

## Chapter 26

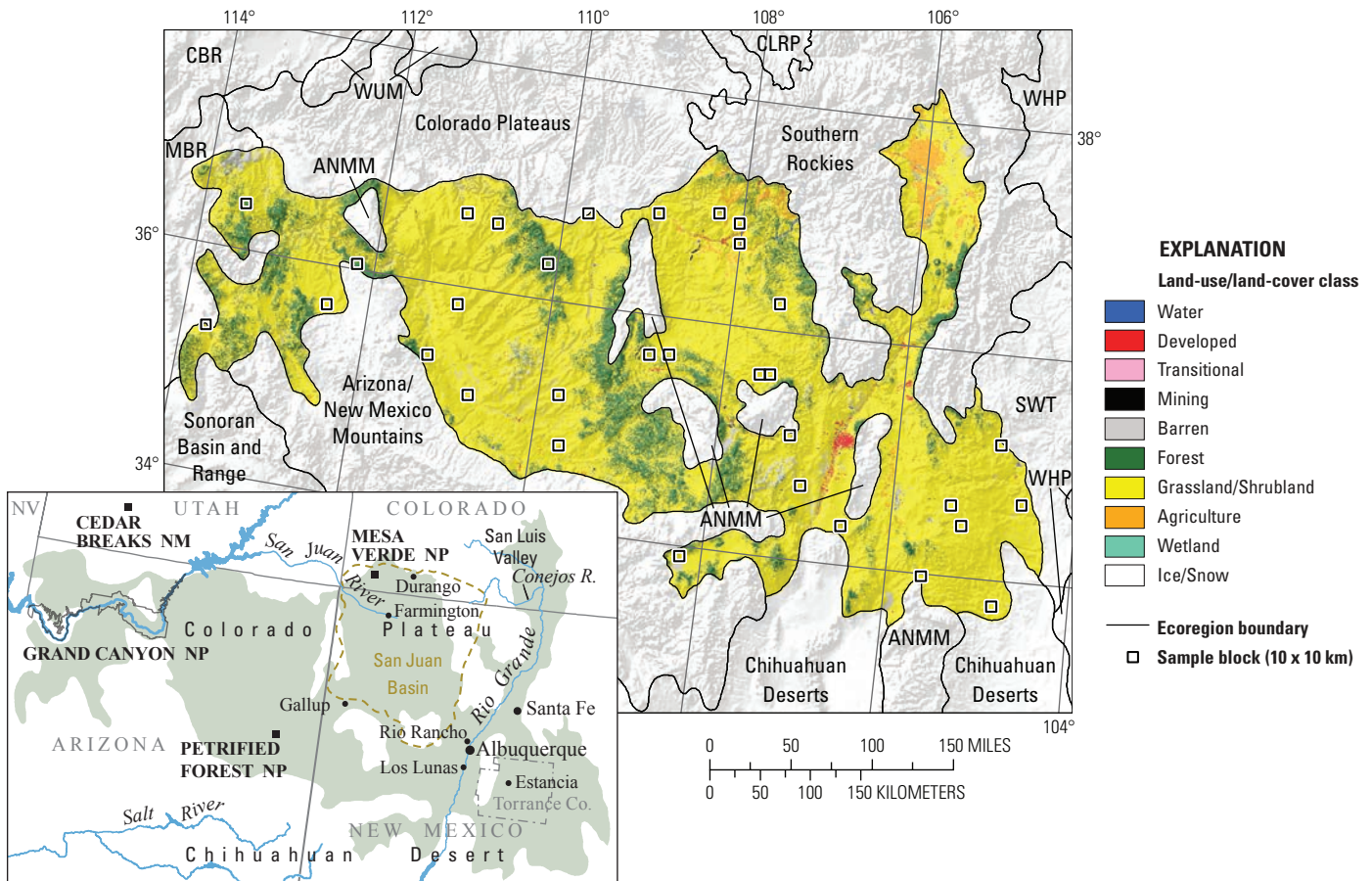
# Arizona/New Mexico Plateau Ecoregion

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## Ecoregion Description

Situated between ecoregions of distinctly different topographies and climates, the Arizona/New Mexico Plateau Ecoregion represents a large area of approximately 192,869 km<sup>2</sup> (74,467 mi<sup>2</sup>) that stretches across northern Arizona, central and northwestern New Mexico, and parts of southwestern Colorado; in addition, a small part extends into southeastern Nevada (fig. 1) (Omernik, 1987; U.S. Environmental Protection Agency, 1997). Forested, mountainous terrain borders the ecoregion

