

Chapter 14

North Cascades Ecoregion

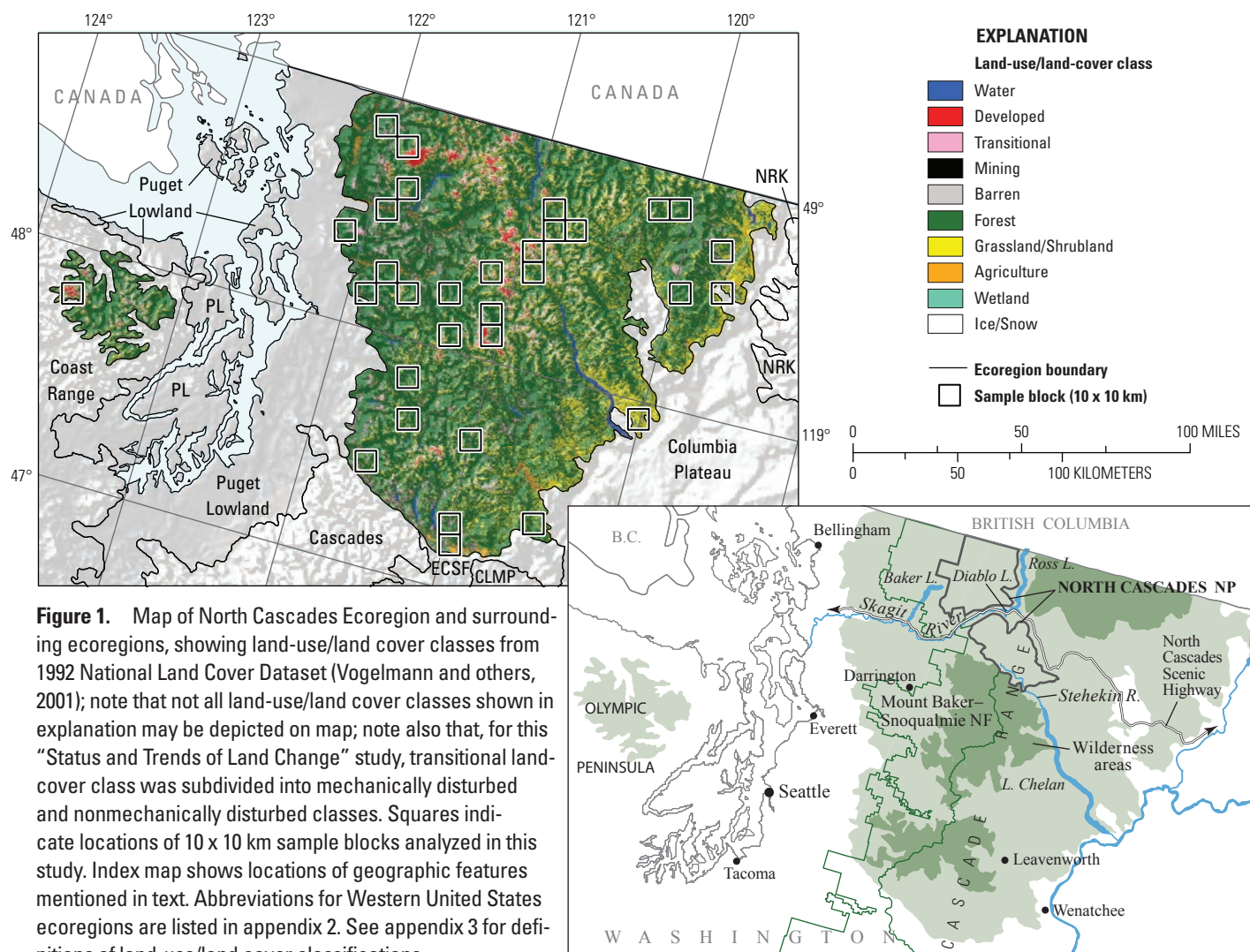
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Ecoregion Description

The North Cascades Ecoregion (Omernik, 1987; U.S. Environmental Protection Agency, 1997) covers approximately 30,421 km² (11,746 mi²) of predominantly steep, mountainous terrain, home to peaks rising more than 3,000 m, which are carved by valleys that drop below 150 m elevation (fig. 1). The unique topography in this geographically isolated ecoregion has been shaped by glacial processes, and its deep drainage canyons have been further incised by subsequent runoff. Beautiful alpine scenery is

a major feature of the ecoregion, which includes several national forests, parks, and wilderness areas such as the North Cascades National Park, the Mount Baker–Snoqualmie National Forest, the Okanogan National Forest, and the Wenatchee National Forest, as well as the Pasayten Wilderness, the Glacier Peak Wilderness, the Alpine Lakes Wilderness, and the Henry M. Jackson Wilderness.

