Status and Trends of Land Change in the Western United States—1973 to 2000
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U.S. Geological Survey Professional Paper 1794–A, 2012

Chapter 24

Snake River Basin Ecoregion

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Ecoregion Description

Located in south-central Idaho, the Snake River Basin Ecoregion spans 66,063 km^2 (25,507 mi^2) of mostly sagebrush-steppe (*Artemisia tridentata*) with some areas of saltbush-greasewood (*Atriplex* spp. and *Sarcobatus* spp.) and barren lava fields (fig. 1) (Omernik, 1987; U.S. Environmental Protection Agency, 1997). The Snake River is the dominant hydrographic feature extending the full length (east to west) of the ecoregion. Elevation ranges from approximately 640 m in the "Treasure Valley" (Canyon County, near Nampa, Idaho) to 2,000 m in the semiarid foothills and eastern Snake River Plain. Mean annual precipitation ranges from 15 to 50 cm annually, and highest precipitation occurs in the high elevations of the dissected plateaus and Teton Basin along the eastern edge of the ecoregion. Mean January temperatures range from –14 to 4°C, with mean July temperatures ranging from 8 to 32°C.

Land cover in the Snake River Basin Ecoregion is dominated by grassland/shrubland, which covered approximately two-thirds of the landscape in 2000 (fig. 2). The sagebrush-steppe ecosystems of the Snake River Plain consist of a mosaic of sagebrush and perennial grass species, including Wyoming big sagebrush (*Artemisia tridentata*), bluebunch wheatgrass (*Pseudoroegneria spicata*), basin wildrye (*Leymus cinereus*), rabbitbrush (*Chrysothamnus viscidiflorus*), Thurber needlegrass (*Achnatherum thurberianum*), Idaho fescue (*Festuca*

