

Chapter 4

Canadian Rockies Ecoregion

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Ecoregion Description

The Canadian Rockies Ecoregion covers approximately 18,494 km² (7,141 mi²) in northwestern Montana (Omernik, 1987; U.S. Environmental Protection Agency, 1997). The east side of the ecoregion is bordered by the Montana Valley and Foothill Prairies Ecoregion, which also forms a large part of the western border of the ecoregion. In addition, the Northern Rockies Ecoregion wraps around the ecoregion to the northwest and south (fig. 1). As the name implies, the Canadian Rocky Mountains are located mostly in Canada, straddling the border between Alberta and British Columbia. However, this ecoregion only includes the part of the northern Rocky Mountains that is in the United States. This ecoregion is characterized by steep, high-elevation mountain ranges similar to most of the rest of the Rocky Mountains. Compared to the Northern Rockies Ecoregion, however, the Canadian Rockies Ecoregion reaches higher elevations and contains a

greater proportion of perennial snow and ice (Omernik, 1987) (fig. 2). Over the years, this section of the Rocky Mountains has garnered many different names, including “Crown of the Continent” by George Bird Grinnell (Waldt, 2008) and “Backbone of the World” by the Blackfeet (Pikuni) Nation.

Throughout the ecoregion, montane, subalpine, and alpine ecosystems have distinct flora and fauna elevation zones. Glaciers, permanent snowfields, and seasonal snowpack are found at the highest elevations. Spring and summer runoff fills lakes and tarns that form the headwaters of numerous streams and rivers, including the Columbia and Missouri Rivers that flow west and east, respectively, from the Continental Divide.

Many of the vast coniferous forests (fig. 3) throughout the Canadian Rockies Ecoregion lie within four national forests (Flathead, Lolo, Lewis and Clark, and Helena), and Glacier National Park is located entirely within the ecoregion. In 1932, Glacier National Park was combined with Waterton Lakes National Park, just across the Canadian border, to form

