Status and Trends of Land Change in the Western United States—1973 to 2000
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Chapter 7

Northern Rockies Ecoregion

By Janis L. Taylor

Ecoregion Description

The Northern Rockies Ecoregion (Omernik, 1987; U.S. Environmental Protection Agency, 1997) covers approximately 162,746 km^2 (63,200 mi^2), primarily in Idaho but also including areas in western Montana and northeastern Washington (fig. 1). Canada forms the northern border of the ecoregion. To the west it is bordered by the Columbia Plateau and Blue Mountains Ecoregions, to the south by the Snake River Basin Ecoregion, and to the east by the Canadian Rockies, Middle Rockies, Northwestern Great Plains, and Northwestern Glaciated Plains Ecoregions; also to the east, the Northern Rockies Ecoregion interfingers with the Montana Valley and Foothill Prairies Ecoregion, each enclosing some isolated areas of the other (fig. 1).

The ecoregion is composed of a series of high, rugged mountain ranges, mostly oriented northwest-southeast, with intermontane valleys between them (fig. 2). The entire ecoregion was glaciated during the Pleistocene (1,800,000 to 11,400 years ago), and today numerous large lakes occupy basins

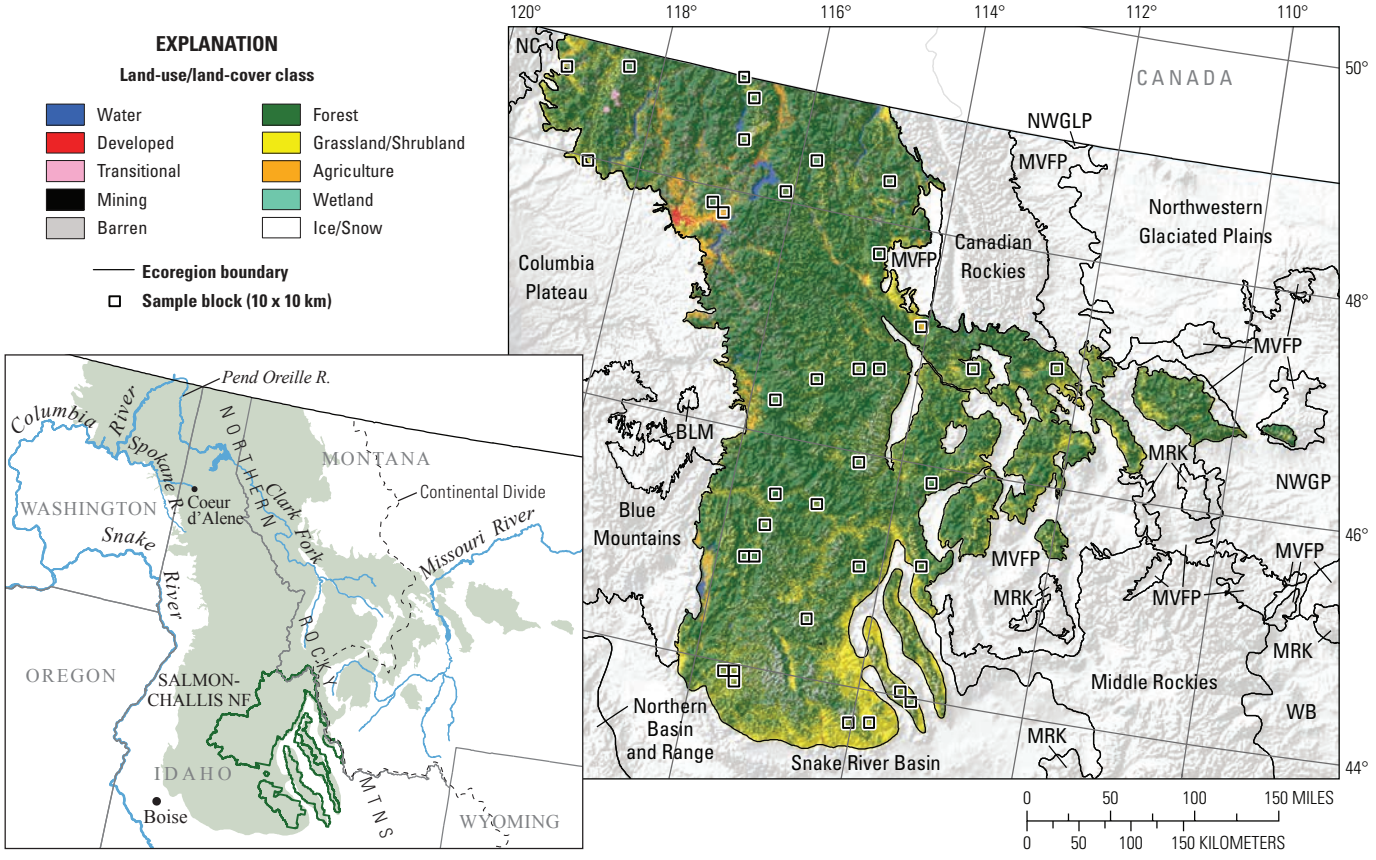

Figure 1. Map of Northern Rockies Ecoregion and surrounding ecoregions, showing land-use/land-cover classes from 1992 National Land Cover Dataset (Vogelmann and others, 2001); note that not all land-use/land-cover classes shown in explanation may be depicted on map; note also that, for this "Status and Trends of Land Change" study, transitional land-cover class was subdivided into mechanically disturbed and nonmechanically disturbed classes. Note that all small areas entirely surrounded by Northern Rockies Ecoregion are parts of Montana Valley and Foothill Prairies Ecoregion. 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. Also shown are parts of two Great Plains ecoregions: Northwestern Glaciated Plains (NWGLP) and Northwestern Great Plains (NWGP). See appendix 3 for definitions of land-use/land-cover classifications.

formed by glacial action (Omernik, 1987; Habeck and Mutch, 1973). Streams draining these mountain ranges provide a water source for many western cities and towns (fig. 3). The Continental Divide, located at the highest elevations along the northern Rocky Mountains, separates rivers that flow westward into the Columbia River watershed from those that flow eastward into the Missouri River watershed.