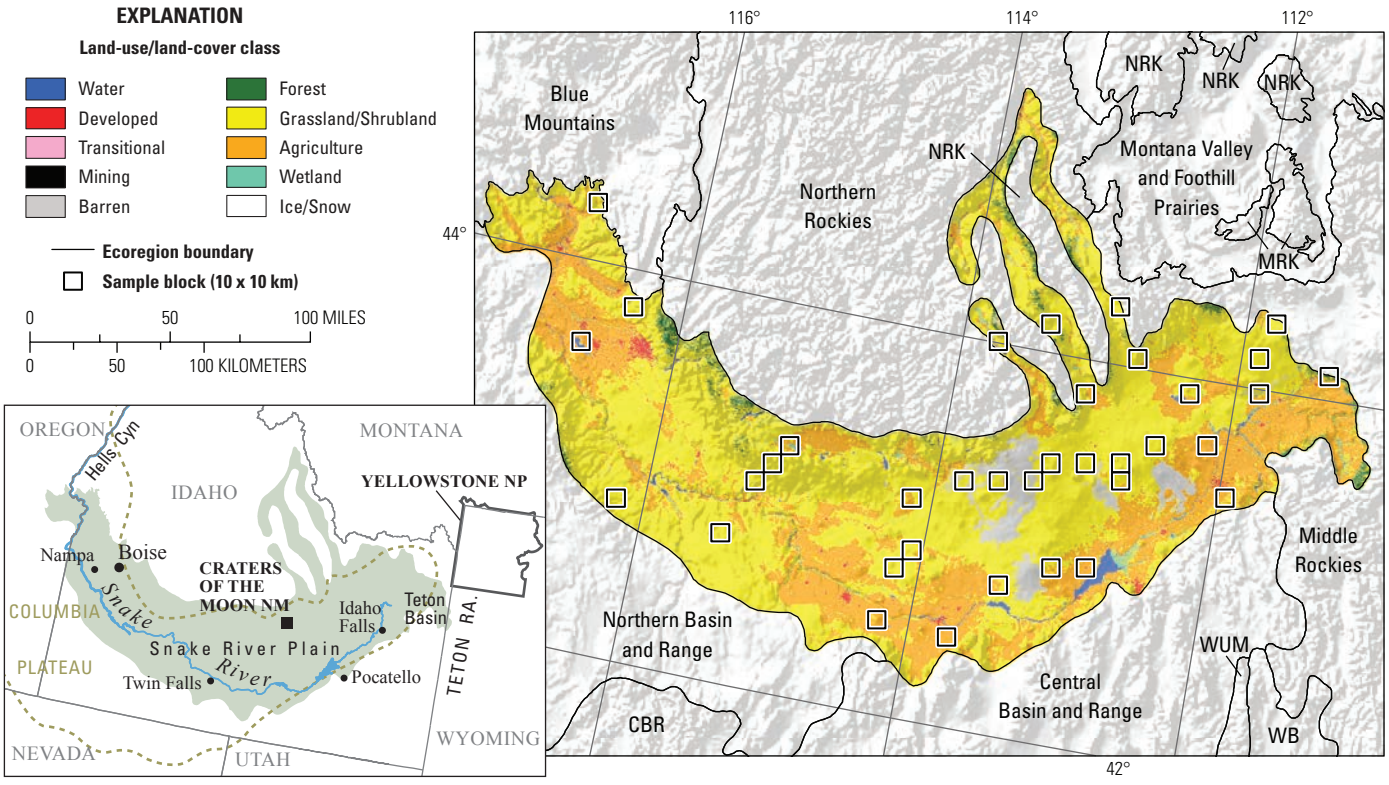

Figure 1. Map of Snake River Basin Ecoregion and surrounding ecoregions, showing land-use/land-cover classes from 1992 National Land Cover Dataset (Vogelmann and others, 2001); note that not all land-use/land-cover classes shown in explanation may be depicted on map; note also that, for this "Status 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.

Figure 2. Sagebrush steppe, which characterizes Snake River Basin Ecoregion.

Figure 3. Road serving as fire break in Snake River Basin Ecoregion. Area on right recently burned and has been revegetated with grasslands. Area to left of road was not burned and is dominated by sagebrush steppe.

idahoensis), threetip sagebrush (*Artemisia tripartita*), Gardner's saltbush (*Atriplex gardneri*), black greasewood (*Sarcobatus vermiculatus*), Indian ricegrass (*Achnatherum hymenoides*), fourwing saltbush (*Atriplex canescens*), crested wheatgrass (*Agropyron cristatum*), alkali sagebrush (*Artemisia longiloba*), and cheatgrass (*Bromus tectorum*) (McGrath and others, 2001). Disturbance from fire occurs at relatively long periods with low severity burns most common. However, due to the introduction of exotic species, such as cheatgrass, and managed burns to clear sagebrush for rangeland improvements, fire regimes have been altered, resulting in decreased fire-return periods with higher severity (fig. 3). Whisenant (1990) found fire-return periods had decreased from more than 75 years to as little as 5 to 10 years in some areas. The result on the landscape is a reduced ability of sagebrush species to recover postdisturbance, which may impact the long-term viability of sage-dependent species (Knick and Rotenberry, 1995).

Agriculture was the second most common land-use/land-cover type, accounting for approximately one-quarter of the ecoregion's area (fig. 4). Barren lands, primarily volcanic basalt flows, cover 2.6 percent of the ecoregion (fig. 5), and wetlands cover an additional 1.9 percent. Developed lands accounted for only 0.5 percent of the Snake River Basin Ecoregion. Whereas developed lands were limited, five of Idaho's largest cities are found within the Snake River Basin Ecoregion, including Boise (population 185,787), Nampa (population 51,867), Pocatello (population 51,466), Idaho Falls (population 50,730), and Twin Falls (population 34,469) (U.S. Census Bureau, 2010).