The North Cascades Ecoregion extends north of the Canadian border into British Columbia; however, this study covers only the part that is in the United States, in north-central Washington (fig. 1). The ecoregion is bounded on the



east by the Columbia Plateau Ecoregion; on the south by the Cascades Ecoregion and the Eastern Cascades Slopes and Foothills Ecoregion; and on the west by the Puget Lowland Ecoregion. Farther west, an isolated section of the ecoregion on the Olympic Peninsula is entirely surrounded by the Coast Range Ecoregion.

Climate in the North Cascades Ecoregion is remarkably varied. From fall to spring, most upper elevation areas are blanketed in snow. Strong weather systems from the Pacific Ocean pass over the mountain peaks, making this region one of the snowiest on earth (National Park Service, 2009). The western part of the North Cascades Ecoregion receives, on average, 193 cm of rain and 1,034 cm of snow annually, creating the lush, evergreen forests in this area. These precipitation totals are higher than in the far eastern part of the ecoregion (National Park Service, 2009), where conditions are markedly drier and where dense forests give way to more grasses and shrubland (fig. 1). Harnessing the annual snowmelt are the large-scale dam operations, reservoirs, and hydroelectric power plants at Diablo Lake (4 km²; fig. 2), Ross Lake (48 km²), and Baker Lake (15 km²), as well as Lake Chelan (247 km²), the third deepest lake in the entire United States at 457 m deep.

This ecoregion is sparsely populated: its largest towns are Darrington (population 1,354 in 2009) and Leavenworth (population 2,347 in 2009), Washington (U.S. Census Bureau, 2009). However, several cities are located not far outside the ecoregion boundary (for example, Seattle, Tacoma, Everett, Bellingham, and Wenatchee, Washington). Agriculture, which is a major land use along low-lying valley bottoms, consists of irrigated pastureland and crops such as alfalfa, wheat, corn, and other feed crops in the western part of the ecoregion. Apple and pear orchards predominate in the ecoregion's eastern part.

The North Cascades Ecoregion supports a diverse range of forests, including some of the oldest and richest tracts remaining in the conterminous United States. At lower elevations and along the west flank of the Cascade Range, these forests are composed of western red cedar (*Thuja plicata*),



Figure 2. Diablo Lake, man-made reservoir along North Cascades Highway in North Cascades National Park, Washington.



Figure 3. Lush riparian forest and undergrowth within Mount Baker–Snoqualmie National Forest, Washington.

Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), red alder (*Alnus rubra*), and bigleaf maple (*Acer macrophyllum*) (fig. 3). Upslope, lodgepole pine (*Pinus contorta*), ponderosa pine (*Pinus ponderosa*), Pacific silver fir (*Abies amabilis*), Engelmann spruce (*Picea engelmannii*), western larch (*Larix occidentalis*), and whitebark pine (*Pinus albicaulis*) are more common (Uhler, 2007; Washington Department of Fish and Wildlife, 2005).

Late 20th century land-cover change in the North Cascades Ecoregion was associated predominantly with timber harvesting by means of clearcut logging (fig. 4). Large-scale forestry operations were established in areas of easiest access, where harvest-delivery options were most efficient. Timber harvesting, which is more common on private rather than public lands, is especially important along the ecoregion periphery at lower elevations. According to the National Park Service (1999), widespread logging in this area was not logistically possible in the 19th century given the rugged terrain and lack of reliable transportation. In addition, the availability of more accessible stands elsewhere in the area further slowed its expansion (National Park Service, 1999). In the late 1800s to early 1900s, mills operated along the Stehekin River valley (upstream of Lake Chelan), processing logs for use as apple shipping boxes (National Park Service, 2009). Selective harvest of western red cedar also was allowed along the Skagit River in the early 20th



Figure 4. Clearcut logging and regrowth in North Cascades Ecoregion, Washington.

century in what today is the Mount Baker–Snoqualmie National Forest, but the harvest was halted by the early 1920s (National Park Service, 1999).

