USGS
science for a changing world

Land-Cover Change in the Ozark Highlands, 1973–2000

Open-File Report 2010–1198

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

Cover photographs. Pasture and algal covered farm pond in southwest Franklin County, Missouri. Background photograph of hay pasture south of Jefferson City, Missouri. Photographs by U.S. Geological Survey, 2009.

Land-Cover Change in the Ozark Highlands, 1973–2000

By Krista A. Karstensen

Open-File Report 2010–1198

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

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2010

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment, visit http://www.usgs.gov or call 1-888-ASK-USGS

For an overview of USGS information products, including maps, imagery, and publications, visit http://www.usgs.gov/pubprod

To order this and other USGS information products, visit http://store.usgs.gov

Suggested citation:
Karstensen, K.A., 2010, Land-cover change in the Ozark Highlands, 1973–2000: U.S. Geological Survey Open-File Report 2010–1198, 13 p.

Contents

Figures

Tables

Conversion Factors and Datum

Multiply	By	To obtain
	Length	
meter (m)	39.37	inch (in)
centimeter (cm)	0.3937	inch (in)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)
square kilometer (km^2)	247.1	acre

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

Land-Cover Change in the Ozark Highlands, 1973–2000

By Krista A. Karstensen

Project Background

Led 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 Project was initiated in 1999 and aims to document the types, geographic distributions, and rates of land-cover change on a region by region basis for the conterminous United States, and to determine some of the key drivers and consequences of the change (Loveland and others, 2002). For 1973, 1980, 1986, 1992, and 2000 land-cover maps derived from the Landsat series are classified by visual interpretation, inspection of historical aerial photography and ground survey, into 11 land-cover classes. The classes are defined to capture land cover that is discernable in Landsat data. A stratified probability-based sampling methodology undertaken within the 84 Omernik Level III Ecoregions (Omernik, 1987) was used to locate the blocks, with 9 to 48 blocks per ecoregion. The sampling was designed to enable a statistically robust "scaling up" of the sample-classification data to estimate areal land-cover change within each ecoregion (Loveland and others, 2002; Stehman and others, 2005).

At the time of writing, approximately 90 percent of the 84 conterminous United States ecoregions have been processed by the Land-Cover Trends Project. Results from these completed ecoregions illustrate that across the conterminous United States there is no single profile of land-cover/land-use change, rather, there are varying pulses affected by clusters of change agents (Loveland and others, 2002).

Land-Cover Trends Project results for the conterminous United States to-date are being used for collaborative environmental change research with partners such as; the National Science Foundation, the National Oceanic and Atmospheric Administration, and the U.S. Fish and Wildlife Service. The strategy has also been adapted for use in a NASA global deforestation initiative, and elements of the project design are being used in the North American Carbon Program's assessment of forest disturbance.

Ecoregion Description

The Ozark Highlands Ecoregion area is approximately 108,332 square kilometers (km^2) and encompasses the states of southeastern Kansas, southern Missouri, northern Arkansas, and northeastern Oklahoma (fig. 1). Neighboring ecoregions are the Interior River Lowlands, Central Irregular Plains, Mississippi Alluvial Plain, and the Boston Mountains (fig. 1). Elevations in the ecoregion range from 76 to 274 meters (m) and local relief ranges from 15 to 244 m (Woods and others, 2004a, 2004b). Major urban areas in the ecoregion include the cities of Jefferson City, Columbia, Springfield, Joplin, and Branson in Missouri; and Bentonville and Fayetteville in Arkansas.

In 2000, developed land accounted for a mere 2.1 percent of the ecoregion. While the sampled statistics do not reflect an overall increase in the amount of developed land in the ecoregion for the study period, it is important to note that there was an absence of sample blocks for image interpretation around the Missouri cities of Branson and Springfield each of which expanded significantly during the study period (fig. 2). In 1994, Branson, Missouri, had a resident population of only 3,700 people, but the local entertainment and recreational opportunities attracted 4.2 million tourists (Adamski and others, 1995; U.S. Department of Commerce, Bureau of Census, 1990). It is also important to note that the cities of Saint Robert and Waynesville, Missouri, began their rapid expansion in 1960 following growth of the Fort Leonard Wood Military Reservation. One sample block included in this ecoregion analysis is