The high-elevation mountains surrounding the eastern Snake River Basin Ecoregion provide abundant high-quality water to the region. The absence of large settlements and industry contribute to the high quality of the water entering the basin. The Snake River derives as much as 50 percent of its annual flow from natural spring discharge (Miller and others, 2003). Surface water feeds the Snake River Basin aquifer, which is as much as 400 m thick, underlies 26,000 km^2 of the ecoregion, and contains about 1.23 x 10^{12} m^3 (100 million acre-ft) of water (Smith, 2004). Johnson and Cosgrove (1997) estimated that total groundwater storage declined on average about 350,000 acre-ft per year between 1975 and 1995, a cumulative decrease of 7 million acre-ft. Drought conditions caused declines in spring discharge and subsequent declines in groundwater levels as recharge capability dropped while withdrawals continued (Kjelstrom, 1986). However, in certain areas of the ecoregion, declines may be predominantly the result of a single factor (Idaho Department of Water Resources, 1999). For example, groundwater declines of 10 ft or more in Minidoka County were attributed to increased groundwater pumping in that area (Lindholm and others, 1988). Agricultural activities, urban runoff, and historical disposal practices at the Idaho National Engineering and Environmental Laboratory are major threats to groundwater quality (Smith, 2004).

Base flow of the Snake River was reduced, in part, owing to the introduction of more efficient irrigation technologies and a conversion from surface water to groundwater irrigation sources (Idaho Department of Water Resources, 1999; Miller and others, 2003). The net effect of efficiency improvements and pumpage by 1992 was an annual decrease in aquifer recharge of more than 2.1 million acre-ft, leading to groundwater-level and springflow declines (Idaho Department of Water Resources, 1999). Demands for Snake River water are diverse and include competition among agriculture, municipal users, industry, hydroelectric-power-generating utilities, recreation, and fish and wildlife. Federal and state management agencies are attempting to adjust to changing values while maintaining most of the traditional demands (Miller and others, 2003).

Contemporary Land-Cover Change (1973 to 2000)

Overall spatial change in the Snake River Basin Ecoregion, or the area that changed at least one time between 1973 and 2000, was 8.5 percent (5,604 km^2) (table 1). Compared to other western ecoregions, the Snake River Basin Ecoregion experienced a modest amount of change (fig. 6). Of the

Figure 4. Irrigated potato field near Twin Falls, Idaho.

Figure 5. Lava field at Craters of the Moon National Monument and Preserve, Idaho.

total area that changed, 6.6 percent of the ecoregion changed in only one time period, while 1.8 percent of the ecoregion changed in two periods. Changes in multiple dates are primarily attributed to fire disturbance and subsequent revegetation in following periods.

Change by time period ranged from 1.0 percent to 5.0 percent (table 2). When the time periods are normalized to account for the varying lengths of time, the highest rate of change was an estimated 411 km^2 of change per year between 1992 and 2000. The second highest rate of change was 343 km^2 per year between 1986 and 1992. The first two periods (1973–1980, 1980–1986) were relatively stable at an estimated 0.2 percent change per year. Rates of overall land-cover change in the Snake River Basin Ecoregion are unique from surrounding ecoregions (fig. 7). Ecoregions to the north are characterized by changes associated with forest disturbance from both natural and anthropogenic sources, whereas to the south change was relatively low in the basin-and-range ecoregions. The Snake River Basin Ecoregion contains a mix of land-cover changes that are generally associated with three themes: rangeland fire, agricultural expansion and contraction, and urbanization.

Grassland/shrubland declined 2.3 percent over the 27-year period, from 66.3 percent of the ecoregion in 1973 to 64.8 percent of the ecoregion in 2000. This amounts to a loss of 988 km^2. The period of greatest decline was between 1992 and 2000—an estimated loss of 1,232 km^2 over the 8-year period. The first three time periods were relatively stable in terms of net changes in grassland/shrubland (table 3; fig. 8). The large loss of grassland/shrubland between 1992 and 2000 was primarily a result of fire disturbance. During that period, an estimated 1,907 km^2 of grassland/shrubland were disturbed by fire, whereas 500 km^2 converted from a disturbed state back to grassland/shrubland (table 4).

