except that they grow to 50 pounds and require heavy tackle to land. These bass are primarily in the lower Illinois River downstream of Tenkiller Dam.

Fishing for channel catfish in the spring is usually most successful beginning in May. Fish any fresh water running into the lake from spring rains, especially where the water is turbid. Trotline fishing is the most popular and productive method used to catch channel catfish.

Rainbow trout are stocked year round in the Illinois River below Tenkiller Dam. Weekly to monthly stocking of 9- to 14-inch fish amounts to an annual total of 120,000 trout in the 12-mile area of the Illinois River. Water from the bottom of Tenkiller Lake helps to keep the river water at about a 60-degree temperature, which enables the trout to survive hot summers in the river. Fishing is good all year with success being limited only by fishing pressure.

The Environmental Protection Agency (EPA) contracted the University of Arkansas and Oklahoma State University in 1990 to examine fish and benthic macroinvertebrates collections that have been taken from the Illinois River and its tributaries.

The study concluded that the river contains a diverse assemblage of fish. The 132 species collected in the 43 study areas are listed in appendix A. Based on qualitative information, it appears that a diverse and abundant assemblage of fish are in the Illinois River. The number of species, species diversity, intolerant species, and sport species increased between 1976 to 1981 in the river near Tahlequah.

The study also noted that benthic (bottom organisms) macroinvertebrate populations in streams should be sampled because they are valuable in the food chain. They also provide information on current stream conditions as well as conditions that existed during their development. The use of these organisms as a "built-in bioassay" has been demonstrated many times. However, use of the benthic assemblage to provide information on stream conditions requires a standardized sampling program over a long period of time. Although this has been the practice for water quality parameters, no studies of benthic macroinvertebrates in the Illinois River have been conducted over long time periods. Few studies of benthic macroinvertebrates have been quantitative, which would have enabled additional analyses. No consistent method of collecting organisms has been used. Variation has also existed in the stations sampled, and almost all studies lacked a statistical design. Benthic data can provide important information about a stream system. However, unless a well-designed sampling program is developed and followed, few valid conclusions can be made. Appendix B lists the benthos collected.

Human Resources

Economic conditions

The general level of economic activity of the Illinois Basin is influenced by the cities of Bentonville, Siloam Springs, Fayetteville, and Springdale, Arkansas. Headquarters of major corporations as well as the University of Arkansas are in these cities. The major cities in the Oklahoma part of the basin are Stilwell and Tahlequah. Northeastern Oklahoma University is in Tahlequah. The balance of the area is rural, with scattered towns, farms, and residences.

Census data from Benton and Washington Counties, Arkansas, and Adair, Cherokee, Delaware, and Sequoyah Counties, Oklahoma, show that generally the Arkansas part has a higher level of economic activity. From 1980 to 1986 the basin area population increased by about 11 percent (fig. 11). This compares to 4 percent for the state of Arkansas and 9 percent for the state of Oklahoma. Continued economic and population growth is expected because of the broad industrial base.

Benton and Washington Counties have per capita incomes above the Arkansas state average because of the concentration of the University Arkansas and the corporate headquarters of major national business concerns, such as Wal-Mart and J.B Hunt. Large poultry and food processing organizations, such as Georges, Tysons, Hudsons, Cargills, and Campbell Soup, also have headquarters in this area (fig. 12). This creates a bimodal income grouping with groups of high and low income rather than an even distribution. Incomes in the Oklahoma part are generally lower than the Oklahoma state average income.

Unemployment rates in the basin reflect the expected relationship to higher levels of economic activity in the Arkansas part, where unemployment rates are considerably less than that of the state of Arkansas (fig. 13). Unemployment in the Oklahoma part is near the state average.

From 1980 to 1986 the labor force increased 11 percent from 156,786 to 175,005 (table 4).

A valuable statistic to measure the health of an area's economy is the percent of the population below thepoverty level. In the Arkansas part or the basin, markedly less of the population is under this level thanin the rest of the State of Arkansas. In the Oklahoma part more people are below the poverty level than the state average (table 5).

Another measure of relative economic well being is the educational attainment of the area's population. In

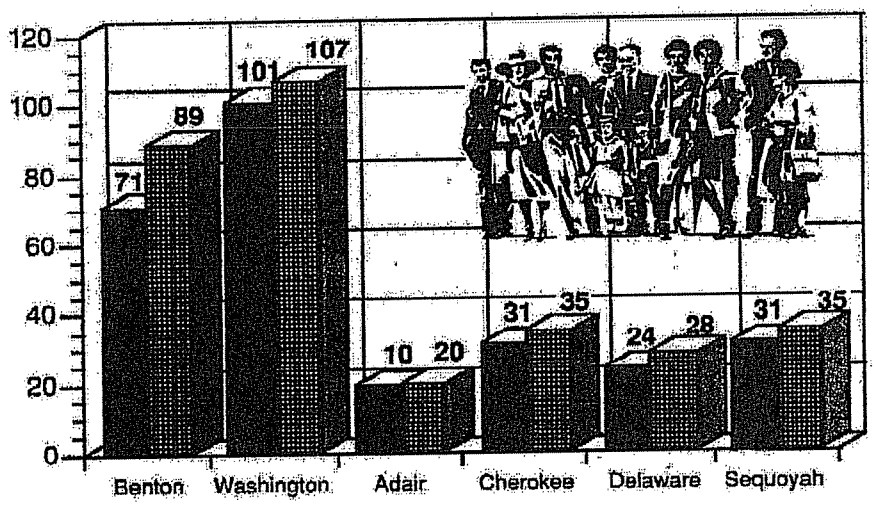

Figure 11. Population. (*U.S. Bureau of the Census, County and City Data Book, 1988*)