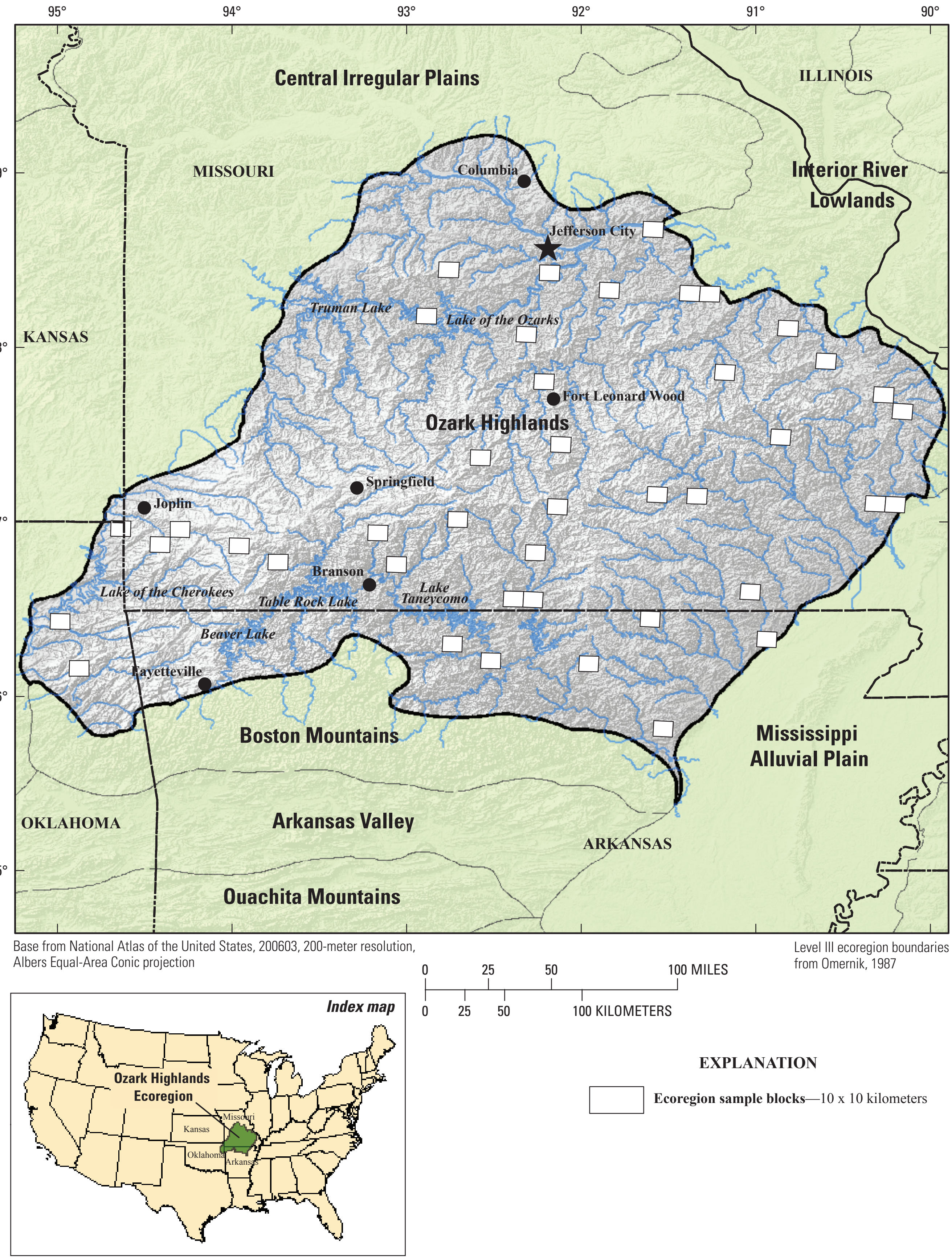

Figure 1. The Ozark Highlands Ecoregion.

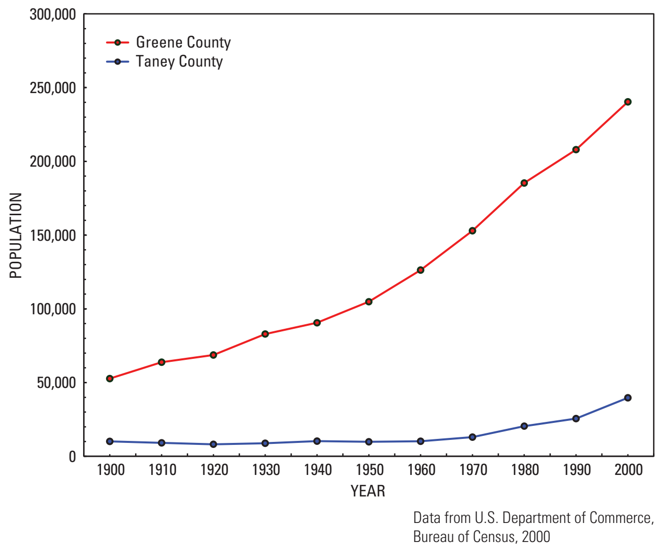

Figure 2. The exponential population growth in Greene and Taney Counties, Missouri. The growth of these counties is primarily because of the increasing populations of Springfield and Branson, Missouri.

approximately 1.5 kilometer (km) away from the installation's border (fig. 3). The block contains Waynesville, which is one of the larger towns adjacent to Fort Leonard Wood. The military installation continues to expand as it has been a recipient of the Base Realignment and Closure (BRAC) program which may be a driving force of environmental change and response on military installations (Karstensen and Loveland, 2008). The addition of a substantial number of military personnel to any one location has the potential to cause changes in the land-cover footprint of not only the installation, but also the surrounding community.

Land cover in the Ozark Highlands Ecoregion is characterized primarily by forest in the east and agriculture in the west (figs. 4 and 5). The oak-hickory forest found in this ecoregion provided a profitable environment for the timber boom that occurred in the late 1800s until 1920. In this period the ecoregion experienced cutover and controlled forest burns were suppressed. In the post-timber boom years (after 1960), land was cleared for pasture and row crop and seasonal burning became more common. From 1960 to 1993, uplands were used for increased grazing and row crops; valley slopes for woodland grazing, managed timber, and controlled burns; and valley bottoms were cleared for pasture and row crop with some reversion to forest (Jacobson and Primm, 1997). The ecoregion suffered substantially during the Midwest agricultural crisis during the 1980s (Demissie, 1986). Throughout this period, the amount of acres harvested for crop as well as the amount of cattle sold decreased substantially until recovery in the early 1990s. Most farm income in the ecoregion in the early 2000s was from the sale of cattle, poultry, or hogs (Woods and others, 2004b).

The ecoregion is part of the Ozark Plateaus geomorphic province consisting of a structural dome of sedimentary and igneous rocks (Davis and Bell, 1998). Sedimentary rocks generally dip away from the igneous core of the St. Francois Mountains in southeastern Missouri to form the ecoregion's two distinct physiographic sections (Fenneman, 1938)—the Salem Plateau and the Springfield Plateau. These plateaus are underlain by the limestone and dolomite that are responsible for the karst topography that contributes to shaping the ecoregion's unique hydrologic features. The soils resulting from this geologic landscape have played a large role in shaping the natural vegetation and agriculture of the Ozarks (Larry Handley, U.S. Geological Survey, written commun., 2010).

The Ozark Highlands Ecoregion is generally categorized as having a mesic temperature regime and receives approximately 107 to 124 centimeters (cm) of precipitation annually (Woods and others, 2004b). The continental climatic nature of the ecoregion is affected by prevailing easterly storm systems, Gulf Coast moisture sources, and occasional incursions of the polar front (Jacobson and Primm, 1997).

