**Status and Trends of Land Change in the Western United States—1973 to 2000**
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# Chapter 25

# Wyoming Basin Ecoregion

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## Ecoregion Description

The Wyoming Basin Ecoregion (Omernik 1987; U.S. Environmental Protection Agency, 1999) covers approximately 128,914 km$^2$ (49,774 mi$^2$) in Wyoming and parts of northwestern Colorado, northeastern Utah, southeastern Idaho, and southern Montana (fig. 1). The ecoregion is bounded on the east by the Northwestern Great Plains Ecoregion; on the south and east by the Southern Rockies Ecoregion; on the south by the Colorado Plateaus Ecoregion; on the south and west by the Wasatch and Uinta Mountains Ecoregion; and on the north by the Middle Rockies Ecoregion and parts of the Montana Valley and Foothill Prairies Ecoregion (fig. 1). The ecoregion generally consists of broad intermountain basins dominated by arid

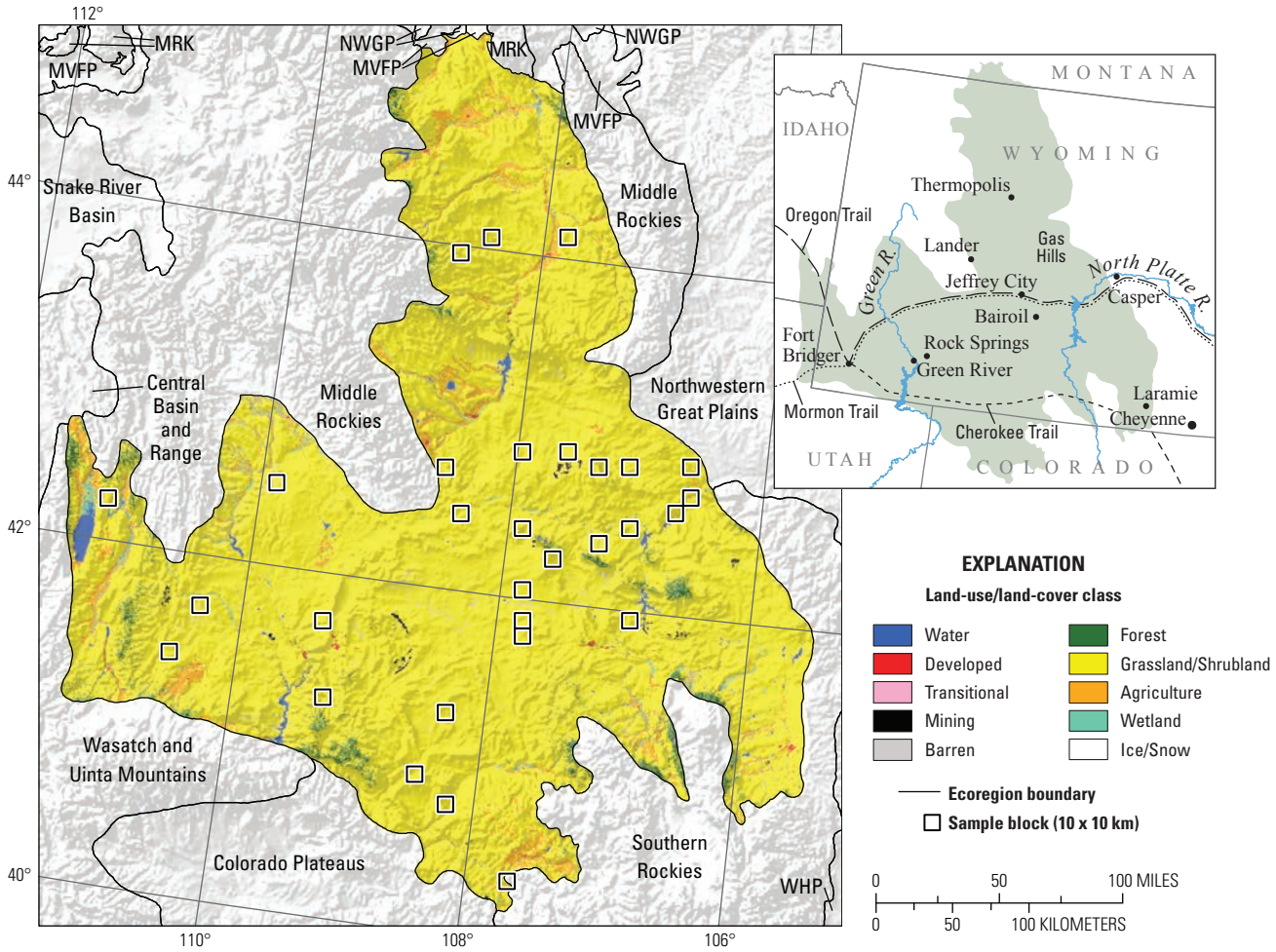


**Figure 1.** Map of Wyoming Basin Ecoregion and surrounding ecoregions, showing land-use/land-cover classes from 1992 National Land Cover Dataset (Vogelmann and others, 2001); note that not all land-use/land-cover classes shown in explanation may be depicted on map; note also that, for this "Status 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. Also shown on map are parts of two Great Plains ecoregions: Northwestern Great Plains (NWGP) and Western High Plains (WHP). See appendix 3 for definitions of land-use/land-cover classifications.

grasslands and shrublands, as well as isolated hills and low mountains that merge to the south into a dissected plateau.

The climate in the Wyoming Basin Ecoregion is semi-arid continental, and it is drier and windier than most places in the United States. The average annual precipitation from rain is 20 cm in Green River, Wyoming, 28 cm in Thermopolis, Wyoming, and 30 cm in Casper, Wyoming. The average annual snowfall is 74 cm in Green River, 76 cm in Thermopolis, and 198 cm in Casper. Average maximum monthly temperatures range from 32°C and above in July to near −17°C in January (Desert Research Institute, 2011). Nearly surrounded by forest-covered mountains, the region is somewhat drier than the Northwestern Great Plains Ecoregion to the northeast.