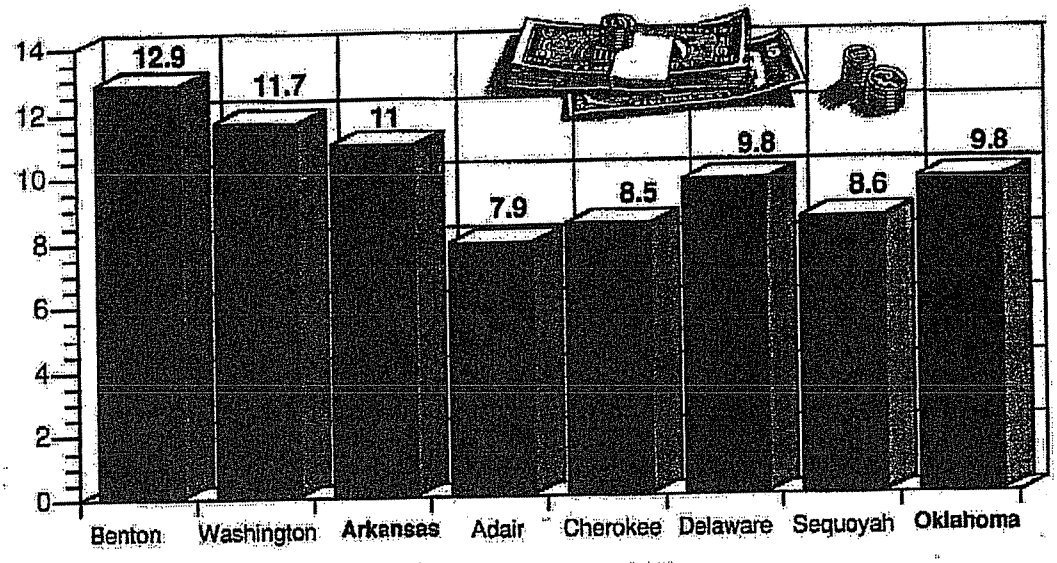

Figure 12. Per capita income, 1986.

the Arkansas part of the river basin, the percent of students completing 12 and 16 years of schooling was higher than the state average. The presence of the University of Arkansas in Fayetteville is the major contributing factor (table 6). In the Oklahoma part the educational attainment is lower than the state average except in Cherokee County where Northeastern Oklahoma University is located. Tahlequah is the capitol of the Cherokee Nation. About 13 percent, or 41,000 of the 313,900 people in the basin are Indians or other minorities. More than 200 of the farms in the basin are operated by Indians or other minorities.

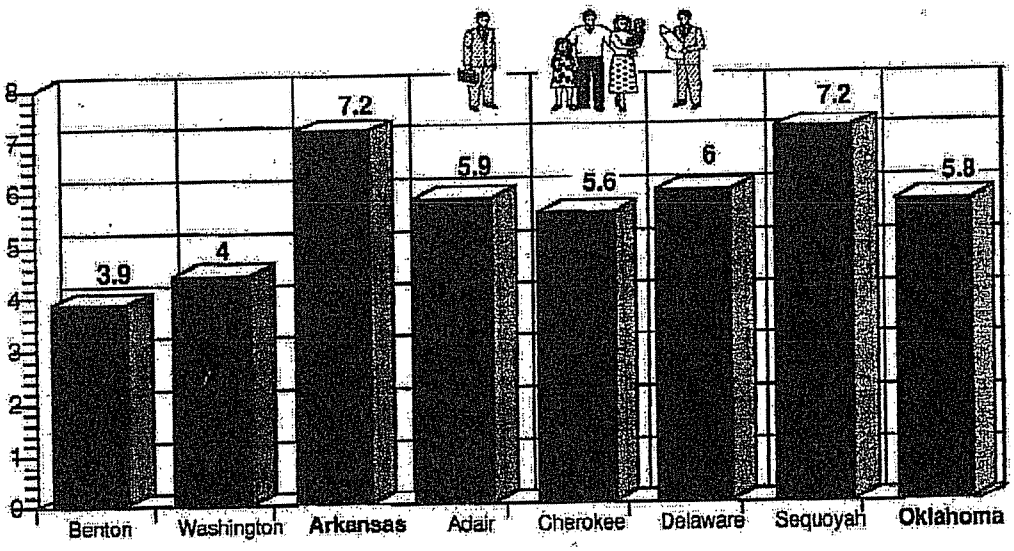

Figure 13. Unemployment rate, percent in the Illinois River Basin, 1990. (*Arkansas and Oklahoma Employment and Security Divisions, 1990*)