The ecoregion consists of montane, subalpine, and alpine ecosystems that have distinct floral and faunal elevation zones, with the highest elevations in the southern part of the ecoregion. The lower elevation montane forest provides habitat for mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), moose (*Alces alces*), mountain lions (*Puma concolor*), bears (*Ursus* spp.), and raptors (for example, bald eagles (*Haliaeetus leucocephalus*), Swainson's hawks (*Buteo swainsoni*), and American kestrels (*Falco sparverius*)) (fig. 4). The winter snowfall supports a lucrative skiing and tourism economy, and ski resorts have been built throughout the midelevation subalpine forest. Alpine ecosystems occupy the highest elevations, where harsh climates support trees and shrubs with smaller, dwarfed structures and more dense ground cover (Barrera, 2009). In addition to the vast conifer forests throughout the Northern Rockies Ecoregion, there are also many mountain meadows, foothill grasslands, and riparian woodlands (fig. 5).

Climate within the Northern Rockies Ecoregion varies extensively from west to east, as well as north to south. The climate on the west side of the Rocky Mountains is moderated by a maritime influence, whereas the climate on the east side is harsher and more continental. Climate likewise varies from north to south across latitude. In general, the higher elevations receive more precipitation and have lower average temperatures. Orographic lifting of air masses over the mountains forces much of the moisture content to precipitate (primarily as snow). Because of the mountainous terrain, local microclimates are highly variable as a result of differences in slope aspect, exposure to prevailing wind, thermal inversions, and dry pockets (Ricketts and others, 1999).

This ecoregion is sparsely populated, but it has been occupied for more than 5,000 years by indigenous peoples who hunted throughout the foothills and valleys of the mountains. In the last two centuries, trappers, traders, and explorers led the tide of European settlers into the ecoregion. The Lewis and Clark expedition crossed through the northern Rocky Mountains twice on their journey to the Pacific Ocean and back. Miners and trappers explored every mountain and established the first industries in the ecoregion. After railroads made the ecoregion more accessible, hard-rock mines for gold, silver, lead, molybdenum, zinc, and even garnets were established. Along with mining, logging of the ecoregion's vast conifer forests still provides its economic backbone (fig. 6).