Vegetation consists of grasses interspersed among big sagebrush (*Artemisia tridentata*). Higher elevations harbor some quaking aspen (*Populus tremuloides*) and patches of coniferous forest. Open water is rare in this ecoregion, consisting mainly of reservoirs on the North Platte and Green Rivers, as well as on smaller rivers that traverse the area. Many minor waterways have been dammed to provide water for livestock. Stream beds are often dry in these riparian areas. Wetlands are especially rare and typically are riparian.

This ecoregion has a rich history in the settlement of the American West. Several major trails cross through the ecoregion, as it provides a low pass across the Rocky Mountains (fig. 1). The Oregon Trail was used by settlers heading west during the 1840s to 1890s. The northern route of the Cherokee Trail, which crosses through southern Wyoming, was used primarily by travelers heading west to the California gold fields. The Mormon Trail was used between 1846 and 1857 by Mormons fleeing to Utah after persecution in the Midwest (Hill, 1987). The short-lived Pony Express also had stations lining an east-to-west route near the Oregon Trail (Di Certo, 2002). Evidence of many of these old trails is still visible. The Pony Express and overland movement along wagon trails started to decline with the increase in rail travel and telegraph use starting in the mid- to late-1800s.

Human population in the Wyoming Basin Ecoregion is sparse. The largest cities in the ecoregion are Casper (population, 49,644 in 2000), Laramie (27,204), and Rock Springs (18,708), Wyoming (U.S. Census Bureau, 2011). Much of the ecoregion is used for cattle and sheep grazing, often in managed pastures, and ranches are common, but many areas lack sufficient vegetation to support grazing. Agriculture is limited primarily to irrigated hay, corn, and sugar beets along river bottoms (fig. 2). Much of the land is owned by the Bureau of Land Management and is leased to ranches for cattle grazing.

The Wyoming Basin Ecoregion has a long history of energy development, as it holds large reserves of minerals, oil, and natural gas (fig. 3). Wyoming accounts for roughly 40 percent of all coal production in the United States, the most of any state (Freme, 2009). Much of the coal mined in Wyoming is shipped to the Midwest, producing approximately 30 percent of the electricity consumed in the United States.

