Status and Trends of Land Change in the Western United States—1973 to 2000
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Chapter 27

Chihuahuan Deserts Ecoregion

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Ecoregion Description

The Chihuahuan Desert is the largest of the North American deserts, extending from southern New Mexico and Texas deep into Mexico, with approximately 90 percent of its area falling south of the United States–Mexico border (Lowe, 1964, p. 24). The Chihuahuan Deserts Ecoregion covers approximately 174,472 km^2 (67,364 mi^2) within the United States, including much of west Texas, southern New Mexico, and a small portion of southeastern Arizona (Omernik, 1987; U.S. Environmental Protection Agency, 1997). The ecoregion is generally oriented from northwest to southeast, with the Madrean Archipelago Ecoregion to the west; the Arizona/New Mexico Mountains, Arizona/New Mexico Plateau, Southwestern Tablelands, and Western High Plains Ecoregions to the north; and the Edwards Plateau and Southern Texas Plains Ecoregions to the east (fig. 1).

The Chihuahuan Desert is distinguished from other hot deserts in the Southwest by its higher elevation and summer-dominant rainfall. The terrain consists of broad basins and valleys bordered by sloping alluvial fans and terraces, along with isolated mesas and mountains. The alluvial fans and basins

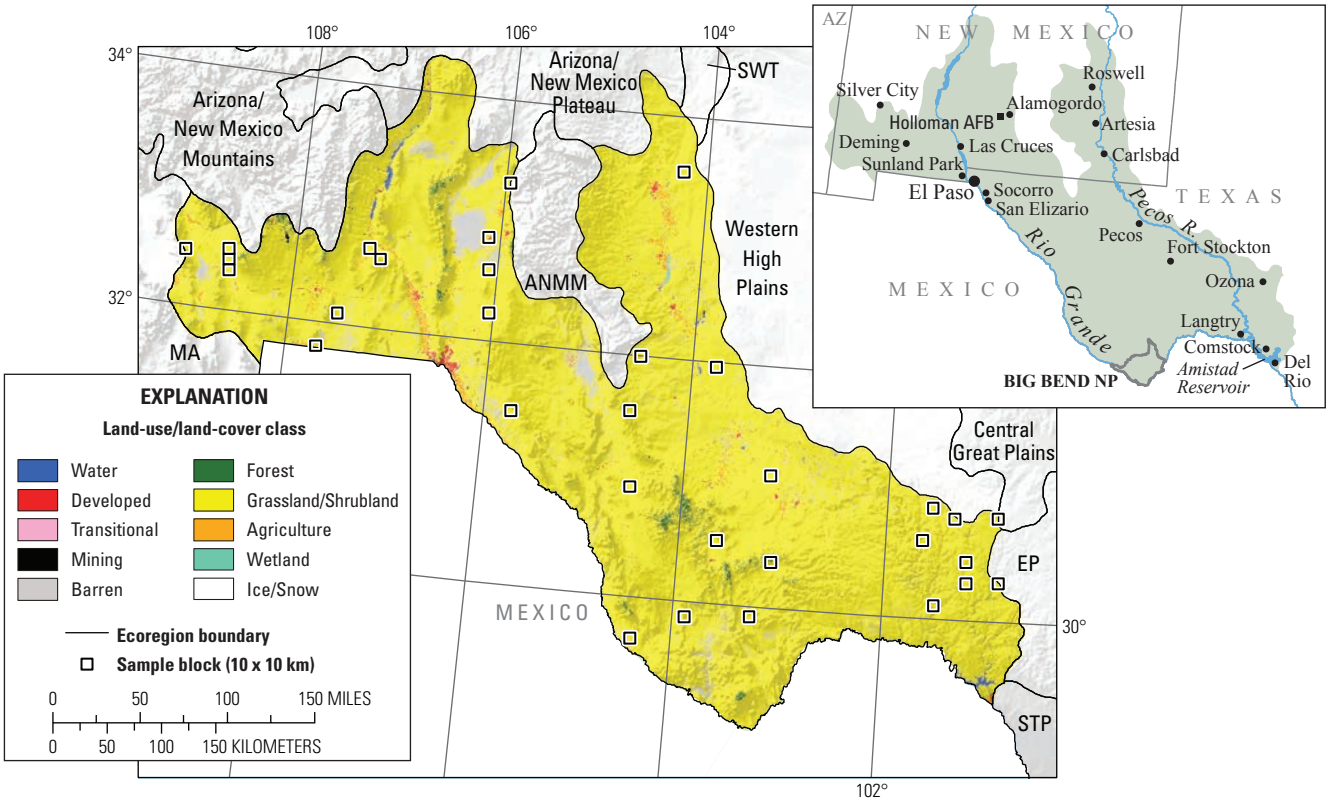

Figure 1. Map of Chihuahuan Deserts Ecoregion and surrounding ecoregions, showing land-use/land-cover classes from 1992 National Land Cover Dataset (Vogelmann and others, 2001); note that not all land-use/land-cover classes shown in explanation may be depicted on map; note also that, for this "Status 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 five Great Plains Ecoregions: Central Great Plains, Edwards Plateau (EP), Southern Texas Plains (STP), Southwestern Tablelands (SWT), and Western High Plains. See appendix 3 for definitions of land-use/land-cover classifications.

play an important role in groundwater recharge of the alluvial-basin aquifer systems that supply water to human populations along the Texas–Mexico border.

In the northern Chihuahuan Desert, annual precipitation averages 245 to 265 mm, with most of the precipitation falling in the summer (Gucker, 2006; Schmidt, 1983). Annual mean temperatures range from less than 12°C to greater than 20°C throughout the part of the Chihuahuan Desert that is north of the border (Daly and others, 2002). January minimum temperatures reach near or below freezing except along parts of the Rio Grande in Texas, where July maximum temperature. exceed 36°C (National Park Service, 2007).

