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Land-Cover Change in the Central Irregular Plains, 1973–2000

Open-File Report 2009–1159

U.S. Department of the Interior
U.S. Geological Survey

Cover photograph. Horse drawn carriage in the northwest region of the Central Irregular Plains (U.S. Geological Survey, 2006).

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Conversion Factors

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

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Project Background

Spearheaded by the Geographic Analysis and Monitoring Program of the U.S. Geological Survey (USGS) in collaboration with the U.S. Environmental Protection Agency (EPA) and the National Aeronautics and Space Administration (NASA), the Land Cover Trends is a research project focused on understanding the rates, trends, causes, and consequences of contemporary United States land-use and land-cover change. Using the EPA Level III ecoregions as the geographic framework, scientists process geospatial data collected between 1973 and 2000 to characterize ecosystem responses to land-use changes. The 27-year study period was divided into five temporal periods: 1973–1980, 1980–1986, 1986–1992, 1992–2000 and 1973–2000. General land-cover classes for these periods were interpreted from Landsat Multispectral Scanner, Thematic Mapper, and Enhanced Thematic Mapper Plus imagery to categorize land-cover change and evaluate using a modified Anderson Land Use Land Cover Classification System for image interpretation.

The rates of land-cover change are estimated using a stratified, random sampling of 10-kilometer (km) by 10-km blocks allocated within each ecoregion. For each sample block, satellite images are used to interpret land-cover change. Additionally, historical aerial photographs from similar timeframes and other ancillary data such as census statistics and published literature are used. The sample block data are then incorporated into statistical analyses to generate an overall change matrix for the ecoregion. These change statistics are applicable for different levels of scale, including total change for the individual sample blocks and change estimates for the entire ecoregion. The results illustrate that there is no single profile of land-cover change but instead point to geographic variability that results from land uses within ecoregions continuously adapting to various factors including environmental, technological, and socioeconomic.

Central Irregular Plains Ecoregion Description

The Central Irregular Plains ecoregion, as defined by Omernik (1987), encompasses 122,589 square kilometers (km^2) across southern Iowa, northern and central Missouri and fractions of eastern Kansas and northeastern Oklahoma (fig. 1). The ecoregion includes the Chariton, Des Moines, Grand, Missouri, and Thompson Rivers and their tributaries.

The Central Irregular Plains tends to be topographically more irregular than the Western Corn Belt Plains to the north but is less irregular and less forested than the ecoregions to the south and east. The topography of the northern sections of the Central Irregular Plains found in northern Missouri and southern Iowa ranges from flat to moderately hilly. This portion of the ecoregion includes natural wetlands along the Grand River. The soils in the ecoregion vary from north to south in that glacial tills form the parent material for most of the soil in Iowa and the northern half of Missouri while the southern portion of the ecoregion was not glaciated (Chapman and others, 2002). Additionally, loess deposits generally increase near the Missouri River (Chapman and others, 2002). The topographic features of the southwestern sections of the ecoregion, in west central Missouri, western Kansas, and northern Oklahoma generally are smoother than the northern till plains (Chapman, and others, 2002). This nonglaciated area is relatively flat and can be distinguished by its claypan soils (Chapman and others, 2002).

The Central Irregular Plains has a variety of land-use types. The gently rolling topography and generally fertile soils of this ecoregion support a variety of agricultural practices, like the contour farming common in Iowa and northern Missouri (Chapman and others, 2002). Agricultural land stretches across the entire boundary of the Central Irregular Plains and is composed of fields of corn, soybeans, and wheat, as well as cattle. Loess deposits near the Missouri River have helped to create inherently fertile soils that provide an ideal environment for crop production (U.S. Department of Agriculture, 2009a)