Most land within the Northern Rockies Ecoregion is publicly owned, the largest part being under the control of the U.S. Forest Service. The first forest reserves in the ecoregion were established in the late 1800s. Today there are 15 different national forests and a number of state-owned forests in the ecoregion (fig. 7). Within the national forests are 10 designated wilderness areas, including the 9,300-km^2 Frank Church–River of No Return Wilderness, the largest contiguous area of protected wilderness in the conterminous United States. There are also four U.S. Fish and Wildlife Service National Wildlife Refuges and several major hydroelectric dams along the ecoregion's large rivers, the Clark Fork, the Pend Oreille River, and the Spokane River.

The Coeur d'Alene metropolitan area in northern Idaho is the largest concentration of population in the ecoregion; in 2000 it had a population of around 100,000. Overall, this large ecoregion includes little developed land. The five Indian reservations within the ecoregion are the Flathead Reservation in Montana (fig. 8), the Colville and the Spokane Reservations in Washington, and the Coeur d'Alene and the Kootenai Reservations in Idaho.

Figure 2. Intermontane valley located between parallel mountain ranges in Northern Rockies Ecoregion. Photograph by Janis Taylor, 2008.

Figure 3. Water, in form of runoff and snowmelt from peaks, feeds rivers and has helped shape mountains in Northern Rockies Ecoregion. These mountain ranges can be considered water towers because they provide water source for many western cities and towns. Photograph by Janis Taylor, 2008.

Figure 4. Lower elevation montane forest in Northern Rockies Ecoregion, which provides habitat for mule deer, elk, moose, mountain lions, raptors, and bears. Photograph by Janis Taylor, 2008.

Figure 7. Salmon-Challis National Forest is just one of 15 national forests within Northern Rockies Ecoregion. Photograph by Janis Taylor, 2008.

Figure 5. Wet meadow occupying valley flat in Northern Rockies Ecoregion, with forested hillsides in distance. Photograph by Janis Taylor, 2008.

Figure 8. Flathead Reservation is just one of five reservations within Northern Rockies Ecoregion. Photograph by Janis Taylor, 2008.

Figure 6. Effect of logging of vast conifer forests in Northern Rockies Ecoregion is seen in large cut area on near slope of this hillside. Photograph by Janis Taylor, 2008.

Contemporary Land-Cover Change (1973 to 2000)

The overall spatial change—the percentage of land area within the ecoregion where land cover changed at least once between 1973 and 2000—was 13.8 percent (22,539 km^2). Of that total, 7.8 percent (12,769 km^2) changed one time, and 5.0 percent (8,192 km^2) changed two or more times (table 1). This ecoregion had the fifth highest overall change among all western United States ecoregions (fig. 9). The four ecoregions that had higher overall change were the Puget Lowland, the Coast Range, the Cascades, and the Willamette Valley Ecoregions.

Total change in each of the four time periods selected for this study ranged from a low of 3.7 percent (6,057 km^2) between 1973 and 1980 to a high of 8.7 percent (14,242 km^2) between 1992 and 2000. After normalizing to an annual rate of change, these two time periods still provided the extreme