Unique in its diversity of yucca (*Yucca* spp.) and agave (*Agave* spp.) species (fig. 2), the Chihuahuan Desert replaces the large cacti, creosote bush (*Larrea tridentata*), and bursage (*Asteraceae* spp.) communities of the Sonoran Desert to the west with large yuccas amid a sea of sparse grass and shrubs. Much of the Chihuahuan Deserts Ecoregion was once covered by healthy semidesert grasslands, but heavy livestock grazing coupled with frequent droughts during the 20th century transformed thousands of acres to desert shrubland, a process that still continues (Hoyt, 2002). Extensive areas of Chihuahuan semidesert grasslands are now dominated by creosote bush (*Larrea tridentata*), tarbush (*Flourensia cernua*), and mesquite (*Prosopis* spp.) (Buffington and Herbel, 1964, p. 139). McClaran and Van Devender (1995, p. 250–251) stated that livestock grazing and range-management programs since the 1870s have "led to soil erosion, destruction of those plants most palatable to livestock, changes in grassland fire ecology, the spread of nonnative plants, and a steady increase in the density of woody shrubs and brush." However, some have challenged these prevailing interpretations of influences on environmental degradation, highlighting the significance of climate variability as a catalyst and the need for a more stakeholder-driven research approach when evaluating ecological stewardship (West and Vásquez-León, 2008).

Water in the ecoregion is limited, which makes its major rivers, the Rio Grande (fig. 3) and the Pecos River (fig. 4), precious resources. These river valleys create large riparian areas, and major pockets of development are located along their corridors (New Mexico State University, 2007). Most of the water in the Chihuahuan Deserts Ecoregion is associated with the Rio Grande and the Pecos River and their tributaries. Reservoirs on these rivers provide water for the ecoregion's limited irrigated agriculture, as well as supply water for its major cities, including Las Cruces and Roswell, New Mexico, and El Paso, Texas.

Livestock, oil and gas production, and tourism are all important to the economy of the Chihuahuan Deserts Ecoregion (Conservation History Association of Texas, 2009). The Natural Resources Conservation Service reported that, in the Chihuahuan Desert Resource Conservation and Development area of Texas, 89 percent of the area was rangeland, and beef cattle, dairy cattle, pecans, onions, and various other crops were the major agricultural products (U.S. Department of Agriculture, 2008). Wheat (mostly irrigated), hay, sorghum,

Figure 2. Soaptree yucca (*Yucca elata*) near Texas–New Mexico border, south of Carlsbad, New Mexico. This is one of many types of yuccas and agaves indigenous to Chihuahuan Deserts Ecoregion.

