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Spatial and Temporal Analyses of the Morphological and Land Use Characteristics of the Buffalo River Watershed

H. Don Scott
University of Arkansas, Fayetteville

Kimberly R. Hofer
Unversity of Arkansas, Fayetteville

Arkansas Water
Resources Center

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SPATIAL AND TEMPORAL ANALYSES OF THE MORPHOLOGICAL AND LAND USE CHARACTERISTICS OF THE BUFFALO RIVER WATERSHED

Final Report to the National Park Service, Harrison, Arkansas

H. Don Scott and Kimberly R. Hofer
Department of Agronomy
University of Arkansas
Fayetteville, Arkansas

Arkansas Water Resources Center
113 Ozark Hall
University of Arkansas
Fayetteville, Arkansas

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Final Report

submitted to

National Park Service

Harrison, AR

by

H. Don Scott and Kimberly R. Hofer

Department of Agronomy

University of Arkansas

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July, 1995

INTRODUCTION

The Buffalo River was established by Congress in 1972 as the first National River in the United States. The Buffalo River, which originates in the higher elevations of the Boston Mountains in Newton County, is one of the few remaining free-flowing streams in Arkansas. It is considered to be one of Arkansas' greatest natural treasures, and thus, there is strong interest in protecting it from anthropogenic influences. An initial characterization of the soil taxonomic units, watershed boundaries, topography and physiographic units in the Buffalo River Watershed was presented by Scott and Smith (1994). The spatial distribution of the geologic units in the watershed was presented by Hofer et al. (1995).

OBJECTIVES

The objectives of this work were to determine the spatial distribution of selected morphological characteristics and temporal changes in land use of the Buffalo River Watershed.

MATERIALS AND METHODS

This work in the Buffalo River Watershed involved the development of (1) additional digital morphological characteristics, (2) classification of 1992 satellite imagery into selected land-use characteristics, and (3) comparisons of land-use characteristics over time and over natural and geopolitical boundaries. This work depended heavily on the previous work of Scott and Smith (1994) along with several digital data layers that have been updated since that report was completed.

Land Use

A combination of source materials was used to develop the spatial and temporal distribution of land use-land cover (LULC) within the Buffalo River Watershed (Table 1). Source materials covering three time periods of land use and the watershed boundaries, at various scales, were furnished by the National Park Service. These maps were produced by photo-interpretation of uncontrolled aerial photography and return beam vidicon imagery. The photo-interpreted polygons had been transferred to mylar overlays using a stereo zoom transfer scope to correct for distortion. In addition, the state-wide digital LULC of 1972 developed by the United States Geological Survey (USGS) was used in this study. The area within the Buffalo River Watershed was extracted from this 1972 LULC digital database and corrected for one area. It was discovered that one area (polygon) in this 1972 USGS LULC database originally had been mislabeled as an urban area. This was corrected by re-labeling the area as agricultural, the correct category. The corrected area falls within portions of the Little Buffalo River, Indian Creek, Bear Creek I, and Shop Creek sub-basins, and is entirely within Newton County.

Table 1. Source materials used for the land use characterization of the Buffalo River Watershed

Year	Source Material
1965	National Park Service, scale 1:20,000
1972	USGS LULC, scale 1:100,000
1974	National Park Service, scale 1:80,000
1979	National Park Service, return beam vidiocon imagery
1992	classified TM imagery, 30m resolution

The fact that these source materials varied in scale and pretreatment means that comparisons of the areal extent of the various land use categories across years should be considered as approximate and not absolute. However, trends in land use over time within a given area should be considered as evidences of the direction and magnitude of the changes in the watershed.

Development of Land use from 1992 Satellite Imagery

Land use - land cover of the Buffalo River Watershed for 1992 was characterized based on Landsat Thematic Mapper (TM) imagery. The imagery was stored as a part of the Center for Advanced Spatial Technology (CAST) state-wide database. For this report, the purpose for the classification was to allow land use comparisons within the watershed between 1992 and the previous years for which LULC data in the watershed already existed (Scott and Smith, 1994). Unsupervised classification techniques were used on the 1992 TM imagery to determine the spatial distribution in the Buffalo River Watershed of the broad categories of agriculture, forest, water, and urban/barren. In addition, the category consisting of transportation, power, and communications was taken from classifications of previous years and incorporated into the 1992 classification.

The TM imagery used for the LULC classification was recorded on the morning of October 10, 1992, and consists of seven seasonally-corrected spectral bands. Bands 1, 2, and 3 are blue (0.45 - 0.53 um), green (0.52 - 0.6-0 um), and red (0.63 - 0.69 um), respectively. Band 4 (0.76 - 0.90 um) records the near-infrared portion of the spectrum. Band 5 (1.55 - 1.75 um) and band 7 (2.08 - 2.35 um) are shortwave infrared bands. Band 6 (10.5 - 12.5 um) is a thermal infrared band. Thematic Mapper imagery has a resolution of 30 meters.

Classification of the 1992 Buffalo River Watershed TM imagery was conducted using PCI v5.3 image classifying software. Two different unsupervised classification algorithms in PCI were utilized. Unsupervised classification of imagery allows a computer algorithm to group image pixels into homogeneous clusters according to their spectral reflectances. Each of the resulting clusters is then assigned to a land use category by the analyst (Schowengerdt, 1983). The KCLUS algorithm uses the K-Means method to classify the image into different clusters. It is an iterative routine which begins with an initial set of spectral clusters. On the first iteration, each pixel in the image is assigned to the cluster whose spectral reflectance most resembles its own. This assignment results in a new set of spectral clusters, to which pixels are reassigned in the same way. The process is repeated until no further movement beyond a specified threshold occurs, or until a maximum number of iterations has been reached. The PCI ISODATA classifier uses the isodata method of classification. This routine is similar to the KCLUS algorithm, but employs a more sophisticated set of heuristic techniques. Details about the K-means and isodata methods of classification can be found in Tou and Gonzales (1974), and in the PCI v5.3 documentation.

Classification routines were run on the TM imagery three separate times. Although each run resulted in a classification that was regarded as good, each subsequent run was considered to be an improvement over the previous run. Results of the third run, therefore, were accepted as the final LULC classification of the imagery, and are presented and discussed in this report. The first run applied the KMEANS classifier to the TM bands, specifying an output of 50 clusters. The ISODATA classifier was used in the second and third runs, and resulted in 100 and 159 clusters, respectively. In addition to the raw TM imagery, results from a tasseled cap analysis were input into the third classification routine. Tasseled cap analysis results in greenness, brightness, and wetness components which are reached by weighting the TM bands differently for each component. Details of this procedure are available in the PCI v5.3 documentation.

Assignment of clusters resulting from the classification routines to land use classes was accomplished using the PCI v5.3 ImageWorks module. The image containing the clusters was displayed. A unique color was selected for each land use category to be classified and, as clusters were assigned to categories, they were displayed in the appropriate color using the ImageWorks pseudo-color table. Throughout the process, the raw TM imagery was viewed in different band and color combinations. In particular, TM bands 4, 3, and 2 were viewed in red, green, and blue, respectively, to achieve a display similar to that of a false-color IR composite. Decisions about category assignments were influenced by several factors, including various sources of ancillary data.

To begin, coincidence reports between the clustering results and the 1979 and 1972 land use maps (Scott and Smith, 1994) were run. Clusters which were accounted for entirely or almost entirely by a particular category in previous years were generally assigned to that category. If any doubt existed as to the proper assignment of a cluster, a decision was not made until other factors were considered. Once as many clusters as possible were classified in this way, remaining clusters were assigned to categories using various strategies. A coincidence report was also run between the clustering results of the third classification routine, and the classified image that was based on the second classification routine. This report was used in a similar way to aid in assigning categories to clusters of the final routine. Doing this was regarded as valid since, though spectral clustering resulting from the third run was the most refined, the second classification was thought to be a generally good one.

Field boundary data collected in 1992 were available from the National Resources

Conservation Service for an eastern portion of the watershed in a vector format (P. Smith, personal communication, 1995). Because these field data were collected in the sub-basins of Tomahawk Creek, Brush Creek I, Brush Creek II, and Calf Creek and near the time of the satellite imagery, they were extremely helpful in verifying the cluster assignments described above, particularly in verifying which clusters should or should not be included with the agricultural category. These vectors also were helpful in selecting additional clusters which had reflectances characteristic of agricultural lands.

General trends in the image became apparent once a sufficient number of clusters were assigned to categories and were displayed in the corresponding colors. Additional clusters could then be examined and classified based on their association. Clusters which were not yet assigned to a category but were largely surrounded by a particular category (mainly agricultural or forest) were displayed separately in a unique color. If it appeared that most of the pixels from that cluster were in fact associated with a certain category, the cluster was assigned to that category.

Because urban and barren areas have similar spectral reflectances (both are very bright), it was not possible to separate them when assigning categories. For example, when a cluster occurring in an urban area was assigned a unique color to distinguish it from its surroundings, it became apparent that pixels belonging to the same cluster also occurred along the Buffalo River in places where the classification of barren (i.e., sand or gravel bar) was far more reasonable. To select clusters for the urban/barren category, the known urban area of the town of Marshall was viewed with Digital Line Graph (DLG) road vectors overlain on the image. Clusters occurring within this area were highlighted using a unique color. The clusters which, when highlighted, proved to be associated only or mostly with the urban area, and usually with likely barren areas, were classified as urban/barren.

All 159 clusters from the third classification routine were assigned to one of the four categories of agricultural, forest, urban/barren, or water. After this was accomplished, it was observed that single pixels classified as urban were scattered throughout areas that were otherwise agricultural. This is not surprising since any type of building existing within an agricultural area, including poultry houses, could give an urban type of reflectance. It was also noted that some pixels classified as forest were scattered throughout agricultural areas, and vice versa. This is not surprising either, since small stands of trees may exist within fields, and since any shrubby vegetation existing within a field may contribute to a spectral signature closer to that of forested areas. To eliminate some of these isolated pixels, a sieve filter routine in PCI v5.3 called SIEVE was run on the classified image. The sieve filter aggregates isolated pixels into the largest surrounding category. Details about SIEVE can be found in the PCI v5.3 documentation.

Areas covered by water, e.g., the Buffalo River and its larger tributaries, were easily detected in the satellite imagery due to the imagery's 30 meter resolution, as well as to the distinctive spectral signature of water. Water has an extremely low near-infrared reflectance. DLG stream vectors were used to further confirm the areas thought to be covered by water. The result was a map having considerably more area classified as water than in any of the classification maps from previous years. This means that most areas, i.e., pixels, classified as water in the 1992 imagery had been classified in other categories in the previous years. In order keep this area constant across all years for comparison purposes, areas classified as water in the 1992 imagery, as well as in any of the previous years, were patched into the maps for every year of analysis. In doing this, the assumption was made that water coverage has not changed drastically over the time period examined.

The category of transportation, power, and communications (primarily roads) was included in the earlier LULC maps (Scott and Smith, 1994). Not all these areas, however, were identified as such in the 1992 classification. It would probably be appropriate for some of the pixels belonging to clusters identified as urban/barren in the 1992 classification to be assigned to this category. In fact, linear trends of areas classed as urban/barren in the classified imagery occurred and coincided DLG road data. Similar spectral reflectances, however, between urban and barren areas, and roads, did not allow separate clusters to be formed for each during the unsupervised classification. Again, in an effort to maintain a uniform comparison across all the years, areas assigned to the transportation, power, and communications category in any of the previous years were patched into the classification maps for all the years, including 1992.

The digital land use data for 1992 was used in combination with digital land use data from 1965, 1972, 1974 and 1979 to quantify changes in land use over time. Overlays were made of the land use on natural and political boundaries and differences in the areal extent in forest and agriculture over time were computed and used to gain additional information on the spatial and temporal changes in land use in the watershed.

RESULTS AND DISCUSSION

Buffalo River Watershed

Physiographic Provinces

The Buffalo River Watershed is found in three physiographic provinces in northern Arkansas. The areal extent of the watershed in these provinces is given in Table 2. The spatial distribution is shown in Figure 1. These data show that almost half of the Buffalo River Watershed occurs in the Springfield Plateau; about one-third of the watershed occurs in the Boston Mountains; and almost 20% occurs in the Salem Plateau. In general, the Springfield Plateau is in the northern and central portion of the watershed, the Boston Mountains is in the southern portion of the watershed and the Salem Plateau is in the eastern portion of the watershed. The areal extent of the watershed is 857,607 acres.

Table 2. Areal extent of the Buffalo River Watershed in the three physiographic provinces in northern Arkansas.

Province	Areal Extent	Percent of total
	acres	
Boston Mountains	293,065	34.17
Springfield Plateau	400,004	46.64
Salem Plateau	164,538	19.19

Political Boundaries

The Buffalo River Watershed is found in nine counties in northern Arkansas. The areal extent of the watershed in these counties is presented in Table 3 and the spatial distribution in Figure 2. The digital county boundaries were obtained from the 1990 U.S. Census Bureau

TIGER files and represent an update from those published in Scott and Smith (1994).

Table 3. Extent and proportion of the Buffalo River Watershed found in the nine counties in northern Arkansas.

County	Areal Extent	Percent of Total
	acres	
Baxter	21,746	2.54
Boone	6,583	0.77
Madison	1,590	0.19
Marion	95,439	11.13
Newton	396,536	46.24
Pope	7,725	0.90
Searcy	319,704	37.28
Stone	6,835	0.80
Van Buren	1,449	0.17

These data show that almost 95% of the watershed is found in three counties: Newton, Searcy and Marion counties. Almost half of the Buffalo River Watershed is found in Newton County alone and over one-third is found in Searcy County.