Table 4. *County labor forces for the Illinois River Basin*

County	1980	1986
Benton	50,875	55,760
Washington	61,575	65,737
Adair	6,530	8,040
Cherokee	15,770	16,213
Delaware	10,240	11,729
Sequoyah	11,796	16,526
Basin	156,786	175,005

Source: *U.S. Bureau of the Census, County and City Data Book, 1988.*

Table 5. *Population percent below the poverty level*

	Persons	Families
Arkansas	19.0	14.9
Benton	11.1	8.8
Washington	14.9	10.3
Oklahoma	13.4	10.3
Adair	27.6	22.1
Cherokee	22.2	18.3
Delaware	21.4	16.7
Sequoyah	20.1	16.3

Source: *U.S. Bureau of the Census, County and City Data Book, 1988.*

Table 6. *Education characteristics, 1980*

	Percent > 12 years	Percent > 16 years
Arkansas	55.0	10.8
Benton	61.8	11.6
Washington	63.8	18.0
Oklahoma	66.0	15.1
Adair	45.1	8.7
Cherokee	56.2	17.8
Delaware	52.8	7.3
Sequoyah	48.2	8.3

Source: *U.S. Bureau of the Census, County and City Data Book, 1988*

Importance of agriculture in the area

The major income produced in the basin area is from poultry (photo 4), cattle, and hogs. Cherokee and Adaair Counties are ranked fourth and fifth, respeciively, in Oklahoma cash receipts from agricultural products sold. Delaware and Adair Counties are ranked first and second iin Oklahoma swine production. Adair and Delaware are second and fourth in number of milk cows in Oklahoma. Benton and Washington Counties, Arkansas, rank first and second in beef cattle, swine, dairy, and broiler production (table 7). Only a small amount of the basin is cropped, but intensive truck crops, such as vegetables, strawberries, and fruit orchards, are an important part of the economy in Cherokee and Adair Counties, Oklahoma (table 8).

Data from the 1988 county business patterns indicate that 105 firms in the basin were in either the agricultural services or food and kindred product sectors of the economy. These firms employed 7,650 people and had annual payrolls of more than $119 million. These sectors provide supplies and services to poultry and other producers and are the processors of poultry and other agricultural products. The firms are concentrated in the Arkansas part of the basin. In addition to these firms, many small firms supply agricultural services as well as small processors of products. Innovative activities in the use of agricultural waste are in the formative stages of development.

Table 8. *Value of agricultural production in the Illinois River Basin, 1987*

	Crop	Livestock	Total
	Percent	*Million*	*Dollars*
Arkansas	48.0	52.0	2,826
Benton	2.5	97.5	154
Washington	1.9	98.1	206
Oklahoma	32.7	67.3	2,530
Adair	2.4	97.6	54
Cherokee	*	*	46
Delaware	5.4	94.6	41
Sequoyah	*	*	10

Source: *U.S. Bureau of the Census, County and City Data Book, 1988.*

* Not shown to avoid disclosure of individuals.

The nursery industry is important in the lower part of the basin. Over 26 nurseries are located along the river in Cherokee, Adair, and Delaware Counties, Oklahoma. One of the nurseries is the largest in Central United States and is in the top 10 in the world.

Table 7. *Animal and nutrient inventory for Illinois River Basin*

animals	Total manure/ IL Basin	Pounds P_2O_5/ animal/year	Total pounds manure/basin	Pounds/ animal/year	Total pounds /animal P_2O_5/basin	Pounds N pounds /year	Total N/basin
Laying hens	7,295,692	62.33	454,740,482	0.71	5,179,941	0.82	5,982,467
Broilers	217,119,403	50.29	10,918,934,777	0.43	93,361,343	0.86	186,722,687
Pullets	2,021,051	41.26	83,388,564	0.35	707,368	0.71	1,434,946
Cornish	1,024,000	29.40	30,105,600	0.25	256,000	0.50	512,000
Breeders	643,767	183.68	118,247,123	1.57	1,010,714	3.15	2,027,866
Turkeys	2,153,380	171.55	369,412,339	1.91	4,112,956	2.26	4,866,639
Swine	96,943	2,730.00	264,654,390	17.18	1,665,481	21.00	2,035,803
Dairy cattle	12,905	37,412.00	482,801,860	97.64	1,260,044	187.06	2,414,009
Unconfined cattle	200,775	27,375.00	5,496,215,625	94.44	18,961,191	182.50	36,641,438
Totals	230,257,293		18,218,500,760* 9,109,250**		126,515,038* 63,258**		242,637,855* 121,319**

* Pounds per year

** Tons manure per year per basin

(Arkansas Agricultural Statistics, Arkansas Agricultural Statistics Service, 1989; SCS Inventory, 1990)