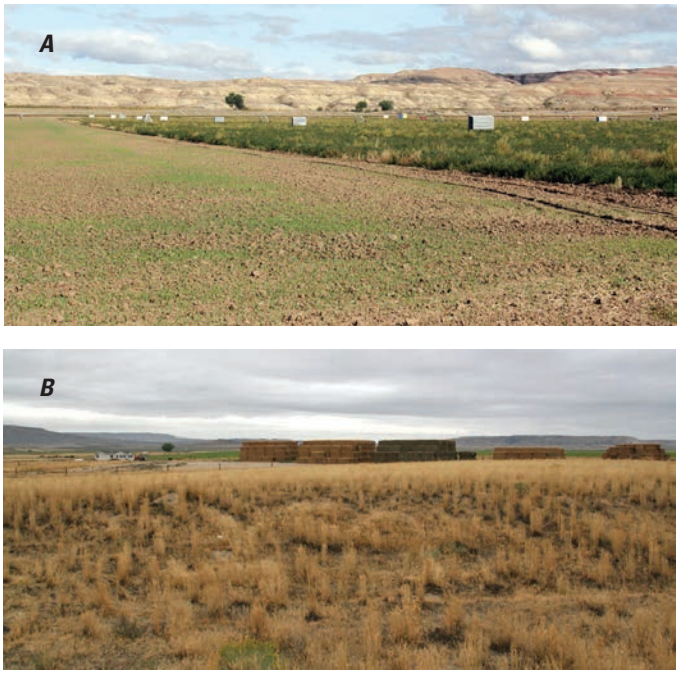


**Figure 2.** Agriculture in Wyoming Basin Ecoregion. *A*, Irrigated crops. *B*, Hay production.

**Figure 3.** Energy development in south-central Wyoming.

**Figure 4.** Reclaimed mine in Gas Hills District of Wyoming.


**Figure 5.** Oil well near Bairoil, Wyoming, and warning sign for hydrogen-sulfide gas.

Coal-fired power plants are scattered throughout the ecoregion, and large transmission lines radiate from them. Uranium mining once was common but decreased in the 1980s after the incidents at Three Mile Island and Chernobyl nuclear power plants. Many of those once-active mines have been reclaimed (fig. 4). Towns associated with uranium mining, such as Jeffrey City, Wyoming, are largely deserted. Today, uranium is mined in place using chemicals to dissolve the minerals before pumping them to the surface (Gregory, 2011).

Wyoming's first oil well was drilled in 1885, just southeast of Lander, Wyoming (Roberts, 2011). As of 2006, Wyoming ranked second in the United States for proven natural-gas reserves and fourth for proven crude-oil reserves (fig. 5). The most recent period of energy development started in the late 1990s and has intensified with rising energy prices during the 2000s. In some places, the density of recent energy development has produced a nearly continuous matrix of wells and their associated transportation networks. There is growing concern about how intensifying energy development will affect the populations and migration patterns of wildlife species that use parts of the Wyoming Basin Ecoregion (Bowen and others, 2009).

## Contemporary Land-Cover Change (1973 to 2000)

Between 1973 and 2000, 1.8 percent of the Wyoming Basin Ecoregion changed land-use/land-cover classes at least once (table 1; fig. 6). In 1.4 percent of the ecoregion, change occurred in land-use/land-cover in one time period. Overall, the average annual rate of land-cover change in the Wyoming Basin Ecoregion was very low, at only 0.1 percent (fig. 7; table 2). Rates of change varied little among the different time periods analyzed. Even though the rate of change appeared low, the Wyoming Basin Ecoregion's size meant that it amounted to nearly 92 to 181 km$^2$ per year of total change, depending on the time period (table 2). Overall, this ecoregion's level of change was one of the lowest among western United States ecoregions (table 1).

The extent of agriculture increased until 1986 and then started to decline, although it remained at 2 percent of ecoregion in 2000. The extent of grassland/shrubland was negatively correlated to agriculture, and it was at its lowest point in 1986. In contrast, the amount of area classified as water, wetland, and mechanically disturbed (primarily reservoir drawdown) fluctuated during each time period (table 3). Conversions between grassland/shrubland and agriculture and between water, wetland, and mechanically disturbed account for the majority of change observed in the ecoregion (table 4).