on the northeast (Southern Rockies Ecoregion) and southwest (Arizona/New Mexico Mountains Ecoregion). Warmer and drier climates exist to the south (Chihuahuan Deserts Ecoregion) and west (Mojave Basin and Range Ecoregion). The semiarid grasslands of the western Great Plains are to the east (Southwestern Tablelands Ecoregion), and the tablelands of the Colorado Plateau in Utah and western Colorado lie to the north (Colorado Plateaus Ecoregion). The Arizona/New Mexico Plateau Ecoregion occupies a significant portion of the southern half of the Colorado Plateau.



**Figure 1.** Map of Arizona/New Mexico Plateau 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: Southwestern Tablelands (SWT) and Western High Plains (WHP). See appendix 3 for definitions of land-use/land-cover classifications.

The Arizona/New Mexico Plateau Ecoregion is covered predominantly in a mosaic of sparse semiarid grassland and desert-scrub species. Major washes and river courses often contain riparian canopies of cottonwood (*Populus deltoides*), desert willow (*Chilopsis linearis*), and salt cedar (*Tamarix* spp.). Juniper (*Juniperus* spp.) and pinyon (*Pinus* spp.) trees are located in the upland areas, with ponderosa pine (*Pinus ponderosa*) forests present at the highest elevations. The climate in the ecoregion is mostly semiarid, but regional topography causes annual precipitation to vary substantially, ranging from 127 to 890 mm (Daly and others, 2002). Most of the ecoregion, however, averages between 152 and 254 mm of precipitation from southwestern monsoonal summer thunderstorms and winter frontal storms. The coldest areas can dip below  $-17.8^{\circ}\text{C}$  in winter, and the hottest summer temperatures can exceed  $36^{\circ}\text{C}$  (Western Regional Climate Center, 2009).

Albuquerque, New Mexico, is the largest urban area, with a 2000 census population of 448,607, followed by Santa Fe, New Mexico, with a population of 62,203. Numerous smaller communities exist within the ecoregion, but only five municipalities had a 2000 census count greater than 10,000: Rio Rancho, Farmington, Gallup, and Los Lunas, New Mexico, and Durango, Colorado (U.S. Census Bureau, 2001a, 2001b). Over 55 percent of the ecoregion is federal land, with the majority occupying one of 29 different Indian reservations and pueblos. The largest of these tribal lands is the Navajo Nation, with 41,562 km<sup>2</sup> within the Arizona/New Mexico Plateau Ecoregion. The next largest federal landholders in the ecoregion are the Bureau of Land Management, Forest Service, and National Park Service. There are 15 National Park Service areas within the ecoregion; many of the national parks and monuments are dedicated to preserving the rich history and remnants from the Southwest's ancient native cultures. Prominent national parks in the ecoregion are the Grand Canyon and the Petrified Forest in Arizona and Mesa Verde in Colorado.

Because of limited rainfall in the ecoregion, crop production is found primarily in close proximity to natural water sources such as the Rio Grande, San Juan River, and Conejos River. The high mountains surrounding the fertile San Luis Valley in south-central Colorado and northern New Mexico provide snowmelt, which supports extensive farming in that area (McNoldy and Doesken, 2007). Likewise, there is considerable agriculture in the closed Estancia basin region in Tarrant County, New Mexico, which is "one of the most productive agricultural counties in the United States" (Tarrant County, New Mexico, 2009).