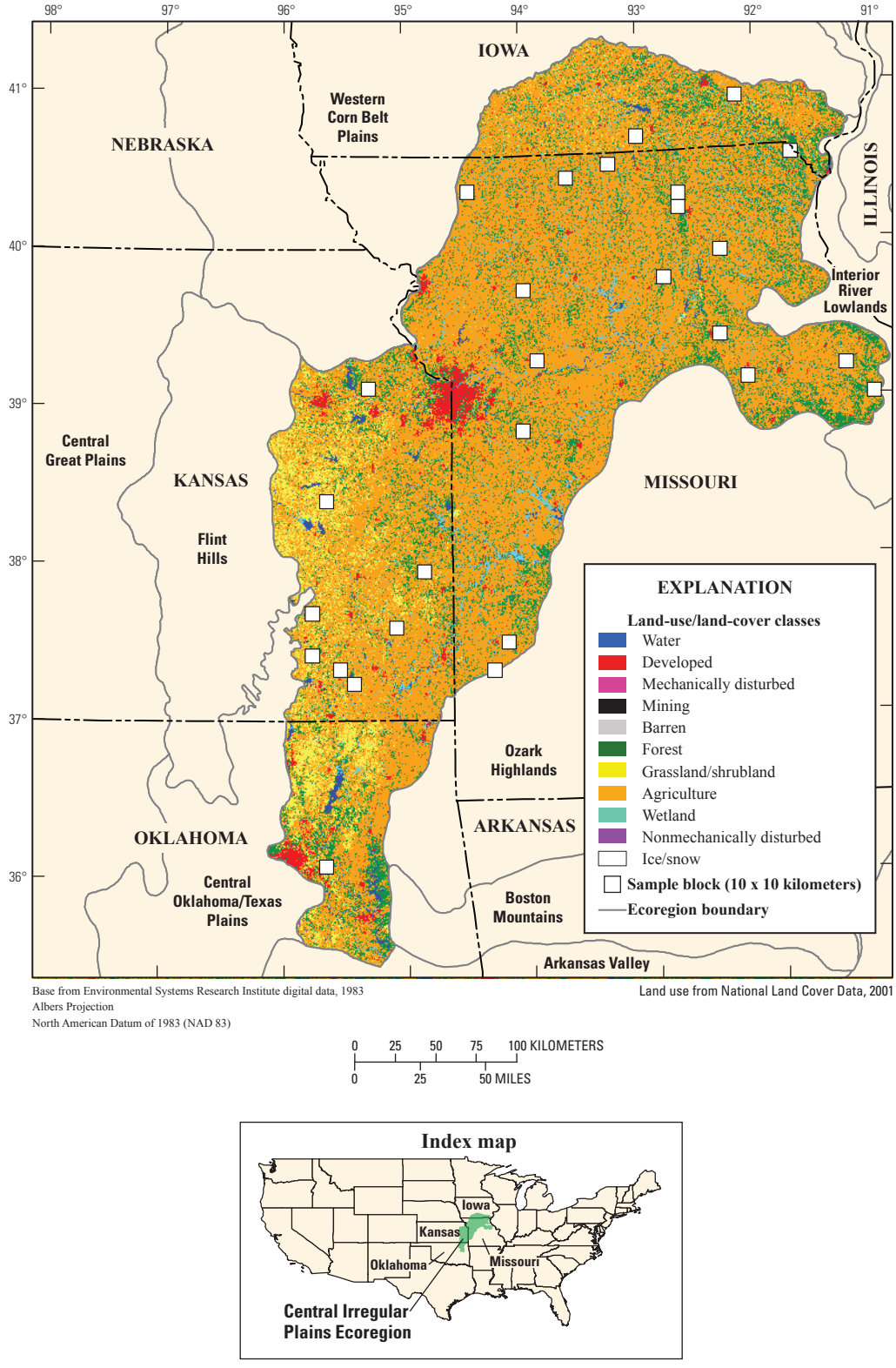

Figure 1. The Central Irregular Plains.

(fig. 2). According to the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS), a majority of the Iowa counties in this ecoregion have at least 50 percent of their land in farms as cropland. To the southwest, the primary crops during the study period in the Kansas counties of the ecoregion were wheat, corn, and sorghum while the counties in Oklahoma harvested mostly wheat and soybeans (U.S. Department of Agriculture Kansas National Agricultural Statistics Service, 2009c and U.S. Department of Agriculture Oklahoma National Agricultural Statistics Service, 2009e).

Figure 2. Wheat field near Jasper, Missouri (U.S. Geological Survey, 2006).

A Summary of Land-Use Change in the Ecoregion

Overall Spatial Change

From 1973 to 2000, 7.2 percent (+/- 2.0 percent) of the Central Irregular Plains ecoregion underwent land-cover change (table 1). When compared to the statistics calculated for the other ecoregions in the Great Plains, the overall spatial change in the Central Irregular Plains was moderate. Results also indicate that the Central Irregular Plains show a greater amount of change than the neighboring ecoregions of the Great Plains.

Number of Changes

An estimated 6.5 percent of land cover in the ecoregion underwent change once. The percentage of the ecoregion that changed more than once during the 30-year study period was low; 0.7 percent of the area changed twice, 0.1 percent changed three times. According to the statistics, the percent of the area that changed twice in this ecoregion is moderately consistent with neighboring ecoregions.