During the 27-year study period, the extent of urban developed land increased from 39 km$^2$ to 61 km$^2$, with most expansion occurring near cities such as Cheyenne and Rock Springs, Wyoming. The amount of forest land decreased by

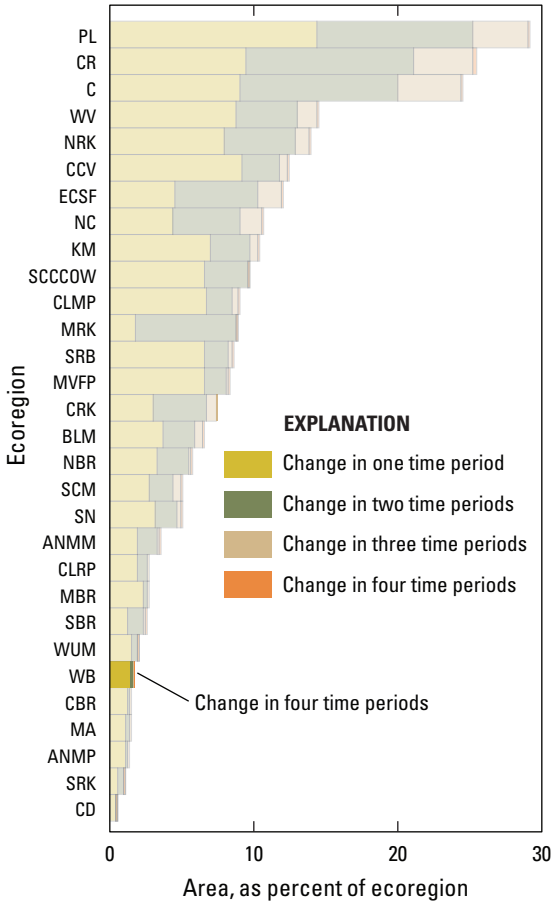


**Figure 6.** Overall spatial change in Wyoming Basin Ecoregion (WB; darker bars) compared with that of all 30 Western United States ecoregions (lighter bars). Each horizontal set of bars shows proportions of ecoregion that changed during one, two, three, or four time periods; highest level of spatial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

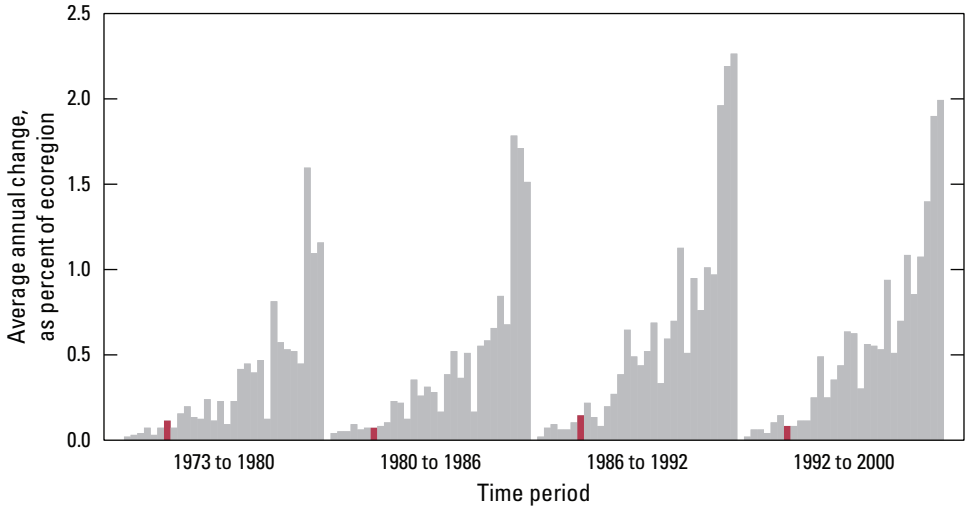


**Figure 7.** Estimates of land-cover change per time period, normalized to annual rates of change for all 30 Western United States ecoregions (gray bars). Estimates of change for Wyoming Basin Ecoregion are represented by red bars in each time period.