Contemporary Land-Cover Change (1973 to 2000)

Between 1973 and 2000, the areal extent of land-use/land-cover change (that is, the area that experienced change during at least one of the four multiyear periods within the 27-year study period) in the North Cascades Ecoregion was 10.5 percent (approximately 3,200 km²) (table 1). The North Cascades Ecoregion experienced a modest amount of change compared to other western United States ecoregions, although the rate was substantially lower than that experienced by other forested ecoregions in the Pacific Northwest (fig. 5). Overall, an estimated 3.9 percent (1,186 km²) of land experienced change in at least one time period, 5.1 percent (1,551 km²) changed in two time periods, 1.4 percent (426 km²) changed in three periods, and 0.1 percent (30 km²) of sampled land area changed in all four time periods (table 1).

The average annual rate of land-cover change in the North Cascades Ecoregion between 1973 and 2000 was 0.7 percent (212.7 km²) in the 27-year study period (table 2). This measurement is a cumulative average of the annual average change values for each time period studied. A steady rate of annual change is observed in the first two time periods (0.6 percent), peaking at 0.9 percent between 1986 and 1992 and dropping again to 0.7 percent between 1992 and 2000 (table 2). Figure 6 shows the percent change by time period, normalized to annual rates for all western United States ecoregions.

In 2000, an estimated 70.3 percent of the North Cascades Ecoregion was covered by forest, followed by grassland/shrubland (17.6 percent), barren (5.2 percent, mostly rock outcrops and mountaintops), and mechanically disturbed (2.0 percent) (table 3). An additional 2.6 percent was covered by ice/snow.

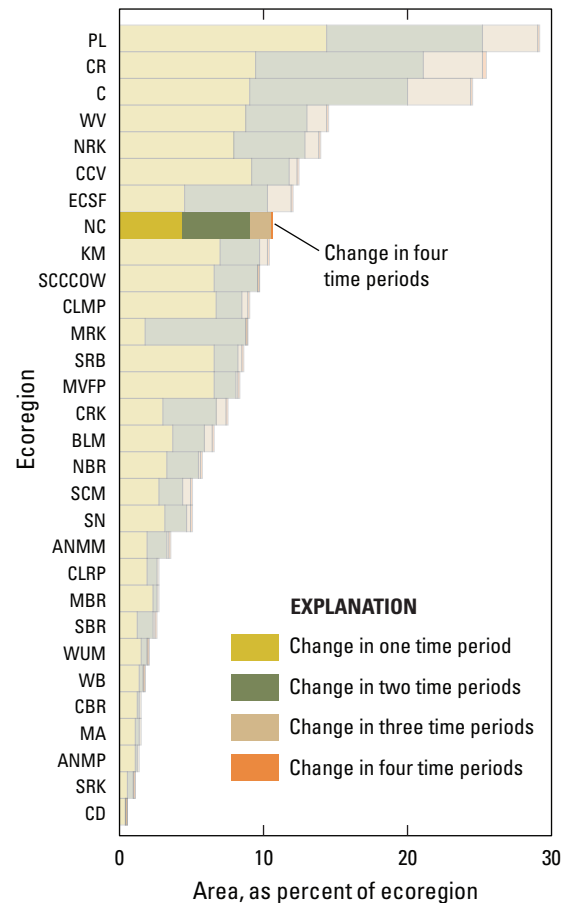
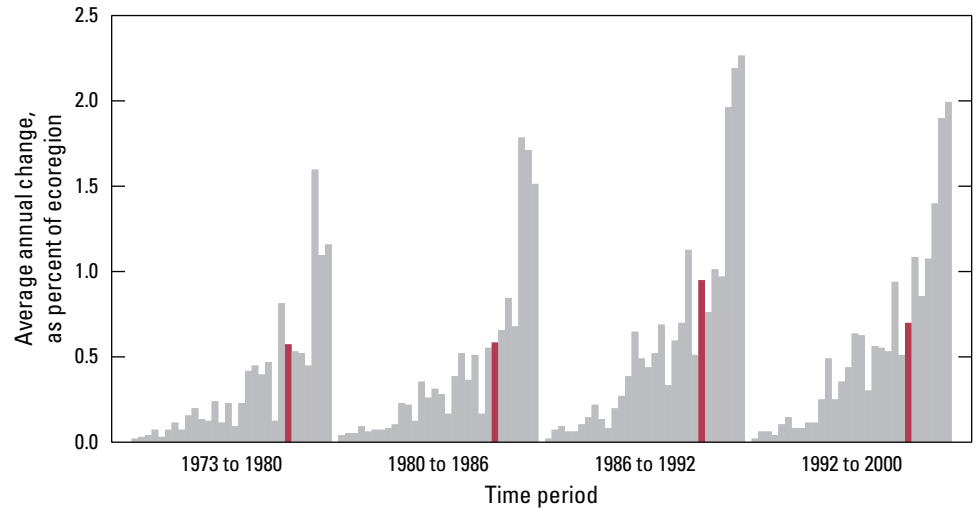