The Snake River Basin Ecoregion is one of five key agricultural regions in the western United States along with the Columbia Plateau, Willamette Valley, Central California Valley, and Southern and Central California Chaparral and Oak Woodlands Ecoregions. Compared to these other agricultural

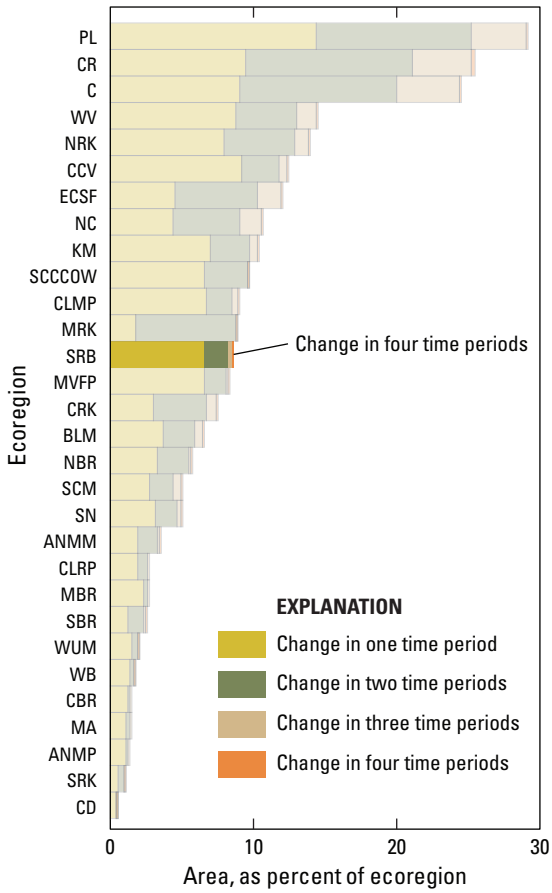

Figure 6. Overall spatial change in Snake River Basin Ecoregion (SRB; darker bars) compared with that of all 30 Western United States ecoregions (lighter bars). Each horizontal set of bars shows proportions of ecoregion that changed during one, two, three, or four time periods; highest level of spatial change in Snake River Basin 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.

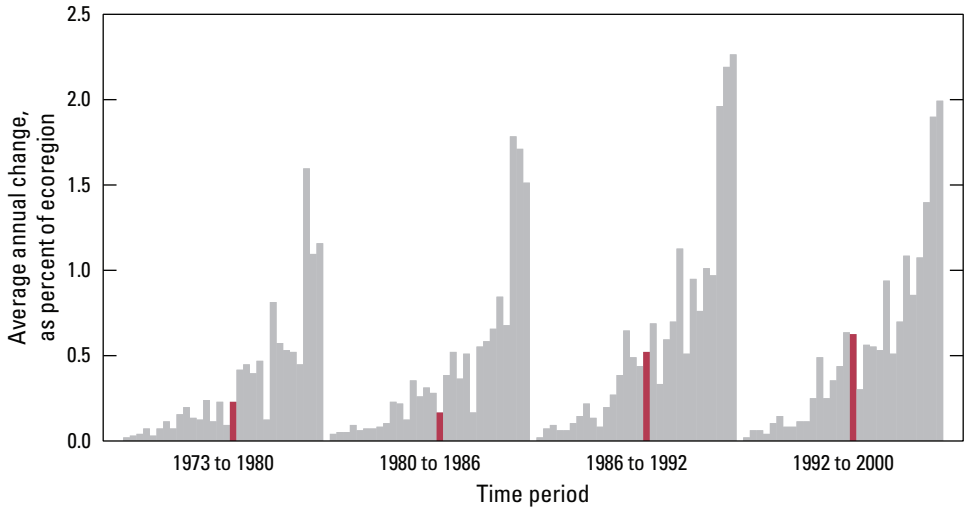

Figure 7. Estimates of land-cover change per time period normalized to annual rates of change for all 30 Western United States ecoregions (gray bars). Estimates of change for Snake River Basin Ecoregion are represented by red bars in each time period.