With over 33 percent of the Arizona/New Mexico Plateau Ecoregion designated as tribal lands, sheep ranching, cattle ranching, and farming (dry and some irrigated) continue to be the primary traditional economic activities for many Native Americans (Grahame and Sisk, 2002). The effect of low regional precipitation levels that can support only scant forage has been exacerbated by a long-term trend toward aridity in this part of the ecoregion (Karl and others, 2009). Combined with historical overgrazing and desertification, the condition of the rangeland in many areas is poor. As early as 1933, the

Bureau of Indian Affairs determined that two-thirds of the Navajo rangeland had been overgrazed (Grahame and Sisk, 2002). Increases in wind erosion and sand-dune mobility that have resulted from current drought conditions across northeastern Arizona have further degraded rangelands (Ferguson and Crimmins, 2009).

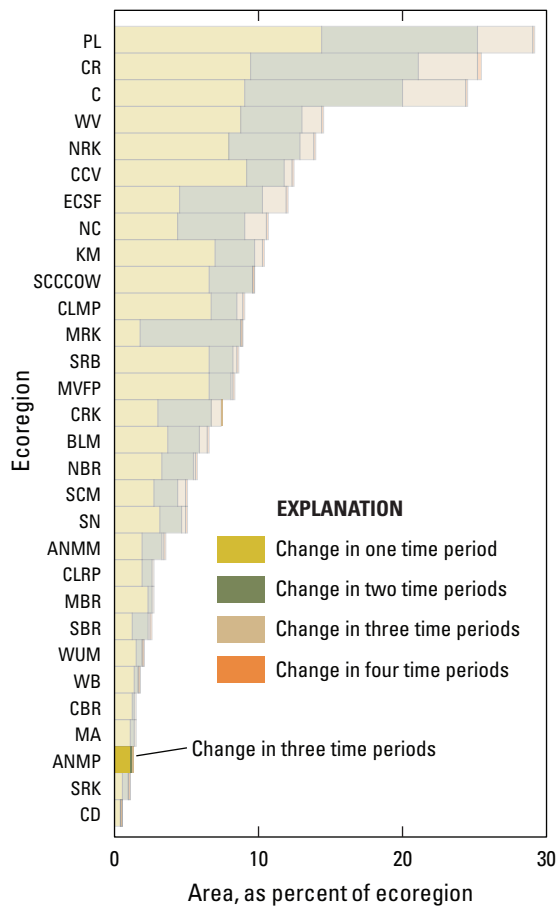
Mining also contributes to local economies in parts of the Arizona/New Mexico Plateau Ecoregion. The San Juan Basin in northwestern New Mexico and southwestern Colorado was at one time the second largest natural-gas reserve in the United States (La Plata County Energy Council, 2009), having 20,000 producing wells (Ortega, 2009). Additionally, the Peabody Western Coal Company mines about 8.5 million tons of coal annually through lease agreements with the Navajo Nation and Hopi Tribe (U.S. Office of Surface Mining, 2008). As the ecoregion's largest city, Albuquerque is also its largest economy. Located at the crossroads of Interstate Highways 25 and 70, Albuquerque has a "diverse economic base consisting of government, services, trade, agriculture, tourism, manufacturing, and research and development" (City-Data.com, 2009). Kirtland Air Force Base is the largest employer in the Albuquerque metropolitan area (Albuquerque Economic Development, Inc., 2010).

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

The Arizona/New Mexico Plateau Ecoregion experienced very little land-cover change during the study period (fig. 2). An estimated 1.2 percent of the ecoregion (2,380 km<sup>2</sup>) converted to other land-cover classes during the study period. Estimates reveal that 1.1 percent of the ecoregion changed only once during the study period, and 0.1 percent changed twice (table 1). However, standard error is high as a proportion of overall spatial change, which is not unusual for an ecoregion with little change. Compared to other western United States ecoregions, the Arizona/New Mexico Plateau Ecoregion had the lowest amount of change other than the Chihuahuan Deserts Ecoregion and the Southern Rockies Ecoregion. Low estimates of land-cover change are consistent with other ecoregions in the Southwest (figs. 2, 3).