Figure 5. Overall spatial change in North Cascades Ecoregion (NC; darker bars) compared with that of all 30 Western United States ecoregions (lighter bars). Each horizontal set of bars shows proportions of ecoregion that changed during time periods 1, 2, 3, or 4; highest level of spatial change in North Cascades 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.

Only 0.6 percent of the ecoregion was developed, and 1.1 percent was devoted to agriculture (table 3). The remaining four land-cover classes made up less than 1 percent of the remaining area in the ecoregion (table 3). Between 1973 and 2000, there were net losses overall of forest (1.8 percent; 385 km²) and mechanically disturbed (16.5 percent; 121 km²) land, as well as net gains in grassland/shrubland (10.4 percent; 507 km²) (fig. 7).

Postclassification analysis of these results allowed for the identification of “from class-to class” land-cover conversions and the ranking of these conversions according to their magnitude. In the North Cascades Ecoregion, more than 97 percent of all land-cover conversions between 1973 and 2000 were related to timber harvesting (forest to mechanically disturbed) and successional regrowth (mechanically disturbed to grassland/shrubland or forest, as well as grassland/shrubland to forest) (table 4). Overall, an estimated 2,320 km² of forest land was mechanically disturbed (table 4), equating to approximately 7.6 percent of the total ecoregion area. Of particular note is the

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 North Cascades Ecoregion are represented by red bars in each time period.



doubling of timber-harvest rates between 1986 and 1992 and the subsequent sharp decline after 1992, although the rate remained above pre-1986 levels (table 4). This pattern is mirrored in other forest-dominated ecoregions of the western United States (for example, the Klamath Mountains, Coast Range, and Sierra Nevada Ecoregions).

The timber industry has had a dominant influence on land-cover change in the North Cascades Ecoregion; however, external drivers of change, such as federal endangered-species protection and international timber markets, have helped dictate the amount and type of forest harvesting during the study period. Public lands occupy most of the North Cascades Ecoregion and are subject to state and federal regulation. The Washington State Wilderness Act of 1984 set aside more than a million acres of new wilderness area in the state, the majority within the North Cascades Ecoregion, including the Mount Baker Wilderness, Henry M. Jackson Wilderness, Lake Chelan–Sawtooth Wilderness, Pasayten Wilderness (additions), Boulder River Wilderness, Buckhorn Wilderness, Clearwater Wilderness, Glacier Peak Wilderness, and others (Arthur and others, 2009; U.S. Congress, 1984).

In 1990, the Northern Spotted Owl (*Strix occidentalis caurina*) was listed as “threatened” under the Endangered Species Act. In addition, new habitat-protection measures outlined by the Northwest Forest Plan in 1994 set harvesting limits on lands administered by the Forest Service and the Bureau of Land Management. Timber yields were set at 25 percent of the 1980s baseline, which dropped the allowable harvest to 1 billion board feet (Espy and Babbitt, 1994). Additional timber-harvesting restrictions imposed by endangered-species protection led to a 30 percent decline in overall timber volume from 1980s levels (Daniels, 2005). These reductions, coupled with reductions in global timber demand, also have influenced the decline in logging activity since 1992 (Warren, 1999; Daniels, 2005). In the 1990s, changes in the Japanese housing industry and Asia’s economic collapse significantly reduced the demand for lumber, along with greater competition from forest products from the southern United States and Canada (Daniels, 2005).