Figure 3. View of Rio Grande from scenic overlook in Big Bend National Park, looking southwest into Mexico at Santa Elena Mountains.

Figure 4. View looking north over Pecos River, between Langtry and Comstock, Texas. This part of river contains water impounded by Amistad Reservoir, located farther downstream.

cotton, and a variety of fruits, nuts, and vegetables, as well as livestock, are important to the economy of all New Mexico counties in the ecoregion (U.S. Department of Agriculture, 2007). Farmers in the ecoregion also grow many varieties of chili peppers in the fertile fields along the Rio Grande in both New Mexico and Texas.

Federal lands make up approximately 28 percent of the Chihuahuan Deserts Ecoregion, with the majority managed by the Bureau of Land Management and the Department of Defense (for example, White Sands Missile Range, Holloman Air Force Base, and Fort Bliss); these military installations are a vital part of the local economies (Las Cruces and Alamogordo, New Mexico, and El Paso, Texas, respectively). Approximately 4,460 km^2 are managed by the National Park Service within seven park units, and these represent the nation's most significant areas of preserved Chihuahuan Desert landscape (National Park Service, 2005). White Sands National Monument and Carlsbad Caverns National Park in New Mexico and Big Bend National Park in Texas are three of the more notable parks within the ecoregion.

Contemporary Land-Cover Change (1973 to 2000)

The Chihuahuan Deserts Ecoregion had very little land-cover change during the study period (fig. 5). An estimated 0.5 percent of the ecoregion (822 km^2) was converted to other land-cover types (table 1). The standard error of 0.2 percent is high in proportion to the overall change of 0.5 percent but is not unusual for an ecoregion with so little change. Compared to other western ecoregions, change in the Chihuahuan Deserts Ecoregion was the lowest (figs. 5,6). Low change is consistent with that of other ecoregions in the arid Southwest. The estimated change in land cover was 0.2 percent between 1980 and 1986 and between 1992 and 2000; it was 0.1 percent between 1973 and 1980 and between 1986 and 1992. When

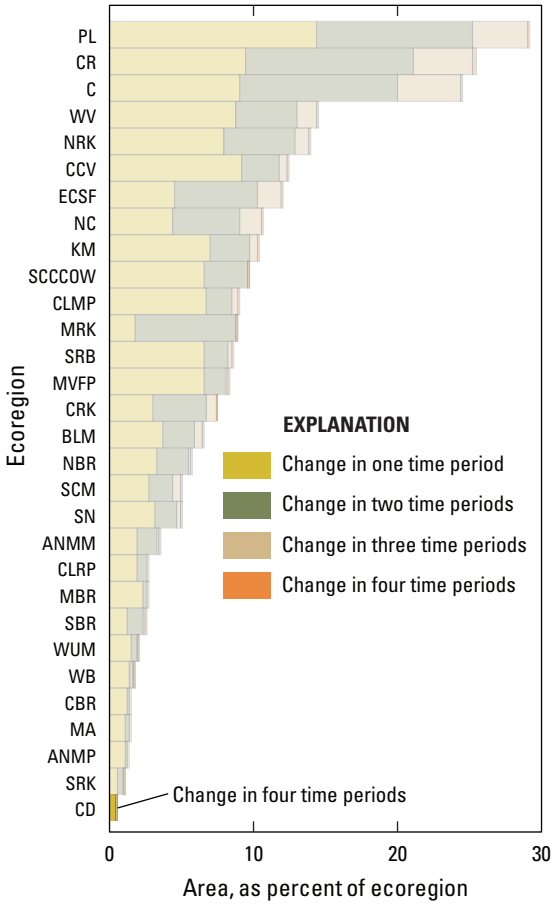

Figure 5. Overall spatial change in Chihuahuan Deserts Ecoregion (CD; darker bars) compared with that of all 30 Western United States ecoregions (lighter bars). Each horizontal set of bars shows proportions of ecoregion that changed during one, two, three, or four time periods; highest level of spatial change in Chihuahuan Deserts 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.