Slopes

The slopes of the Buffalo River Watershed were divided into three broad categories: < 7 degrees, 7 to 14 degrees, and > 14 degrees. A summary of the areal extent of these three slope categories in the watershed is presented in Table 4. The spatial distribution of the three slope categories is shown in Figure 2. These results emphasize the ruggedness of the topography in the watershed. The greatest areal extent, over 45% of the watershed, occurs in the slope category of 7 to 14 degrees. The areal extent of the watershed in the slope categories less than 7 degrees and greater than 14 degrees was about the same. These data indicate that there is a large proportion of the Buffalo River Watershed where the slopes are quite steep.

Table 4. Areal slope characteristics of the Buffalo River Watershed.

Slope category	Areal extent	Percent of Total
degrees	acres	
< 7	225,069	26.24
7 - 14	393,376	45.87
> 14	239,162	27.89

Land Use Characterization

Land use characteristics of the Buffalo River Watershed were estimated for five categories over a 27-year period of time. The results are presented in Bal. Because the coverage for both water and transportation, communication and power was made uniform across all years to improve comparisons made in this report, the values presented in Table 5 for previous years differ slightly from those reported in Scott and Smith (1994). Comparisons of other land use categories made between years in the study period should be regarded as estimates only, due to the differences in classification methods between these years. The spatial distribution of the LULC categories in the watershed for five years is shown in Figures 3-7. For all five years examined, forest represented the largest land use in the watershed and was followed by agricultural, i.e.,, primarily pasture; the combined urban and barren areas; water; and transportation, power and communications. The areal extent of the first three land use categories changed temporally. The area in forest decreased while the areas in agriculture and urban/barren (except for 1979 data) increased during the 27-year period.

Table 5. Estimated land use characteristics of the Buffalo National River Watershed by year.

Land use category	1965	1972	1974	1979	1992
	acres				
Forest	725,545	701,488	681,934	673,220	626,782
Agricultural	122,175	145,912	160,466	174,525	214,955
Urban and barren	2,562	3,481	5,097	3,063	9,175
Water	2,812	2,812	2,812	2,812	2,812
Transportation, power and communication	3,883	3,883	3,883	3,883	3,883

Linear Regression with Time

Regression techniques were used to quantify the temporal relationships between the areal extent in forest and in agriculture (pasture). The statistical analyses were made assuming that sampling began in 1965, i.e., time t equaled zero in 1965. The results, presented in Table 6, indicate that over the 27-year period of study a linear decrease occurred in the acres of forest and a linear increase occurred in the acres of agriculture in the watershed. The slopes of these two regression lines were nearly equal in magnitude but opposite in sign, indicating that the annual decrease in areas of forest was approximately the same as the annual increase in acres of pasture. On the average, about 94.6% of the annual loss of forest area could be accounted for by the increase in pasture. Thus, in this watershed the primary conversion of the forests has been to pasture. In this analysis, the remainder of the area was placed in the urban/barren category.

The regression equations show that, if the annual rates of change in pasture and forest remain the same, by the year 2050 the area of pasture will equal the area of forest in the watershed, and that this area will be about 415,775 acres. At this time, the combined area of forest and pasture in the watershed would be about 831,550 acres leaving about 26,100 acres for other land use categories.

Table 6. Regression coefficients and coefficients of determination for the temporal relationships between forest and agricultural lands in the Buffalo River Watershed.

Category	Intercept	Slope	R^2
	acres	acres/yr	
Forest	723,045	-3,619	0.982
Agricultural	124,588	+3,423	0.990

Land Use Balance by Land Use Category

Changes in area in the watershed by land use category between 1979 and 1992 are summarized in Table 7. The spatial distribution of these changes is shown in Figure 8, where red indicates areas which were classified as forest in 1979, and as agricultural, urban, or barren in 1992. Such areas occur within national park boundaries, as well as outside park boundaries. Many of these areas can be interpreted as having been cleared between 1979 and 1992, although this can not be true for all such areas, particularly those lying within wilderness boundaries. One explanation for those areas meeting the change criteria, which have not in fact undergone conversion during this time period, is that some natural grassy areas (glades) are more likely to resemble pasture lands than forest lands, in terms of spectral signature. These areas would therefore be assigned to the agricultural category based on the unsupervised classification methods applied to the 1992 TM imagery, while the same areas may have been assigned to the category of forest based on visual interpretation of the 1979 air photography and RBV imagery. In addition, relatively small, isolated, grassy areas may have been aggregated into the forest category in the 1979 interpretation, while being classified as spectrally different from surrounding forest in the 1992 classification. Further, some areas of bare rock or exposed cliffs may have been detected as having barren spectral characteristics in the 1992 unsupervised classification of satellite imagery, placing them in the urban or barren category. Some of the same bare rock areas may have been included in the forest category in the 1979 air photography and RBV imagery. Areas in Figure 8 depicted in black were classified as agriculture, urban, or barren in 1979 and as forest in 1992. Differences in classification methods should again be kept in mind when examining these areas. Comparisons made between these years are estimates only, due to the differences in classification methods between 1979 and 1992. These results show that, over this 13-year period and within a given land use category, the land use was dynamic.

A land area balance was computed for the pasture, forest and urban/barren categories by accounting for the additions of land from other categories, losses of land to other categories and the land that remained in the same category. The changes in pasture, forest and urban/barren areas were quantified between 1979 and 1992. Of the 174,525 acres classified as pasture in 1979, about 4,720 and 52,276 acres had been converted by 1992 to urban/barren areas and to forest, respectively. This conversion represented 32.7% of the land area classified in pasture in 1979. Of the 673,220 acres classified as forest in 1979, about 3,724 and 95,845 acres were converted by 1992 to urban/barren areas and to pasture, respectively. This represented about 14.8% of the land area in forest in 1979. Of the 2,209 acres classified as urban/barren areas in 1979, 1,279 and 422 acres were converted to pasture and forest, respectively. These areas represented about 77% of the land area in the urban/barren category in 1979. Therefore, in terms of percent of the land area by category in 1979, the urban/barren areas were the most dynamic. However, in terms of land area within a land use category, the forest category was the most dynamic between 1979 and 1992. These data indicate that there was change in LULC in both directions. However, a greater area of land was converted from forest to agriculture (95,845 acres) than from agriculture to forest (52,276 acres). The spatial distribution of changes in the watershed by land use category over the entire study period is shown in Figure 9. Changes shown between 1965 and 1992 should again be viewed as estimates due to differences in classification methods between these two years.

Table 7. Coincidence table of the changes in land use category between 1979 and 1992 in the Buffalo River Watershed.

Category	Category change to 1992	Area	Percent change in cover
		acres	
Agricultural (1979)		174,525	
	urban/barren	4,720	2.71
	agricultural	117,529	67.34
	forest	52,276	29.95
Forest (1979)		673,220	
	urban/barren	3,724	0.55
	agricultural	95,845	14.24
	forest	573,651	85.21
Urban/barren (1979)		3,063	
	urban/barren	731	23.87
	agricultural	1,576	51.45
	forest	756	24.68

Land Use by Slope Category

Land use characteristics of the Buffalo River Watershed were also analyzed over time by slope category and the results are presented in Table 8. These data show that land use in the watershed is a function of slope category (Figures 10-12). The acreage in forest declined during the 27-year period in each of the three slope categories. The greatest loss of forest was in the 7 to 14 degrees category between all five years examined. Over the 27-year period of study, forest acreage declined by 23,916, 46,000 and 28,846 acres in the < 7, 7 to 14 and > 14 degrees slope categories, respectively. This indicates that the greatest loss of forest was in the two highest slope categories. Using the 1965 data as the base, this represented a percentage decrease in forest area of 16.3, 13.2 and 12.5%, for the same slope categories, respectively. Thus, the largest area of forest lost occurred in the medium slope category but the largest percentage loss occurred in the lowest slope category.

The acreage in pasture increased among all years in all slope categories during the 27-year period. As expected, the greatest extent of pasture was in the lowest slope category, > 7 degrees, and the least was in the highest slope category, > 14 degrees. During the period of study, however, pasture increased by 21,016, 43,444 and 28,319 acres in the < 7, 7 to 14 and > 14 degrees categories, respectively. Based on area, this indicates that the greatest increase in pasture was in the two highest slope categories. Using 1965 data as the base, this represented a percentage increase in pasture of 28.4, 104.1 and 445.1% for these same slope categories, respectively. Therefore, since 1965, significant increases of pasture have occurred in the watershed, particularly in the two higher slope categories.

Table 8. Estimated land use characteristics as a function of slope category in the Buffalo River Watershed over the 5 years of analysis.

Slope	Land use category	1965	1972	Year 1974	1979	1992
degrees				acres		
< 7	forest	146,553	147,907	130,656	128,363	122,637
	agricultural	74,082	72,393	87,797	92,125	95,098
	urban/barren	1,734	2,298	3,211	2,062	4,873
	water	1.052	1,052	1,052	1,052	1,052
	transportation	1,408	1,408	1,408	1,408	1,408
7 - 14	forest	348,133	331,880	325,911	320,927	302,133
	agricultural	41,732	57,417	61,798	69,046	85,176
	urban/barren	631	1,522	1,490	818	3,518
	water	754	754	754	754	754
	transportation	1,795	1,795	1,795	1,795	1,794
> 14	forest	230,858	221,701	225,367	223,931	202,012
	agricultural	6,362	15,259	10,872	13,353	34,681
	urban/barren	196	505	396	183	784
	water	1,005	1,005	1,005	1,005	1,005
	transportation	680	680	680	680	680

Land Use by County within the Watershed

Land use characteristics in the Buffalo River Watershed in the nine counties are presented for three years in Table 9. Data are also presented that quantify the changes in forest and in pasture area in each county between 1965 and 1992. All counties lost land area in forest and gained land area in pasture during this 27-year period. In terms of magnitude, however, the greatest changes occurred in the three counties that comprise the largest proportion of the watershed. For example, Newton, Searcy and Marion counties lost an estimated 43,224, 38,066 and 15,045 acres of forest in the watershed, respectively over the 27-year period. During the same time period, these same respective counties gained 40,949, 35,410 and 14,326 acres of pasture within the watershed.

Examination of land use characteristics within the watershed by county indicates that, within individual counties, the rate of change of land use was not constant over time. For example, between 1979 and 1992, counties such as Boone, Pope, Stone and Van Buren had small increases in pasture area within the watershed, whereas counties such as Baxter, Marion, Newton and Searcy had relatively large increases in pasture acreage within the watershed. Similarly, counties such as Boone, Madison, Pope, Stone and Van Buren were relatively static in forest areas within the watershed, whereas Marion, Newton and Searcy counties had relatively large losses in forest land area.

Table 9. Land use for three years by county within the Buffalo River Watershed. The change represents the difference between the areas in the same category between 1992 and 1965 data.

County	Land use	1965	1979	1992	Change
		------------	acres	------------	
Baxter	agriculture	1,515	1,489	2,014	499
	forest	20,132	20,158	19,574	- 568
	water	99	99	99	
Boone	agriculture	1,395	2,165	2,115	720
	forest	5,185	4,414	4,387	-798
	water	3	3	3	
Madison	agriculture	177	211	297	120
	forest	1,391	1,357	1,255	-136
	water	7	7	7	
Marion	agriculture	11,684	18,504	26,010	14,326
	forest	82,398	75,729	67,353	-15,045
	urban/barren	296	165	1,037	
	water	765	765	765	
	transportation	275	275	275	
Newton	agriculture	38,140	56,224	79,089	40,949
	forest	354,290	336,467	311,066	-43,224
	urban/barren	561	546	3,120	
	water	842	842	842	
	transportation	2,418	2,418	2,418	
Pope	agriculture	815	1,090	1,049	234
	forest	6,798	6,517	6,543	-255
	urban/barren	2	8	24	
	water	6	6	6	
	transportation	104	104	105	
Searcy	agriculture	65,632	91,452	101,042	35,410
	forest	249,909	223,710	211,843	-38,066
	urban/barren	1,701	2,342	4,684	
	water	1,084	1,084	1,084	
	transportation	1,052	1,052	1,052	
Stone	agriculture	2,430	2,746	2,805	375
	forest	4,378	4,062	3,862	-516
	water	6	6	9	
	transportation	20	20	20	
Van Buren	agriculture	387	643	534	147
	forest	1,062	806	899	-163
	urban/barren	0	0	16	

Land Use by Physiographic Region

Land use characteristics within the Buffalo River Watershed in the three physiographic regions are given in Table 10. All three regions lost areas of forest and gained areas of pasture between 1965 and 1992. During the 27-year period, approximately 25,101, 56,906, and 16,757 acres of forest were lost in the Boston Mountains, Springfield Plateau and Salem Plateau, respectively. The greatest losses in land area in forest occurred in the Springfield Plateau and the lowest occurred in the Salem Plateau which was reflective of the proportion of the watershed in these two physiographic regions (Table 2). On a percentage basis, these losses in forest represented 8.6, 14.2 and 10.2% of the areas within the watershed in the Boston Mountains, Springfield Plateau and Salem Plateau, respectively.

During the same time period, land area in pasture increased by approximately 23,874, 52,892 and 16,014 acres in the Boston Mountains, Springfield Plateau and Salem Plateau, respectively. These gains in pasture were only slightly lower than the losses of land area in forest in each region and represent 8.2, 13.2 and 9.7% of the area within the watershed in the three physiographic regions. Significant increases were also found in urban/barren areas in each region over this time period.

When the land use for forest and pasture were considered within a physiographic region, the regression of the LULC relationships with time were linear (Table 11). This indicated that the rate of change in land use of these two LULC categories was constant in each physiographic region. The greatest annual rates of change, as reflected in the slopes, was found in the Springfield Plateau; the lowest was in the Salem Plateau.