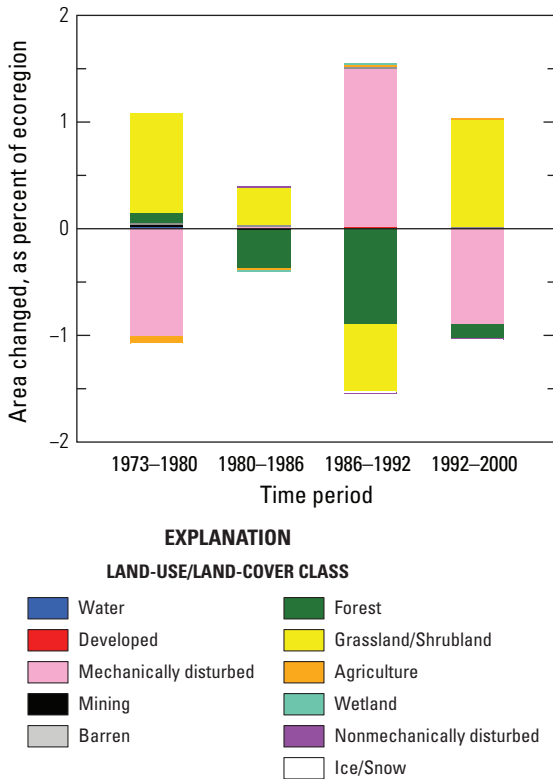


Figure 7. Normalized average net change in North Cascades Ecoregion by time period for each land-cover class. Bars above zero axis represent net gain, whereas bars below zero represent net loss. Note that not all land-cover classes shown in explanation may be represented in figure. See appendix 3 for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

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

[Most sample pixels remained unchanged (89.5 percent), whereas 10.5 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	3.9	1.5	2.4	5.4	1.0	25.4
2	5.1	1.9	3.2	7.0	1.3	25.6
3	1.4	0.7	0.8	2.1	0.4	31.4
4	0.1	0.1	0.0	0.2	0.0	47.9
Overall spatial change	10.5	3.9	6.6	14.4	2.6	25.2

Table 2. Raw estimates of change in North Cascades 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	4.0	1.9	2.1	5.9	1.3	32.1	0.6
1980–1986	3.5	1.5	2.0	5.0	1.0	28.3	0.6
1986–1992	5.7	2.2	3.5	7.8	1.5	25.8	0.9
1992–2000	5.6	2.0	3.5	7.6	1.4	24.6	0.7
Estimate of change, in square kilometers							
1973–1980	1,225	581	644	1,805	393	32.1	175
1980–1986	1,065	444	621	1,510	301	28.3	178
1986–1992	1,724	656	1,069	2,380	444	25.8	287
1992–2000	1,689	614	1,076	2,303	416	24.6	211