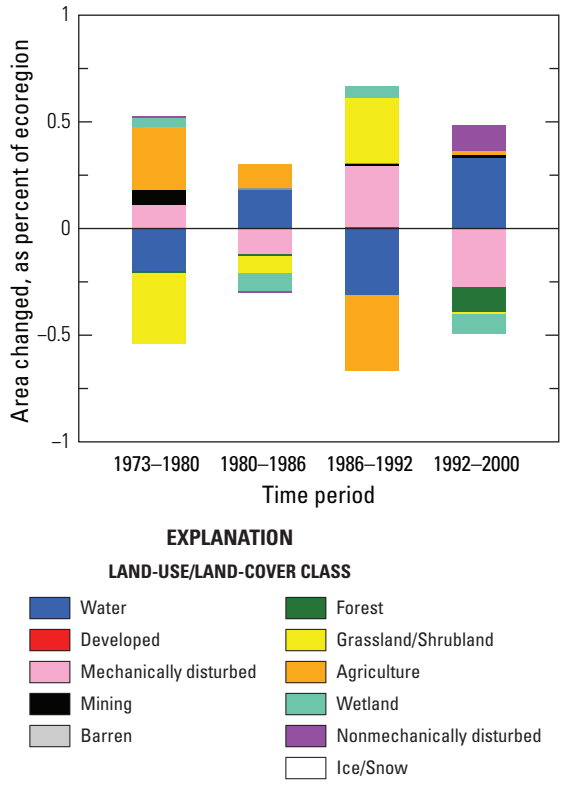


**Figure 8.** Normalized average net change in Wyoming Basin Ecoregion by time period for each land-cover class. Bars above zero axis represent net gain, whereas bars below zero represent net loss. Note that not all land-cover classes shown in explanation may be represented in figure. See appendix 3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

4.2 percent, from 4,205 km$^2$ in 1973 to 4,027 km$^2$ in 2000. Nonmechanical disturbances were rare (table 3; figure 8).

The area covered by energy-related development (mining land-cover class) also was relatively low (0.3 percent in 2000; table 3); however, this area increased substantially, from 301 km$^2$ in 1973 to 435 km$^2$ in 2000 (table 3). Thus, a 44 percent increase occurred in the area impacted by energy development during the 27-year study period. Most of the mining increases took place between 1973 and 1980, during which time mining land cover is estimated to have increased by nearly 30 percent (fig. 8) following the energy boom that occurred in the 1970s.

The amount of area affected by mining may be underestimated, owing to the study's sampling design and the random sample-block selection process, as well as the 60-m resolution of the data. Almost all of the blocks fell outside areas experiencing major energy development. Some sample blocks (143, 533, 622) contained some energy development, but major oil and gas fields such as the Jonah and Pinedale fields were not sampled in the random selection process. Many oil- and gas-well pads are less than 60 m$^2$ and, thus, did not meet the minimum mapping-unit size in this study. Additionally, the extensive transportation networks required to access the oil- and gas-well pads have not been mapped. Thus, the measures of area in the mining and developed land-use/land-cover classes can be interpreted as highly conservative estimates of the true area affected.

Today (2012), Wyoming is in the midst of another energy boom. High demand and increasing prices for oil and gas since 2000 have rapidly transformed Wyoming's economy and landscape. Information from this project and other USGS projects that are examining the impacts of energy development, as well as from anecdotal accounts, indicates that the current rate of energy development is greatly outpacing past rates.

The fact that a large proportion of the Wyoming Basin Ecoregion is public land will constrain certain types of

land-use/land-cover change. Energy exploration and grazing are extensive on both public and private lands, but intensive agricultural and urban development is limited to private lands. This constraint, in addition to a harsh and dry climate, generally limits agriculture to riparian areas where water is directly available for irrigation. The extent of agriculture fluctuated during the study period and is likely to continue to fluctuate as demand for agricultural products changes over time.

Urban development also will be both constrained and driven by land-ownership patterns. On the one hand, public lands preclude housing and urban development. On the other hand, public lands provide natural amenities that often attract low-density-housing development. The greatest increases in developed land occurred between 1986 and 1992, following the energy boom of the mid-1970s, and between 1992 and 2000 (fig. 8). Just as this study provides a conservative estimate of the area impacted by mining, it is probably providing a highly conservative estimate of the area impacted by development.

Most of the Wyoming Basin Ecoregion has not experienced substantial land-use/land-cover change during the past three decades. Large expanses of land remain largely free of development and agriculture; however, Wyoming's mineral resources are abundant, and the only limit to energy development may be the cost of extraction. As demands for energy increase with population growth, energy-related landscape change in the Wyoming Basin Ecoregion will increase. The overall footprint of energy development may be small, but the impacts on wildlife and water quality from mines, well pads, and related transportation infrastructure may extend out for some distance. Balancing wildlife and habitat conservation with the economic and social benefits of agricultural land uses and energy development will become increasingly challenging as the landscape in the Wyoming Basin Ecoregion continues to change.