Table 10. Land use for three years in the three physiographic regions in the Buffalo River Watershed.

Physiographic region	Land use category	1965	Year 1979	1992
		- - - - - - - - - - - acres - - - - - - - - - - - -		
Boston Mountain	agricultural	21,516	31,108	45,390
	forest	269,439	259,727	244,338
	urban/barren	76	242	1,446
	water	257	257	257
	transportation	1,633	1,633	1,633
Springfield Plateau	agricultural	81,545	116,618	134,437
	forest	314,030	278,767	257,124
	urban/barren	1,008	2,182	6,014
	water	822	822	822
	transportation	1,608	1,608	1,608
Salem Plateau	agricultural	19,114	26,799	35,128
	forest	142,076	134,726	125,319
	urban/barren	893	639	1,716
	water	1,733	1,733	1,733
	transportation	643	643	643

A summary of the land use in 1965, 1979 and 1992 by physiographic region of the Buffalo River Watershed by slope category is given in Table 12. These results also indicate that the loss of land area in forest was similar to the gain in land area in pasture in the three regions. In general, the rate of change in land area for both forest and pasture categories at the two higher slope categories was greater during the latest time period, i.e., between 1979 and 1992, than during the earlier time period, i.e., between 1965 and 1979. At slopes < 7 degrees, the rate of change in land use was lower during the latest time period. Also, over the 27-year time period there was a considerable increase in urban/barren areas in the three regions.

Table 11. Linear regression relationships of the land area in pasture and forest categories in the three physiographic regions of the Buffalo River Watershed over the 27-year period.

Region	Land use	Intercept	Slope	R^2
Boston Mountains	agriculture	210,622	881.7	0.982
	forest	270,499	-926.7	0.977
Springfield Plateau	agriculture	83,999	1,966	0.973
	forest	312,183	-2,113	0.987
Salem Plateau	agriculture	18,916	593	0.998
	forest	142,506	-619	0.992

Table 12. Summary of the land use in three years by physiographic region of the Buffalo River Watershed by slope category.

Physiographic region	Slope Category	Land use category	Year 1965	1979	1992
	degrees		- - - - - - - - - - -	acres	- - - - - - - - - -
Boston Mountains	< 7	agriculture	13,254	17,070	18,899
		forest	52,589	48,691	46,295
		urban/barren	46	127	753
		water	192	192	192
		transportation	624	624	624
	7 to 14	agriculture	7,251	11,829	16,901
		forest	124,716	120,087	114,566
		urban/barren	29	110	593
		water	38	38	38
		transportation	753	753	753
	> 14	agriculture	1,010	2,208	9,591
		forest	92,134	90,949	83,477
		urban/barren	2	5	99
		water	27	27	27
		transportation	257	257	257
Springfield Plateau	< 7	agriculture	51,341	63,616	65,157
		forest	71,482	58,971	55,632
		urban/barren	1,248	1,631	3,428
		water	401	401	401
		transportation	568	568	568
	7 to 14	agriculture	26,354	44,906	53,373
		forest	159,812	141,306	131,130
		urban/barren	294	479	2,190
		water	204	204	204
		transportation	743	743	743
	> 14	agriculture	3,850	8,096	15,906
		forest	82,736	78,491	70,362
		urban/barren	51	103	395
		water	217	217	217
		transportation	296	296	296

Table 12. Continued.

Physiographic region	Slope Category	Land use category	1965	Year 1979	1992
	degrees			acres	
Salem Plateau	< 7	agriculture	9,487	11,440	11,043
		forest	22,482	20,701	20,710
		urban/barren	442	305	692
		water	459	459	459
		transportation	216	216	216
	7 to 14	agriculture	8,127	12,311	14,902
		forest	63,605	59,533	56,437
		urban/barren	308	229	734
		water	513	513	513
		transportation	290	299	299
	> 14	agriculture	1,500	3,048	9,183
		forest	55,988	54,492	48,173
		urban/barren	143	105	289
		water	762	762	762
		transportation	128	128	128

Land Use by Soil Category

Land use by soil taxonomic unit is presented for three years in Table 13. The LULC characterization is presented only on those soils occupying greater than 1000 acres in the watershed.

Over the 27-year period, changes in LULC occurred on all soils and the magnitude of some of the changes were significant. Soil taxonomic units with changes from forest to pasture area greater than 1,000 acres included Arkano-Moko complex, Clarksville, Eden-Newnata complex, Enders, Enders-Leesburg, Estate-Lily Udorthorents, Estate-Portia-Moko association, Lily-Udorthorents-rock outcrop, Linker, Linker-Mountainburg complex, Moko-rock outcrop, Nella-Enders, Nella-Steprock complex, Nella-Steprock-Mountainburg complex, Newnata-Eden-Moko complex, Nixa and Noark. Particularly large (approximately 3000 acres or more) increases in pasture occurred on the Arkana-Moko complex, Clarksville, Enders, Enders-Leesburg, Estate-Lily-Udorthents complex, Estate-Portia-Moko association, Nella-Enders, Nella-Steprock-Mountainburg complex, and Noark soils. In particular, over 18,000 acres of forest on the Clarksville and Noark mapping units were converted to pasture during this period.

There were other soils, however, where small changes in LULC occurred from pasture to forest. These soils included Britwater, Healing, Newnata-Eden-Moko complex, Newnata-Summit complex, Nixa-Noark complex, Peridge, Portia, Razort, Riverwash, Samba, Sidon, Spadra and Widemann.

Table 13. Land use on soils occupying areas greater than 1000 acres in the Buffalo River Watershed in three years. The total acres of each soil mapping unit is given in parenthesis.

Soil Taxonomic unit	Land use category	Areal extent 1965	1979	1992
		- - - - - - - -	acres	- - - - - - - - -
Arkana-Moko Complex	urban/barren	15	25	261
(32,740)	agricultural	2,527	3,891	9,021
	forest	29,930	28,561	23,194
	water	81	81	81
	transportation	183	183	183
Britwater	urban/barren	48	48	50
(1,117)	agricultural	615	617	494
	forest	422	415	543
	water	23	23	23
	transportation	6	6	6
Ceda	urban/barren	10	0	56
(1,676)	agricultural	689	873	711
	forest	962	788	894
	water	10	10	10
	transportation	4	4	4
Ceda-Kenn Complex	urban/barren	0	11	46
(2,890)	agricultural	709	1,013	695
	forest	2,167	1,851	2,135
	water	6	6	6
	transportation	8	8	8
Clarksville	urban/barren	43	78	716
(116,560)	agricultural	8,825	19,240	26,829
	forest	107,159	96,758	88,537
	water	66	66	66
	transportation	412	412	412
Eden-Newnata Complex	urban/barren	0	7	128
(15,921)	agricultural	1,087	2,001	2,982
	forest	14,768	13,846	12,745
	water	4	4	4
	transportation	63	63	63

Table 13. Continued.

Soil Taxonomic unit	Land use category	Areal extent 1965	1979	1992
Elsah	urban	0	0	37
(2,116)	agricultural	1,166	1,362	1,430
	forest	942	746	641
	water	1	1	1
	transportation	6	6	6
Enders	urban/barren	223	360	893
(43,754)	agricultural	9,724	12,523	12,723
	forest	33,421	30,485	29,772
	water	139	139	139
	transportation	226	226	226
Enders-Leesburg	urban/barren	0	0	157
(31,389)	agricultural	1,296	2,808	5,023
	forest	29,848	28,388	26,028
	water	28	28	28
	transportation	154	154	154
Enders-Mountainburg Assoc.	urban/barren	2	0	3
(1,739)	agricultural	29	30	57
	forest	1,657	1,658	1,628
	transportation	51	52	52
Enders-Nella	urban/barren	10	36	111
(13,985)	agricultural	1,032	1,721	1,634
	forest	12,906	12,194	12,207
	water	6	6	6
	transportation	26	26	26
Enders-Nella Complex	urban/barren	0	0	6
(1,563)	agricultural	31	116	224
	forest	1,532	1,447	1,333
Estate-Lily-Portia Complex	urban/barren	0	0	48
(9,486)	agricultural	752	1,045	1,539
	forest	8,531	8,289	7,746
	water	83	83	83
	transportation	69	69	69

Table 13. Continued.

Soil Taxonomic unit	Land use category	Areal extent 1965	1979	1992
Estate-Lily-Udorth. Complex (15,584)	urban/barren	0	22	72
	agricultural	517	1,140	3,585
	forest	14,964	14,352	11,857
	water	69	69	69
	transportation	11	11	11
Estate-Portia-Moko Assoc. (53,150)	urban/barren	57	38	293
	agricultural	3,791	5,399	12,496
	forest	48,973	47,384	40,032
	water	212	212	212
	transportation	117	117	117
Healing (1,602)	urban/barren	90	94	61
	agricultural	1,147	1,269	1,052
	forest	302	177	427
	water	55	55	55
	transportation	8	8	8
Lily-Udor.-Rock outcrop (8,029)	urban/barren	21	0	78
	agricultural	720	1,322	2,211
	forest	7,051	6,473	5,506
	water	21	85	85
	transportation	149	149	149
Linker (15,485)	urban/barren	7	38	266
	agricultural	6,254	7,232	7,429
	forest	9,051	8,006	7,618
	water	21	21	21
	transportation	150	150	150
Linker-Mountainburg Complex (16,785)	urban/barren	63	97	201
	agricultural	3,391	4,554	4,786
	forest	13,146	11,946	11,632
	water	21	21	21
	transportation	143	143	143

Table 13. Continued.

Soil Taxonomic unit	Land use category	Areal extent 1965	1979	1992
Moko-Rock outcrop Complex	urban/barren	29	39	57
(8,789)	agricultural	435	731	2,432
	forest	8,181	7,901	6,182
	water	98	98	98
	transportation	20	20	20
Moko-Rock out.-Eden	urban/barren	0	0	12
(4,690)	agricultural	182	280	440
	forest	4,500	4,403	4,231
	water	2	2	2
	transportation	6	6	6
Mountainburg	urban/barren	0	5	60
(4,371)	agricultural	1,168	1,499	1,570
	forest	3,171	2,848	2,721
	water	7	7	7
	transportation	12	12	12
Nauvoo	urban/barren	139	194	233
(7,458)	agricultural	4,179	4,680	4,714
	forest	3,070	2,539	2,466
	water	2	2	2
	transportation	21	21	21
Nella	urban/barren	0	6	79
(9,792)	agricultural	2,950	2,208	2,323
	forest	7,940	7,509	7,320
	water	2	2	2
	transportation	67	67	67
Nella-Enders	urban/barren	10	119	273
(58,439)	agricultural	2,950	4,898	6,949
	forest	55,025	52,970	50,764
	water	20	20	20
	transportation	432	432	432

Table 13. Continued.

Soil Taxonomic unit	Land use category	Areal extent 1965	1979	1992
Nella-Enders Assoc.	urban/barren	0	0	3
(2,713)	agricultural	38	131	153
	forest	2,652	2,560	2,535
	water	1	1	1
	transportation	22	22	22
Nella-Mountainburg Complex	urban/barren	0	0	2
(1,372)	agricultural	23	71	124
	forest	1,350	1,301	1,246
Nella-Steprock Complex	urban/barren	0	3	125
(20,103)	agricultural	1,612	2,479	2,994
	forest	18,299	17,435	16,798
	water	18	18	18
	transportation	168	168	168
Nella-Steprock-Mtburg	urban/barren	6	1	117
(99,210)	agricultural	1,305	2,761	10,613
	forest	97,555	96,131	88,164
	water	33	33	33
	transportation	284	284	284
Nella-Steprock-Mtburg Complex	urban/barren	4	7	27
(31,038)	agricultural	351	698	2,183
	forest	30,588	30,239	28,738
	water	8	8	8
	transportation	83	83	83
Newnata-Eden-Moko Complex	urban/barren	0	16	120
(16,238)	agricultural	2,129	3,771	3,539
	forest	14,055	12,402	12,530
	water	11	11	11
	transportation	38	38	38

Table 13. Continued.

Soil Taxonomic unit	Land use category	Areal extent 1965	1979	1992
Newnata-Summit (2,205)	urban/barren	0	12	74
	agricultural	1,705	1,874	1,818
	forest	498	318	312
	water	1	1	1
Newnata-Summit Complex (2,781)	urban/barren	0	0	75
	agricultural	1,805	2,184	1,909
	forest	963	584	784
	water	1	1	1
	transportation	12	12	12
Nixa (18,465)	urban/barren	0	0	264
	agricultural	2,238	4,066	4,050
	forest	16,133	14,305	14,057
	water	3	3	3
	transportation	91	91	91
Nixa-Noark Complex (6,167)	urban/barren	0	0	103
	agricultural	1,576	2,473	2,203
	forest	4,558	3,672	3,840
	water	3	3	3
	transportation	18	18	18
Noark (129,298)	urban/barren	498	842	2,272
	agricultural	28,272	43,103	46,404
	forest	99,629	84,695	79,972
	water	32	32	32
	transportation	18	18	18
Peridge (1,250)	urban/barren	129	223	111
	agricultural	929	847	930
	forest	185	173	202
	water	3	3	3
	transportation	2	2	2

Table 13. Continued.