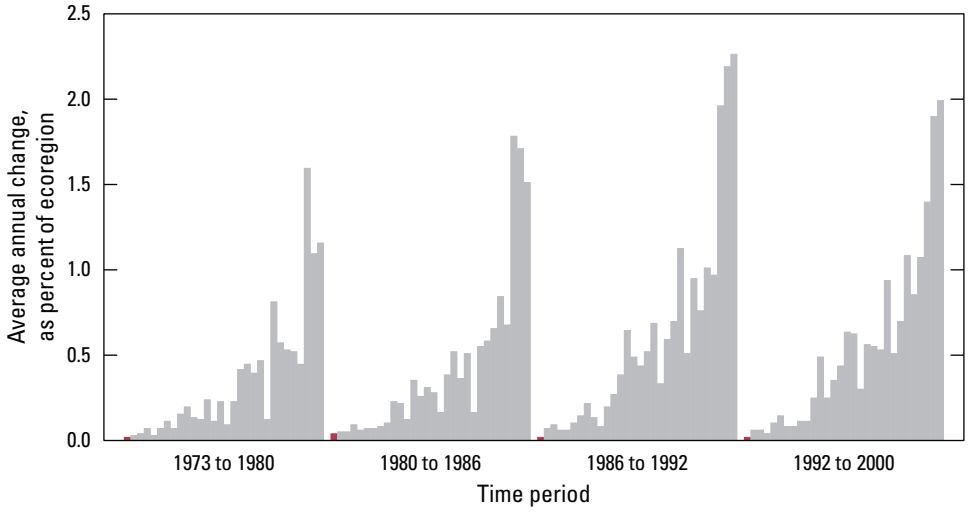

Figure 6. Estimates of land-cover change per time period normalized to annual rates of change for all 30 Western United States ecoregions (gray bars). Estimates of change for Chihuahuan Deserts Ecoregion are represented by red bars in each time period.

the change estimates are normalized to account for the varying lengths of study periods, annual change ranged from 25 km² (1986–1992) to 57 km² (1980–1986) (table 2).

Grassland/shrubland was the predominant land cover, covering 95.6 percent of the Chihuahuan Deserts Ecoregion in 2000 (table 3; fig. 7). Forest (both riparian and higher elevation) was the second largest land cover in 2000 (2.4 percent), followed by developed lands at 1.0 percent. Water, mining, barren land, and agriculture contributed to the remaining 1.0 percent of the ecoregion's land-cover types.

Four classes changed by at least 100 km² during the study period: developed, mining, grassland/shrubland, and agriculture (table 3). The other classes experienced almost no change. Statistically significant, increasing trends of 11.2 percent over the study period were observed for the developed class, and the mining class nearly quadrupled in size, whereas a statistically significant, decreasing trend of 0.1 percent occurred in the grassland/shrubland class (fig. 8). No trend was apparent for agriculture, which fluctuated in gains and losses throughout the study period and had a net loss of 11.2 percent (fig. 8).

The most common conversions were grassland/shrubland to mining (217 km²), grassland/shrubland to developed (187 km²), and agriculture to grassland/shrubland (158 km²) (table 4). The conversion from grassland/shrubland to mining, which occurred in each time period, was attributable to increased oil and gas extraction in the eastern part of the ecoregion (fig. 9). This type of conversion was evident in nine of the Chihuahuan Deserts Ecoregion's study blocks, which are located near the eastern border of the ecoregion and which overlie the Permian Basin, a geological province located in several counties in southeastern New Mexico and western Texas (fig. 10). More than half of the oil and gas production from Texas comes from the Permian Basin, making it the most prolific oil-producing province in United States history (Bureau of Economic Geology, 2005).

Conversion from grassland/shrubland to developed also took place during each time period, and it was the leading

Figure 7. Chihuahuan Desert grasslands south of Fort Stockton, Texas.