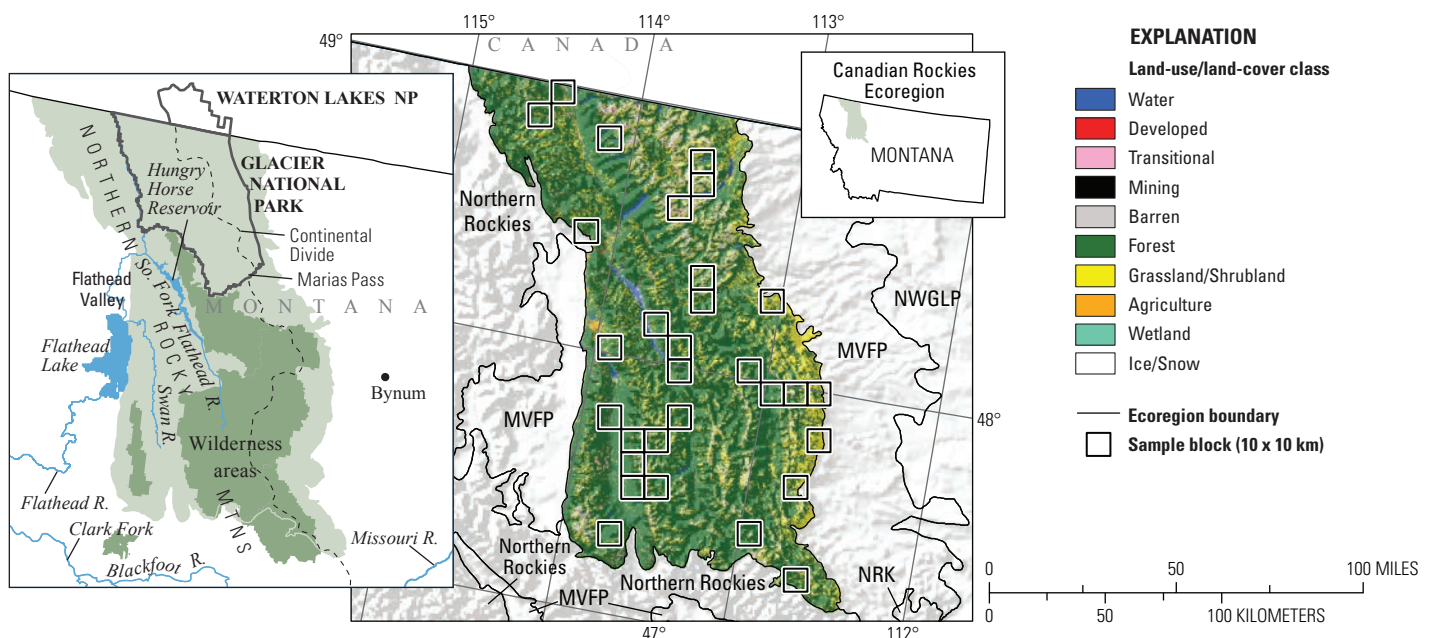


Figure 1. Map of Canadian Rockies Ecoregion and surrounding ecoregions, showing land-use/land-cover classes from 1992 National Land Cover Dataset (Vogelmann and others, 2001); note that not all land-use/land-cover classes shown in explanation may be depicted on map; note also that, for this “Status and Trends of Land Change” study, transitional land-cover class was subdivided into mechanically disturbed and nonmechanically disturbed classes. 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 is part of one Great Plains Ecoregion, Northwestern Glaciated Plains (NWGLP). See appendix 3 for definitions of land-use/land-cover classifications.



Figure 2. High peaks along east slope of northern Rocky Mountains, near Bynum, Montana. State-owned Blackleaf Wildlife Management Area lies at lower elevations in this area. Photograph taken in June 2009.



Figure 3. South Fork Flathead River, with dense forest throughout river valley and hillsides.



Figure 4. Forest logging activity in Swan River valley, Montana.

the world's first International Peace Park, Waterton-Glacier International Peace Park. This area is also designated as a World Heritage Site, and it is rich in flora and fauna.

Throughout the Canadian Rockies Ecoregion, more than 70 species of mammals, including lynx (*Lynx canadensis*), mountain lions (*Puma concolor*), wolves (*Canis lupus irremotus*), black bears (*Ursus americanus*), moose (*Alces alces*), bighorn sheep (*Ovis canadensis*), mountain goats (*Oreamnos americanus*), elk (*Cervus elaphus*), and wolverines (*Gulo gulo*), roam and mate in large tracts of undeveloped land. Designated wilderness areas within the national forests and on tribal lands, combined with Glacier National Park, make up 68 percent of the ecoregion (table 1; fig. 3). Surrounding this large, protected landscape are open lands across the Blackfoot Nation and Flathead Reservations and roadless lands in national forests, as well as wild and scenic rivers, all of which provide habitat vast enough to support large grizzly bear (*Ursus arctos horribilis*) populations (Waldt, 2008; Mace and Chilton, unpub. data, 2009).

Native Americans have hunted in and harvested this ecoregion for over 5,000 years (Malone and others, 1991). Though still sparsely populated, communities are linked together by highway corridors that bisect vast areas of undeveloped, roadless landscape. Economies in the small communities are closely tied to the natural landscape. Approximately 2 million people visit Glacier National Park annually. Lakes, rivers, and winter snow further support a tourism economy through recreation, including skiing, hiking, biking, all-terrain-vehicle use, snowmobiling, camping, hunting, and fishing. Government agencies, the private timber industry, and tourist destinations and services provide the bulk of employment in the ecoregion. Harvesting of timber and other forest products has continued for more than a century (fig. 4). However, harvesting levels have varied over time and under different tract ownership.

Climate within the Canadian Rockies Ecoregion varies significantly from west to east. The climate on the west side of the Rocky Mountains is moderated by a maritime influence, whereas the climate on the east side has a harsher, more continental regime. Throughout the ecoregion, the higher elevations force moisture out of the atmosphere to precipitate primarily as snow, leaving a drier climate in the surrounding valleys. Because of the mountainous terrain, there are many local climatic effects, including aspect, exposure to prevailing wind, thermal inversions, and dry pockets (Ricketts and others, 1999).

Contemporary Land-Cover Change (1973 to 2000)

The overall spatial change—the percentage of land area within the Canadian Rockies Ecoregion where land cover changed at least once between 1973 and 2000—was 7.6 percent (1,397 km²). Estimates show that 3.0 percent (555 km²) of the ecoregion changed at least one time, and 4.6 percent (851 km²) changed two or more times (table 2). Comparing the amount of overall change in each of the 30 western United