Several river systems drain the ecoregion including the Osage, Gasconade, Meramec, St. Francis, Black, White, and Illinois (rivers not shown on fig. 1). Most of the rivers drain radially away from south-central Missouri or northward from the Boston Mountains (Petersen and others, 1998). Annual mean streamflow of individual streams within the ecoregion vary substantially from year to year. For example, between 1951 and 1990, there were periods of low flows (mid-1950s, mid-1960s, and early 1980s), and periods of high flows (early 1950s, early and late 1960s, mid-1970s, and mid-1980s) (Adamski and others, 1995). Generally, minimum monthly streamflows occur in the summer and fall (July to October), while maximum monthly streamflows typically occur in spring (March to May) (Adamski and others, 1995).

The karst topography that shapes the ecoregion contributes to surface water features by producing losing streams, springs, spring-fed streams, seeps, and fens (U.S. Forest Service, 2010). This ecoregion contains some of the largest freshwater springs in North America which provides habitat for a wide variety of endemic species including the Ozark Shiner (The Nature Conservancy, 2003). While some small

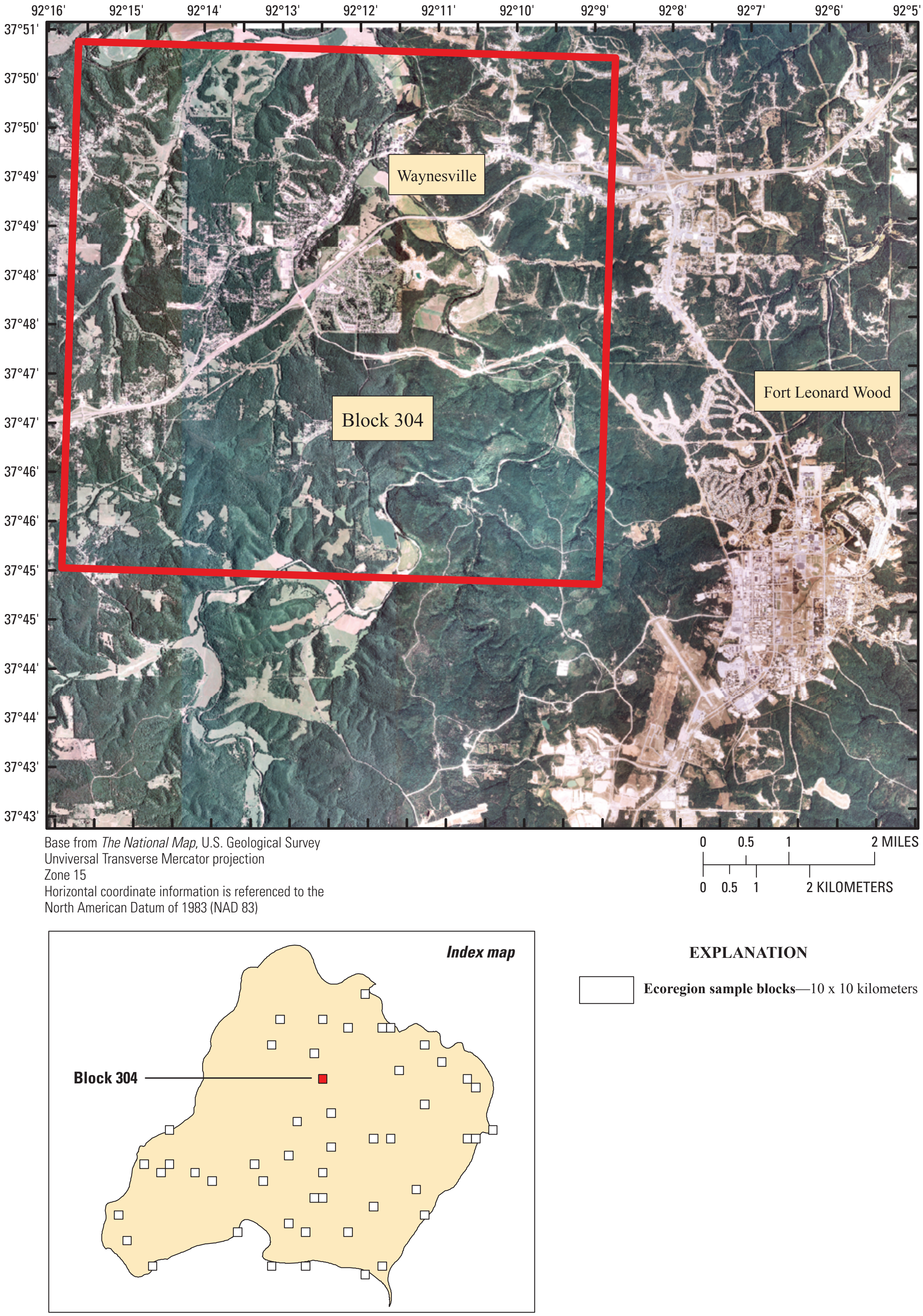

Figure 3. Waynesville, Missouri, is located just outside of the Fort Leonard Wood Military Installation and within sample block 304 of the Ozark Highlands.

Figure 4. Hay pasture south of Jefferson City in Cole County, Missouri. Photograph by U.S. Geological Survey, 2009.

sinkhole ponds exist, there are few natural lakes in this ecoregion (U.S. Forest Service, 2010). It is important to note that the 1939 inception of the Farm Pond Bill had an noticeable affect in this ecoregion. The Bill began as an incentive by the Soil Conservation Service and U.S. Fish Commission to create fish habitat and to conserve top soil (Springer, 2006). Farmers embraced the program as a way to provide water for their livestock, recreation, and domestic use, and sportsmen were also encouraged as the Bill provided habitat incentive for fish and waterfowl (Missouri Department of Conservation, 2010). Whereas most of the ponds are below the minimum mapping unit used by the Land-Cover Trends Project (less than 60 m), it is important to note that this conservation effort is responsible for creating many of the ponds across the ecoregion. More typical of the region are reservoirs that have resulted from the damming of several large rivers. Among them are Lakes Taneycomo, Bull Shoals, Table Rock, Ozark, and Truman (some lakes not shown on fig. 1). These relatively large open water bodies provide recreational boating and fishing activities and generally attract many tourists in the summer months. For example, Lake of the Ozarks is the largest manmade lake in the Midwest, and is 90 miles long with more than 1,100 miles of shoreline. Most of the shoreline is privately owned and occupied by vacation homes, hotels, condominiums, and restaurants.