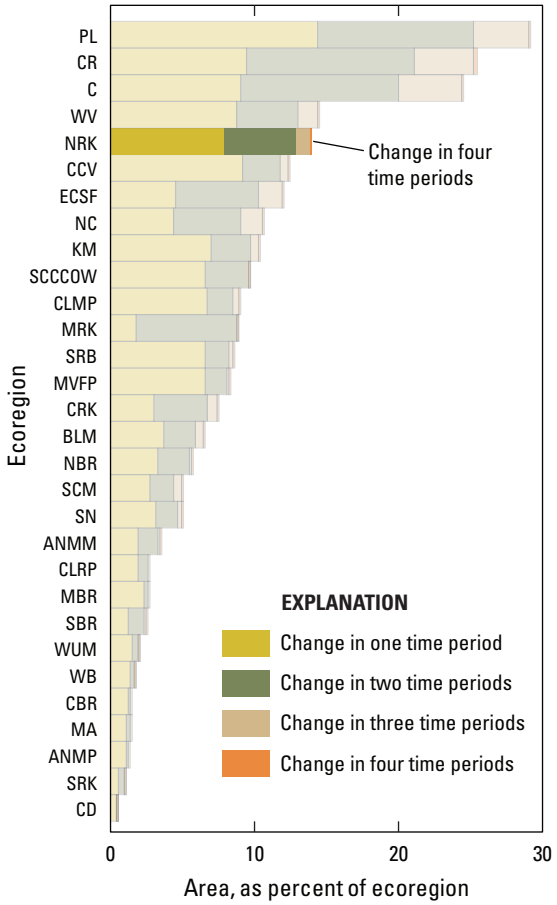

Figure 9. Overall spatial change in Northern Rockies Ecoregion (NRK; darker bars) compared with that of all 30 Western United States ecoregions (lighter bars). Each horizontal set of bars shows proportions of ecoregion that experienced change during one, two, three, or four time periods; highest level of spatial change in Northern Rockies 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.

values: 0.5 percent (818 km^2) per year and 1.1 percent (1,801 km^2) per year, respectively (table 2; fig. 10).

Between 1973 and 1980, forest and grassland/shrubland combined to account for 90 percent (146,557 km^2) of the land cover in the ecoregion (fig. 11). The amount of forest decreased from 72.2 percent (117,534 km^2) of the ecoregion in 1973 to 66.5 percent (108,290 km^2) in 2000 (table 3). The amount of grassland/shrubland increased from 17.8 percent (29,023 km^2) of the ecoregion in 1973 to 20.3 percent (32,962 km^2) in 2000. Net changes in land-use/land-cover classes by period are found in figure 12.

The top four land-cover conversions are forest to mechanically disturbed, forest to nonmechanically disturbed, mechanically disturbed to grassland/shrubland, and grassland/shrubland to forest. These changes are all components of forest change resulting from logging, wildfires, and insect-caused mortality, all common occurrences in the Rocky Mountains. In the first three time periods (1973–1980, 1980–1986, and 1986–1992), the most common land-cover conversion was the result of timber harvest, in which forest is converted to mechanically disturbed land, which regrows to grassland/shrubland and eventually back to forest, representing a cyclic pattern of land-cover change (table 4). Large wildfires (fig. 13) and (or) increased insect mortality (fig. 14) in the last time period (1992–2000) made forest to nonmechanically disturbed the most common land-cover conversion for that time period.

The continuing pattern of timber harvest is supported by the fact that there were areas of mechanically disturbed land in all time periods between 1973 and 2000; 1.9 percent (3,057 km^2) of land was classified as mechanically disturbed in 1973 and 1.1 percent (1,749 km^2) in 2000 (table 3). New forest areas were logged in each of the time periods, and these return to grassland/shrubland and eventually to forest land cover in subsequent time periods.

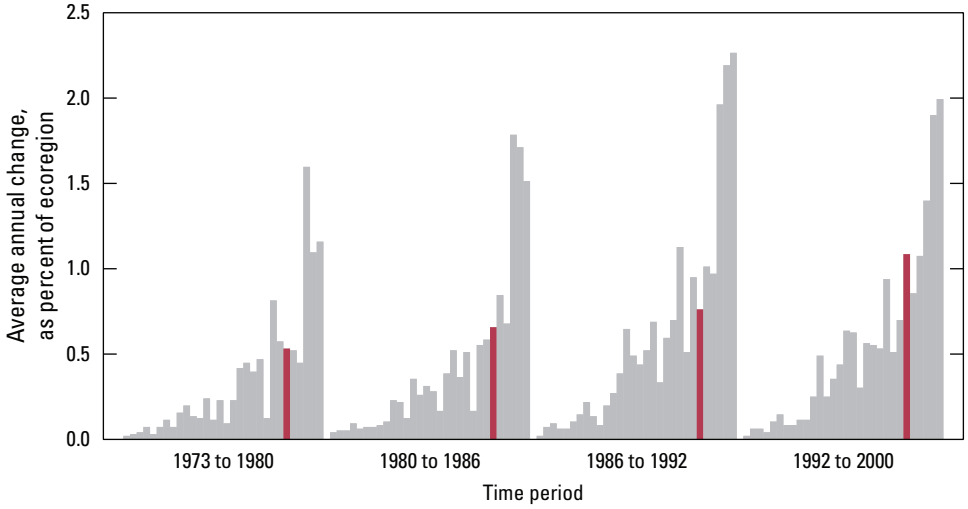

Figure 10. Estimates of land-cover change per time period, normalized to annual rates of change for all 30 Western United States ecoregions (gray bars). Estimates of change for Northern Rockies Ecoregion are represented by red bars in each time period.