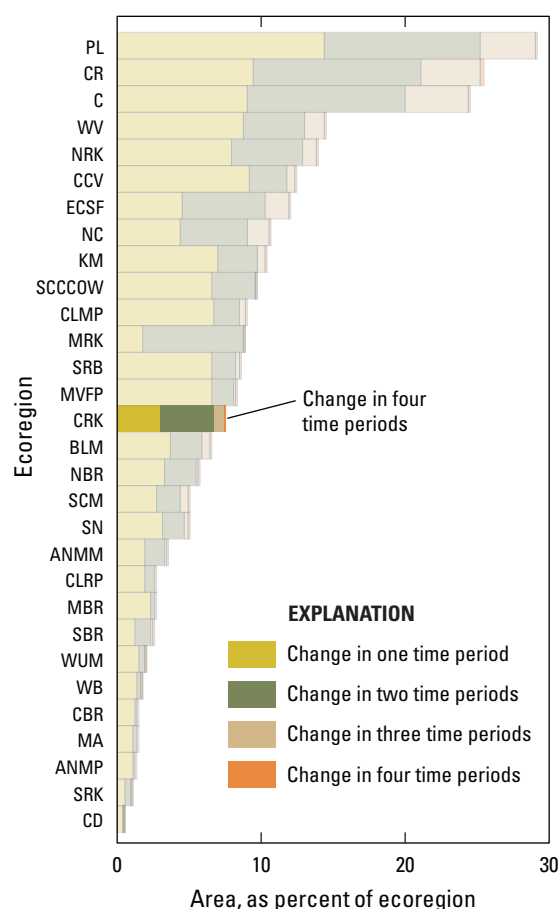


Figure 5. Overall spatial change in Canadian Rockies Ecoregion (CRK; darker bars) compared with that of all 30 Western United States ecoregions (lighter bars). Each horizontal set of bars shows proportions of ecoregion that change during one, two, three, or four time periods; highest level of spatial change in Canadian Rockies Ecoregion (four time periods) labeled for clarity. See table 3 for years covered by each time period. See appendix 2 for key to ecoregion abbreviations.

States ecoregions, the Canadian Rockies Ecoregion's overall change is moderate (fig. 5).

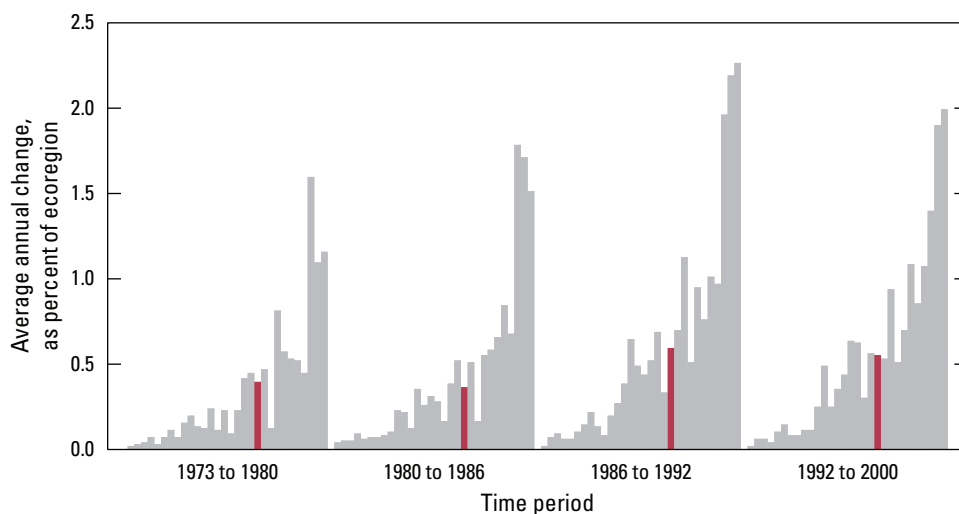
Total percent change in each of the four time periods in this study ranges from a low of 2.2 percent (400 km²) between 1980 and 1986 to a high of 4.4 percent (809 km²) between 1992 and 2000. After normalizing the land-cover change in each time period to an annual rate of change, the rates range from a low of 0.4 percent (67 km²) per year between 1980 and 1986 to a high of 0.6 percent (110 km²) per year between 1986 and 1992 (table 3) (fig. 6).

Forest, the major land-cover class, covered 70.1 percent (12,964 km²) of the ecoregion in 1973, and it experienced a 2.3 percent (293 km²) decrease during the entire study period. Grassland/shrubland, which covered 18.5 percent (3,418 km²) of the ecoregion in 1973, increased 8.2 percent (277 km²) over the study period. The mechanically disturbed class accounted for 1.5 percent (281 km²) of the land cover in 1973 and 1.1 percent (196 km²) in 2000 (table 4). Net change in all land-use/land-cover categories is presented in figure 7.