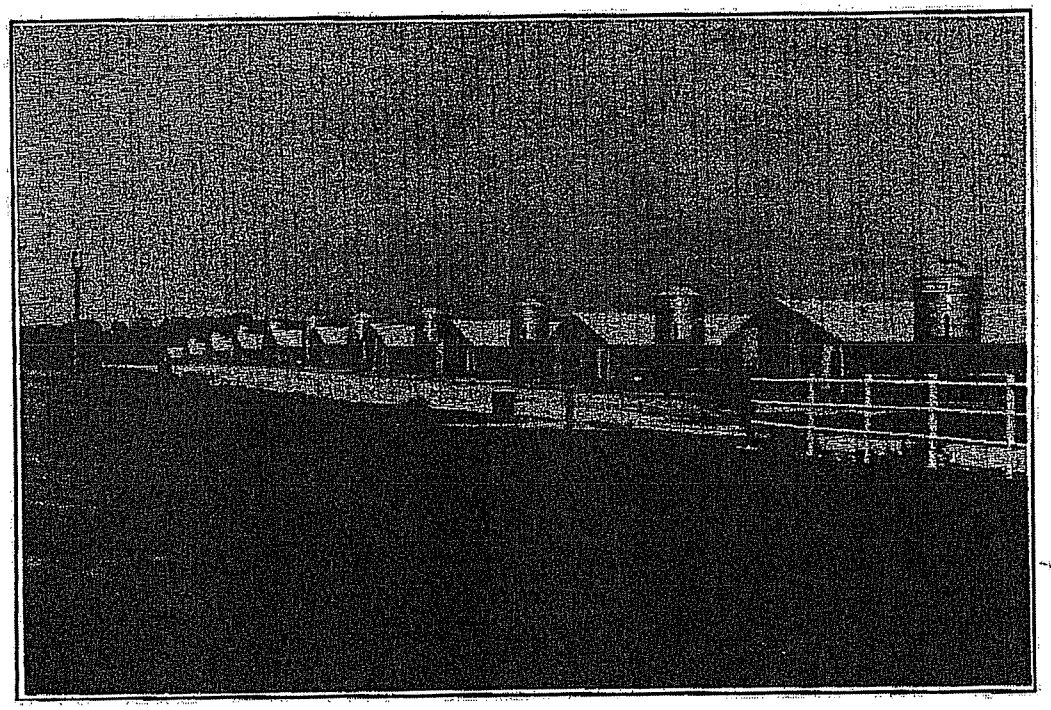

Photo 4. Poultry is big business in the river basin.

Erratum

Table 7. *Average annual animal production in the Illinois River Basin*

	Arkansas	Oklahoma	Total
Laying hens	6,022,393	1,273,299	7,295,692
Broilers	170,332,476	46,786,927	217,119,403
Pullets	1,813,691	207,360	2,021,051
Cornish	0	1,024,000	1,024,000
Breeders	643,767	0	643,767
Turkeys	700,760	1,452,620	2,153,380
Swine	60,543	36,400	96,943
Dairy cattle	8,228	4,677	12,905
Unconfined cattle	117,724	83,051	200,775

(Arkansas Agricultural Statistics, Arkansas Agricultural Statistics Service, 1989; SCS Inventory, 1990)

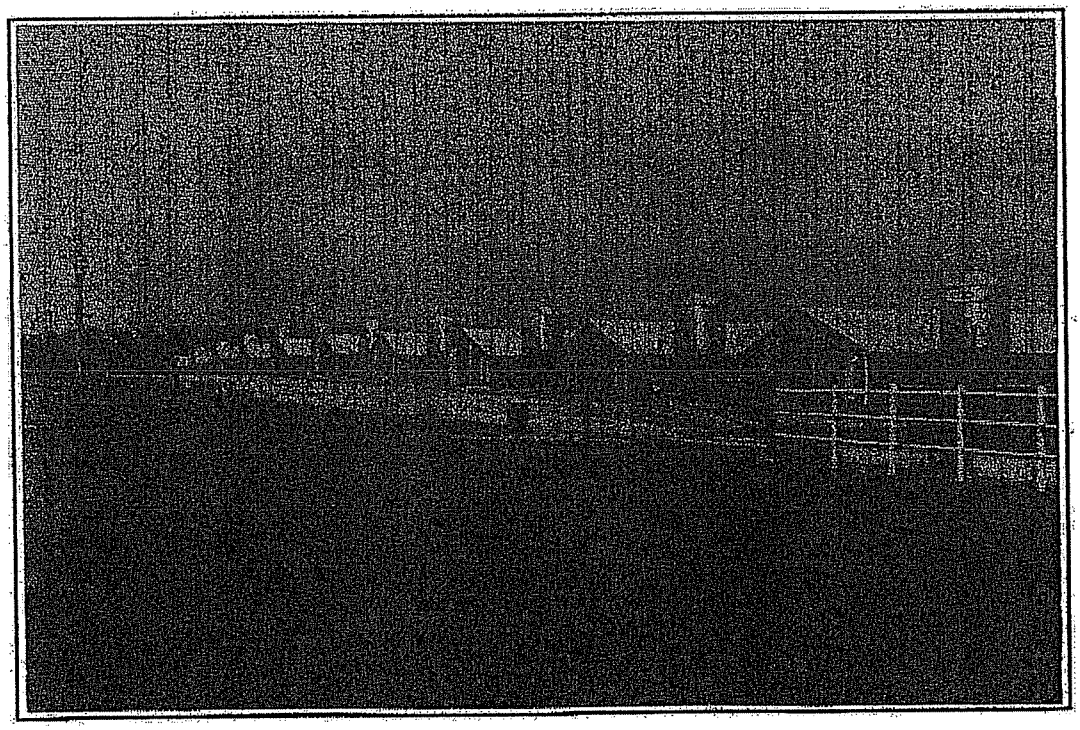

Photo 4. Poultry is big business in the river basin.