Land-Cover Conversions in the Ozark Highlands

A Summary of Contemporary Land-Cover Change

The overall spatial change from 1973 to 2000 for the Ozark Highlands Ecoregion was 5.9 percent (plus or minus 0.7 percent) (table 1). Approximately 4.7 percent (plus or minus 0.5 percent) of the ecoregion changed from one land-cover type to another once in the study period, whereas 1.1 percent (plus or minus 0.3 percent) changed twice and 0.1 percent changed three times (table 1). The amount of change varied slightly from 1973 to 2000, with the total change (percent of the ecoregion) ranging from 1.5 to 2.0 percent (table 2). The average annual rate of change for the first three time periods (1973–80, 1980–86, and 1986–92) was 0.3 percent and was 0.2 percent for 1992 to 2000 (table 2). Overall, the approximate land-cover change was the greatest in the first period before decreasing in the later periods. This decrease of overall change in the middle of the study period may be due to the Midwest agricultural crisis that occurred in the 1980s.

When compared to the neighboring ecoregions, the Ozark Highlands underwent the third highest overall spatial change after the Mississippi Alluvial Plain and the Central Irregular Plains ecoregions (table 3).

The forest and agricultural classes underwent the most change during the study period (table 4). Despite covering 60,893 km^2 of the ecoregion in 2000, the forest class had a net loss of 2.3 percent (plus or minus 0.4 percent). Agriculture covered approximately 39,820 km^2 in 2000 and had a net gain of 1.7 percent (plus or minus 0.5 percent). Grassland/shrubland and developed land were the third and fourth most extensive land-cover classes in 2000 covering 2.8 percent and 2.1 percent of the ecoregion, respectively.

Table 1. Percentage of the Ozark Highlands Ecoregion that experienced change and associated error.

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

Number of changes	Percent of ecoregion (%)	Margin of error (+/- %)	Lower bound (%)	Upper bound (%)	Standard error (%)	Relative error (%)
1	4.7	0.5	4.2	5.2	0.3	7.3
2	1.1	.3	.8	1.3	.2	16.6
3	.1	0	.1	.1	0	29.4
4	0	0	0	0	0	57.7
Overall spatial change	5.9	.7	5.3	6.6	.4	7.6

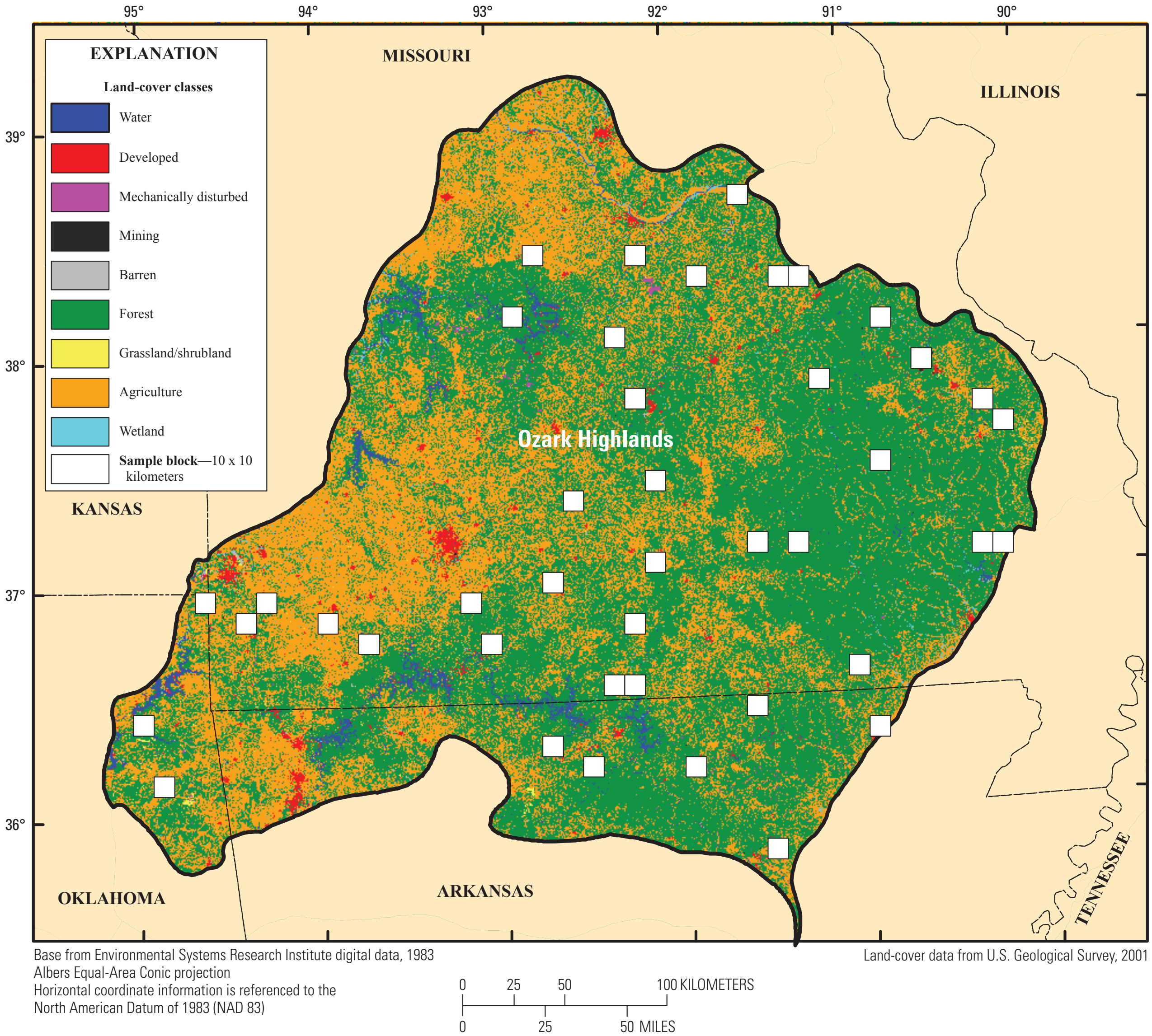

Figure 5. Land-cover data illustrating that the eastern portion of the ecoregion is more forested and becomes more agricultural in the west.