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

[Most sample pixels remained unchanged (98.2 percent), whereas 1.8 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 | 1.4 | 0.7 | 0.6 | 2.1 | 0.5 | 35.6 |
| 2 | 0.3 | 0.2 | 0.1 | 0.5 | 0.1 | 41.9 |
| 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 56.4 |
| 4 | 0.2 | 0.3 | −0.1 | 0.5 | 0.2 | 97.5 |
| Overall spatial change | 1.8 | 0.9 | 1.0 | 2.7 | 0.6 | 32.0 |

**Table 2.** Raw estimates of change in Wyoming 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 | 0.8 | 0.4 | 0.4 | 1.2 | 0.3 | 34.7 | 0.1 |
| 1980–1986 | 0.4 | 0.3 | 0.1 | 0.7 | 0.2 | 47.1 | 0.1 |
| 1986–1992 | 0.8 | 0.7 | 0.2 | 1.5 | 0.5 | 54.0 | 0.1 |
| 1992–2000 | 0.7 | 0.5 | 0.2 | 1.1 | 0.3 | 46.5 | 0.1 |
| Estimate of change, in square kilometers | | | | | | | |
| 1973–1980 | 1,018 | 523 | 495 | 1,541 | 354 | 34.7 | 145 |
| 1980–1986 | 550 | 383 | 167 | 933 | 259 | 47.1 | 92 |
| 1986–1992 | 1,087 | 868 | 219 | 1,955 | 587 | 54.0 | 181 |
| 1992–2000 | 858 | 591 | 267 | 1,449 | 399 | 46.5 | 107 |

**Table 3.** Estimated area (and margin of error) of each land-cover class in Wyoming 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 | 0.5 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.6 | 0.5 | 3.3 | 1.9 | 92.3 | 2.4 | 1.9 | 1.4 | 1.2 | 0.5 | 0.0 | 0.0 |
| 1980 | 0.3 | 0.2 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.3 | 0.6 | 0.5 | 3.3 | 1.9 | 92.0 | 2.5 | 2.2 | 1.5 | 1.2 | 0.5 | 0.0 | 0.0 |
| 1986 | 0.5 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.6 | 0.5 | 3.2 | 1.9 | 91.9 | 2.5 | 2.3 | 1.5 | 1.1 | 0.5 | 0.0 | 0.0 |
| 1992 | 0.2 | 0.1 | 0.0 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.6 | 0.5 | 3.2 | 1.9 | 92.2 | 2.3 | 2.0 | 1.1 | 1.2 | 0.5 | 0.0 | 0.0 |
| 2000 | 0.5 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.6 | 0.5 | 3.1 | 1.7 | 92.2 | 2.3 | 2.0 | 1.2 | 1.1 | 0.5 | 0.1 | 0.2 |
| Net change | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | −0.1 | 0.2 | −0.1 | 0.7 | 0.1 | 0.7 | −0.1 | 0.1 | 0.1 | 0.2 |
| Gross change | 1.1 | 1.4 | 0.0 | 0.0 | 0.8 | 0.9 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.2 | 1.1 | 0.6 | 0.9 | 0.6 | 0.5 | 0.4 | 0.1 | 0.2 |
| Area, in square kilometers | | | | | | | | | | | | | | | | | | | | |
| 1973 | 659 | 576 | 39 | 40 | 6 | 9 | 301 | 289 | 749 | 581 | 4,205 | 2,426 | 118,962 | 3,124 | 2,511 | 1,812 | 1,483 | 642 | 0 | 0 |
| 1980 | 403 | 276 | 40 | 40 | 152 | 219 | 390 | 371 | 751 | 581 | 4,193 | 2,423 | 118,539 | 3,192 | 2,886 | 1,917 | 1,548 | 620 | 13 | 19 |
| 1986 | 638 | 545 | 42 | 41 | 1 | 1 | 397 | 369 | 755 | 581 | 4,184 | 2,421 | 118,426 | 3,206 | 3,028 | 1,967 | 1,444 | 608 | 0 | 0 |
| 1992 | 234 | 164 | 57 | 43 | 362 | 397 | 416 | 371 | 759 | 581 | 4,183 | 2,421 | 118,825 | 2,958 | 2,570 | 1,476 | 1,508 | 603 | 0 | 0 |
| 2000 | 660 | 566 | 61 | 44 | 10 | 7 | 435 | 380 | 760 | 581 | 4,027 | 2,229 | 118,822 | 2,947 | 2,595 | 1,498 | 1,388 | 586 | 157 | 229 |
| Net change | 1 | 21 | 23 | 13 | 4 | 11 | 134 | 95 | 10 | 16 | −178 | 230 | −140 | 857 | 85 | 845 | −96 | 69 | 157 | 229 |
| Gross change | 1,412 | 1,769 | 23 | 13 | 1,033 | 1,221 | 140 | 101 | 22 | 16 | 179 | 231 | 1,422 | 807 | 1,113 | 831 | 589 | 560 | 183 | 231 |