Soil Taxonomic unit	Land use category	Areal extent 1965	1979	1992
Portia	urban/barren	0	14	59
(5,720)	agricultural	3,108	3,095	2,504
	forest	2,513	2,559	3,106
	water	13	13	13
	transportation	38	38	38
Razort	urban/barren	28	28	340
(10,286)	agricultural	7,733	7,961	6,934
	forest	2,249	2,114	2,858
	water	123	123	123
	transportation	32	32	32
Riverwash	urban/barren	0	352	458
(3,560)	agricultural	1,152	1,630	1,122
	forest	2,249	1,379	1,781
	water	189	189	189
	transportation	10	10	10
Rock Outcrop	urban/barren	1	20	13
(1,052)	agricultural	17	51	344
	forest	971	919	633
	water	62	62	62
Samba	urban/barren	6	8	24
(1,029)	agricultural	846	885	855
	forest	165	124	138
	water	9	9	9
	transportation	3	3	3
Secesh	urban/barren	0	9	41
(1,980)	agricultural	1,330	885	1,315
	forest	651	124	624
	water	0	9	9

Table 13. Continued.

Soil Taxonomic unit	Land use category	Areal extent 1965	1979	1992
Sidon	urban/barren	0	0	128
(5,730)	agricultural	3,523	3,930	3,648
	forest	2,118	1,712	1,865
	water	42	42	42
	transportation	46	46	46
Spadra	urban/barren	12	15	75
(3,788)	agricultural	2,891	3,048	2,764
	forest	869	711	935
	water	10	10	10
	transportation	5	5	5
Steprock	urban/barren	0	0	40
(1,459)	agricultural	371	440	587
	forest	1,056	1,003	816
	water	2	2	2
	transportation	14	14	14
Widemann	urban/barren	270	122	202
(3,501)	agricultural	1,705	1,302	1,606
	forest	1,324	1,302	1,492
	water	1	1	1
	transportation	4	4	4

Land use by Sub-basin

Land use in selected sub-basins of the Buffalo River Watershed for three years are presented in Table 14, and the locations of the sub-basins are shown in Figure 13. These data provide a closer examination of the land use changes over the 27-year period in each of the larger sub-basins of the watershed.

Between 1965 and 1992, over 9,000 acres of forest were converted to other land uses such as pasture in both the Big Creek II (9,574 acres) and Little Buffalo (9,420 acres) sub-basins. Large losses of forest were also found in Tomahawk Creek (6,591 acres) and Bear Creek II (6,239 acres) sub-basins. In terms of the area of each sub-basin, these losses represented 11.1, 10.2, 27.7, and 10.4% for the Big Creek II, Little Buffalo, Tomahawk Creek and Bear Creek II sub-basins, respectively. Although lower in total area of forest lost over the 27-year period, the sub-basins Clabber Creek, Mill Creek II, Rush Creek, Mill Creek I and Davis Creek each lost over 15% of the sub-basin area originally in forest in 1965. These losses of forest were nearly offset by the areal gains in pasture.

The land use results indicate that the rate of change in forest area was not constant in each sub-basin. Considering only the changes between 1979 and 1992, Calf Creek, Cave Creek and Water Creek seem to have escaped significant conversion from forest to pasture. Also during this same time period, there were significant increases in urban/barren areas in all sub-basins except Mill Creek II.

Table 14. Land use in selected sub-basins of the Buffalo River Watershed in three years. The areal extent of each sub-basin is given in parenthesis.

Sub-basin	Land use category	1965	1979	1992
		acres		
Little Buffalo (92,309)	urban/barren	221	147	889
	agriculture	8,323	12,169	17,082
	forest	82,851	79,054	73,431
	water	148	148	148
	transportation	759	759	759
Upper Buffalo (34,455)	urban/barren	14	0	70
	agriculture	1,632	1,939	4,885
	forest	32,644	32,352	29,336
	water	14	14	14
	transportation	150	150	150
Bear Creek II (58,610)	urban/barren	325	640	1,078
	agriculture	13,922	19,392	19,431
	forest	44,007	38,245	37,768
	water	88	88	88
	transportation	245	245	245
Big Creek I (57,664)	urban/barren	25	183	625
	agriculture	7,350	10,791	11,763
	forest	49,848	46,320	44,911
	water	74	74	74
	transportation	291	291	291
Big Creek II (86,311)	urban/barren	39	97	1,315
	agriculture	21,176	28,366	29,662
	forest	64,788	57,728	55,214
	water	100	100	100
	transportation	20	20	20
Calf Creek (31,516)	urban/barren	188	83	482
	agriculture	9,524	11,818	11,895
	forest	21,411	19,254	18,778
	water	42	42	42
	transportation	320	320	320

Table 14. Continued.

Sub-basin	Land use category	1965	1979	1992
Cave Creek	urban/barren	0	65	203
(33,553)	agriculture	3,519	5,370	5,655
	forest	29,782	27,886	27,463
	water	108	108	108
	transportation	123	123	123
Cecil Creek	urban/barren	0	0	106
(14,913)	agriculture	1,894	2,734	3,633
	forest	12,927	12,088	11,083
	water	17	17	17
	transportation	74	74	74
Clabber Creek	urban/barren	12	0	210
(16,735)	agriculture	3,113	3,844	6,354
	forest	13,463	12,743	10,024
	water	10	10	10
	transportation	138	138	138
Davis Creek	urban/barren	2	0	256
(17,926)	agriculture	3,339	4,329	5,921
	forest	14,408	13,482	11,634
	water	5	5	5
	transportation	10	10	10
Mill Creek I	urban/barren	0	0	197
(13,422)	agriculture	2,082	3,556	4,146
	forest	11,200	9,761	8,974
	water	26	26	26
	transportation	79	79	79
Mill Creek II	urban/barren	143	271	216
(10,005)	agriculture	2,400	3,076	4,268
	forest	7,379	6,591	5,454
	water	8	8	8
	transportation	59	59	59

Table 14. Continued.

Sub-basin	Land use category	1965	1979	1992
Richland Creek	urban/barren	50	122	245
(84,141)	agriculture	5,848	7,339	10,285
	forest	77,679	76,085	73,081
	water	100	100	100
	transportation	431	431	431
Rush Creek	urban/barren	1	0	98
(10,233)	agriculture	371	1,567	2,216
	forest	9,818	8,623	7,876
	water	27	27	27
	transportation	16	16	16
Tomahawk Creek	urban/barren	4	32	420
(23,822)	agriculture	5,540	9,034	11,801
	forest	18,107	14,671	11,516
	water	18	18	18
	transportation	67	67	67
Water Creek	urban/barren	5	0	235
(24,556)	agriculture	4,811	7,515	7,781
	forest	19,591	16,670	16,401
	water	14	14	14
	transportation	125	125	125

Land use by Sub-basin by Slope

Further analysis of the changes in land use by sub-basin was accomplished by considering the coincidence of land use by slope category. For the larger sub-basins, the LULC for the three years is given in Table 15 and indicates that the temporal changes occurred at different rates and slope categories. Over the 27-year period, the greatest loss of area in forest occurred in the Bear Creek II, Big Creek II, and Tomahawk Creek sub-basins and mostly on lands with slopes of < 7 and between 7 and 14 degrees. For the Little Buffalo sub-basin, however, the larger losses of forest occurred at the two higher slope categories. These losses in forest area occurred in the same sub-basins where the greatest total areal losses occurred (Table 14).

Table 15. Influence of three categories of slope on land use within selected sub-basins of the Buffalo River Watershed.

Sub-basin	Slope Category	Land use Category	Areal exhibit 1965	1979	1992
			- - - - - - - - - - acres	- - - - - - - - - -	
Little Buffalo	< 7	urban/barren	164	99	422
		agricultural	4,348	5,400	5,747
		forest	12,187	11,183	10,531
		water	60	60	60
		transportation	234	234	234
	7 to 14	urban/barren	45	38	385
		agricultural	3,391	5,581	7,723
		forest	41,202	39,014	36,536
		water	38	38	38
		transportation	382	382	382
	> 14	urban/barren	10	10	81
		agricultural	584	1,189	3,612
		forest	29,462	28,857	26,364
		water	51	51	51
		transportation	144	143	134
Bear Creek II	< 7	urban/barren	273	487	687
		agricultural	9,662	12,181	11,747
		forest	10,718	7,991	8,152
		water	69	69	69
		transportation	102	102	102
	7 to 14	urban/barren	50	131	385
		agricultural	3,645	6,032	6,156
		forest	20,936	18,477	18,152
		water	10	10	10
		transportation	101	101	101
	> 14	urban/barren	1	11	81
		agricultural	613	1,179	1,446
		forest	12,353	11,777	11,464
		water	8	8	8
		transportation	41	41	41

Table 15. Continued.

Sub-basin	Slope Category	Land use Category	Areal exhibit 1965	1979	1992
Big Creek I	< 7	urban/barren	70	127	308
		agricultural	4,341	5,329	4,882
		forest	8,702	7,663	7,929
		water	47	47	47
		transportation	107	107	107
	7 to 14	urban/barren	2	55	258
		agricultural	2,635	4,511	4,936
		forest	22,902	20,987	20,361
		water	6	6	6
		transportation	129	129	129
	> 14	urban/barren	6	0	59
		agricultural	374	951	1,944
		forest	18,244	17,670	16,622
		water	22	22	22
		transportation	54	54	54
Big Creek II	< 7	urban/barren	59	62	596
		agricultural	10,509	12,375	12,387
		forest	12,379	10,536	9,989
		water	53	53	53
		transportation	2	2	2
	7 to 14	urban/barren	32	29	570
		agricultural	8,830	12,963	13,614
		forest	32,829	28,777	27,586
		water	17	17	17
		transportation	14	14	14
	> 14	urban/barren	9	6	149
		agricultural	1,837	3,028	3,661
		forest	19,580	18,415	17,640
		water	22	22	22
		transportation	3	3	3

Table 15. Continued.

Sub-basin	Slope Category	Land use Category	Areal exhibit 1965	1979	1992
Calf Creek	< 7	urban/barren	141	73	334
		agricultural	7,559	8,699	8,369
		forest	6,417	5,359	5,426
		water	27	27	27
		transportation	189	189	189
	7 to 14	urban/barren	44	8	120
		agricultural	1,780	2,724	2,920
		forest	9,820	8,931	8,623
		water	1	1	1
		transportation	100	100	100
	> 14	urban/barren	2	2	27
		agricultural	185	395	605
		forest	5,173	4,964	4,729
		water	14	14	24
		transportation	32	32	32
Cave Creek	< 7	urban/barren	0	56	130
		agricultural	2,551	3,206	3,188
		forest	6,888	6,182	6,125
		water	41	41	41
		transportation	59	59	59
	7 to 14	urban/barren	0	6	71
		agricultural	846	1,802	1,760
		forest	13,696	12,746	12,724
		water	47	47	47
		transportation	40	40	40
	> 14	urban/barren	0	3	3
		agricultural	122	363	707
		forest	9,199	8,958	8,614
		water	21	21	21
		transportation	24	24	24

Table 15. Continued.

Sub-basin	Slope Category	Land use Category	Areal exhibit 1965	1979	1992
Cecil Creek	< 7	urban/barren	0	0	66
		agricultural	1,261	1,683	1,716
		forest	2,790	2,368	2,269
		water	9	9	9
		transportation	30	30	30
	7 to 14	urban/barren	0	0	34
		agricultural	603	962	1,352
		forest	5,982	5,623	5,199
		water	4	4	4
		transportation	32	32	32
	> 14	urban/barren	0	0	6
		agricultural	30	88	564
		forest	4,155	4,988	3,615
		water	4	4	4
		transportation	12	12	12
Clabber Creek	< 7	urban/barren	3	0	73
		agricultural	1,963	2,117	2,585
		forest	2,845	2,695	2,154
		water	3	3	3
		transportation	50	50	50
	7 to 14	urban/barren	3	0	117
		agricultural	1,107	1,623	3,013
		forest	7,529	7,016	5,510
		water	4	4	4
		transportation	59	59	59
	> 14	urban/barren	6	0	21
		agricultural	43	105	756
		forest	3,089	3,032	2,361
		water	3	3	3
		transportation	29	29	29

Table 15. Continued.

Sub-basin	Slope Category	Land use Category	Areal exhibit 1965	1979	1992
Davis Creek	< 7	urban/barren	1	0	126
		agricultural	1,798	1,988	2,325
		forest	3,269	3,018	2,645
		water	4	4	4
		transportation	3	3	3
	7 to 14	urban/barren	0	0	117
		agricultural	1,473	2,160	2,981
		forest	8,124	7,470	6,532
		water	1	1	1
		transportation	6	6	6
	> 14	urban/barren	1	0	12
		agricultural	68	181	616
		forest	3,015	2,903	2,456
		water	0	0	0
		transportation	0	0	0
Mill Creek I	< 7	urban/barren	0	0	91
		agricultural	1,335	1,833	1,736
		forest	2,446	1,965	1,970
		water	10	10	10
		transportation	19	19	19
	7 to 14	urban/barren	0	0	82
		agricultural	686	1,481	1,776
		forest	5,931	5,153	4,775
		water	12	12	12
		transportation	43	43	43
	> 14	urban/barren	1	0	24
		agricultural	61	242	634
		forest	2,823	2,644	2,228
		water	4	4	4
		transportation	17	17	17

Table 15. Continued.

Sub-basin	Slope Category	Land use Category	Areal exhibit 1965	1979	1992
Mill Creek II	< 7	urban/barren	135	238	169
		agricultural	1,966	2,297	2,824
		forest	2,694	2,275	1,817
		water	5	5	5
		transportation	24	24	24
	7 to 14	urban/barren	7	33	44
		agricultural	412	740	1,255
		forest	3,573	3,220	2,693
		water	2	2	2
		transportation	26	26	26
	> 14	urban/barren	1	0	3
		agricultural	22	38	188
		forest	1,223	1,096	944
		water	0	0	0
		transportation	10	10	10
Richland Creek	< 7	urban/barren	41	68	185
		agricultural	4,777	5,612	5,756
		forest	18,394	17,480	17,297
		water	53	53	53
		transportation	159	159	159
	7 to 14	urban/barren	8	52	54
		agricultural	949	1,427	2,778
		forest	37,469	36,932	35,599
		water	21	21	21
		transportation	216	216	216
	> 14	urban/barren	1	3	5
		agricultural	122	260	1,750
		forest	21,817	21,673	20,184
		water	26	26	26
		transportation	56	56	56

Table 15. Continued.