The top four land-cover conversions were all components of man-made and naturally occurring forest change and regeneration: (1) forest to mechanically disturbed, (2) mechanically disturbed to grassland/shrubland, (3) grassland/shrubland to forest, and (4) forest to nonmechanically disturbed (table 5). Forest cuts, which were documented as mechanically disturbed, were the most common land-cover conversions between 1980 and 1986 and between 1986 and 1992 (table 4). Between 1986 and 1992, the second most common conversion was forest to nonmechanically disturbed, a result of natural-disturbance events such as fire and (or) beetle kill.

Forest products and their rate of harvest have changed in the decades between 1970 and 2000, affecting the rates of change of forest land cover. As early as 1976, the U.S. Forest Service stopped approving the clearcutting of areas larger than 40 acres (U.S. Department of Agriculture, 1998). In 1989, the U.S. Forest Service established and implemented an annual forest-management plan that defined a more comprehensive

Figure 6. 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 Canadian Rockies Ecoregion are represented by red bars in each time period.



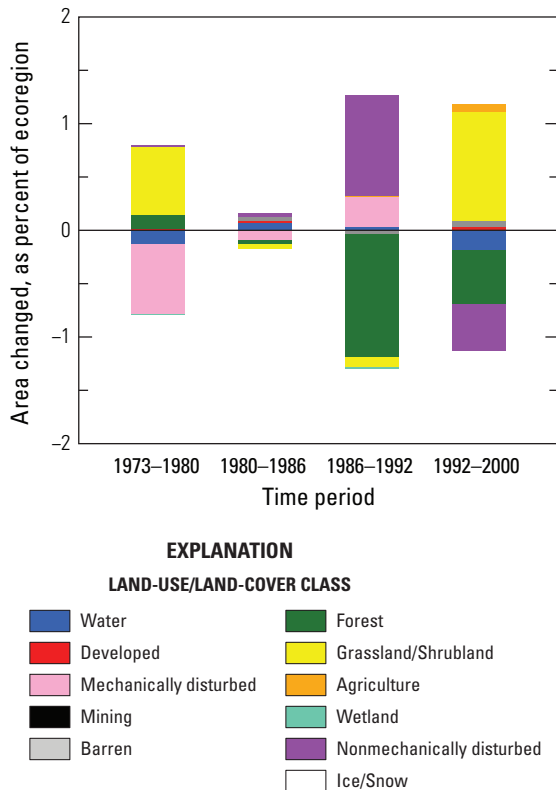


Figure 7. Normalized average net change in Canadian Rockies Ecoregion by time period for each land-cover class. Bars above zero axis represent net gain, whereas bars below zero represent net loss. Note that not all land-cover classes shown in explanation may be represented in figure. See appendix 3 for definitions of land-use/land-cover classifications.

list of forest uses. After 1992, stringent restrictions were applied to clearcutting, and its use continues to decline. The most common timber harvested in the 1980s was the large-girth tree for lumber and sheet products, but this is being replaced by the harvest of dead or small-diameter trees by stewardship projects, which aim to improve wildlife habitat and (or) enhance cultural features. Today, overall timber-harvest rates are near 1950 levels (U.S. Department of Agriculture, 1998).

The vast wild and protected landscapes in the Canadian Rockies Ecoregion provide a crucial link for the Yellowstone to Yukon (“Y2Y”) Initiative. Furthermore, the “Crown of the Continent” is a priority area where various conservation efforts are underway to protect movement of animals as they travel between parks and other forested lands. A goal of the Y2Y Initiative is to protect both the wild and human inhabitants so that they remain connected and healthy into the future. The grizzly bear is one of the many animals that require large amounts of land. The Northern Continental Divide Grizzly Bear Project has determined that this area has the largest grizzly bear populations found in the lower 48 states (Kendall and others, 2008; Mace and Chilton, unpub. data, 2009). Projects



Figure 8. Glaciers and snowpack in Glacier National Park.



Figure 9. Tourists in Glacier National Park.



Figure 10. Highway 2 over Rocky Mountains at Marias Pass, Montana. Highway affects movement of large mammals in region.

like the Y2Y Initiative may limit future land-use/land-cover change if implementation successfully continues.

Mountain glaciers, along with annual snowpack and rainfall, support the headwaters of large rivers (fig. 8). Because of the quality and quantity of the water, the rivers and streams, along with the riparian corridors that they flow through, provide habitat for a wide variety of species, as well as critical habitat for several fish species. A particularly important factor is the input of glacial meltwater that enters the streams during



Figure 11. Remnants of forest fire above Hungry Horse Reservoir, Montana.

the hottest and driest days of late summer, sustaining temperature-sensitive species (Hall and Fagre, 2003).