Estimated land-cover change per time period started with 0.2 percent between 1973 and 1980, and it increased 0.1 percent each time period thereafter, to reach 0.5 percent between 1992 and 2000. When the change estimates are normalized to account for the varying lengths of time between satellite imagery dates, the average rate of change per year was less than 100 km<sup>2</sup> between 1973 and 1980 and between 1980 and 1986, 131 km<sup>2</sup> between 1986 and 1990, and 111 km<sup>2</sup> between 1992 and 2000 (table 2; fig. 3).

Results showed that grassland/shrubland and forest were the predominant land-cover classes within the ecoregion. Grassland/shrubland encompassed approximately 78 percent of the land cover in each time period, whereas forest covered



**Figure 2.** Overall spatial change in Arizona/New Mexico Plateau Ecoregion (ANMP; 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 Arizona/New Mexico Plateau Ecoregion (three time periods) labeled for clarity. See table 2 for years covered by each time period. See appendix 2 for key to ecoregion abbreviations.

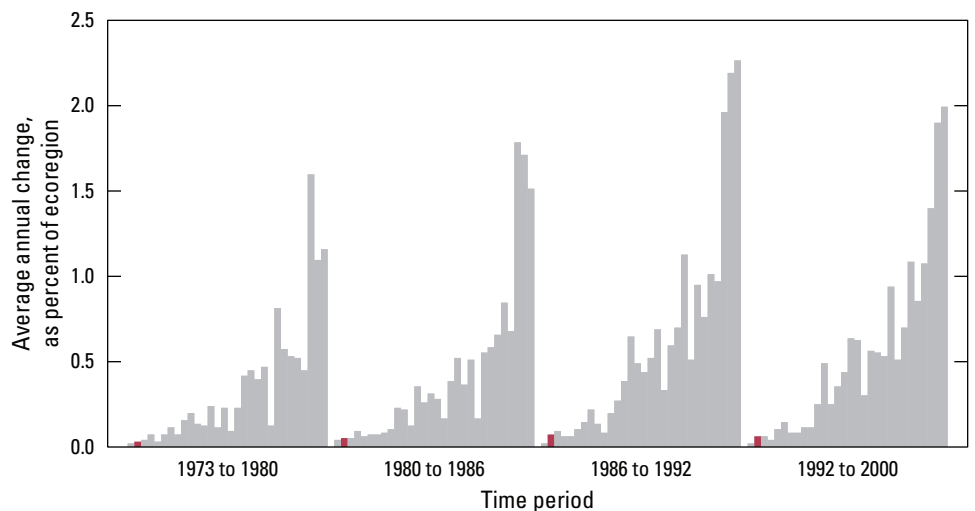
19 percent (table 3). The barren class accounted for 1.7 percent of the land cover, and the water, developed, mining, agriculture, wetland, and nonmechanically disturbed classes collectively made up the remaining land cover.

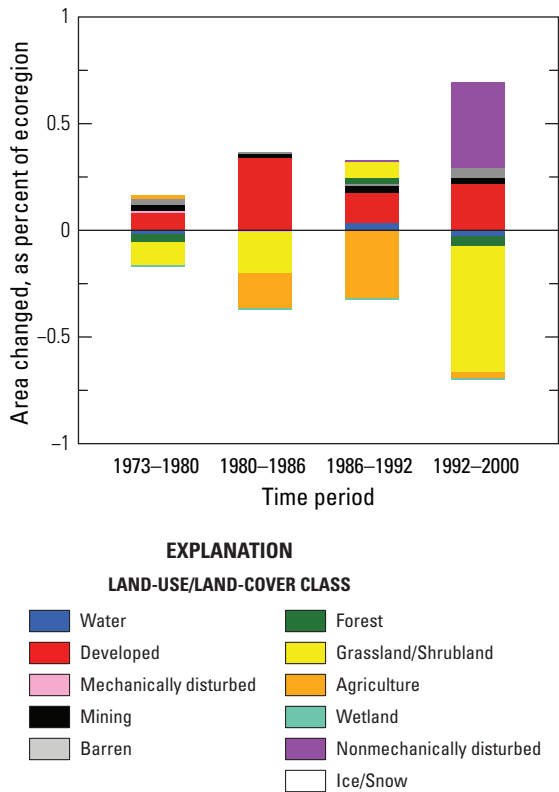
The developed and grassland/shrubland classes had the greatest net change during the study period. Grassland/shrubland declined by 0.5 percent (810 km<sup>2</sup>), from 78.0 to 77.6 percent of the ecoregion. The developed class increased by 144 percent during the study period but remained only 0.7 percent of the ecoregion in 2000. The remaining classes experienced minimal net change (table 3).