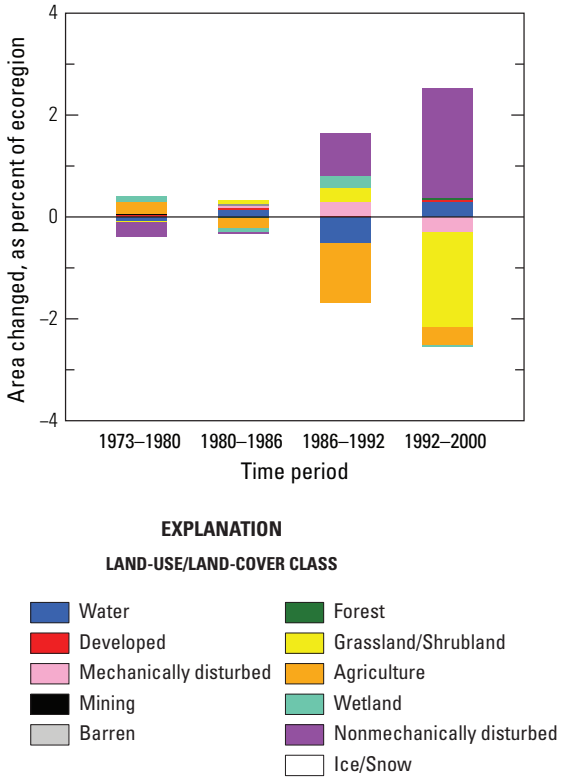

Figure 8. Normalized average net change in Snake River Basin Ecoregion by time period for each land-cover class. Bars above zero axis represent net gain, whereas bars below zero represent net loss. Note that not all land-cover classes shown in explanation may be represented in figure. See appendix 3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

ecoregions, the Snake River Basin Ecoregion had the lowest overall spatial change but lost the largest amount of agriculture over the 27-year period (table 5).

The 1973 to 1980 period was the only period that realized a net increase (153 km^2) of agricultural land. Following 1980, agriculture began to decline and reached its largest period of loss between 1986 and 1992—a net loss of 773 km^2. Between 1992 and 2000, there was a net decline of 260 km^2 of agriculture. Driving the high amount of net loss in agriculture between 1986 and 1992 was the establishment of the Conservation Reserve Program (CRP). CRP enrollments began in 1986 and provided incentives for landowners to convert marginal and highly erodible croplands into natural vegetation. Based on county data from the U.S. Department of Agriculture (1999), counties in the Snake River Basin Ecoregion enrolled a total of 147,787 acres (598 km^2) into CRP by 1992. The main counties in Idaho that contributed to the program were Clark, Elmore, Madison, Teton, Bingham, and Twin Falls. Combined, they accounted for over three-quarters of all Snake River Basin Ecoregion CRP enrollments in 1992 (fig. 9).

Over the 27-year study period, developed land increased 47 percent. However, developed land uses make up less than 1 percent of the total ecoregion area. In 1973, an estimated 0.4 percent of the ecoregion was developed land, including the largest developed areas in the western part of the ecoregion associated with the cities of Boise and Nampa, Idaho. By 2000, developed land had increased to account for approximately 0.5 percent of the ecoregion—a gain of 112 km^2. Over the same three-decade period, population of counties that intersect the Snake River Basin Ecoregion increased from 561,641 in 1970 to 1,041,398 in 2000, an increase of 85 percent (U.S. Census Bureau, 2010).