Total Change Per Period

The total amount of change was relatively low during the study period. The total change during the 1973 to 1980 time period was 1.8 percent (+/- 0.6 percent). During the 1986-1992 and the 1992–2000 time periods, the total change slightly increased to 2.0 percent (+/- 0.6 percent) and 2.2 percent (+/- 0.8 percent) respectively. (table 2). Overall, these changes are moderately higher than values for the neighboring ecoregions. All of the change estimates have an associated margin of error of less than +/- 0.9 percent. The margin of error varied directly with the percent change in that it decreased with the lower amount of change from 1986 to 1992 and increased slightly between 1992 and 2000.

Land-Cover Composition and Net Change

Agriculture is the principal land cover in the Central Irregular Plains. Though it experienced a slight decline to grassland/shrubland, agriculture covered 59.9 percent (+/- 4.8 percent) of the ecoregion in 2000 (table 3). Forest was the second highest land-cover type covering 20.4 percent of the ecoregion in 1973 and 20 percent in 2000 (table 3). The forested woodlands of the Central Irregular Plains, including oak-hickory, are primarily concentrated in the eastern portion of the ecoregion. Grassland/shrubland, the third most extensive land-cover type, had a steady gain from 13.5 percent in 1973 to 15.9 percent in 2000 (table 3).

Table 1. Percentage of the Central Irregular Plains that experienced spatial change and associated error.

[+, plus; -, minus; %, percent]

Number of changes	Percent of ecoregion	Margin of error (+/- %)	Lower bound (%)	Upper bound (%)	Standard error (%)	Relative error (%)
1	6.5	1.7	4.8	8.2	1.2	17.8
2	.7	.3	.3	1	.2	33.3
3	.1	.1	0	.1	0	64
4	0	0	0	0	0	98.8
Overall spatial change	7.2	2	5.3	9.2	1.3	18.4

Table 2. Raw estimates of percent change in the Central Irregular Plains computed for each of the four time periods and associated error at an 85-percent confidence level.

[%, percent; +, plus; -, minus; km^2, square kilometers]

Period	Total change (% of ecoregion)	Margin of error (+/- %)	Lower bound (%)	Upper bound (%)	Standard error (%)	Relative error (%)	Average rate (% per year)
1973–1980	1.8	0.6	1.2	2.4	0.4	22.3	0.3
1980–1986	2.2	.8	1.3	3	.6	25.6	.4
1986–1992	2	.6	1.4	2.7	.4	20.8	.3
1992–2000	2.2	.8	1.3	3	.6	25.9	.3

Period	Total change (km^2 of ecoregion)	Margin of error (+/- km^2)	Lower bound (km^2)	Upper bound (km^2)	Standard error (km^2)	Relative error (%)	Average rate (km^2 per year)
1973–1980	2,218	734	1,484	2,951	495	22	317
1980–1986	2,663	1,012	1,652	3,675	683	26	444
1986–1992	2,511	774	1,737	3,285	522	21	418
1992–2000	2,644	1,017	1,628	3,661	686	26	331

Most Common Land-Cover Conversions

The five leading land-cover conversions from 1973 to 2000 were: (1) agriculture to grassland/shrubland, (2) grassland/shrubland to agriculture, (3) agriculture to developed, (4) forest to agriculture, and (5) grassland/shrubland to forest (table 4).

Overall, the most common type of conversion during each study period was the conversion from agriculture to grassland/shrubland. Between 1973 and 2000, 5,362 km^2 were converted from agriculture to grassland/shrubland (table 4). However, this conversion did not result in a large net increase in grassland/shrubland because during the same time, the second most common conversion was grassland/shrubland being converted to agricultural land (2,128 km^2).

Discussion

In 2000, agricultural land accounted for the highest amount of area in the ecoregion (73,466 km^2) despite a net decrease of 3.02 percent. Economics play an important role in the land-use story of the Central Irregular Plains.

Factors Affecting Land-Cover Change in the Ecoregion

The major factors affecting conversion of agricultural land to grassland/shrubland land during the study period were:

- the economic crisis of the 1980's;
- the agroeconomics related to advances in conservation tillage (no-till);
- the socioeconomic repercussions associated with the Great Flood of 1993; and
- the Conservation Reserve Program (CRP).

Economic Climate of the 1970s

The economic climate of the 1970s encouraged farmers to expand production in an effort to benefit from improved export opportunities, strong commodity prices, farm income, and farmland values. While abundant credit from various sources helped finance the expansion, high rates of inflation and low real-estate interest rates further encouraged investment in farmland. During this time, a considerable number of farmers took on heavy debt loads and became vulnerable to sudden shifts in economic forces (Stam and Dixon, 2004).