Examination of net-change values alone can mask land-cover dynamics that occur within a given study period. Figure 4 illustrates the fluctuations that occurred in land-cover classes between time periods. Changes in grassland/shrubland occurred at variable rates over the study period; a slight increase occurred between 1986 and 1992, and the greatest decrease occurred between 1992 and 2000. The developed class increased the most between 1980 and 1986 but consistently gained over the entire study period. Mobility in active sand dunes was mapped during the study period, and it is conceivable the intense drought that began in this area in 1996 allowed for more sand deposition and active transport than in previous years, possibly explaining the 80 km<sup>2</sup> growth of the barren class over the study period. Research by U.S. Geological Survey scientists confirmed that drought conditions on the Navajo Nation Reservation have accelerated destabilization and mobility of sand dunes, owing to the detrimental effect on stabilizing vegetation (Redsteer and Block, 2004).

The most common land-cover conversions between 1973 and 2000 involved the grassland/shrubland, agriculture, and developed classes (table 4). Grassland/shrubland to developed (533 km<sup>2</sup>) was the primary conversion between 1973 and 2000, followed by agriculture reverting to grassland/shrubland (470 km<sup>2</sup>). Fire caused the next most common conversion of grassland/shrubland to nonmechanically disturbed, which occurred between 1992 and 2000 (393 km<sup>2</sup>). Agriculture to

**Figure 3.** 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 Arizona/New Mexico Plateau Ecoregion are represented by red bars in each time period.





**Figure 4.** Normalized average net change in Arizona/New Mexico Plateau 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.

developed was the fourth most common land-cover conversion. The overall net loss in agriculture (to grassland/shrubland and developed) was 30.8 percent of the area occupied by agriculture in 1973. However, although fieldwork confirmed the presence of many of the conversions listed in table 4, the margins of error in the table demonstrate the high degree of uncertainty derived from this study’s interpretations.

The Arizona/New Mexico Plateau Ecoregion experienced little change in major land-cover classes between 1973 and 2000. Except for the Albuquerque metropolitan area, the ecoregion is sparsely populated, consisting mainly of large expanses of grassland/shrubland devoted to grazing (fig. 5). In an ecoregion where 78 percent of the land cover is grassland/shrubland, most land-cover change would be expected to occur in that dominant class. Change in grassland/shrubland class was distributed throughout the ecoregion, occurring in 26 out of 32 study blocks.

Change in the agriculture class occurred mainly in study blocks located along the San Juan River or in or near the Estancia basin region of central New Mexico. The largest observed area of former agricultural lands had evidence of abandoned canals leading from the nearby river. Statistics for the ecoregion’s largest agricultural area, the San Luis Valley,

indicated a small decrease (1.5 percent) in acreage devoted to farming between 1987 and 2002 (U.S. Department of Agriculture, 1992, 2002).

The Albuquerque metropolitan area is the location of most of the growth of developed land in the ecoregion. In 2000, Albuquerque’s population was 448,607 (U.S. Census Bureau, 2001b), having grown from 243,751 in 1970 (U.S. Census Bureau, 1973). This 84 percent growth rate is substantial; moreover, the entire Albuquerque metropolitan area grew 125.7 percent within this same time frame (U.S. Census Bureau, 1973, 2001b). This population growth is reflected in the continually increasing acreage devoted to urban development. A 1997 U.S. Geological Survey study that mapped urban land use from aerial photographs noted that the Albuquerque metropolitan area had grown from 49,746 to 84,889 acres between 1973 and 1991, a 71 percent increase in area (Braun and others, 1998). Growth of the Albuquerque metropolitan area is expected to continue, with population projected to hit one million by 2021 or before (Siemers, 2007).