Figure 11. Grassland/shrubland land cover in Northern Rockies Ecoregion. Photograph by Janis Taylor, 2008.

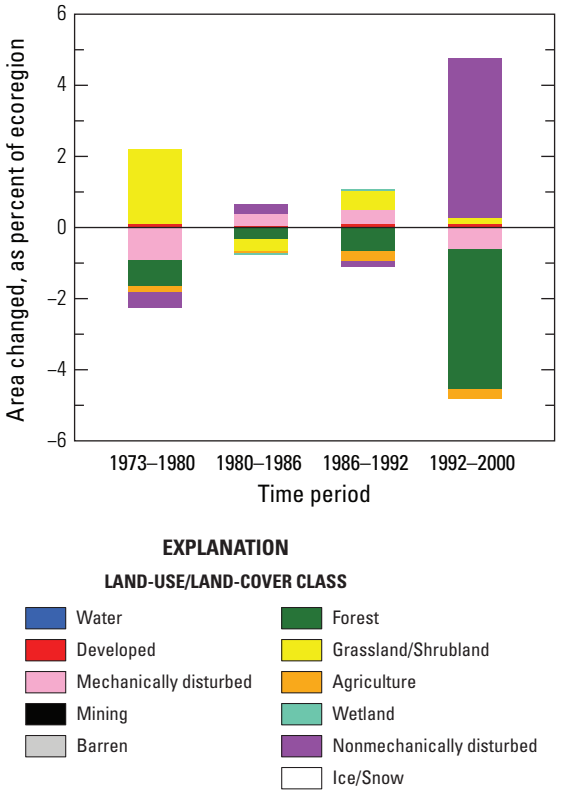

Figure 12. Normalized average net change in Northern Rockies Ecoregion by time period for each land-cover class. Bars above zero axis represent net gain, whereas bars below zero represent net loss. Note that not all land-cover classes shown in explanation may be represented in figure. See appendix 3 for definitions of land-use/land-cover classifications.

The conversion of forest to nonmechanically disturbed land—resulting from wildfires and insect-caused mortality—was not as common in earlier time periods, and the cyclic pattern of land-cover change in forest land was not as prominent. The amount of nonmechanically disturbed land cover was only 0.4 percent (712 km^2) in 1973, increasing dramatically in the last time period to 4.7 percent (7,624 km^2) in 2000, a pattern common throughout the western United States.

This ecoregion provides numerous ecosystem services. Probably the most important is the large amounts of fresh water demanded by rapidly growing urban populations in neighboring ecoregions, as well as for agricultural irrigation, industry, and power generation. Other ecosystem services include wildlife habitat, timber, and snow-based recreation such as ski resorts. Local economies promote tourism through outdoor recreation opportunities, including hiking, backpacking, hunting, fishing, whitewater rafting, mountain biking, skiing, and snowmobiling.

Even though mining was only a minor land cover identified during the study period, there is a long history of mining activity throughout the northern Rocky Mountains. Today, there are numerous abandoned mines, as well as associated

Figure 13. Trees killed during wildfire that burned through previously logged areas in Northern Rockies Ecoregion. Photograph by Janis Taylor, 2008.

Figure 14. Trees killed by insects can be seen on hillside in Northern Rockies Ecoregion. Photograph by Janis Taylor, 2008.

mine tailings, contaminated soils and waterways, and erosion. Many of these mines have had documented impacts on fisheries and vegetation throughout the northern Rocky Mountains (U.S. Environmental Protection Agency, 2001; Montana Department of Environmental Quality, 2009) (fig. 15). Some abandoned open-pit mines have become small mountain lakes. Other mines have reopened with the resurgence in the price of metals. The Coeur d'Alene mining district in Shoshone County in northern Idaho is still considered one of the richest metal mining areas in the world.