Economic Crisis of the 1980s

During the economic crisis of the early 1980s, those economic shifts were felt when economic conditions reversed and export markets contracted and input prices and interest rates rose (Stam and Dixon, 2004). Monetary policies designed to reduce inflation prompted interest rates to rise to unprecedented levels in the early 1980s. The financial stress became more severe when declines in farm commodity prices, income, and land values (the largest asset used to secure debt) made it difficult for some farmers to service their debts (Stam and Dixon, 2004). While several factors came together to create the crisis, the massive increase in farmland prices in the late 1970s, followed by the sharp decline in land prices between 1981 and 1992, significantly contributed to the adverse effects on farmers and their lenders (Cofer and others, 2009) and may

Table 3. Estimated area for each land-cover class in the Central Irregular Plains between 1973 and 2000.

[%, percent; +, plus; -, minus; km², square kilometers]

	Water		Developed		Mechanically distrubed		Mining		Barren		Forest		Grass/shrub		Agriculture		Wetlands		Nonmechanically disturbed	
	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-
1973	0.7	0.2	1.4	0.4	0	0	0	0	0	0	20.4	3.1	13.5	3.3	62.9	4.4	1.0	0.4	0	0
1980	.7	.2	1.5	.5	0.1	0.1	0	0	0	0	20.1	3.1	13.8	3.4	62.7	4.4	1.0	.4	0	0
1986	.8	.2	1.6	.5	0	0	0	0	0	0	20	3.1	14.3	3.5	62.1	4.5	1.0	.4	0	0
1992	.9	.2	1.8	.7	0	0	0.1	0	0	0	20	3.1	15.2	3.7	60.9	4.6	1.0	.4	0	0
2000	.9	.2	2.1	.8	0	0	.1	0	0	0	20	3.1	15.9	3.8	59.9	4.8	1.0	.4	0	0
Net change	.2	.1	.7	.4	0	0	.1	0	0	0	-.3	.2	2.4	1.5	-3.0	1.6	0	0	0	0
Gross change	.3	.1	.7	.4	.2	.1	.1	0	0	0	.7	.2	4.2	1.3	4.8	1.4	0	0	0	0

	Water		Developed		Mechanically distrubed		Mining		Barren		Forest		Grass/shrub		Agriculture		Wetlands		Nonmechanically disturbed	
	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-
1973	821	218	1,722	540	29	35	28	24	28	37	24,956	3,782	16,572	4,055	77,166	5,344	1,266	517	0	0
1980	831	213	1,894	596	88	88	54	30	35	38	24,697	3,751	16,912	4,202	76,813	5,399	1,265	517	0	0
1986	1,011	246	2,022	660	0	0	58	31	30	37	24,564	3,755	17,575	4,321	76,072	5,518	1,257	512	0	0
1992	1,059	247	2,259	798	5	8	73	36	29	37	24,570	3,766	18,695	4,533	74,648	5,694	1,253	510	0	0
2000	1,097	247	2,611	975	8	7	110	57	42	39	24,539	3,741	19,463	4,692	73,466	5,920	1,251	509	0	0
Net change	276	127	889	537	-21	36	82	52	14	13	-418	290	2,890	1,888	-3,700	2,009	-16	20	0	0
Gross change	387	148	892	536	219	177	84	52	29	33	873	254	5,116	1,643	5,907	1,734	40	24	0	0

Table 4. Leading land-cover conversions in the Central Irregular Plains during each of four time periods.

[km², square kilometers; +, plus; -, minus]