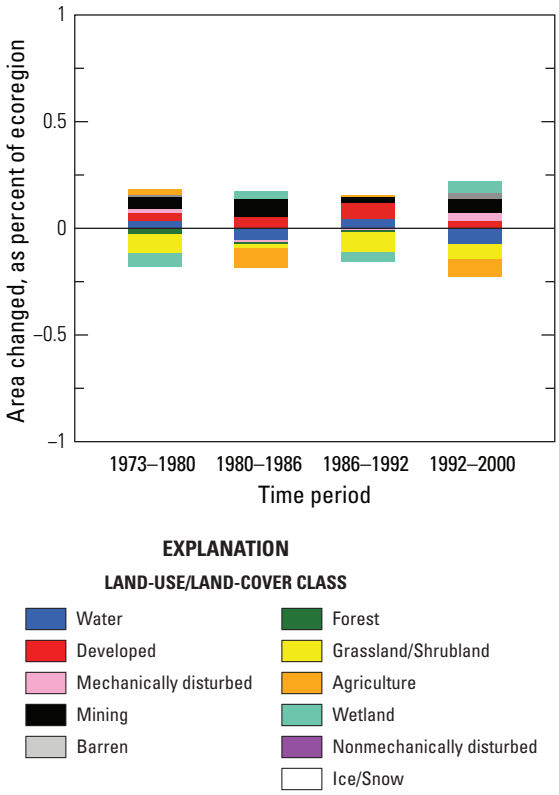

Figure 8. Normalized average net change in Chihuahuan Deserts Ecoregion by time period for each land-cover class. Bars above zero axis represent net gain, whereas bars below zero represent net loss. Note that not all land-cover classes shown in explanation may be represented in figure. See appendix 3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

conversion between 1986 and 1992. The majority of mapped development increases, which were captured in three study blocks, took place in or near cities and near Holloman Air Force Base, New Mexico. Overall, developed land is estimated to have increased by 174 km² between 1973 and 2000.

Mining in the Chihuahuan Deserts Ecoregion is likely to continue to increase. In 2007, the U.S. Geological Survey estimated that 41 trillion ft³ of undiscovered natural gas and 1.3 billion barrels of undiscovered oil are in the Permian Basin Province (Schenk and others, 2008). A decision in 2005 by the Bureau of Land Management allowed for oil and gas leasing and development on public lands in southern New Mexico's Sierra and Otero Counties. Publicized as one of the most restrictive plans ever developed for oil and gas leasing on federal lands, the plan provided for a variety of environmental protections and reclamation efforts for Chihuahuan Desert grasslands within the planning area (U.S. Bureau of Land Management, 2006).

Conversion of grassland/shrubland to developed is also likely to continue within the ecoregion. Areal interpolation of census-block data was used to obtain population totals for the Chihuahuan Deserts Ecoregion (U.S. Census Bureau, 2000). Using this technique, population in the ecoregion

Figure 9. Hydrocarbon-extraction facility southwest of Ozona, Texas.

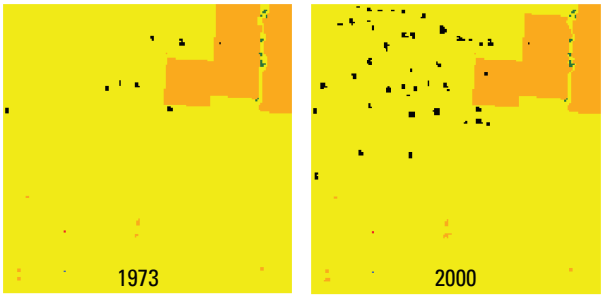

Figure 10. Sample block 24-1094, located between Pecos and Fort Stockton, Texas, showing land-use/land-cover data in 1973 (left) and 2000 (right). Between 1973 and 2000, oil and gas exploration and production increased in Permian Basin, part of Chihuahuan Deserts Ecoregion. Sample blocks show conversion between 1973 and 2000 of grassland/shrubland (yellow) to mining (black) associated with energy production; also shown are small areas of grassland/shrubland converting to agriculture (orange).

grew from 851,797 in 1980 to 1,178,626 in 2000, an increase of 38.4 percent. The population of the largest cities showed an overall increase of 67.1 percent between the 1970 and 2000 census (table 5).