Aside from timber harvesting, wildfires and insect-caused mortality are the major disturbance regimes in the Northern Rockies Ecoregion. Human control of wildfires, notably the fire-suppression efforts between 1930 and 1950, have altered the size, incidence, and location of wildfires (Gruell, 1983). As a result, by 1950 the size and intensity of wildfires had grown significantly (Arno, 1980). In the 1980s, these suppression tactics ceased; wildfires were again allowed to burn, and there were notable fires in the Selway-Bitterroot Wilderness and Kootenai National Forest (Arno and Allison-Bunnell, 2002). Scientists continue to study the role of fire as a natural process and its effects on people, wildlife, soil, and water.

Forest recovery has also been studied thoroughly since the 1980s; the following are a couple of findings that are reflected in the state of land cover through time. Some areas that have burned more than one time have the potential to stay in a grassland/shrubland state for a longer period of time than those burned just once. Disturbances that occur near timberline can also expect a slow recovery (Arno and Allison-Bunnell, 2002). On the basis of their study, the overall increase in the amount of grassland/shrubland may, in part, be a result of multiple wildfires at high elevations.

Figure 15. Example of impact from numerous abandoned mines throughout Northern Rockies Ecoregion, showing mine tailings, contaminated soils and waterways, and erosion. Photograph by Janis Taylor.

Current research indicates that climate change will result in a higher likelihood of wildfires and insect-caused mortality (Carter, 2003). In this ecoregion, the number of frost-free days per year has already increased, and there have been fewer extended periods of very cold temperatures during winter. Because of these changes, in combination with recurring drought, scientists predict an increase in insect infestations (Shore and others, 2003), killing more trees and thus adding to a higher potential for regional fire events.

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

[Most sample pixels remained unchanged (86.2 percent), whereas 13.8 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	7.8	2.9	4.9	10.8	2.0	25.5
2	5.0	1.7	3.3	6.8	1.2	23.5
3	0.9	0.6	0.3	1.5	0.4	45.0
4	0.0	0.1	0.0	0.1	0.0	75.4
Overall spatial change	13.8	3.9	9.9	17.8	2.7	19.2

Table 2. Raw estimates of change in Northern Rockies 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	3.7	1.7	2.0	5.4	1.2	31.5	0.5
1980–1986	3.9	1.8	2.1	5.7	1.2	30.9	0.7
1986–1992	4.5	1.5	3.0	6.1	1.0	22.8	0.8
1992–2000	8.7	2.9	5.8	11.6	2.0	22.6	1.1
Estimate of change, in square kilometers							
1973–1980	5,990	2,774	3,217	8,764	1,884	31.5	856
1980–1986	6,408	2,912	3,496	9,320	1,978	30.9	1,068
1986–1992	7,394	2,485	4,909	9,879	1,688	22.8	1,232
1992–2000	1,4169	4,710	9,459	18,879	3,200	22.6	1,771

Table 3. Estimated area (and margin of error) of each land-cover class in Northern Rockies 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	0.8	0.3	0.3	1.9	1.0	0.0	0.0	3.0	1.6	72.2	5.3	17.8	3.7	3.2	2.7	0.4	0.2	0.4	0.6
1980	0.8	0.8	0.4	0.5	1.0	0.5	0.0	0.0	3.0	1.6	71.5	5.3	19.9	3.5	3.0	2.5	0.4	0.2	0.0	0.0
1986	0.8	0.8	0.5	0.6	1.3	0.6	0.0	0.0	3.0	1.6	71.2	5.4	19.6	3.5	3.0	2.5	0.4	0.2	0.3	0.3
1992	0.8	0.8	0.6	0.8	1.6	0.6	0.0	0.0	3.0	1.6	70.5	5.4	20.1	3.8	2.8	2.2	0.4	0.2	0.2	0.1
2000	0.8	0.8	0.7	0.9	1.1	0.4	0.0	0.0	3.0	1.6	66.5	5.6	20.3	3.7	2.5	2.0	0.4	0.2	4.7	2.9
Net change	0.0	0.0	0.4	0.6	−0.8	0.9	0.0	0.0	0.0	0.0	−5.7	3.2	2.4	1.3	−0.6	1.0	0.0	0.0	4.2	3.0
Gross change	0.0	0.0	0.4	0.6	4.2	1.4	0.0	0.0	0.0	0.0	9.3	3.2	5.8	2.3	0.8	1.0	0.0	0.0	6.0	2.9
Area, in square kilometers																				
1973	1,290	1,280	495	529	3,057	1,584	21	17	4,833	2,540	117,534	8,592	29,023	6,012	5,131	4,348	646	274	712	1,036
1980	1,275	1,277	694	804	1,555	885	37	26	4,842	2,540	116,362	8,611	32,412	5,752	4,920	4,089	629	264	20	20
1986	1,266	1,260	813	947	2,059	964	27	23	4,844	2,542	115,864	8,786	31,834	5,765	4,899	4,026	624	262	515	547
1992	1,274	1,277	1,031	1,246	2,673	976	38	34	4,840	2,540	114,770	8,821	32,725	6,147	4,515	3,610	628	264	248	206
2000	1,274	1,277	1,212	1,466	1,749	678	61	56	4,842	2,541	108,290	9,114	32,962	6,097	4,102	3,231	628	265	7,624	4,666
Net change	−16	24	717	938	−1,308	1,500	40	57	9	9	−9,244	5,237	3,939	2,183	−1,030	1,559	−18	21	6,913	4,847
Gross change	63	52	717	938	6,865	2,272	61	56	18	16	15,086	5,219	9,364	3,794	1,244	1,555	36	35	9,753	4,707