Table 3. Estimated area (and margin of error) of each land-cover class in North Cascades 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		Snow/Ice	
	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-
Area, in percent stratum																				
1973	0.3	0.1	0.5	0.5	2.4	1.3	0.0	0.0	5.1	1.7	71.6	5.2	16.0	4.5	1.2	0.9	0.2	0.1	2.6	1.5
1980	0.3	0.1	0.5	0.5	1.4	0.7	0.0	0.0	5.2	1.7	71.7	5.2	16.9	4.4	1.1	0.9	0.2	0.1	2.6	1.5
1986	0.3	0.1	0.5	0.5	1.4	0.6	0.0	0.0	5.2	1.7	71.3	5.2	17.2	4.3	1.1	0.9	0.2	0.1	2.6	1.5
1992	0.3	0.1	0.6	0.5	2.9	1.1	0.0	0.0	5.2	1.8	70.5	5.1	16.6	4.4	1.1	0.9	0.2	0.1	2.6	1.5
2000	0.3	0.1	0.6	0.5	2.0	0.9	0.0	0.0	5.2	1.8	70.3	5.1	17.6	4.3	1.1	0.9	0.2	0.1	2.6	1.5
Net change	0.0	0.0	0.0	0.0	-0.4	1.2	0.0	0.0	0.1	0.1	-1.3	1.6	1.7	0.7	0.0	0.1	0.0	0.0	-0.1	0.1
Gross change	0.0	0.0	0.0	0.0	6.0	2.1	0.0	0.0	0.1	0.1	6.6	2.6	4.6	2.0	0.1	0.2	0.0	0.0	0.1	0.1
Area, in square kilometers																				
1973	85	36	165	139	733	399	7	8	1,566	529	21,781	1,571	4,856	1,356	361	266	66	31	801	464
1980	92	43	166	139	425	211	9	9	1,572	532	21,813	1,568	5,139	1,324	343	263	66	31	795	459
1986	92	42	166	139	434	176	6	4	1,573	531	21,705	1,569	5,248	1,323	338	261	65	30	795	459
1992	94	43	169	139	886	332	4	3	1,582	533	21,432	1,553	5,057	1,343	339	261	66	31	792	456
2000	95	45	169	139	612	265	4	3	1,588	537	21,396	1,564	5,362	1,305	347	264	64	29	783	450
Net change	10	12	4	4	-121	368	-3	8	22	17	-385	493	507	216	-14	28	-2	3	-18	17
Gross change	13	13	4	4	1,836	625	7	8	30	20	1,999	777	1,407	618	39	47	5	6	18	17

Table 4. Principal land-cover conversions in North Cascades 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	Forest	Mechanically disturbed	420	211	143	1.4	34.3
	Mechanically disturbed	Forest	412	322	218	1.4	33.7
	Mechanically disturbed	Grassland/Shrubland	309	192	130	1.0	25.2
	Grassland/Shrubland	Forest	46	36	24	0.1	3.7
	Agriculture	Grassland/Shrubland	18	25	17	0.1	1.4
	Other	Other	20	n/a	n/a	0.1	1.6
	Totals		1,225			4.0	100.0
1980–1986	Forest	Mechanically disturbed	415	176	119	1.4	39.0
	Mechanically disturbed	Grassland/Shrubland	314	186	126	1.0	29.5
	Grassland/Shrubland	Forest	217	124	84	0.7	20.4
	Mechanically disturbed	Forest	93	74	50	0.3	8.7
	Agriculture	Grassland/Shrubland	9	12	8	0.0	0.8
	Other	Other	17	n/a	n/a	0.1	1.6
	Totals		1,065			3.5	100.0
1986–1992	Forest	Mechanically disturbed	876	328	222	2.9	50.8
	Grassland/Shrubland	Forest	388	237	161	1.3	22.5
	Mechanically disturbed	Forest	225	124	84	0.7	13.1
	Mechanically disturbed	Grassland/Shrubland	203	86	58	0.7	11.7
	Forest	Barren	7	7	5	0.0	0.4
	Other	Other	26	n/a	n/a	0.1	1.5
	Totals		1,724			5.7	100.0
1992–2000	Forest	Mechanically disturbed	609	264	179	2.0	36.0
	Mechanically disturbed	Grassland/Shrubland	475	220	149	1.6	28.1
	Mechanically disturbed	Forest	408	260	176	1.3	24.2
	Grassland/Shrubland	Forest	166	79	54	0.5	9.8
	Snow/Ice	Barren	8	8	6	0.0	0.5
	Other	Other	22	n/a	n/a	0.1	1.3
	Totals		1,689			5.6	100.0
1973–2000 (overall)	Forest	Mechanically disturbed	2,320	882	598	7.6	40.7
	Mechanically disturbed	Grassland/Shrubland	1,301	537	364	4.3	22.8
	Mechanically disturbed	Forest	1,139	703	477	3.7	20.0
	Grassland/Shrubland	Forest	816	391	265	2.7	14.3
	Agriculture	Grassland/Shrubland	26	37	25	0.1	0.5
	Other	Other	100	n/a	n/a	0.3	1.8
	Totals		5,703			18.7	100.0

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