Sub-basin	Slope Category	Land use Category	Areal exhibit 1965	1979	1992
Rush	< 7	urban/barren	0	0	45
		agricultural	179	540	571
		forest	2,028	1,668	1,592
		water	12	12	12
		transportation	9	9	9
	7 to 14	urban/barren	0	0	44
		agricultural	142	846	1,057
		forest	4,848	4,144	3,890
		water	11	11	11
		transportation	7	7	7
	> 14	urban/barren	0	0	9
		agricultural	49	181	588
		forest	2,942	2,811	2,394
		water	4	4	4
		transportation	1	1	1
Tomahawk Creek	< 7	urban/barren	10	0	226
		agricultural	3,453	5,069	6,016
		forest	5,939	4,359	3,195
		water	4	4	4
		transportation	33	33	33
	7 to 14	urban/barren	9	15	165
		agricultural	1,977	3,681	4,999
		forest	9,490	7,810	6,343
		water	8	8	8
		transportation	29	29	29
	> 14	urban/barren	0	8	29
		agricultural	110	284	786
		forest	2,678	2,501	1,978
		water	5	5	5
		transportation	4	4	4

Table 15. Continued.

Sub-basin	Slope Category	Land use Category	Areal exhibit 1965	1979	1992
Upper Buffalo	< 7	urban/barren	5	0	31
		agricultural	853	856	1,514
		forest	6,848	6,950	6,161
		water	8	8	8
		transportation	50	50	50
	7 to 14	urban/barren	10	0	31
		agricultural	668	912	2,047
		forest	15,740	15,505	14,340
		water	3	3	3
		transportation	89	89	89
	> 14	urban/barren	0	0	8
		agricultural	111	170	1,324
		forest	10,056	9,997	8,835
		water	2	2	2
		transportation	11	11	11
Water Creek	< 7	urban/barren	2	0	115
		agricultural	2,270	3,135	2,976
		forest	4,739	3,876	3,921
		water	6	6	6
		transportation	37	37	37
	7 to 14	urban/barren	3	0	109
		agricultural	2,411	3,940	3,966
		forest	10,586	9,066	8,931
		water	6	6	6
		transportation	74	74	74
	> 14	urban/barren	0	0	11
		agricultural	131	440	839
		forest	4,267	3,959	3,549
		water	2	2	2
		transportation	14	14	14

SUMMARY

In this work, we quantified the LULC of the Buffalo River Watershed during 1992 using TM satellite imagery. The land area in each of five land use categories were compared with those same areas determined in a previous study in order to give insights as to the directions and magnitude of change over time.

For the Buffalo River Watershed, land area in forest, agricultural (pasture), and urban/barren has varied since 1965. A greater area of land was converted from forest to pasture than from pasture to forest. The net conversion out of forest was constant during this same time period and was slightly greater than the increase in pasture. Smaller increases in area over time were also found in the urban/barren category.

Rates of change in land use within different portions of the watershed were not constant. There were areas where the losses in forest area were more rapid than in other areas where the losses were practically insignificant. It appears that a considerable conversion from forest to pasture has occurred at the higher slopes and on some of the better soils in the watershed. The changes in land use appear to be greater in the eastern portion than in the western portion of the watershed and along the US highway 65 corridor.

LITERATURE CITED

Hofer, K.R., H.D. Scott and J.M. McKimmey. 1995. Spatial distribution of the surface geology and 1992 land use of the Buffalo River Watershed. Arkansas Water Resources Center Technical Completion Report. (In press).

Schowengerdt, R.A. 1983. Techniques for image processing and classification in remote sensing. Academic Press, New York, NY.

Scott, H.D. and P.A. Smith. 1994. The prediction of sediment and nutrient transport in the Buffalo River Watershed using a geographic information system: characterization of the soils, elevations and land use in the Buffalo River Watershed using a geographic information system. Arkansas Water Resources Center. Technical Completion Report 167. 56 p.

Smith, P. April, 1995. Personal conversation. Natural Resources Conservation Service, Fayetteville, Arkansas.

Tou, J.T. and R.C. Gonzales. 1974. Pattern recognition principles. Addison-Wesley Publishing Company, London.

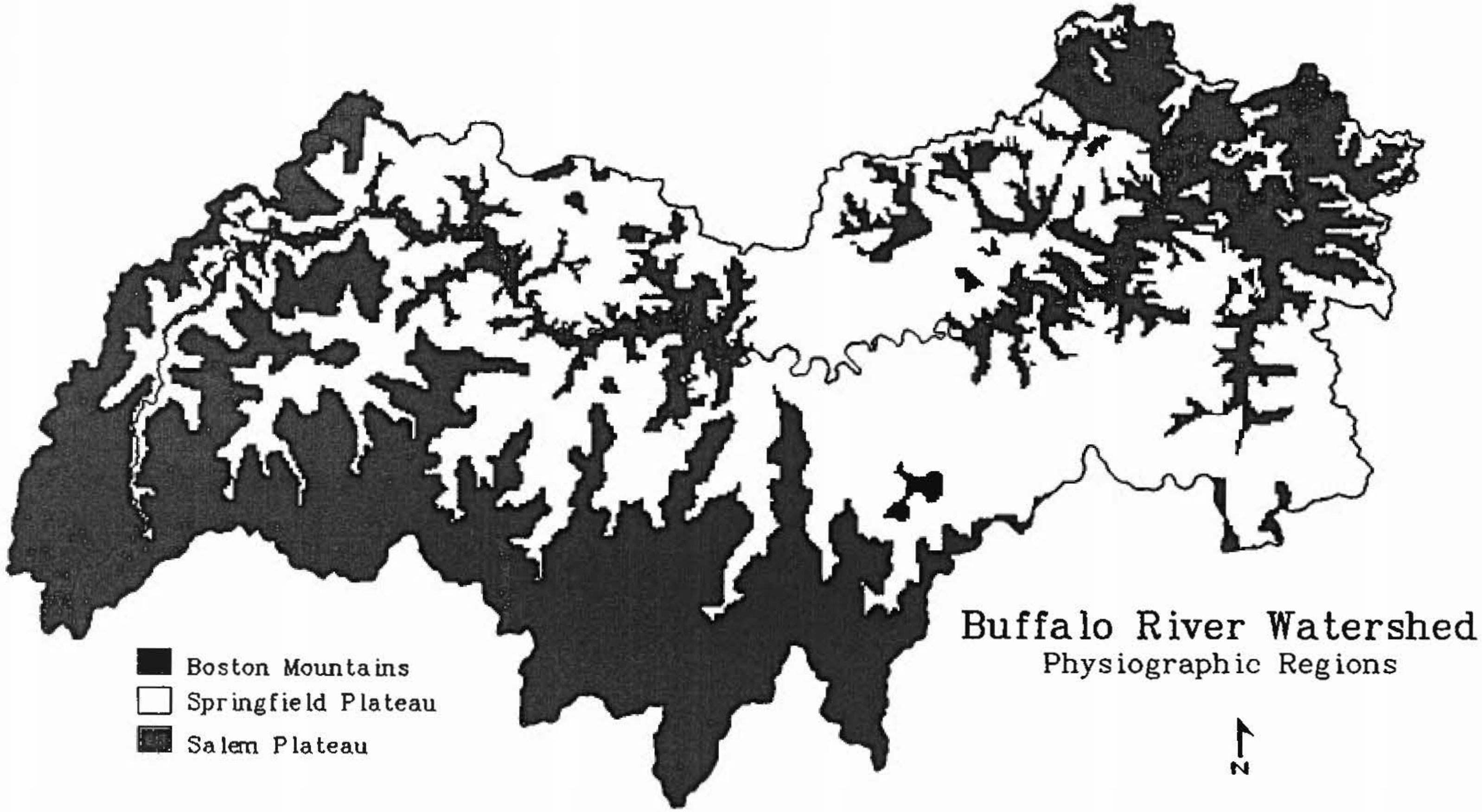

Figure 1. Spatial distribution of the three physiographic provinces.

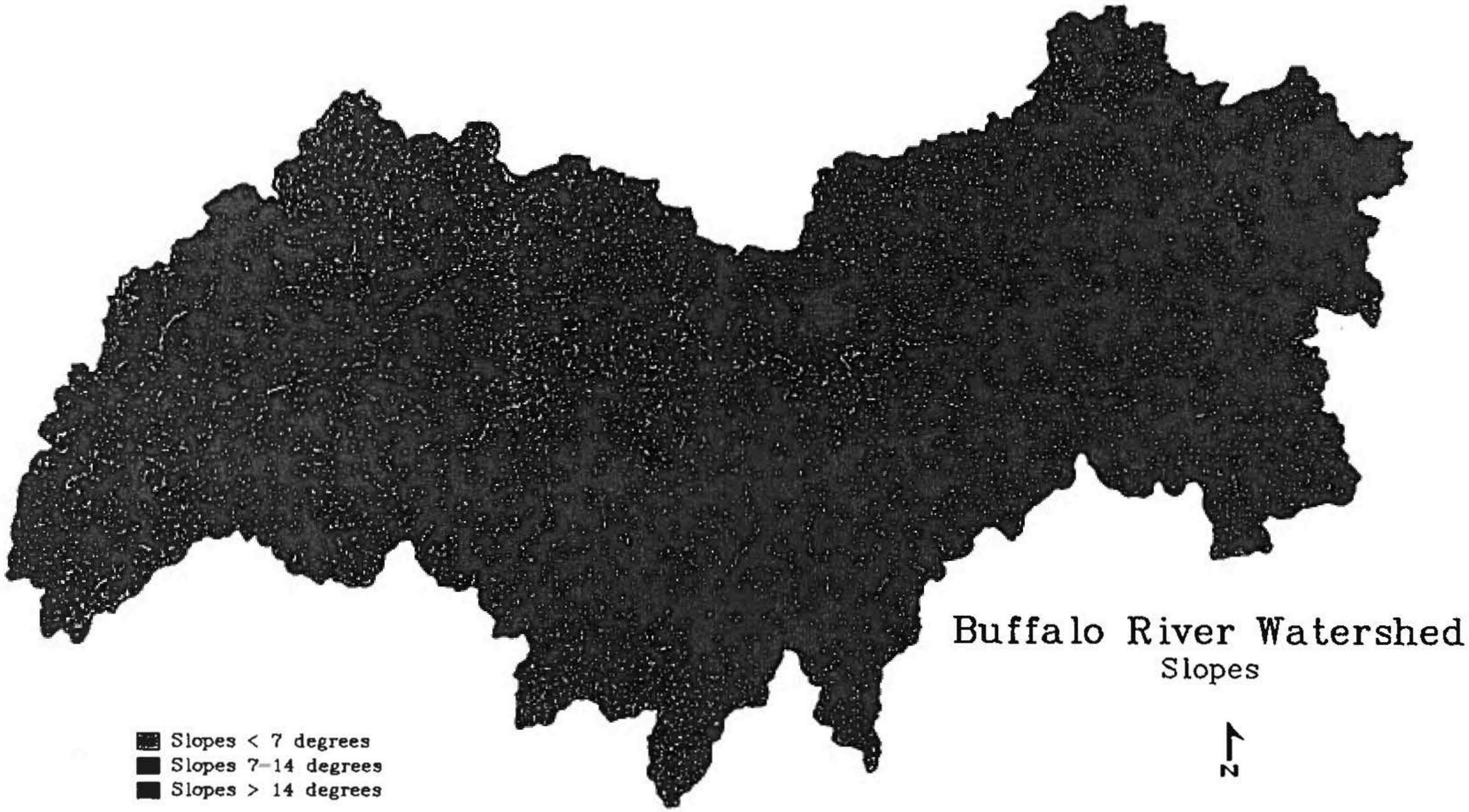

Figure 2. Spatial distribution of the three slope categories.