Coal mining in the Navajo Nation and the prolific amount of coal-bed methane available in the San Juan Basin will remain important and have many potential impacts on the Arizona/New Mexico Plateau Ecoregion. The area occupied by mining more than doubled during the study period (although the area remained as roughly 0.1 percent of ecoregion area). This small reported area might be attributable to the fact that no areas of coal mining were captured in our study blocks, as well as the fact that the footprint of new oil or gas wells mapped in study blocks within the San Juan Basin was minimal. Increased mining activity in the future may cause more land-cover change in the ecoregion, especially in the San Juan Basin.

The small land-cover changes that did occur during the study period were mainly due to increased urbanization, at the expense of natural grassland/shrubland and agricultural lands, as well as agricultural abandonment. It is important to keep in mind, however, that these land-cover changes were minor, and they represent a small percentage of the overall land cover of the ecoregion.



**Figure 5.** Rangeland southwest of Albuquerque, New Mexico.

**Table 1.** Percentage of Arizona/New Mexico Plateau Ecoregion land cover that changed at least one time during study period (1973–2000) and associated statistical error.

[Most sample pixels remained unchanged (98.8 percent), whereas 1.2 percent changed at least once throughout study period. Two dashes (--) indicate that, because zero pixels changed four times during study period, relative error is not calculable]

Number of changes	Percent of ecoregion	Margin of error (+/- %)	Lower bound (%)	Upper bound (%)	Standard error (%)	Relative error (%)
1	1.1	0.6	0.5	1.8	0.4	38.9
2	0.1	0.0	0.0	0.1	0.0	34.3
3	0.0	0.0	0.0	0.0	0.0	39.2
4	0.0	0.0	0.0	0.0	0.0	--
Overall spatial change	1.2	0.7	0.6	1.9	0.5	36.9

**Table 2.** Raw estimates of change in Arizona/New Mexico Plateau 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 time 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	0.2	0.1	0.1	0.3	0.1	40.2	0.0
1980–1986	0.3	0.3	0.0	0.5	0.2	66.4	0.0
1986–1992	0.4	0.3	0.1	0.7	0.2	44.6	0.1
1992–2000	0.5	0.3	0.1	0.8	0.2	49.2	0.1
Estimate of change, in square kilometers							
1973–1980	422	250	171	672	170	40.2	60
1980–1986	513	503	10	1,016	341	66.4	85
1986–1992	789	520	269	1,308	352	44.6	131
1992–2000	891	647	245	1,538	438	49.2	111