Importance of forests in the area

Present forest stands are relatively of low commercial quality reflecting noneconomic forest management practices over a long time. High grading "cutting the best and leave the rest" and overgrazing are the main reasons for poor commercial quality. Over 12 percent of the timber volume is in trees considered cull and unsuitable for timber products.

Timber harvesting is projected to increase significantly on private nonindustrial forest lands in the next decade. Foreign and domestic demands for low quality hardwoods are expected to increase because of new technology that uses fiber and stock of nonstandard dimensions from a greater variety of species.

Between 2 and 3 percent of all timber stands are subject to some harvesting activity in an average year. Average annual timber removals exceed 1 million cubic feet. About 97 percent of the harvest is hardwood, and 3 percent is pine. Nearly 50 percent of total removals are sawtimber. The total stumpage value of the timber harvested is estimated at $210,000. This amounts to an annual stumpage value of $1.32 per acre per year.

Timber stands are only producing about 30 percent of the potential wood volume that could be realized if managed properly. Only about 5 percent of the sites are considered prime timberland capable of producing at least 85 cubic feet of wood per acre per year on a sustained basis. Fifty-two percent have a moderate production potential in the 50 to 85 cubic feet per acre per year range, and 43 percent are only capable of producing at a rate of less than 50 cubic feet per acre per year.

Importance of recreation in the area

The Illinois River is cherished for its beauty. It is nestled in the heart of the beautiful Ozark Mountains with their ever-changing Oak-Hickory forests and offers breathtaking sights throughout the year. Recreation activities on the Illinois and its tributaries include fishing, swimming, and canoeing. Only a few recreation sites are developed in the upper part of the basin located in Arkansas; however, the potential for development is significant.

Benton and Washington Counties rank fourth and fifth as Arkansas counties most visited by tourist. The Forest Service Wedington Unit of the Ozark-St. Francis National Forest is probably the dominant recreation area in the upper basin. Camping and boat launching facilities are available. A developed hiking trail leads from Lake Wedington to the North Twin Peaks Special Interest Area and then down the Illinois River.

Prairie Grove Battlefield State Park is near Prairie Grove in Washington County. A Civil War historical site, the park features picnicking, battlefield museum, and restored 19th century hill community structures. Camping facilities are nearby.

Canoeing is one of the most popular activities on the Illinois River. About 100 miles of interesting and sometimes challenging stream can be enjoyed. The upper part of the Illinois River is easy flowing and has delightful scenery and several stretches of mild rapids. It is an excellent fishing stream that has smallmouth (brownies) and largemouth bass, walleye, and various sunfishes. Like most brownie streams, the Illinois is best fished from a boat early in spring and fished on foot at other times.

Recreation is a major industry in the Oklahoma part of the river basin. Most recreation activities directly related to the Illinois River occur in the Oklahoma part because it offers the most opportunities for canoeing and fishing. The upper 70 miles of the Illinois River in Oklahoma has been designated a scenic river and is overseen by the Oklahoma Scenic River Commission. Arrangements can be made with any of 16 commercial outfitters to place you in and pick you up anywhere you desire. Associated restaurants, motels, and campgrounds provide services. About 53,000 float trips were taken in 1988. The number of float trips has declined more than 20 percent since 1984.

The upper Illinois River empties into Tenkiller Ferry Reservoir, which is operated by the Corps of Engineers. This 12,500-acre lake is noted for its excellent fishery and water sport opportunities including scuba diving. The lake has 10 marinas, 24 boat launching ramps, and 14 Corps and State parks with campgrounds. Lodging is available at six parks and the many resorts and motels around the lake. Some also have dining facilities. A variety of other businesses serve the recreation interest.

The lower part of the Illinois River is a favorite for canoeing, swimming, picnicking, and fishing. It flows from the Tenkiller Lake Dam through the Tenkiller Valley into Kerr Lake. This 12-mile stretch of the river is excellent for the beginning canoeist and offers a challenge for the experienced canoeist.

A scenic wonder of natural woodlands with a variety of trees, flowers, and birds, the lower Illinois River also has an abundance of fish. Rainbow trout and striped bass are the most sought after by the fishing canoeist. The bottom of the river is gravel or rock, and several bluffs and gravel bar islands are in its path. A series of pools with rock riffles between them make this river best traveled by canoe.

In addition to providing necessary food and shelter for wildlife, the streamside forests also benefit people. Hunters will find a wide variety of game animals including deer, rabbit, squirrel, woodcock, and wood duck. These species can thrive because of the variety of plants that provide their specific food and shelter requirements.