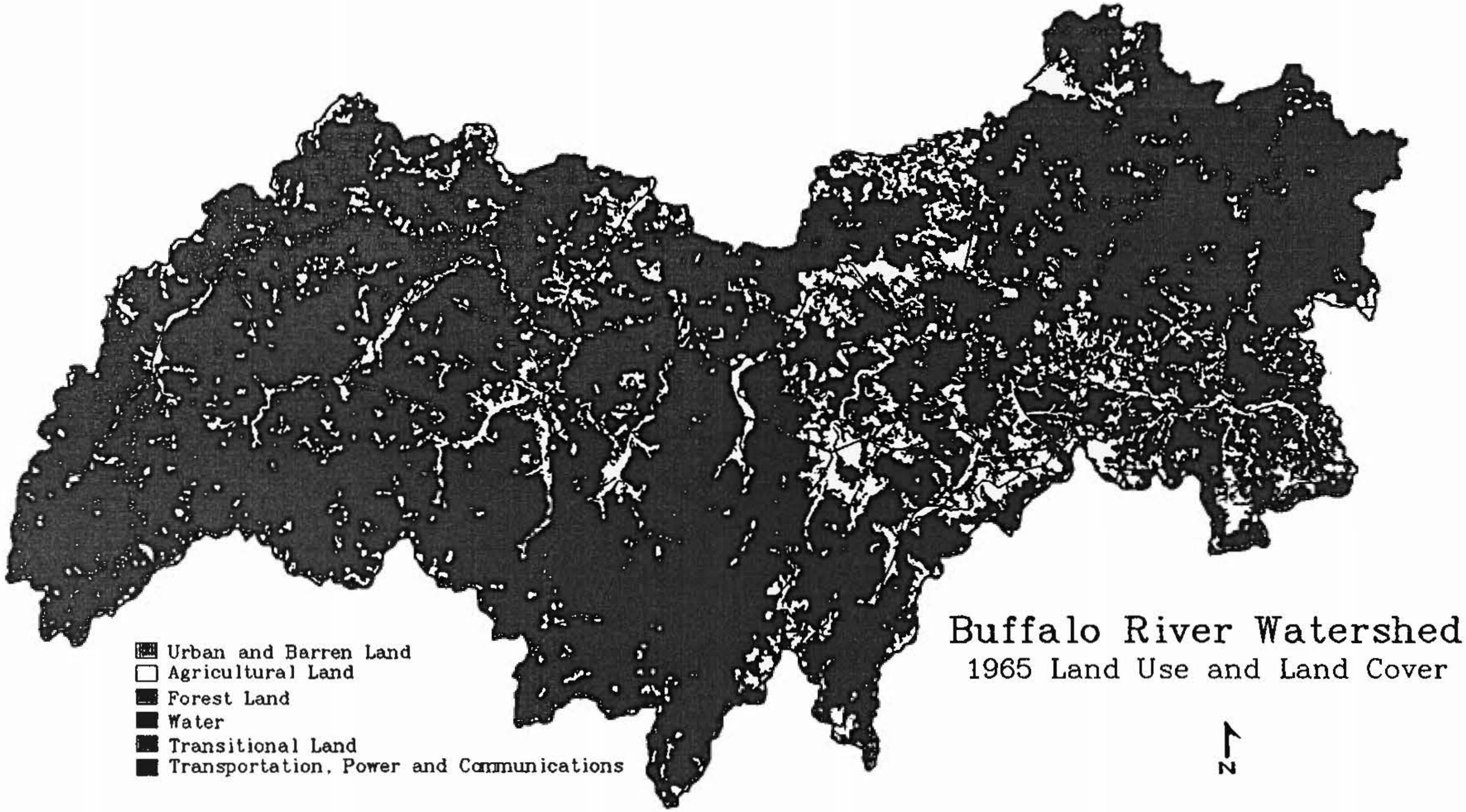

Figure 3. Spatial distribution of LULC in 1965.

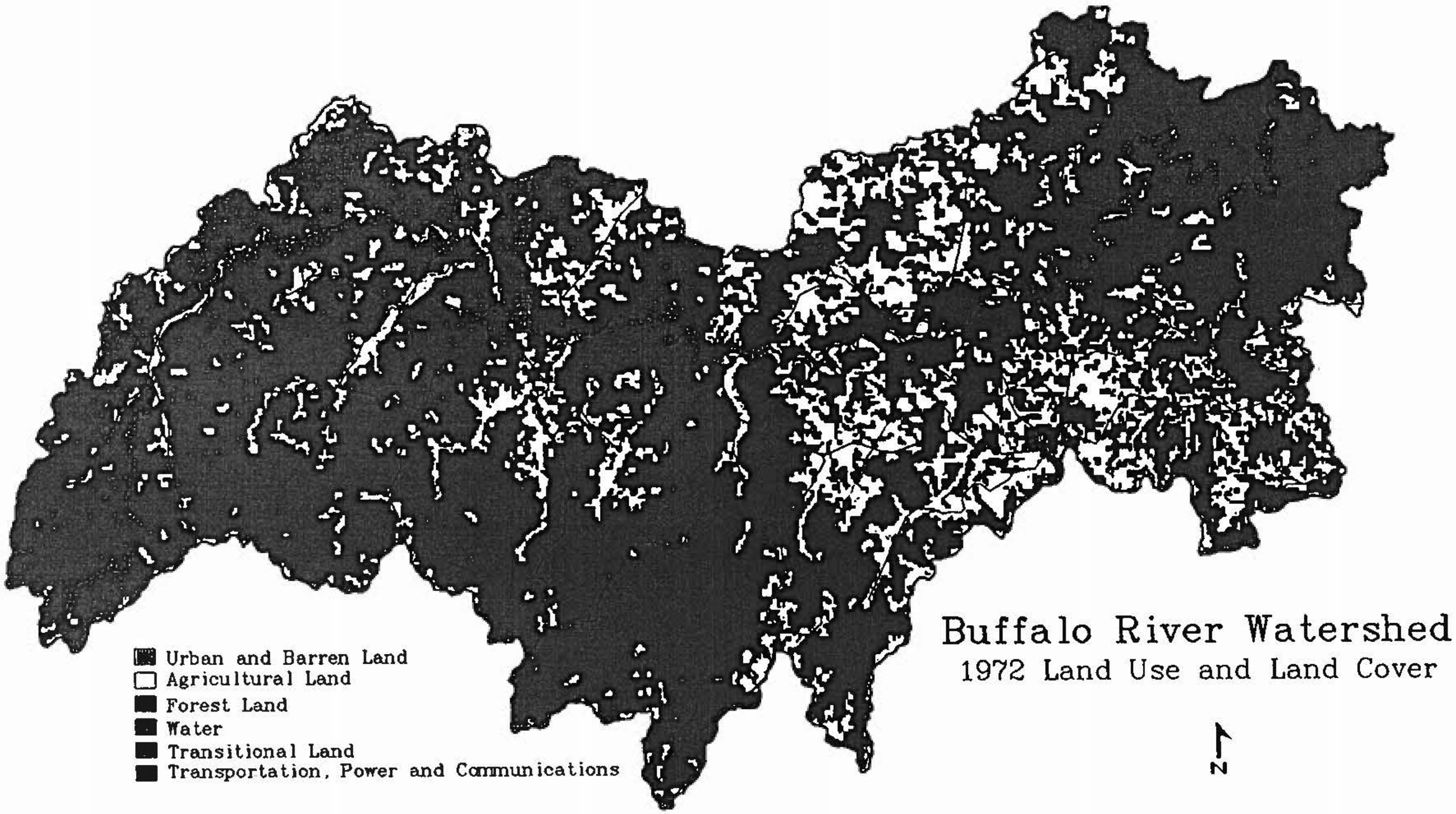

Figure 4. Spatial distribution of LULC in 1972.

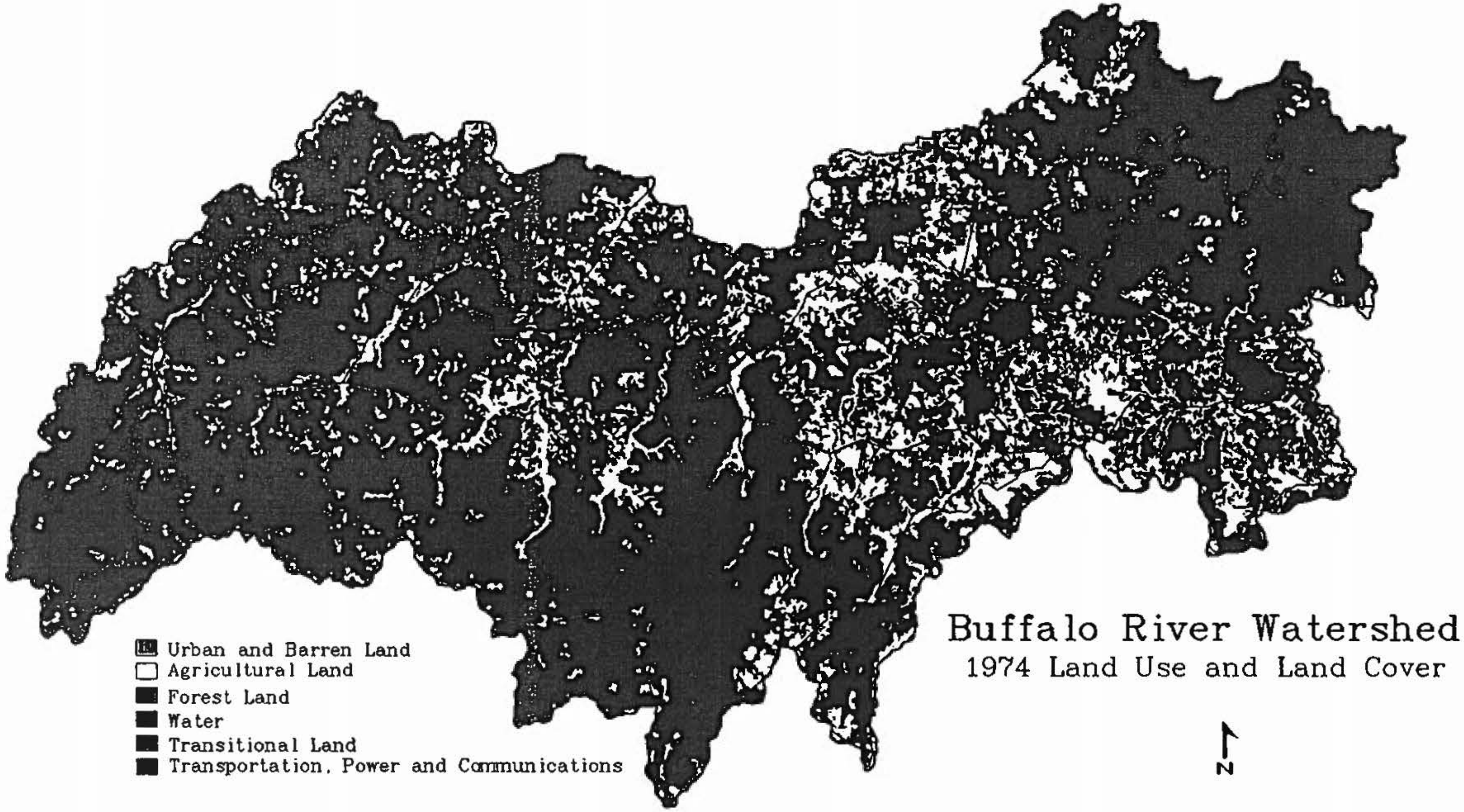

Figure 5. Spatial distribution of LULC in 1974.

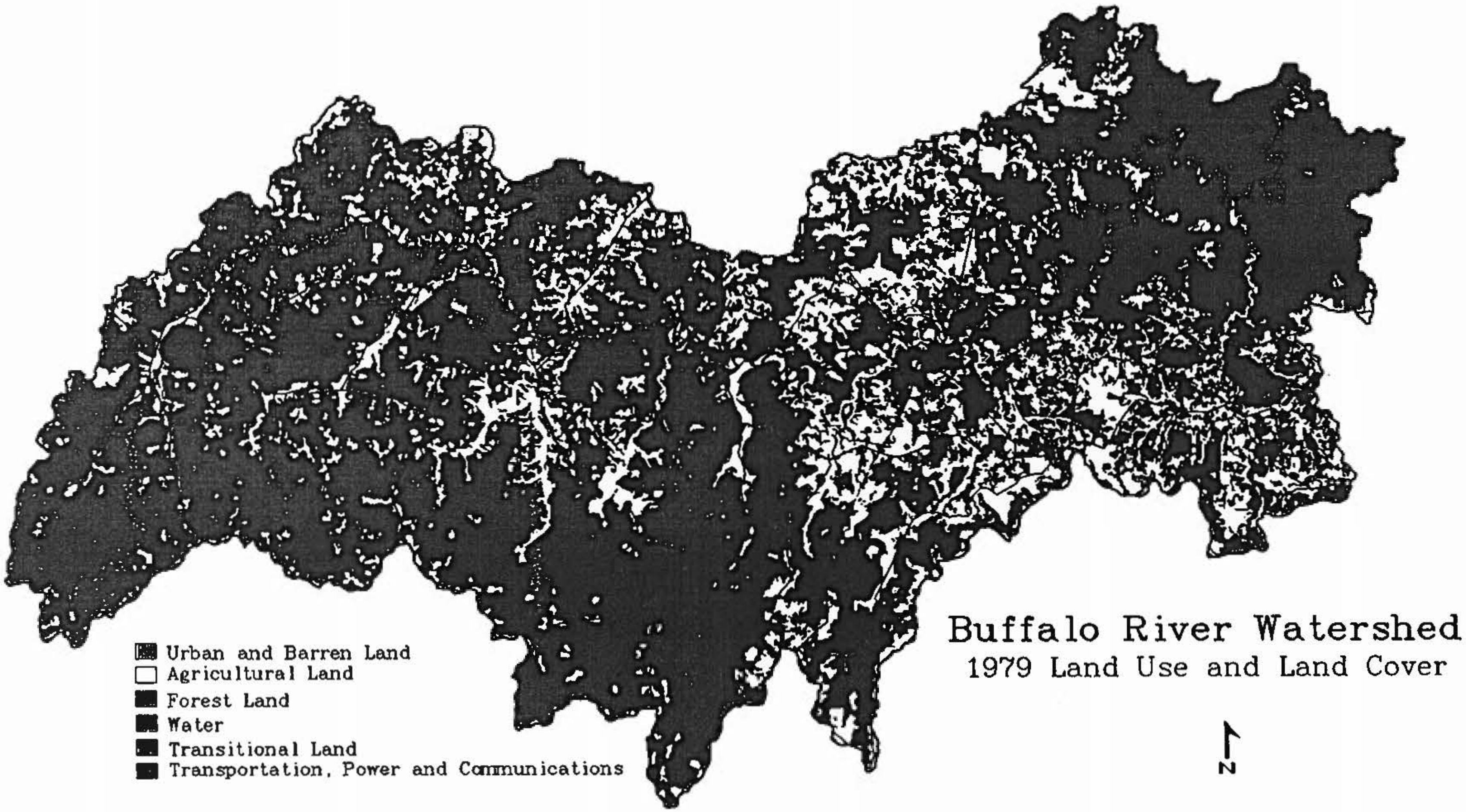

Figure 6. Spatial distribution of LULC in 1979.