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

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

Period	Total change (% of ecoregion)	Margin of error (+/- %)	Lower bound (%)	Upper bound (%)	Standard error (%)	Relative error (%)	Average rate (% per year)
1973–1980	2	0.4	1.7	2.4	0.2	11.9	0.3
1980–1986	1.5	.2	1.3	1.8	.2	10	.3
1986–1992	1.8	.3	1.5	2.1	.2	11	.3
1992–2000	1.8	.3	1.6	2.1	.2	9.5	.2
Period	**Total change (km² of ecoregion)**	**Margin of error (+/- km²)**	**Lower bound (km²)**	**Upper bound (km²)**	**Standard error (km²)**	**Relative error (%)**	**Average rate (km² per year)**
1973–1980	2,201	386	1,816	2,587	263	11.9	314
1980–1986	1,665	245	1,420	1,910	167	10	277
1986–1992	1,955	315	1,640	2,271	215	11	326
1992–2000	2,003	278	1,725	2,281	189	9.5	250

Table 3. Overall spatial change of the Ozark Highlands Ecoregion compared to neighboring ecoregions.

Ecoregion	Overall spatial change
Ozark Highlands	5.9
Central Irregular Plains	7.2
Interior River Lowland	5.6
Mississippi Alluvial Plain	9.4
Boston Mountains	5.5

Neighboring ecoregions also experienced an overall net loss of forest (Karstensen 2008, 2009a, 2009b; Sayler, 2009); however, it is important to note that forest loss in the Ozark Highlands is likely because of agricultural expansion, whereas the driving force of land-cover change in the neighboring ecoregions is because of more complex driving forces. For example, in the Boston Mountains, which had a total net forest loss of 1.7 plus or minus 0.5 percent between 1973 and 2000, agricultural expansion also occurred (0.7 percent, plus or minus 0.2 percent) in the same period; however, the forest loss in the Boston Mountains is likely to be more attributed to the logging practices associated with the mechanically disturbed land-cover classification. A neighboring ecoregion that also illustrated an increase in agricultural land was the Interior River Lowlands (0.66 percent, plus or minus 1.3 percent).

The three leading land-cover conversions from 1973 to 2000 in the Ozark Highlands were: (1) forest to agriculture, (2) agriculture to grassland/shrubland, and (3) grassland/ shrubland to forest (table 5). Overall, the most common type of conversion in each temporal period was from forest to agriculture. Between 1973 and 2000, 2,593 km^2 were converted from forest to agriculture. This conversion may have resulted in a larger net increase in agricultural land had agriculture not been converting to grassland/shrubland, which may have been the result of the Conservation Reserve Program (CRP), which offered financial incentives for farmers to retire marginal agricultural land to native grasses or trees, usually for 10 years in duration (Johnson and Maxwell, 2001).

Drivers of Land-Cover Change in the Ecoregion

Most of the large-scale timber operations in the Ozark Highlands began in the late 1800s with the construction of railroads. The peak of timber production in the ecoregion occurred from approximately 1880 to 1920 (Jacobson and Primm, 1997). At the end of this Timber Boom period (1920), most of the marketable shortleaf pine was depleted, thereby shifting production to smaller companies that made railroad ties, stave bolts, firewood, and charcoal (Jacobson and Primm, 1997; Cunningham and Hauser, 1989; Stevens, 1991). Increases in timber production from the mid-1950s to the early 1970s represent renewed cutting of second growth forests (Jacobson and Primm, 1997; Cunningham and Hauser, 1989). This ecoregion analysis illustrates that the 1973 period had the greatest amount of forest cover when compared to the other four periods. This may be indicative of the second growth forests that were allowed to reach maturity before a period of increased agricultural expansion and less frequent burning.

In the late 1960s and early 1970s, net farm income in the Ozark Highlands increased significantly because of an increase in domestic prices and growth in export markets (Demissie, 1986). This was a common trend in the Midwest in this period. For example, the economic climate of the neighboring Central Irregular Plains ecoregion also encouraged farmers to expand production in an effort to take advantage of the export markets, strong commodity prices, farm income, and farmland values. Overall agricultural expansion in the Midwest was primarily because of the availability of abundant credit from various sources, high inflation rates, and low real-estate rates. In fact, Missouri's net farm income doubled between 1964 and 1974 (Demissie, 1986). This trend may be captured in the statistics of this ecoregion study as the greatest amount of area that was converted from forest to agricultural land occurred between 1973 and 1980, and is likely because of forest being cleared for agricultural (primarily cattle and poultry) expansion.

The agroeconomic market is subject to flux and in this time a considerable number of farmers took on heavy debt loads and became financially vulnerable to sudden shifts in economic forces (Stam and Dixon, 2004). In the early 1980s economic conditions reversed; total farm debt increased, land values became inflated, the export market reduced substantially, and there were substantial problems with farm lenders. The economic crisis is important to note primarily because in this time period agricultural land was still the dominant land-cover type despite the decreased production. For example, figure 6 shows that corn production and total cattle numbers decreased between the 1980 to 1986 and 1986 to 1992 periods.

Table 4. Estimated area for each land-cover class in the Ozark Highlands Ecoregion between 1973 and 2000.