The waterways along these forests provide anglers with a wide variety of fish. Inland rivers and streams have bass, sunfish, catfish, and trout.

Riparian forest provide a "living classroom" for nature studies of life histories and behavior of animals, plants, and fish. Nature organizations, science classes, and outdoors clubs use riparian areas for educational opportunities and such recreational activities as camping and hiking. The forests offer a variety of birds for birdwatchers.

The total economic significance of the recreation industry in the Illinois River Basin is difficult to assess. Many firms that cater to recreationists also supply other groups. Additionally, much of the recreation industry is small operations that would not be separated in the general economic data. An indication of the importance of canoeing is that in 1991 an estimated 114,000 people enjoyed canoeing and spent about $1,610,000.

Cultural resources

Archeological

Most archeological information from the Ozarks is in unpublished reports, thesis, and dissertations that are dispersed throughout the region and the country. From these and other sources, a number of site types are currently known. The wide variation in site type is most likely the result of the variety of activities in spatially discrete locations carried out by past human populations.

Surveys and excavations reveal numerous lithic sites extending along ridgetops. In some instances dense accumulations of debris and some fragments of bifacial tools, "nutting stones," cores, and abrading tools have been uncovered from sites that extend for hundreds of meters.

Few archeologists doubt that substantial sites are buried within the flood plains of major Ozark streams. Some of these sites can be characterized as small midden mounds (garbage dumps) because their elevation varies slightly from the surrounding terrain. Investigation of this kind of site has been rare, however, because few such sites are recognized. Most bottom fields are obscured by dense pasture or woods, and no systematic surveys have been undertaken in northwest Arkansas. An abundance of archeological sites in bluff shelters seems to have diverted attention from flood plain sites.

The research potential of flood plain sites is suggested, however, by excavations at the Lake Sequoyah site (3WA107) in 1977. At this site on the White River in Washington County, a late Archaic midden was found sealed under 1 to 3 meters of sediment and strata containing artifacts from later time periods.

Many surface sites are on stream terraces. Test excavations within the Beaver Reservoir flood pool revealed that most of its open sites had no undisturbed buried deposits in spite of abundant remains of lithic tools and debris on the surface. Only 4 of the 26 open sites tested by archeologists below 50 centimeters encountered sterile soil immediately below the plow zone. However, most of the test squares did find sterile soil. Scholtz attributed the shallowness of deposits to recent erosion *(32)*. Physiographic and biotic factors

may have been conducive to deposition even before the terraces were deforested and cultivated.

Two excavations at a bluff shelter site in extreme northwest Washington County (3WA252) in 1977 revealed a substantial, stratified site located in a hillside bench immediately below the shelter. Over 3 meters of cultural deposits were uncovered, spanning a time period from the early Archaic period to the late prehistoric *(30, 31)*.

The gently rolling upland surface of the Springfield Plateau in Benton and Northern Washington Counties has numerous sites that have not been examined using a settlement-subsistence approach. The extent of these sites varies considerably with a number of recorded locations occupying considerable amounts of space and containing intensive remains of prehistoric habitations. A paper by Gayle Fritz *(10)* indicates a substantial possibility that one or more of the three known prehistoric mound groups in extreme northwest Arkansas represents an extension of Chadian groups into the Ozarks of Arkansas. It is increasingly apparent that many prehistoric rock art sites are in northwest Arkansas. Rock art is a distinctive aspect of the archeological resources of the Ozarks that should be considered in preservation planning.

Evidence suggests that outcrops of chert were probably used repeatedly over a long time as a source of raw materials for stone tools. The quarries seem more important to understanding the behavior of local groups than tracing movement of stone over long areas. Future research should be alert to the existence of possible quarry sites.

The Arkansas Historical Preservation Office and the State Archeological Survey files show 619 archeological sites. One site appears on the National Register of Historic Places (NRHP), and seven sites are listed as potentially eligible. Site numbers have been assigned to 11 sites, but these sites are determined not eligible for NRHP. Site numbers have been assigned to 600 sites, but the sites have not been evaluated.

The Illinois River Basin region of Oklahoma is one of the most studied areas within Oklahoma. As early as 1894, W.H. Holmes of the Bureau of American Ethnology visited and reported upon prehistoric flint quarries and a spring that yielded spear points. A survey of the proposed Tenkiller Reservoir on the Illinois River resulted in 38 sites being found. Of these, the Vanderpool, Morris, and Cookson sites were extensively excavated by the University of Oklahoma and Smithsonian Institution crews.

Because of the many sites that have been tested and excavated, more substantial information is available on cultural sequences, their ages, assemblage variation through time, site structure, activity areas, and associated tools and refuse for this region than for other areas within the state. However, most of this knowledge comes from findings along major streams; thus little is known about prehistoric people's habitation of uplands or their use of upland resources. Because large villages and rock shelters have attracted more archeological work than other kinds of sites, information on the last 1,000 years of prehistory exceeds that for earlier periods.