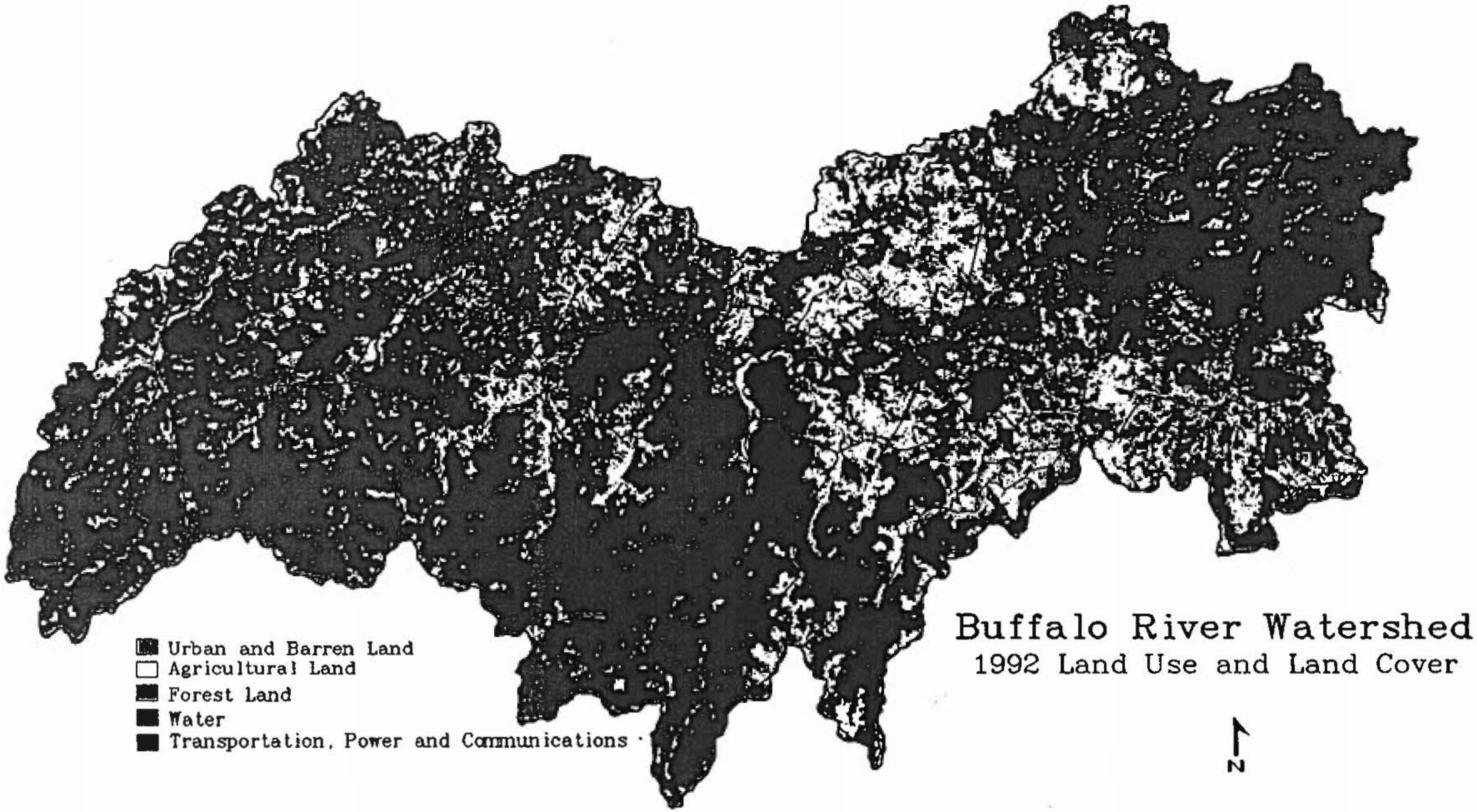

Figure 7. Spatial distribution of LULC in 1992.

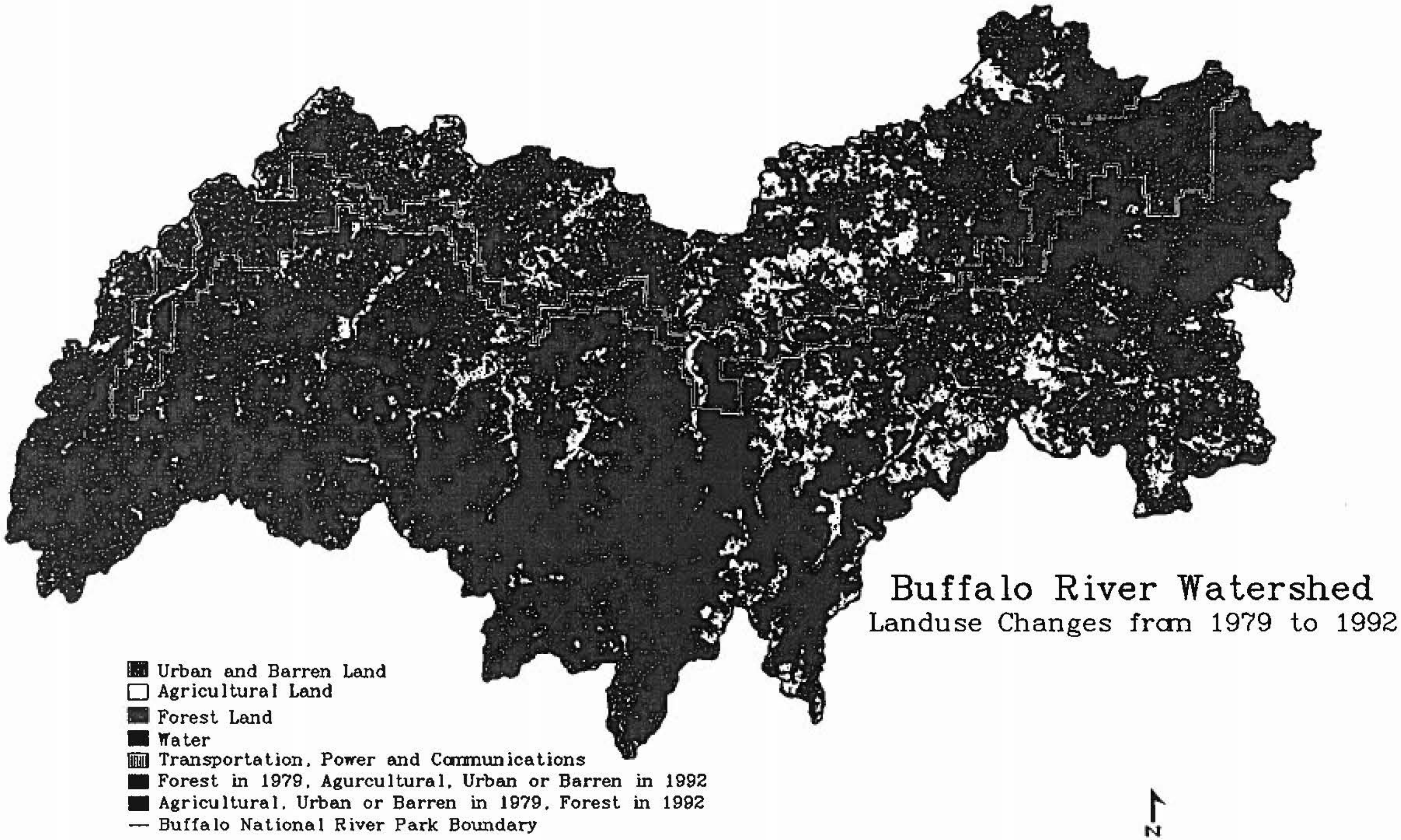

Figure 8. Changes in LULC between 1979 and 1992.

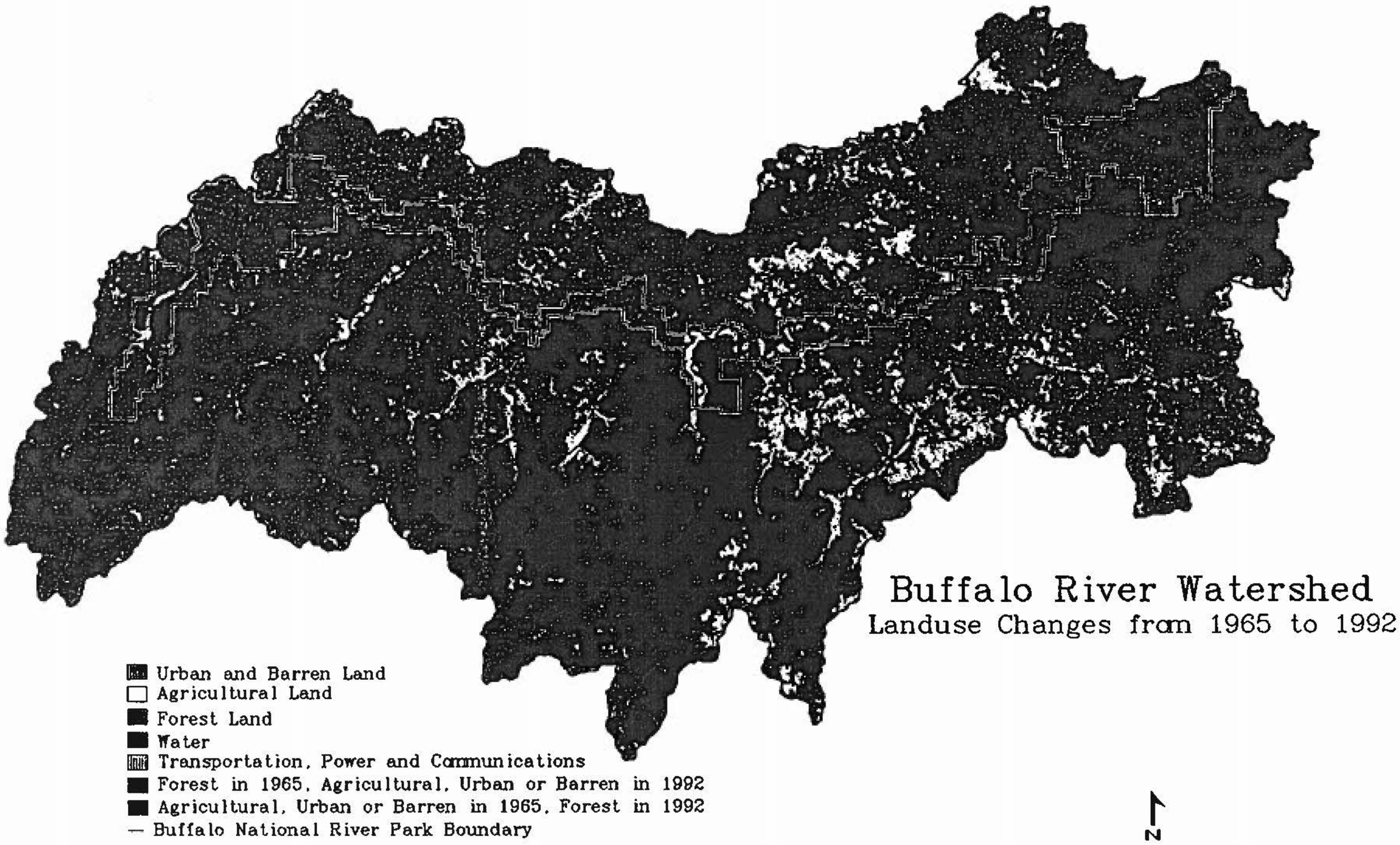

Figure 9. Changes in LULC between 1965 and 1992.