Table 4. Principal land-cover conversions in Northern Rockies 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	Margin of error	Standard error	Percent of ecoregion	Percent of all changes
			(km²)	(+/– km²)	(km²)		
1973–1980	Mechanically disturbed	Grassland/Shrubland	2,697	1,535	1,043	1.7	45.0
	Forest	Mechanically disturbed	1,543	881	599	0.9	25.8
	Nonmechanically disturbed	Grassland/Shrubland	707	1,029	699	0.4	11.8
	Mechanically disturbed	Forest	336	261	177	0.2	5.6
	Grassland/Shrubland	Forest	162	116	79	0.1	2.7
	Other	Other	545	n/a	n/a	0.3	9.1
		Totals	5,990			3.7	100.0
1980–1986	Forest	Mechanically disturbed	2,018	949	644	1.2	31.5
	Grassland/Shrubland	Forest	1,879	1,596	1,084	1.2	29.3
	Mechanically disturbed	Grassland/Shrubland	1,363	860	584	0.8	21.3
	Forest	Nonmechanically disturbed	433	495	336	0.3	6.8
	Mechanically disturbed	Forest	169	138	94	0.1	2.6
	Other	Other	545	n/a	n/a	0.3	8.5
		Totals	6,408			3.9	100.0
1986–1992	Forest	Mechanically disturbed	2,597	949	644	1.6	35.1
	Mechanically disturbed	Grassland/Shrubland	1,672	925	628	1.0	22.6
	Grassland/Shrubland	Forest	1,286	921	625	0.8	17.4
	Nonmechanically disturbed	Grassland/Shrubland	427	457	310	0.3	5.8
	Mechanically disturbed	Forest	346	227	154	0.2	4.7
	Other	Other	1,066	n/a	n/a	0.7	14.4
		Totals	7,394			4.5	100.0
1992–2000	Forest	Nonmechanically disturbed	6,906	4,510	3,064	4.2	48.7
	Forest	Mechanically disturbed	1,729	673	457	1.1	12.2
	Mechanically disturbed	Grassland/Shrubland	1,727	713	484	1.1	12.2
	Grassland/Shrubland	Forest	1,476	700	475	0.9	10.4
	Mechanically disturbed	Forest	722	500	340	0.4	5.1
	Other	Other	1,609	n/a	n/a	1.0	11.4
		Totals	14,169			8.7	100.0
1973–2000 (overall)	Forest	Mechanically disturbed	7,888	2,834	1,926	4.8	23.2
	Forest	Nonmechanically disturbed	7,459	4,494	3,053	4.6	22.0
	Mechanically disturbed	Grassland/Shrubland	7,458	3,575	2,429	4.6	22.0
	Grassland/Shrubland	Forest	4,803	2,986	2,028	3.0	14.1
	Mechanically disturbed	Forest	1,573	867	589	1.0	4.6
	Other	Other	4,780	n/a	n/a	2.9	14.1
		Totals	33,962			20.9	100.0

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