Shrubland	89	128	87	0.1	9.0
	Other	Other	195	n/a	n/a	0.2	19.8
	Totals		985			0.8	100.0
1973–2000 (overall)	Water	Grassland/Shrubland	833	809	551	0.7	17.8
	Grassland/Shrubland	Water	682	620	422	0.6	14.6
	Grassland/Shrubland	Agriculture	651	427	291	0.6	13.9
	Agriculture	Grassland/Shrubland	360	241	164	0.3	7.7
	Water	Wetland	358	514	350	0.3	7.7
	Other	Other	1,786	n/a	n/a	1.5	38.2
	Totals		4,671			4.0	100.0

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