**Table 3.** Estimated area (and margin of error) of each land-cover class in Arizona/New Mexico Plateau 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	0.1	0.0	0.3	0.2	0.0	0.0	0.1	0.0	1.7	1.6	18.8	6.1	78.0	6.0	0.8	0.8	0.3	0.3	0.0	0.0
1980	0.1	0.0	0.3	0.3	0.0	0.0	0.1	0.1	1.7	1.6	18.8	6.1	78.0	6.0	0.8	0.7	0.3	0.3	0.0	0.0
1986	0.1	0.0	0.5	0.4	0.0	0.0	0.1	0.1	1.7	1.6	18.8	6.1	77.9	6.0	0.7	0.6	0.3	0.3	0.0	0.0
1992	0.1	0.1	0.6	0.5	0.0	0.0	0.1	0.1	1.7	1.6	18.8	6.1	77.9	6.0	0.6	0.6	0.2	0.3	0.0	0.0
2000	0.1	0.0	0.7	0.6	0.0	0.0	0.1	0.1	1.7	1.6	18.8	6.1	77.6	5.9	0.5	0.6	0.2	0.3	0.2	0.3
Net change	0.0	0.0	0.4	0.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-0.4	0.5	-0.2	0.3	0.0	0.0	0.2	0.3
Gross change	0.1	0.0	0.4	0.5	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.1	0.9	0.5	0.3	0.3	0.0	0.0	0.2	0.3
Area, in square kilometers																				
1973	111	83	524	463	0	0	102	93	3,289	2,999	36,322	11,852	150,513	11,487	1,523	1,447	486	529	0	0
1980	99	82	606	518	8	9	129	120	3,313	2,998	36,283	11,843	150,403	11,487	1,543	1,423	485	529	0	0
1986	104	85	934	856	3	5	147	122	3,318	2,998	36,282	11,842	150,212	11,506	1,385	1,231	484	526	0	0
1992	138	106	1,067	964	8	7	180	135	3,330	2,998	36,305	11,838	150,281	11,536	1,073	1,151	481	521	6	9
2000	116	79	1,277	1,187	3	4	212	155	3,369	2,996	36,265	11,833	149,703	11,471	1,053	1,130	475	514	396	580
Net change	5	40	753	900	3	4	110	76	80	76	-57	68	-810	981	-470	517	-10	16	396	580
Gross change	168	96	753	900	27	20	110	76	102	86	178	148	1685	967	590	512	13	16	409	580

**Table 4.** Principal land-cover conversions in Arizona/New Mexico Plateau 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 <sup>2</sup> )	Margin of error (+/- km <sup>2</sup> )	Standard error (km <sup>2</sup> )	Percent of ecoregion	Percent of all changes
1973–1980	Grassland/Shrubland	Agriculture	104	101	68	0.1	24.7
	Agriculture	Grassland/Shrubland	62	66	45	0.0	14.7
	Grassland/Shrubland	Developed	59	73	50	0.0	14.0
	Forest	Grassland/Shrubland	38	53	36	0.0	9.0
	Grassland/Shrubland	Barren	31	33	22	0.0	7.4
	Other	Other	127	n/a	n/a	0.1	30.1
	Totals		422			0.2	100.0
1980–1986	Grassland/Shrubland	Developed	172	214	145	0.1	33.6
	Agriculture	Developed	151	221	150	0.1	29.5
	Agriculture	Grassland/Shrubland	49	55	37	0.0	9.5
	Grassland/Shrubland	Agriculture	40	39	27	0.0	7.8
	Grassland/Shrubland	Water	22	12	8	0.0	4.2
	Other	Other	79	n/a	n/a	0.0	15.4
	Totals		513			0.3	100.0
1986–1992	Agriculture	Grassland/Shrubland	327	445	302	0.2	41.4
	Grassland/Shrubland	Developed	113	116	79	0.1	14.4
	Grassland/Shrubland	Forest	96	133	90	0.0	12.2
	Forest	Grassland/Shrubland	61	83	56	0.0	7.8
	Grassland/Shrubland	Water	55	60	41	0.0	7.0
	Other	Other	137	n/a	n/a	0.1	17.3
	Totals		789			0.4	100.0
1992–2000	Grassland/Shrubland	Nonmechanically disturbed	393	575	390	0.2	44.1
	Grassland/Shrubland	Developed	188	212	143	0.1	21.1
	Forest	Grassland/Shrubland	53	77	52	0.0	6.0
	Grassland/Shrubland	Barren	42	43	29	0.0	4.8
	Agriculture	Grassland/Shrubland	32	35	24	0.0	3.6
	Other	Other	182	n/a	n/a	0.1	20.4
	Totals		891			0.5	100.0
1973–2000 (overall)	Grassland/Shrubland	Developed	533	598	405	0.3	20.4
	Agriculture	Grassland/Shrubland	470	467	316	0.2	18.0
	Grassland/Shrubland	Nonmechanically disturbed	393	575	390	0.2	15.0
	Agriculture	Developed	201	293	198	0.1	7.7
	Grassland/Shrubland	Agriculture	197	151	102	0.1	7.5
	Other	Other	821	n/a	n/a	0.4	31.4
	Totals		2,615			1.4	100.0

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