**Table 4.** Principal land-cover conversions in Wyoming 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 | 423 | 339 | 229 | 0.3 | 41.6 |
| | Water | Mechanically disturbed | 150 | 219 | 148 | 0.1 | 14.8 |
| | Water | Wetland | 122 | 170 | 115 | 0.1 | 11.9 |
| | Grassland/Shrubland | Mining | 89 | 84 | 57 | 0.1 | 8.7 |
| | Agriculture | Grassland/Shrubland | 82 | 109 | 74 | 0.1 | 8.1 |
| | Other | Other | 152 | n/a | n/a | 0.1 | 14.9 |
| | | Totals | 1,018 | | | 0.8 | 100.0 |
| 1980–1986 | Grassland/Shrubland | Agriculture | 135 | 88 | 59 | 0.1 | 24.6 |
| | Mechanically disturbed | Water | 133 | 195 | 132 | 0.1 | 24.3 |
| | Wetland | Water | 107 | 155 | 105 | 0.1 | 19.5 |
| | Grassland/Shrubland | Wetland | 43 | 41 | 28 | 0.0 | 7.9 |
| | Wetland | Grassland/Shrubland | 40 | 29 | 19 | 0.0 | 7.2 |
| | Other | Other | 91 | n/a | n/a | 0.1 | 16.6 |
| | | Totals | 550 | | | 0.4 | 100.0 |
| 1986–1992 | Agriculture | Grassland/Shrubland | 498 | 716 | 484 | 0.4 | 45.8 |
| | Water | Mechanically disturbed | 333 | 397 | 269 | 0.3 | 30.6 |
| | Water | Wetland | 82 | 113 | 77 | 0.1 | 7.5 |
| | Grassland/Shrubland | Agriculture | 39 | 33 | 22 | 0.0 | 3.6 |
| | Grassland/Shrubland | Mechanically disturbed | 23 | 32 | 22 | 0.0 | 2.1 |
| | Other | Other | 112 | n/a | n/a | 0.1 | 10.3 |
| | | Totals | 1,087 | | | 0.8 | 100.0 |
| 1992–2000 | Mechanically disturbed | Water | 336 | 397 | 268 | 0.3 | 39.2 |
| | Forest | Nonmechanically disturbed | 157 | 229 | 155 | 0.1 | 18.3 |
| | Wetland | Water | 88 | 121 | 82 | 0.1 | 10.3 |
| | Grassland/Shrubland | Agriculture | 77 | 75 | 50 | 0.1 | 9.0 |
| | Agriculture | Grassland/Shrubland | 59 | 54 | 37 | 0.0 | 6.8 |
| | Other | Other | 141 | n/a | n/a | 0.1 | 16.5 |
| | | Totals | 858 | | | 0.7 | 100.0 |
| 1973–2000 (overall) | Grassland/Shrubland | Agriculture | 675 | 456 | 309 | 0.5 | 19.2 |
| | Agriculture | Grassland/Shrubland | 641 | 874 | 591 | 0.5 | 18.3 |
| | Water | Mechanically disturbed | 486 | 611 | 413 | 0.4 | 13.8 |
| | Mechanically disturbed | Water | 472 | 587 | 397 | 0.4 | 13.4 |
| | Wetland | Water | 217 | 277 | 187 | 0.2 | 6.2 |
| | Other | Other | 1,022 | n/a | n/a | 0.8 | 29.1 |
| | | Totals | 3,513 | | | 2.7 | 100.0 |

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