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

	Water		Developed		Mechanically disturbed		Mining		Barren		Forest		Grassland/ shrubland		Agriculture		Wetlands		Nonmechanically disturbed	
	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-
1973	1.2	0.6	1.7	0.8	0.1	0.1	0.1	0.1	0.1	0.1	58.5	4.2	3	0.9	35.0	4.2	0.3	0.1	0	0
1980	1.2	.6	1.8	.9	.2	.1	.1	.1	.1	.1	57.7	4.1	2.8	.8	35.7	4.2	.3	.1	0	0
1986	1.2	.6	1.9	.9	.1	.1	.1	.1	.1	.1	57.4	4.1	2.6	.8	36.2	4.2	.3	.1	0	0
1992	1.3	.6	2.0	.9	.1	.1	.1	.1	.1	.1	56.9	4.1	2.7	.8	36.5	4.2	.3	.1	0	0
2000	1.3	.6	2.1	1	.3	.1	.1	.1	.1	.1	56.2	4	2.8	.8	36.8	4.2	.3	.1	0	0
Net change	.1	0	.4	.2	.2	.2	-0	0	-0	0	-2.3	.4	-.2	.3	1.7	.5	-0	0	0	0
Gross change	.1	0	.4	.2	.8	.2	0	0	.1	0	3.1	.4	1.6	.3	3	.3	0	0	0	0

	Water		Developed		Mechanically disturbed		Mining		Barren		Forest		Grassland/ shrubland		Agriculture		Wetlands		Nonmechanically disturbed	
	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-
1973	1,292	617	1,789	849	115	108	74	83	141	99	63,377	4,515	3,247	925	37,939	4,581	358	130	0	0
1980	1,309	613	1,957	950	178	64	63	82	148	95	62,541	4,426	3,081	918	38,698	4,550	357	130	0	0
1986	1,342	616	2,034	971	154	62	65	82	137	89	62,192	4,430	2,828	857	39,226	4,579	356	128	0	0
1992	1,365	618	2,160	1,020	162	69	66	82	134	87	61,684	4,430	2,876	834	39,529	4,590	356	128	0	0
2000	1,387	619	2,273	1,073	346	154	67	82	136	86	60,893	4,336	3,060	890	39,820	4,566	352	127	0	0
Net change	94	38	484	244	230	188	-7	17	-6	25	-2,484	471	-188	361	1,881	543	-6	12	0	0
Gross change	161	54	484	244	827	223	17	17	63	40	3,311	420	1,776	369	3,258	376	52	30	0	0

Table 5. Leading land-cover conversions during each of the four time periods.

[km², square kilometers; +, plus; -, minus; n/a, not applicable]

Period	From class	To class	Area changed (km²)	Margin of error (+/- km²)	Standard error (km²)	Percent of ecoregion	Percent of all changes
1973–1980	Forest	Agriculture	905	189	129	0.8	41.1
	Grassland/shrubland	Forest	321	158	108	.3	14.6
	Agriculture	Grassland/shrubland	241	75	51	.2	10.9
	Forest	Mechanically disturbed	177	64	43	.2	8.1
	Grassland/shrubland	Agriculture	158	100	68	.1	7.2
	Other	Other	399	n/a	n/a	.4	18.1
	Total		2,201			2	100
1980–1986	Forest	Agriculture	477	117	80	0.4	28.7
	Grassland/shrubland	Forest	307	115	79	.3	18.4
	Grassland/shrubland	Agriculture	193	111	76	.2	11.6
	Agriculture	Grassland/shrubland	166	79	54	.2	10
	Forest	Mechanically disturbed	153	62	42	.1	9.2
	Other	Other	369	n/a	n/a	.3	22.2
	Total		1,665			1.5	100
1986–1992	Forest	Agriculture	581	134	92	0.5	29.7
	Agriculture	Grassland/shrubland	367	125	85	.3	18.8
	Grassland/shrubland	Agriculture	222	120	82	.2	11.4
	Grassland/shrubland	Forest	176	78	53	.2	9
	Forest	Mechanically disturbed	157	69	47	.1	8
	Other	Other	452	n/a	n/a	.4	23.1
	Total		1,955			1.8	100
1992–2000	Forest	Agriculture	630	130	89	0.6	31.5
	Agriculture	Grassland/shrubland	375	119	81	.3	18.7
	Forest	Mechanically disturbed	344	154	105	.3	17.2
	Grassland/shrubland	Forest	184	69	47	.2	9.2
	Grassland/shrubland	Agriculture	105	43	29	.1	5.2
	Other	Other	365	n/a	n/a	.3	18.2
	Total		2,003			1.8	100
1973–2000 Overall	Forest	Agriculture	2,593	392	267	2.4	33.1
	Agriculture	Grassland/shrubland	1,148	295	201	1.1	14.7
	Grassland/shrubland	Forest	987	295	201	.9	12.6
	Forest	Mechanically disturbed	831	263	180	.8	10.6
	Grassland/shrubland	Agriculture	679	324	221	.6	8.7
	Other	Other	1,586	n/a	n/a	1.5	20.3
	Total		7,824			7.2	100

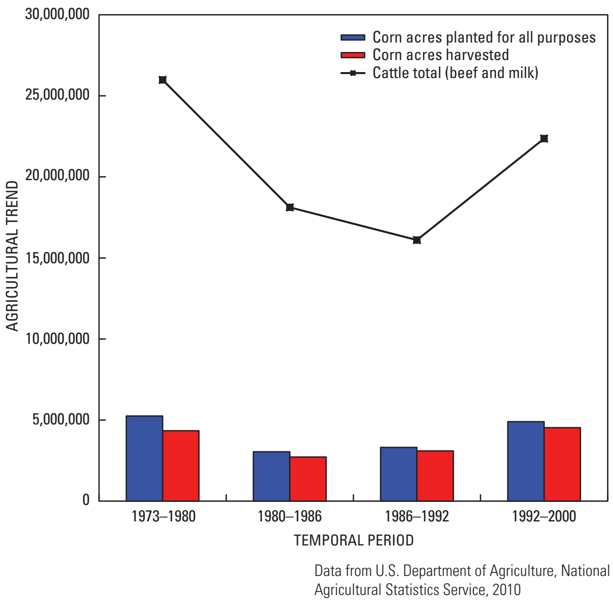

Figure 6. The decline of corn planted and harvested and number of cattle in the ecoregion in the agroeconomic crisis of the 1980s.