Wetlands accounted for slightly less than 2 percent of the ecoregion and experienced a statistically significant

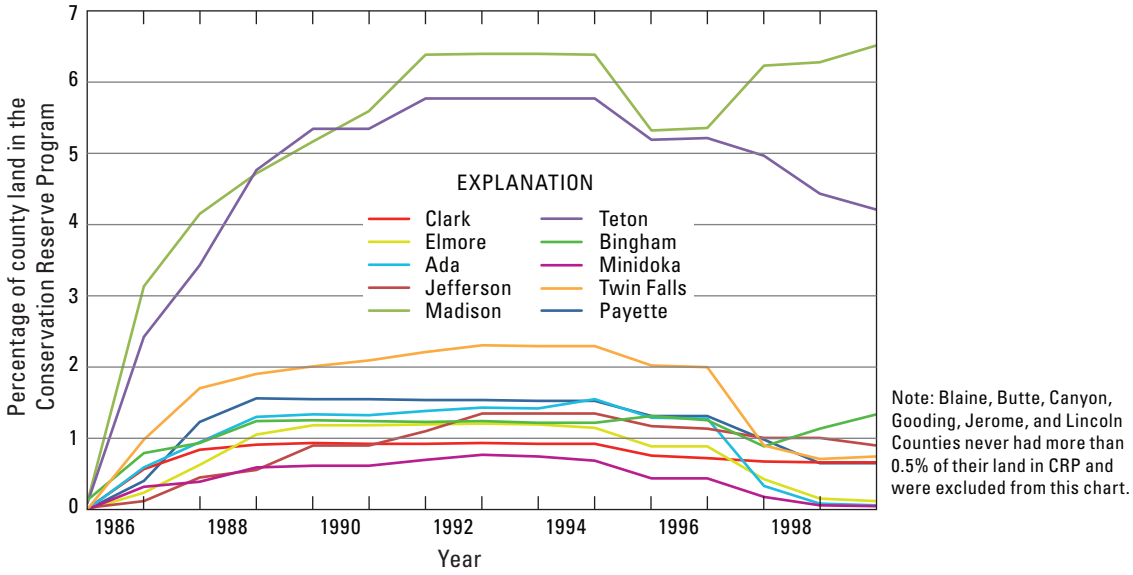

Figure 9. Enrollments in Conservation Reserve Program (CRP) for counties in Idaho that intersect Snake River Basin Ecoregion.

increasing trend throughout the study period. In 1973, wetlands accounted for 1.7 percent of the ecoregion, and by 2000 they accounted for 1.9 percent, an increase of 156 km^2.

As with many western ecoregions, ecosystem disturbance played an important role in the Snake River Basin Ecoregion. Nonmechanical disturbance, primarily from fire, accounted for an estimated 2,517 km^2 over the 27-year study period (table 4). Between 1973 and 1992, fire disturbance was relatively low with less than one percent of the ecoregion experiencing a disturbance in any of the periods. However, between 1992 and 2000, fire disturbance affected an estimated 3.0 percent of the ecoregion. Introduction of nonnative species and managed burns to remove sagebrush for range improvement are largely the cause of increased fire frequency (Pellant, 1990; Whisenant, 1990; Billings, 1994).

Land-cover change in the Snake River Basin Ecoregion generally involved land conversions into and out of the grassland/shrubland class (table 4). Conversions from grassland/shrubland to and from agriculture were most common and ranked in the top five conversions in each of the four time periods. Conversion from agricultural land to grassland/shrubland between 1980 and 1992 were especially common and were the top-ranked conversion during that time. From 1973 to 1980 and 1980 to 1986, conversion of grassland/shrubland to agriculture was the first and second most common conversion, respectively. Irrigation projects and technology advances, such as the adoption of center-pivot irrigation, likely resulted in the increase in agricultural land during this time. Changes associated with fire were most common in the last two time periods. Between 1992 and 2000 an estimated 1,907 km^2 converted from grassland/shrubland to nonmechanically disturbed, whereas an additional 500 km^2 of area classified as nonmechanically disturbed in the previous time period converted back to grassland/shrubland.