Period	From class	To class	Area changed (km²)	Margin of error (+/- km²)	Standard error (km²)	Percent of ecoregion	Percent of all changes
1973–1980	Agriculture	Grassland/shrubland	905	381	257	0.7	40.8
	Grassland/shrubland	Agriculture	585	480	324	0	26.4
	Forest	Grassland/shrubland	146	108	73	0	6.6
	Forest	Agriculture	144	65	44	0	6.5
	Agriculture	Developed	106	116	78	0	4.8
	Other	Other	331	n/a	n/a	0	14.9
			2,218			2	100
1980–1986	Agriculture	Grassland/shrubland	1,337	607	409	1	50.2
	Grassland/shrubland	Agriculture	648	450	304	1	24.3
	Grassland/shrubland	Forest	105	66	44	0	3.9
	Forest	Grassland/shrubland	104	96	65	0	3.9
	Forest	Agriculture	85	44	30	0	3.2
	Other	Other	384	n/a	n/a	0	14.4
			2,663			2	100
1986–1992	Agriculture	Grassland/shrubland	1,663	594	401	1	66.2
	Grassland/shrubland	Agriculture	391	289	195	0	15.6
	Agriculture	Developed	136	85	57	0	5.4
	Grassland/shrubland	Forest	73	39	26	0	2.9
	Grassland/shrubland	Developed	70	83	56	0	2.8
	Other	Other	178	n/a	n/a	0	7.1
			2,511			2	100
1992–2000	Agriculture	Grassland/shrubland	1,456	878	592	1	55
	Grassland/shrubland	Agriculture	505	312	211	0	19.1
	Agriculture	Developed	206	139	94	0	7.8
	Grassland/shrubland	Developed	105	107	72	0	4.0
	Grassland/shrubland	Forest	89	54	36	0	3.4
	Other	Other	284	n/a	n/a	0	10.7
			2,644			2	100
Overall							
1973–2000	Agriculture	Grassland/shrubland	5,362	2,006	1,354	4	53.4
	Grassland/shrubland	Agriculture	2,128	1,243	839	2	21.2
	Agriculture	Developed	506	254	171	0	5
	Forest	Agriculture	323	125	84	0	3.2
	Grassland/shrubland	Forest	314	125	84	0	3.1
	Other	Other	1,403	n/a	n/a	1	14
			10,036			8	100

have had an affect in the amount of agricultural land in the Central Irregular Plains.

A direct example of the effects of this crisis was found in Appanoose County, Iowa. The banking crisis of the early 1980s was the cause of many land-use changes in southern Iowa (D. Clarke, U.S. Department of Agriculture, written commun., 2009). The financial institutions needed money back from farmers because of the low crop yields (D. Clarke, U.S. Department of Agriculture, written commun., 2009). Overall, the collapse of the farm banks in the 1980s inflicted particular economic hardship on small family-operated farms as a number of farm banks failed causing many to foreclose on their farms.

No-Till Conservation Tillage

The second economic factor affecting land-use change in the Central Irregular Plains is conservation tillage, specifically no-till. No-till conservation tillage was not only popular but encouraged in many parts of the ecoregion in the 1980s and continues to be widely practiced. No-till is a practice where the soil is left virtually undisturbed from harvest to planting and has increased specifically in southern Iowa and eastern Kansas in recent years (D. Clarke, U.S. Department of Agriculture, written commun., 2009; M. Glissman, U.S. Department of Agriculture, written commun., 2009). The overall rate of increase in the use of conservation tillage of non-highly erodible land has been similar to that on highly erodible land, indicating that all producers are motivated by the potential of conservation tillage systems to reduce costs, improve efficiency, and increase soil productivity (U.S. Department of Agriculture Economic Research Service, 1997). However, the use of conservation tillage has leveled off in several regions since 1993 due in part to the unusual weather patterns—primarily heavy rainfall and cool planting conditions, which create unfavorable planting conditions for conservation tillage (U.S. Department of Agriculture Economic Research Service, 1997). It is important to note that more than 50 percent of the scenes used to classify these data were collected from spring and late fall months, which may explain that while the land in no-till has an agricultural land use, it may spectrally appear as grassland/shrubland (fig. 3).

The Great Flood of 1993

The devastation of cropland that was associated with the Great Flood of 1993 had an affect on land use in the Central Irregular Plains. Specifically, greater than 61 centimeters (cm) of rain fell on central and northeastern Kansas, northern and central Missouri, most of Iowa, southern Minnesota, and southeastern Nebraska, and as much as 97 cm fell in east-central Iowa (Johnson and others, 2004). These amounts were approximately 2003 to 50 percent greater than normal (Johnson and others, 2004). From April 1 to August 31, precipitation amounts approached 122 cm in east-central Iowa, easily surpassing the area's normal annual precipitation of 76 to 91 cm (Johnson and others, 2004). A substantial amount of cropland was lost, which had a particular downward effect on soybean and corn yields. While the floodwaters did not have a substantial effect on the entire ecoregion, the extent of the damage on agricultural resources was essential to understanding how climatic affects on land use may affect the land change.

Figure 3. No-till farming near Hamilton, Missouri (U.S. Geological Survey, 2006).

The Conservation Reserve Program

The U.S. Department of Agriculture NASS CRP annual cumulative enrollment statistics show that overall, acres enrolled in the CRP in the ecoregion declined slightly in the later portion of the study period (fig. 4). While that may have had a significant affect on the land-change conversion from agriculture to grassland/shrubland, other factors such as economics and climate also should be considered.

Figure 4. Conservation Reserve Program land near Graysville, Missouri (U.S. Geological Survey, 2006).

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