Moreover, the two periods that capture the economic crisis, may reflect the increased amount of abandoned agricultural land. And while CRP drastically decreased in the late-90s, it may have contributed to the land-cover pattern across the ecoregion (fig. 7). The agricultural land abandonment and CRP may be captured in this study as land classified as converting from agricultural land to grassland/shrubland. The 1986 to 1992 and 1992 to 2000 periods may be illustrative of farmers putting marginal agricultural land into contract or abandoning agricultural management practices for economic reasons.

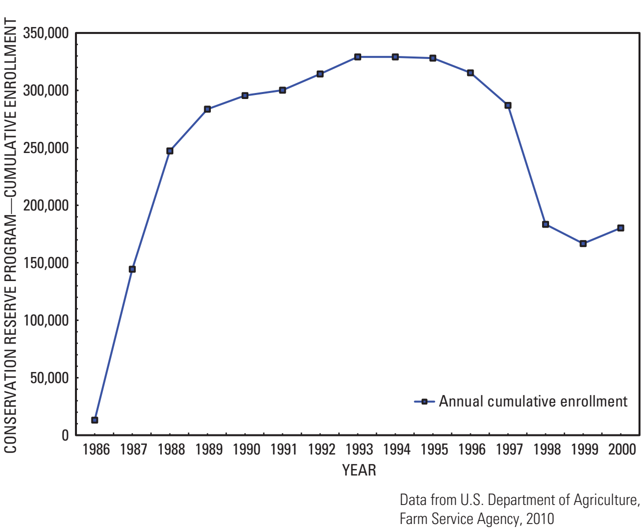

Figure 7. The annual cumulative enrollment in Conservation Reserve Program contracts in the ecoregion.

Conclusion

The dominate changes in the Ozark Highlands Ecoregion can be attributed to forest being cut for agricultural expansion. This is illustrated in the ecoregion statistics, as in each of the five study periods, forest cover decreased and agriculture increased. Despite the economic hardships that severely affected farms of the ecoregion in the 1980s, agricultural land cover increased in the study period even though production rates and value may have declined. Cattle and hogs continue to be the primary livestock grazed and sold, and corn continues to be the primary agricultural crop throughout the ecoregion.

In an excerpt from a historical land-use study on the Ozark Plateaus (Jacobson and Primm, 1997) the authors summarize land change in the ecoregion as:

> "Different types of land-use have taken place on different parts of the landscape of the Ozark Highlands. Uplands have been subjected to suppression of a natural regime of wildfire followed by logging, annual burning to support open range, patchy and transient attempts at cropping, a second wave of timber cutting, and most recently grazing intensity."

In forecasting future land-cover change in the Ozark Highlands it will be important to consider the rapid growth of the larger cities in the ecoregion. It is possible that the growing population will impose a greater demand for resource supply which will result in future demand on land cover and land use throughout the region.

References Cited

Adamski, J.C., Petersen, J.C., Freiwald, D.A., and Davis, J.V., 1995, Environmental and hydrologic setting of the Ozark Plateaus study unit, Arkansas, Kansas, Missouri, and Oklahoma: U.S. Geological Survey Water-Resources Investigations Report 94–4022, 69 p.

Fenneman, N.M., 1938, Physiography of the eastern United States: New York, McGraw-Hill, 714 p.

Cunningham, R.J., and Hauser, C., 1989, The decline of the Missouri Ozark forest between 1820 and 1920, *in* Waldrop, T.A., ed., Proceedings of the conference on pinehardwood mixtures: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, p. 34–37.

Davis, J.V., and Bell, R.W., 1998, Water-quality assessment of the Ozark Plateaus study unit, Arkansas, Kansas, Missouri, and Oklahoma—Nutrients, bacteria, organic carbon, and suspended sediment in surface water, 1993–95: U.S. Geological Survey Water-Resources Investigations Report 98–4164, 56 p.

Demissie, E., 1986, Farm financial trend in Missouri and its future implications: Agriculture and Human Values, v. 3, no. 4, p. 66–74.

Jacobson, R.B., and Primm, A.T., 1997, Historical land-use changes and potential effects on stream disturbance in the Ozark Plateaus, Missouri: U.S. Geological Survey, Water-Supply Paper 2484, 85 p.

Johnson, J., and Maxwell, B., 2001, The role of the Conservation Reserve Program in controlling rural residential development: Journal of Rural Studies, v. 17, p. 323–332.

Karstensen, K.A., 2008, Interior River Lowland Ecoregion Summary Report: U.S. Geological Survey Open-File Report 2008–1088, 5 p.

Karstensen, K.A., 2009a, Land-cover change in the Boston Mountains, 1973–2000: U.S. Geological Survey Open-File Report 2009–1281, 10 p.

Karstensen, K.A., 2009b, Land-cover change in the Central Irregular Plains, 1973–2000: U.S. Geological Survey Open-File Report 2009–1159, 8 p.

Karstensen, K.A., and Loveland, T.R., 2008, Monitoring land use on military installations, The Military Engineer , v. 101, no. 657, p. 47–48.

Loveland, T.R., Sohl, T.L., Stehman, S.V., Gallant, A.L., Sayler, K.L., and Napton, D.E., 2002, A strategy for estimating the rates of recent United States land cover changes: Photogrammetric Engineering and Remote Sensing, v. 68, no. 10, p. 1,091–1,099.

Missouri Department of Conservation, 2010, Wildlife Division: accessed June 9, 2010, at *http://mdc4.mdc.mo.gov/Documents/2050.pdf*.

Omernik, J.M., 1987, Ecoregions of the conterminous United States: Annals of the Association of American Geographers, v. 77, no. 1, p. 118–125.

Petersen, J.C., Adamski, J.C., Bell, R.W., Davis, J.V., Femmer, S.R., Freiwald, D.A., and Joseph, R.L., 1998, Water quality in the Ozark Plateaus, Arkansas, Kansas, Missouri, and Oklahoma, 1992–95: U.S. Geological Survey Circular 1158, 33 p.