Drivers of land-cover and land-use change in the Snake River Basin Ecoregion are primarily associated with anthropogenic alteration of the sagebrush-steppe ecosystem. In the 1970s, areas of new agriculture outpaced areas converted out of agriculture by a 2:1 margin. With the implementation of the federal CRP program in the late 1980s, the trend reversed and nearly six times as much land ceased to be used for agriculture as there was new agricultural land. Historic management practices and the introduction of cheatgrass have influenced land change by promoting a change in historic fire regimes to more frequent and higher intensity burns. Managed burning to remove sagebrush for range improvement has also contributed to changes in land cover.

Table 1. Percentage of Snake River Basin Ecoregion land cover that changed at least one time during study period (1973–2000) and associated 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	6.6	2.7	3.8	9.3	1.9	28.4
2	1.8	1.1	0.6	2.9	0.8	43.5
3	0.2	0.1	0.1	0.2	0.1	29.5
4	0.0	0.0	0.0	0.0	0.0	61.2
Overall spatial change	8.5	3.0	5.5	11.5	2.1	24.3

Table 2. Raw estimates of change in Snake River Basin 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	1.6	0.4	1.1	2.0	0.3	18.6	0.2
1980–1986	1.0	0.4	0.6	1.4	0.3	27.7	0.2
1986–1992	3.1	1.6	1.6	4.7	1.1	33.9	0.5
1992–2000	5.0	2.6	2.4	7.6	1.8	35.9	0.6
Estimate of change, in square kilometers							
1973–1980	1,024	280	744	1,305	190	18.6	146
1980–1986	665	271	394	936	184	27.7	111
1986–1992	2,056	1,026	1,030	3,082	697	33.9	343
1992–2000	3,292	1,738	1,553	5,030	1,181	35.9	411

Table 3. Estimated area (and margin of error) of each land-cover class in Snake River Basin 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	1.0	0.9	0.4	0.2	0.0	0.0	0.1	0.0	2.6	1.9	3.1	2.7	66.3	8.3	24.5	7.5	1.7	1.2	0.4	0.3
1980	1.0	0.9	0.4	0.3	0.0	0.0	0.1	0.1	2.6	1.9	3.1	2.7	66.2	8.4	24.7	7.5	1.8	1.3	0.1	0.1
1986	1.1	0.9	0.4	0.3	0.1	0.1	0.1	0.1	2.6	1.9	3.1	2.6	66.3	8.4	24.5	7.5	1.7	1.2	0.0	0.0
1992	0.7	0.5	0.5	0.3	0.3	0.3	0.1	0.1	2.6	1.9	3.1	2.6	66.6	8.2	23.3	7.3	1.9	1.4	0.9	1.1
2000	0.9	0.8	0.5	0.3	0.0	0.0	0.1	0.1	2.6	1.9	3.2	2.7	64.8	8.2	22.9	7.2	1.9	1.4	3.0	2.6
Net change	−0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−1.5	2.9	−1.5	1.5	0.2	0.2	2.7	2.4
Gross change	1.1	0.9	0.2	0.1	0.7	0.7	0.0	0.0	0.0	0.0	0.1	0.1	7.8	3.5	3.3	1.5	0.6	0.5	5.0	3.4
Area, in square kilometers																				
1973	678	592	237	138	27	27	41	30	1,704	1,272	2,074	1,755	43,775	5,491	16,154	4,964	1,126	818	248	181
1980	644	591	277	166	23	20	48	35	1,698	1,269	2,072	1,752	43,764	5,561	16,307	4,981	1,191	866	42	59
1986	758	618	297	178	41	42	56	43	1,699	1,269	2,063	1,735	43,825	5,577	16,177	4,961	1,148	823	0	0
1992	429	337	329	198	206	229	51	35	1,704	1,270	2,065	1,735	44,019	5,441	15,404	4,812	1,288	925	569	711
2000	622	555	349	213	27	24	56	41	1,706	1,270	2,089	1,767	42,787	5,385	15,144	4,787	1,282	917	2,000	1,718
Net change	−56	69	112	91	1	32	15	15	2	7	15	16	−988	1,930	−1,009	1,010	156	140	1,752	1,613
Gross change	732	568	116	90	476	450	33	29	14	14	46	57	5,160	2,299	2,154	1,016	409	343	3,319	2,256