A major concern in the Chihuahuan Deserts Ecoregion is the ongoing transformation of semidesert grassland into shrubland and a more desertlike ecosystem. The change in composition of the Chihuahuan grasslands has changed dramatically in the last century and continues to be observed (Brown, 1994, p. 169). Desert-scrub communities, which now make up nearly one half of the total vegetation in the Chihuahuan Desert, may have grown to their present extent through invasion of eroded grasslands (Chihuahuan Desert Research Institute, 2009). Scientists disagree, however, on the relative importance of factors such as livestock grazing, fire, and climate change as drivers of this transformation (McClaran and Van Devender, 1995, p. 265). (Note that the desertification of the Chihuahuan Desert grasslands is not reflected in the statistics of this report because capturing change within land-cover classes is not part of the Status and Trends of Land Change project design.)

Major land-cover classes changed very little in the Chihuahuan Deserts Ecoregion between 1973 and 2000. The small changes that did occur were due to increased oil and gas extraction and some urban growth, but these localized changes accounted for a small fraction of the overall ecoregion area. Except for its major cities, the ecoregion remains sparsely populated and consists mainly of large expanses of grassland and shrubland that are devoted to grazing. Little rainfall and a scarcity of both surface water and groundwater inhibit anthropogenic change in much of the ecoregion and will continue to be a challenge to future growth.

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

[Most sample pixels remained unchanged (99.5 percent), whereas 0.5 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	0.4	0.2	0.2	0.6	0.1	29.8
2	0.0	0.0	0.0	0.1	0.0	45.9
3	0.0	0.0	0.0	0.0	0.0	85.3
4	0.0	0.0	0.0	0.0	0.0	99.1
Overall spatial change	0.5	0.2	0.2	0.7	0.2	32.1

Table 2. Raw estimates of change in Chihuahuan Deserts 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	0.1	0.1	0.0	0.2	0.0	38.2	0.0
1980–1986	0.2	0.1	0.1	0.3	0.1	39.7	0.0
1986–1992	0.1	0.1	0.0	0.2	0.0	51.6	0.0
1992–2000	0.2	0.1	0.1	0.3	0.1	33.6	0.0
Estimate of change, in square kilometers							
1973–1980	198	112	87	310	76	38.2	28
1980–1986	341	200	141	541	135	39.7	57
1986–1992	151	115	36	266	78	51.6	25
1992–2000	299	148	151	447	100	33.6	37

Table 3. Estimated area (and margin of error) of each land-cover class in Chihuahuan Deserts 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	0.1	0.9	1.0	0.0	0.0	0.0	0.0	0.2	0.1	2.4	1.3	95.8	2.3	0.6	0.6	0.0	0.1	0.0	0.0
1980	0.1	0.1	0.9	1.0	0.0	0.0	0.1	0.0	0.2	0.1	2.4	1.3	95.7	2.3	0.6	0.6	0.0	0.0	0.0	0.0
1986	0.1	0.1	0.9	1.0	0.0	0.0	0.1	0.1	0.2	0.1	2.4	1.3	95.7	2.3	0.6	0.5	0.0	0.0	0.0	0.0
1992	0.1	0.1	1.0	1.0	0.0	0.0	0.1	0.1	0.2	0.1	2.4	1.3	95.7	2.3	0.6	0.5	0.0	0.0	0.0	0.0
2000	0.1	0.0	1.0	1.0	0.0	0.0	0.2	0.1	0.2	0.1	2.4	1.3	95.6	2.3	0.6	0.5	0.0	0.0	0.0	0.0
Net change	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	−0.1	0.1	−0.1	0.1	0.0	0.0	0.0	0.0
Gross change	0.1	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.3	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Area, in square kilometers																				
1973	123	122	1,553	1,659	5	7	73	38	266	205	4,159	2,316	167,127	4,034	1,084	961	81	105	0	0
1980	160	175	1,581	1,675	22	26	124	65	271	205	4,139	2,298	167,043	4,050	1,107	969	25	26	0	0
1986	114	109	1,627	1,709	11	8	201	99	271	205	4,138	2,299	167,024	4,005	1,029	925	57	70	0	0
1992	153	163	1,692	1,746	5	7	227	104	271	205	4,131	2,299	166,941	4,022	1,032	926	18	19	0	0
2000	93	79	1,727	1,752	35	29	283	124	300	210	4,127	2,297	166,879	4,014	963	909	66	83	0	0
Net change	−30	46	174	116	30	28	210	98	34	49	−33	30	−249	151	−122	110	−15	22	0	0
Gross change	189	264	174	116	77	61	218	102	34	49	36	31	512	168	188	155	175	256	0	0