Sayler, K.L., 2009, Contemporary land-cover change in the Mississippi Alluvial Plain ecoregion: accessed June 2, 2010, at *http://landcovertrends.usgs.gov/mw/eco73Report.html.*

Springer, C., 2006, Farm ponds: an introduction to the outdoors: accessed June 15, 2010, at *http://sports.espn.go.com/outdoors/general/news/story?page=c_fea_Springer_farmpond.*

Stam, J.M., and Dixon, B.L., 2004, Farmer bankruptcies and farm exits in the United States, 1899–2002: Washington, D.C., Economic Research Service, U.S. Department of Agriculture, Agriculture Bulletin Number 788, accessed June 7, 2010, at *http://www.ers.usda.gov/publications/aib788/aib788.pdf.*

Stehman, S.V., Sohl, T.L., and Loveland, T.L., 2005, An evaluation of sampling strategies to improve precision of estimates of gross change in land use and land cover: International Journal of Remote Sensing: v. 26, p. 4,941–4,957.

Stevens, D.L., 1991, A homeland and hinterland—The Current and Jacks Fork riverways: National Park Service, 248 p.

The Nature Conservancy, Ozarks Ecoregional Assessment Team, 2003, Ozarks Ecoregional Conservation Assessment: Minneapolis, Minn., The Nature Conservancy Midwestern Resource Office, 48 p.

U.S. Department of Agriculture, Farm Service Agency, 2010, Conservation Reserve Program cumulative enrollment by year: accessed June 10, 2010, at *http://www.fsa.usda.gov/Internet/FSA_File/cumulative08.xls.*

U.S. Department of Agriculture, National Agricultural Statistics Service, 2010, Data and statistics, U.S. and state data: accessed June 10, 2010, at *http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/index.asp.*

U.S. Department of Commerce, Bureau of Census, 1990, Population of counties by decennial census, 1900 to 1990: accessed June 3, 2010, at *http://www.census.gov/population/cencounts/mo190090.txt.*

U.S. Department of Commerce, Bureau of Census, 2000, State and county quick facts: accessed June 3, 2010, at *http://quickfacts.census.gov/qfd/states/29000.html.*

U.S. Forest Service, 2010, Ecological subregions of the United States: Compiled by Eastern Region and Minnesota Department of Natural Resources, chapter 17, section 222A: accessed June 3, 2010, at *http://www.fs.fed.us/land/pubs/ecoregions/ch17.html#222A*.

U.S. Geological Survey, 2001, Multi-resolution land characteristics consortium: National land cover database (NLCD 2001) multi-zone download site, accessed August 2, 2010, at *http://www.mrlc.gov/nlcd_multizone_map.phP*.

Woods, A.J., Foti, T.L., Chapman, S.S., Omernik, J.M., Wise, J.A., Murray, E.O., Prior, W.L., Pagan, J.B., Cornstock, J.A., and Radford, M., 2004a, Ecoregions of Arkansas: U.S. Geological Survey, accessed July 13, 2009, at *ftp://ftp.epa.gov/wed/ecoregions/ar/ar_front.pdf*.

Woods, A.J., Foti, T.L., Chapman, S.S., Omernik, J.M., Wise, J.A., Murray, E.O., Prior, W.L., Pagan, J.B., Cornstock, J.A., and Radford, M., 2004b, Ecoregions of Arkansas: U.S. Geological Survey, accessed July 13, 2009, at *ftp://ftp.epa.gov/wed/ecoregions/ar/ar_back.pdf*.

Glossary

Agriculture Land in either a vegetated or an unvegetated state used for the production of food and fiber. This includes cultivated and uncultivated croplands, hay lands, pasture, orchards, vineyards, and confined livestock operations. Note that forest plantations are considered forests regardless of the use of the wood products.

Barren Land comprised of soils, sand, or rocks where less than 10 percent of the area is vegetated. Barren lands are usually naturally occurring.

Developed Areas of intensive use with much of the land covered with structures or anthropogenic impervious surfaces (for example, high-density residential, commercial, industrial, roads) or less intensive uses where the land-cover matrix includes both vegetation and structures (for example, low-density residential, recreational facilities, cemeteries, parking lots, utility corridors), including any land functionally related to urban or built-up environments (for example, parks, golf courses,).

Forest Tree-covered land where the tree cover density is greater than 10 percent. Note that cleared forest land (clear-cuts) is mapped according to current cover (for example, mechanically disturbed or grassland/shrubland).

Grassland/Shrubland Land predominately covered with grasses, forbs, or shrubs. The vegetated cover must comprise at least 10 percent of the area.

Ice and Snow Land where the accumulation of snow and ice does not completely melt in the summer period (for example, alpine glaciers and snowfields).

Mechanically disturbed Land in an altered and often unvegetated state that, because of disturbances by mechanical means, is in transition from one cover type to another. Mechanical disturbances include forest clear-cutting, earthmoving, scraping, chaining, reservoir drawdown, and other similar human-induced changes.

Mining Areas with extractive mining activities that have a substantial surface expression. This includes (to the extent that these features can be detected) mining buildings, quarry pits, overburden, leach, evaporative, tailings, or other related components.

Non-mechanically disturbed Land in an altered and often unvegetated state that because of disturbances by non-mechanical means, is in transition from one cover type to another. Non-mechanical disturbances are caused by fire, wind, floods, animals, and other similar phenomena.

Water Areas persistently covered with water, such as streams, canals, lakes, reservoirs, bays, or oceans.

Wetland Land where water saturation is the determining factor in soil characteristics, vegetation types, and animal communities. Wetlands usually contain water and vegetated cover.

Publishing support provided by:
Rolla Publishing Service Center

For more information concerning this publication, contact:
Director, USGS Mid-Continent Geographic Science Center
1400 Independence Road
Rolla, MO 65401
(573) 308–3550

Or visit the Mid-Continent Geographic Science Center Web site at:
http://mcgsc.usgs.gov

Karstensen—**Land-Cover Change in the Ozark Highlands, 1973–2000**—Open-File Report 2010–1198