The landscape is rich in the ecosystem services that it provides, which include forest products, habitat for wildlife, fresh water, and recreational opportunities. In the future, these services may change along with the forest as the result of both human and natural processes.

Natural amenities, such as forests, lakes, and rivers, provide outdoor recreation opportunities for numerous visitors, making them an economic asset to local communities (fig. 9). Towns directly adjacent to the Canadian Rockies Ecoregion,

such as those in the Flathead Valley, observed an increase in population and housing starts throughout the 1980s and 1990s (Baron and others, 2000), and the ecoregion's developed area doubled in size (from 17 to 33 km²) over the course of the study.

Future change in this forested ecoregion is inevitable. Increased human use of the landscape may affect water quality (and quantity) and, thus, wildlife habitat, and transportation corridors may fragment the landscape (fig. 10). Clean water may be especially at risk owing to human activities such as mining, as well as human-caused impacts from erosion and runoff from landscaping and septic systems (Baron and others, 2000). Because humans have actively controlled and suppressed fire in this region for decades, forests have grown dense with vegetation, and infestations have killed off large swaths of trees. Future wildfires may be large and devastating in some areas (Arno and Allison-Bunnell, 2002).

Climate change may also play a strong role in future changes. Glaciers are melting in Glacier National Park (Fagre, 2005); as of 2000, only 37 of the estimated original 150 mountain glaciers remained. Summer and winter temperatures are expected to rise; models predict that by 2030 all of the glaciers within Glacier National Park will have melted (Fagre, 2005; Hall and Fagre, 2003; Fagre and others, 2003). Increasing temperatures, increasing numbers of frost-free days, and decreasing numbers of extended periods of very cold temperatures during winter may further influence disturbance regimes in the forests from both wildfires (fig. 11) and insect infestations (Carter, 2003).

Table 1. Sizes of natural areas in Montana, which together represent one of the most completely preserved mountain ecosystems in the world.

Natural area	Acres	Square kilometers	Square miles
Bob Marshall Wilderness	1,009,356	4,085	1,577
Scapegoat Wilderness	239,936	971	375
Great Bear Wilderness	286,700	1,160	448
Mission Mountains Wilderness	73,877	299	115
Mission Mountains Tribal Wilderness	89,500	362	140
Jewel Basin	15,349	62	24
Hungry Horse Reservoir	23,813	96	37
Glacier National Park	1,400,000	5,665	2,187
Total	3,138,531	12,701	4,904

Table 2. Percentage of Canadian Rockies Ecoregion land cover that changed at least one time during study period (1973–2000) and associated statistical error.

[Most sample pixels remained unchanged (92.4 percent), whereas 7.6 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	3.0	1.3	1.8	4.3	0.9	28.2
2	3.8	1.3	2.5	5.1	0.9	23.8
3	0.7	0.4	0.3	1.0	0.2	36.8
4	0.1	0.0	0.0	0.1	0.0	47.6
Overall spatial change	7.6	2.4	5.1	10.0	1.6	21.7

Table 3. Raw estimates of change in Canadian 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	2.7	1.1	1.6	3.9	0.8	27.7	0.4
1980–1986	2.2	0.8	1.4	3.0	0.5	25.0	0.4
1986–1992	3.6	1.3	2.3	4.8	0.8	23.8	0.6
1992–2000	4.4	1.4	2.9	5.8	1.0	22.1	0.5
Estimate of change, in square kilometers							
1973–1980	505	207	299	712	140	27.7	72
1980–1986	400	148	252	548	100	25.0	67
1986–1992	659	232	427	891	157	23.8	110
1992–2000	809	264	545	1074	179	22.1	101