Historical

The Tenkiller Lake area is inseparably linked with the history of the Cherokee Indian. Before 1800, this area was the ancestral home and territorial hunting domain of the Caddo Indians and then the Osage Indians. Most of the Indian artifacts are of those tribes.

About 1800, an Indian trader named Lovely made a purchase agreement with the Osage Indians for a 100 square mile of land. This land became known as "Lovely's Purchase." He built a courthouse at a site known as Kildron that was the seat of governmental affairs. After the Cherokees arrived, Kildron became Dwight Mission. Dwight Mission is 15 miles east of Gore, Oklahoma, and north of Highway 64.

Many American Indian tribes favored the area that made up Adair County because of its superior hunting and fishing. However, by about 1808 the western Cherokees became the predominant tribe. These Indians had left voluntarily the main tribe and their homes in Georgia, Tennessee, and North Carolina to migrate west. More than 7,000 had settled in Arkansas between the Arkansas and the White Rivers before their title to the land was confirmed by the United States in the treaty of 1817.

A new treaty 11 years later gave them a grant of 7 million acres, part of which extended west to the 100th meridian, in exchange for their homes in Arkansas. Many of the western Cherokees that were forced to move into the Indian Territory elected to settle just across the border in the rugged, mountainous area in which they had hunted and fished. This became the last Cherokee stronghold. In 1839 this area as part of the Flint and Going Snake Districts belonged to the old Cherokee Nation. In 1907 the Indian Territory was admitted to the Union as the State of Oklahoma. The Cherokee area was included as a county and named Adair in honor of a prominent Cherokee jurist and educator.

The early settlement of Cherokee and Delaware Counties was by the Cherokee, Delaware, and Seneca Indians. When Oklahoma became a State, the counties were named after the Cherokee and Delaware Indians. Land was allotted to the Indians on basis of its cash value, the largest allotments in size being in the hilly, timbered areas. Land also could be leased for farming subject to the supervision of the Indian Agency. The sale or lease of land brought white settlers. After a short while, many farmers quit farming and sold out because the land was not suitable for cultivation. Farmers in other areas acquired these farms to increase the size of their farm units.

The first known white man to settle in the river basin was Captain Mark Bean. In 1803 he established a farm on the bank of the Illinois River and farmed the area encompassing Lake Tenkiller Dam.

The Treaty of 1817 between the U.S. Government and a part of the Cherokee Nation started the Cherokee migration to the Lake Tenkiller area. This western nation and Chief John Jolly established a settlement and capital called Tahlanteeskee. The settlement had a National Council House and courthouse on the Illinois River just east of Gore. The state maintains this historical site.

When the Eastern Cherokee Nation was driven from their homeland on the "Trail of Tears" in 1838 and 1839, the two nations were reunited. The capital was reestablished at Tahlequah. The U.S. Government forced Captain Mark Bean and numerous other white settlers to move from this area in 1829 because the land was decreed Cherokee Land.

George Gist (Sequoyah), a member of the Western Cherokee Nation, developed the Cherokee alphabet (syllabary) around 1820. This allowed the tribe to better communicate in their language on paper. Gist became a noted leader in the Cherokee Nation. His home site, the Sequoyah Memorial, is a few miles north of Sallisaw. It is maintained by the State and is open for visitation.

The Cherokee Nation, now a model of creating success from hardship, maintains several historical sites that developed since its arrival in Oklahoma. The Cherokee Capital Building, old Tribal Prison, Cherokee Supreme Court Building, Female Seminary built in 1889, an historic Indian Village and museum, and the famous outdoor drama at Tsa-La-Giln are in or near Tahlequah. The Cherokee Nation maintains a school for Indians and a successful modern business complex and manufacturing facility.

About 91 percent of the people living in the southern part of Adair County are of Cherokee descent. The county has the greatest concentration of Cherokee Indians in the United States.

The Lake Tenkiller Ferry Dam is named for the Cherokee family from whom the land and the ferry were obtained to build the dam. The Tenkillers were prominent Cherokees. Legend is that the Cherokee warrior was given this name by the white soldiers and pioneers of Fort Gibson because of the 10 notches on his bow.

The Prairie Grove Battlefield State Park is 10 miles west of Fayetteville at Prairie Grove. It offers a self-guided driving tour designed to provide a complete view of the battlefield with stops at important points of interest.

The Battle of Prairie Grove, which occurred December 7, 1862, climaxed Major. Gen. Thomas C. Hindman's campaign (11,000 men) to defeat the Union army of Brig. Generals James G. Blunt and Francis J. Herron (8,500 men) and to regain control of northwest Arkansas.

The Arkansas State Historic Preservation Officer has identified and given site numbers to 86 historical structures.

Problems, concerns, and ongoing activities

Water quality problems

In recent years degradation of ground and surface water resources has become apparent in parts of the Illinois River Basin. Water quality data indicate that phosphorus, nitrogen, bacteria, and turbidity commonly exceed stream guidelines and standards to maintain their designated uses. Because several public water supply lakes are eutrophic, the public perception is that loss of public water supplies is imminent. Water quality for safe recreation in the basin's waters is not being maintained. The sources of pollution are numerous, but nonpoint source from animal operations has the greatest potential for contamination. The economic base of the region is dependent upon the vitality and growth of the animal industry, recreational opportunities, and safe drinking water supplies.