Table 4. Principal land-cover conversions in Snake River Basin 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	Agriculture	382	157	107	0.6	37.3
	Nonmechanically disturbed	Grassland/Shrubland	248	180	123	0.4	24.2
	Agriculture	Grassland/Shrubland	169	102	69	0.3	16.5
	Water	Wetland	54	54	36	0.1	5.2
	Grassland/Shrubland	Nonmechanically disturbed	42	59	40	0.1	4.1
	Other	Other	130	n/a	n/a	0.2	12.7
		Totals	1,024			1.6	100.0
1980–1986	Agriculture	Grassland/Shrubland	200	124	84	0.3	30.1
	Grassland/Shrubland	Agriculture	151	83	56	0.2	22.6
	Wetland	Water	109	129	88	0.2	16.4
	Agriculture	Wetland	49	71	48	0.1	7.4
	Nonmechanically disturbed	Grassland/Shrubland	42	59	40	0.1	6.2
	Other	Other	114	n/a	n/a	0.2	17.1
		Totals	665			1.0	100.0
1986–1992	Agriculture	Grassland/Shrubland	890	721	490	1.3	43.3
	Grassland/Shrubland	Nonmechanically disturbed	569	711	483	0.9	27.7
	Water	Mechanically disturbed	182	225	153	0.3	8.8
	Grassland/Shrubland	Agriculture	143	122	83	0.2	7.0
	Water	Wetland	138	137	93	0.2	6.7
	Other	Other	134	n/a	n/a	0.2	6.5
		Totals	2,056			3.1	100.0
1992–2000	Grassland/Shrubland	Nonmechanically disturbed	1,907	1,635	1,111	2.9	57.9
	Nonmechanically disturbed	Grassland/Shrubland	500	706	480	0.8	15.2
	Agriculture	Grassland/Shrubland	375	261	177	0.6	11.4
	Mechanically disturbed	Water	178	225	153	0.3	5.4
	Grassland/Shrubland	Agriculture	173	71	48	0.3	5.3
	Other	Other	158	n/a	n/a	0.2	4.8
		Totals	3,292			5.0	100.0
1973–2000 (overall)	Grassland/Shrubland	Nonmechanically disturbed	2,517	1,831	1,244	3.8	35.8
	Agriculture	Grassland/Shrubland	1,634	1,030	700	2.5	23.2
	Grassland/Shrubland	Agriculture	849	276	187	1.3	12.1
	Nonmechanically disturbed	Grassland/Shrubland	789	720	489	1.2	11.2
	Mechanically disturbed	Water	208	229	156	0.3	3.0
	Other	Other	1,039	n/a	n/a	1.6	14.8
		Totals	7,036			10.7	100.0

Table 5. Overall spatial change and net agricultural change in five main agricultural ecoregions of western United States.

Ecoregion	Overall spatial change (percent of ecoregion)	Agricultural change (km^2)	Agricultural change (percent ecoregion)
Snake River Basin	8.5	−1,022	−1.6
Southern and Central California Chaparral and Oak Woodlands	9.7	−862	−0.8
Willamette Valley	14.5	−322	−2.2
Central California Valley	12.4	+358	+0.8
Columbia Plateau	9.0	+534	+0.6

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