Table 4. Principal land-cover conversions in Chihuahuan Deserts 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	Mining	51	34	23	0.0	25.8
	Wetland	Water	37	54	36	0.0	18.5
	Grassland/Shrubland	Developed	28	24	16	0.0	14.1
	Grassland/Shrubland	Agriculture	23	27	18	0.0	11.9
	Wetland	Grassland/Shrubland	20	29	20	0.0	10.0
	Other	Other	39	n/a	n/a	0.0	19.7
		Totals	198			0.1	100.0
1980–1986	Grassland/Shrubland	Mining	85	47	32	0.0	24.9
	Agriculture	Grassland/Shrubland	85	89	61	0.0	24.8
	Grassland/Shrubland	Developed	63	61	42	0.0	18.4
	Water	Wetland	32	47	32	0.0	9.4
	Developed	Grassland/Shrubland	19	28	19	0.0	5.6
	Other	Other	57	n/a	n/a	0.0	16.8
		Totals	341			0.2	100.0
1986–1992	Grassland/Shrubland	Developed	62	44	30	0.0	41.1
	Wetland	Water	41	59	40	0.0	27.0
	Grassland/Shrubland	Mining	27	18	12	0.0	18.1
	Forest	Grassland/Shrubland	7	11	7	0.0	4.8
	Mechanically disturbed	Developed	3	5	3	0.0	2.1
	Other	Other	10	n/a	n/a	0.0	6.9
		Totals	151			0.1	100.0
1992–2000	Agriculture	Grassland/Shrubland	71	67	46	0.0	23.8
	Grassland/Shrubland	Mining	53	33	23	0.0	17.8
	Water	Wetland	48	70	48	0.0	16.1
	Grassland/Shrubland	Developed	34	23	16	0.0	11.3
	Grassland/Shrubland	Mechanically disturbed	29	28	19	0.0	9.8
	Other	Other	63	n/a	n/a	0.0	21.2
		Totals	299			0.2	100.0
1973–2000 (overall)	Grassland/Shrubland	Mining	217	101	68	0.1	21.9
	Grassland/Shrubland	Developed	187	134	91	0.1	18.9
	Agriculture	Grassland/Shrubland	158	133	90	0.1	15.9
	Water	Wetland	82	120	81	0.0	8.3
	Wetland	Water	77	113	77	0.0	7.8
	Other	Other	269	n/a	n/a	0.2	27.2
		Totals	989	n/a	n/a	0.6	100.0

Table 5. Populations of largest cities in Chihuahuan Deserts Ecoregion that had both 1970 and 2000 census data. Cities of Socorro and San Elizario, Texas, and Sunland Park, New Mexico, had 2000 populations greater than 10,000, but no 1970 census data was available (U.S. Census Bureau, 2000).

City	State	1970 population	2000 population	County	Percent increase
El Paso	TX	322,261	563,662	El Paso	74.91
Las Cruces	NM	37,857	74,267	Dona Ana	96.18
Roswell	NM	33,908	45,293	Chaves	33.58
Alamogordo	NM	23,035	35,582	Otero	54.47
Del Rio	TX	21,330	33,867	Val Verde	58.78
Carlsbad	NM	21,297	25,625	Eddy	20.32
Deming	NM	8,343	14,116	Luna	69.20
Artesia	NM	10,315	10,692	Eddy	3.65
Silver City	NM	8,557	10,545	Grant	23.23
	Total	486,903	813,649		
	Total increase:		67.11%	Average increase:	48.26%

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