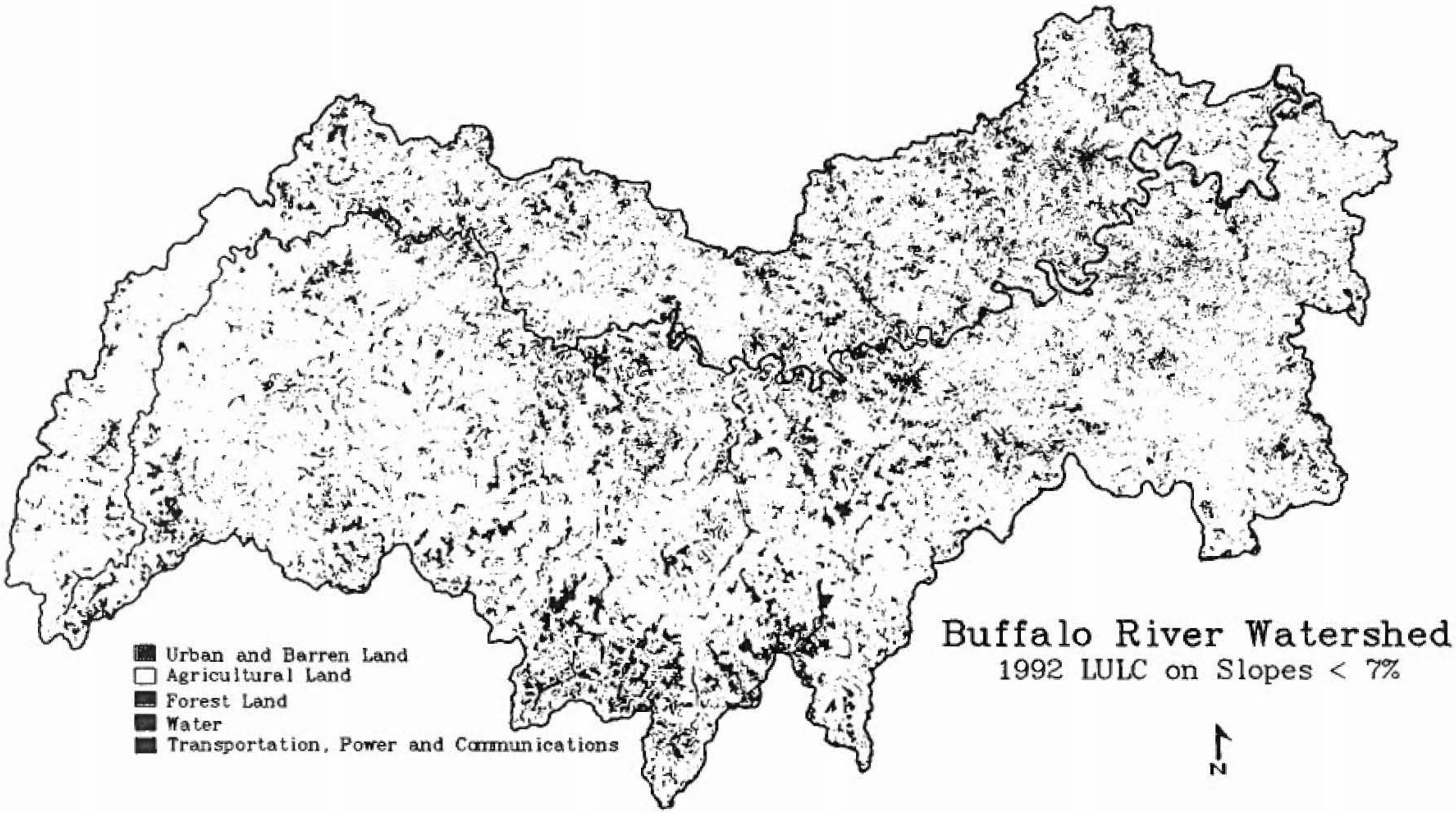

Figure 10. Spatial distribution of 1992 LULC on slopes less than 7%.

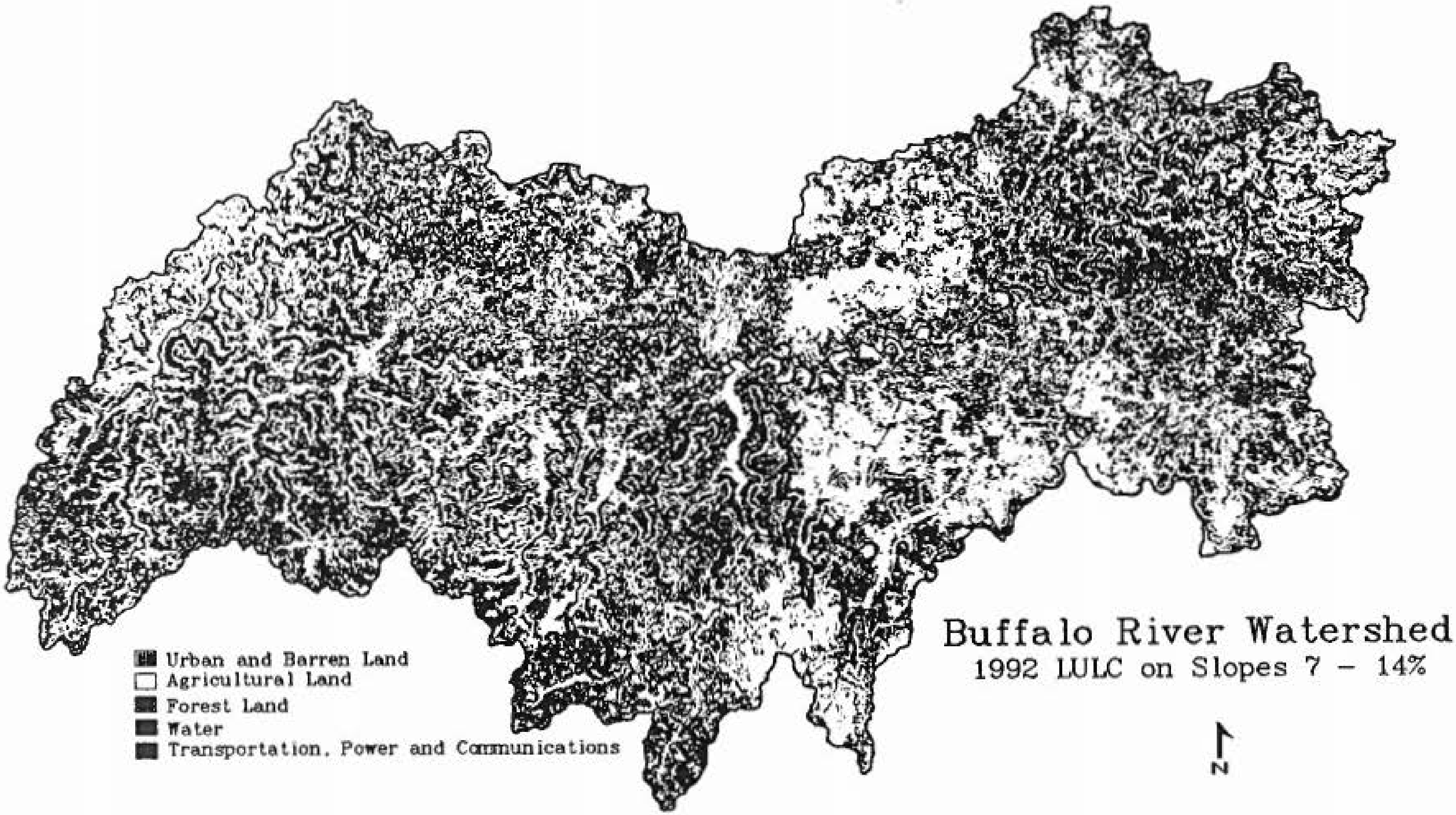

Figure 11. Spatial distribution of 1992 LULC on slopes between 7 and 14%.

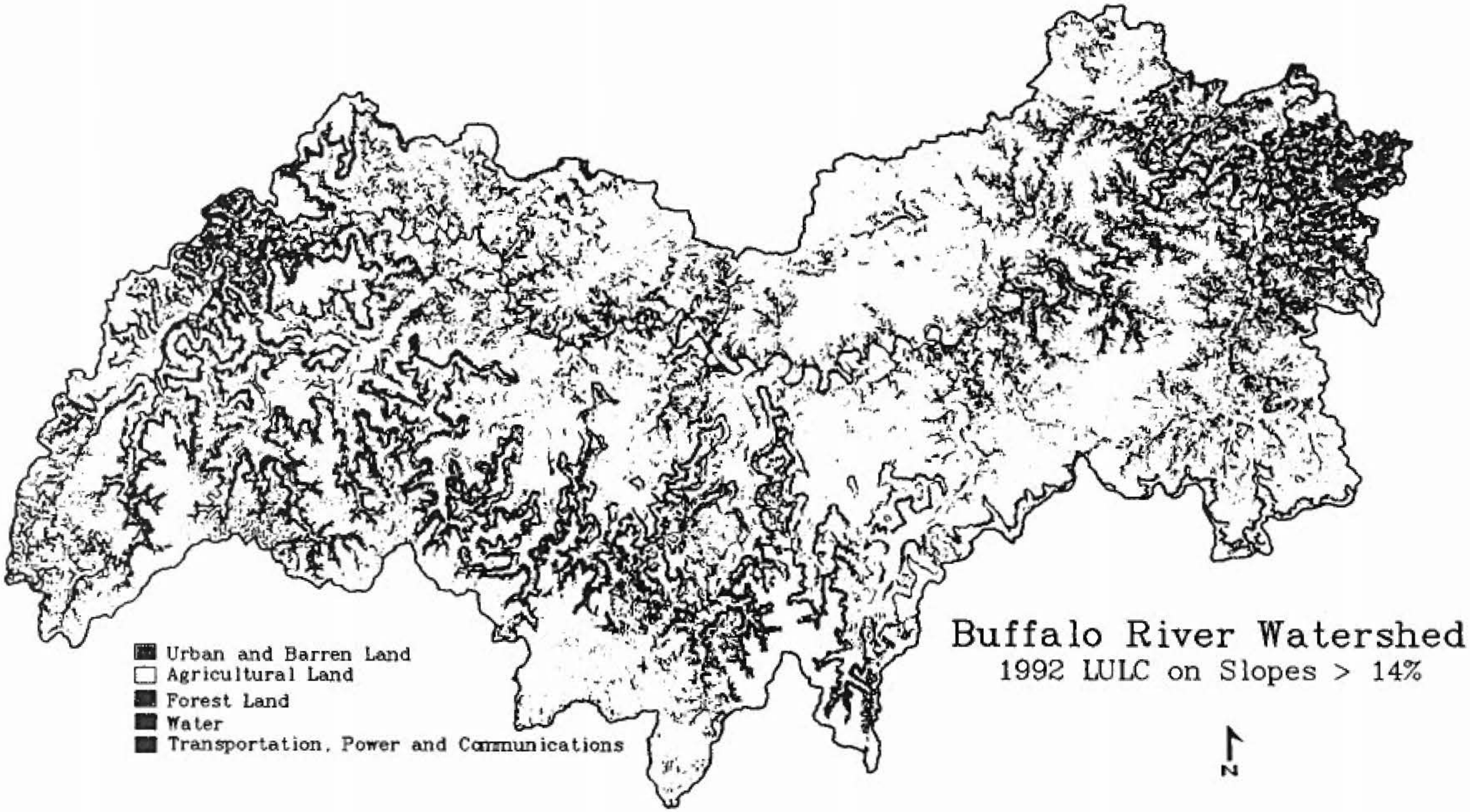

Figure 12. Spatial distribution of 1992 LULC on slopes greater than 14%.

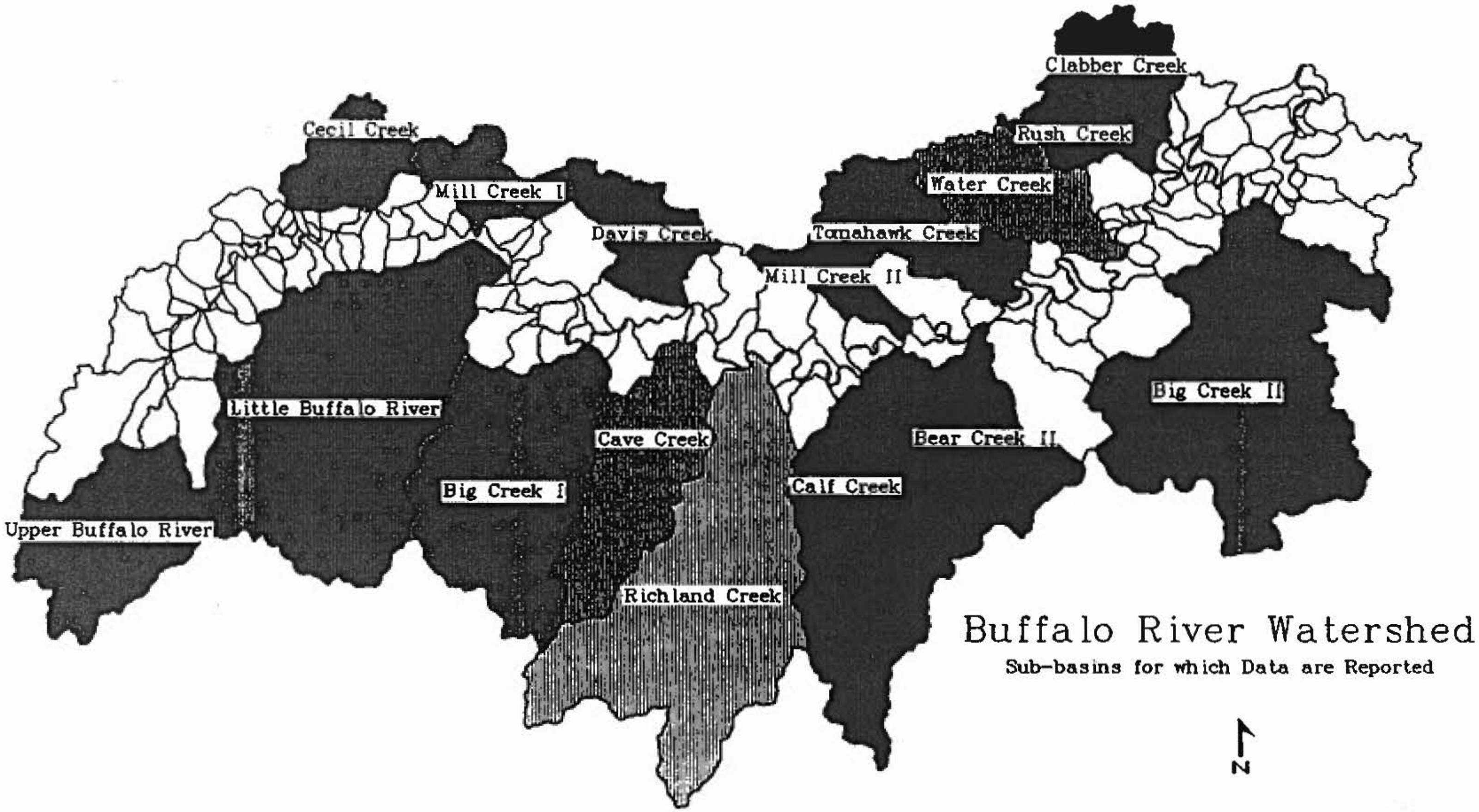

Figure 13. Location of the larger sub-basins in the Buffalo River Watershed.