Table 4. Estimated area (and margin of error) of each land-cover class in Canadian 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	1.7	0.8	0.1	0.1	1.5	0.7	0.0	0.0	6.9	2.6	70.1	4.7	18.5	3.8	0.3	0.3	0.4	0.2	0.0	0.0
1980	1.6	0.8	0.1	0.1	0.9	0.4	0.0	0.0	6.9	2.6	70.2	4.7	19.1	3.7	0.4	0.3	0.4	0.2	0.0	0.0
1986	1.6	0.8	0.1	0.1	0.8	0.4	0.0	0.0	7.0	2.6	70.2	4.7	19.1	3.7	0.4	0.3	0.4	0.2	0.0	0.0
1992	1.7	0.8	0.1	0.1	1.1	0.4	0.0	0.0	6.9	2.6	69.0	4.7	19.0	3.8	0.4	0.3	0.4	0.2	1.0	0.9
2000	1.5	0.7	0.2	0.1	1.1	0.5	0.0	0.0	7.0	2.6	68.5	4.6	20.0	3.7	0.4	0.3	0.4	0.2	0.5	0.5
Net change	-0.2	0.2	0.1	0.1	-0.5	0.5	0.0	0.0	0.1	0.1	-1.6	1.2	1.5	1.1	0.1	0.1	0.0	0.0	0.5	0.5
Gross change	0.4	0.5	0.1	0.1	3.4	1.2	0.0	0.0	0.1	0.1	4.1	1.2	3.4	1.2	0.1	0.1	0.0	0.0	2.6	1.9
Area, in square kilometers																				
1973	312	152	17	10	281	124	1	1	1,284	474	12,964	878	3,418	700	64	54	80	29	0	0
1980	288	147	21	13	159	73	1	1	1,284	474	12,988	874	3,536	691	65	55	80	29	0	1
1986	303	149	24	15	144	70	1	1	1,291	477	12,980	873	3,527	691	66	55	80	29	6	8
1992	309	151	27	18	194	82	1	1	1,285	474	12,765	862	3,510	696	67	55	79	28	182	174
2000	277	137	33	23	196	89	2	1	1,294	479	12,671	847	3,699	691	80	60	79	28	98	91
Net change	-35	35	16	13	-85	99	1	1	10	12	-293	213	281	196	16	19	-1	1	98	91
Gross change	78	88	16	13	622	226	1	1	21	20	751	231	621	216	18	19	2	1	473	353

Table 5. Principal land-cover conversions in Canadian 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 (km ²)	Margin of error (+/- km ²)	Standard error (km ²)	Percent of ecoregion	Percent of all changes
1973–1980	Mechanically disturbed	Grassland/Shrubland	174	87	59	0.9	34.3
	Forest	Mechanically disturbed	137	70	47	0.7	27.1
	Mechanically disturbed	Forest	107	91	62	0.6	21.2
	Grassland/Shrubland	Forest	58	66	45	0.3	11.6
	Water	Mechanically disturbed	21	28	19	0.1	4.1
	Other	Other	9	n/a	n/a	0.0	1.7
Totals			505			2.7	100.0
1980–1986	Forest	Mechanically disturbed	141	70	47	0.8	35.3
	Grassland/Shrubland	Forest	84	44	30	0.5	21.0
	Mechanically disturbed	Grassland/Shrubland	76	56	38	0.4	19.0
	Mechanically disturbed	Forest	62	45	30	0.3	15.4
	Mechanically disturbed	Water	15	20	13	0.1	3.7
	Other	Other	23	n/a	n/a	0.1	5.7
Totals			400			2.2	100.0
1986–1992	Forest	Mechanically disturbed	194	81	55	1.1	29.5
	Forest	Nonmechanically disturbed	182	174	118	1.0	27.6
	Grassland/Shrubland	Forest	120	69	47	0.6	18.2
	Mechanically disturbed	Grassland/Shrubland	102	59	40	0.5	15.4
	Mechanically disturbed	Forest	41	24	16	0.2	6.2
	Other	Other	21	n/a	n/a	0.1	3.1
Totals			659			3.6	100.0
1992–2000	Nonmechanically disturbed	Grassland/Shrubland	182	174	118	1.0	22.5
	Forest	Mechanically disturbed	165	88	59	0.9	20.3
	Mechanically disturbed	Grassland/Shrubland	123	60	41	0.7	15.2
	Grassland/Shrubland	Forest	110	75	51	0.6	13.6
	Forest	Nonmechanically disturbed	86	78	53	0.5	10.6
	Other	Other	144	n/a	n/a	0.8	17.8
Totals			809			4.4	100.0
1973–2000 (overall)	Forest	Mechanically disturbed	637	258	174	3.4	26.8
	Mechanically disturbed	Grassland/Shrubland	474	218	147	2.6	20.0
	Grassland/Shrubland	Forest	372	213	144	2.0	15.7
	Forest	Nonmechanically disturbed	275	185	125	1.5	11.6
	Mechanically disturbed	Forest	272	174	117	1.5	11.4
	Other	Other	345	n/a	n/a	1.9	14.5
Totals			2,374			12.8	100.0

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