Eutrophication

A water body with excessive aquatic vegetation is said to be eutrophic. Under normal conditions plants raise the dissolved oxygen levels during the day by evolving oxygen through photosynthesis. Oxygen also enters the water via surface turbulence from wind in impounded water and from flowing over shoals in streams. Plant respiration (an oxygen demanding process) at night reduces dissolved oxygen levels. Under eutrophic conditions oxygen problems often arise following several windless, cloudy days: less than optimum oxygen has been introduced into the water. Low oxygen levels result in fish kills. When excessive vegetation dies and decays, even more oxygen is required to decompose the dead plant material; further exacerbating the problem. If low dissolved oxygen levels continue, the fish species community changes to favor low oxygen-requiring trash fish. Intake filters at water treatment plants are clogged more frequently by excessive algae. Proliferation of macrophytic plants clogs waterways, lines, and lake banks, and pollutes beaches.

The high eutrophication rates have a definite detrimental economic impact on the area as well as the effect they have on the fisheries and wildlife in the lakes. The cost of treating public drinking water supplies increases dramatically because of high nutrient concentrations. Movement of nitrogen into the water table is indicated in the upper reach of the basin. This degrades shallow water wells used by many rural residents.

Arkansas.—Bob Kidd Lake in Arkansas shows signs of being eutrophic, such as large algae blooms and various rank vegetation occurring in the lake. Recreation use of the lake consisted of swimming and fishing when it first opened. The vegetative growth has caused the beach constructed for primary contact recreation to be abandoned. Drinking water supplies of Lincoln and Prairie Grove Lakes are being impaired. Growing numbers of confined animal operations are the primary source of the threat. Lincoln Lake and Prairie Grove Lake are eutrophic with massive algae proliferation during the summer months. Water users from Lincoln Lake complain of taste and odor problems. Higher than normal pH levels have been reported from water samples.

Oklahoma.—Oklahoma's Lake Tenkiller has experienced abnormally high eutrophication rates that are adversely impacting fisheries, public drinking water supplies, primary body contact recreation, and esthetics. Concerns about water quality problems in the Illinois River may have already had a negative impact on the recreation industry along the river. This is particularly the case for the canoe rental industry that includes 14 public access points, 7 scenic river sites, and 18 camp sites. In addition, 21 commercial float trip vendors operate on the river. From 1984 to 1990 the number of canoeist floating the river declined by 33 percent. A Scenic Rivers Commission spokesperson attributed this decline to negative news releases about water quality problems in the river. Excessive nutrients stimulate algae growth, which can reduce the esthetics of the river, but no documentation was discovered to indicate that pollution in the river poses any serious threat to human health. The adverse impact on the industry is significant.

Potential pollution sources

The numerous potential sources of point and nonpoint source pollution to the Illinois River include:

- Sewage treatment plant effluent
- Private sewage disposal systems
- Industrial discharges
- Soil erosion
- Commercial nursery runoff

- Gravel removal
- Road construction
- Recreation
- Irrigation return water
- Uncontrolled solid waste disposal sites
- Agricultural uses of commercial fertilizer, pesticides, and herbicides
- Land application of animal wastes
- Improper disposal of dead animals

A significant part of the water quality problems in the basin appear to be a precipitate of the large volume of poultry waste generated and disposed of in the basin each year. Adequate management to distribute this litter uniformly over the basin and transport the excess litter out of the basin would probably remove the water quality problem. The transportation cost for large volumes of raw poultry litter is high compared to the value of the nutrients it contains. This economic factor limits the market area and disposal area of the raw litter to a concentrated area around the poultry operations. It also encourages land application of the waste in excessive quantities, at improper times, and in unsuitable locations, and causes other waste mismanagement. This mismanagement can result in impaired downslope water resources. Poor waste management around confined animal operations can also allow contaminants to enter surface and ground water. Nutrients from animal wastes and other sources enter the water courses via leaching through the soil or by surface runoff from land applied waste. The consequent impairments to water quality are nutrient enrichment and oxygen depletion. Excessive nitrogen and phosphorus cause proliferation of algae and rooted aquatic plants. Proliferating vegetation culminates into algae mats and decaying algae clumps producing undesirable odors, taste, and discoloration of the water.

Amounts of nutrients

Elevated nitrogen and phosphorus levels in area streams and lakes are causing problems. About 17,500 tons of nitrogen and 11,000 tons of phosphorus as P_2O_5 are generated in animal wastes each year in the Illinois Basin.

Water quality standards

The water of the Illinois River Basin in Arkansas has been designated by the ADPC&E as suitable for the propagation of fish and wildlife, primary and secondary contact recreation, and public, industrial, and agricultural water supplies. The water quality standards for nutrients to support this classification require that materials stimulating algal growth shall not be present in concentrations sufficient to cause objectionable algal densities or other nuisance aquatic vegetation. Total phosphorus should not exceed 0.1 mg/L in streams or 0.05 mg/L in lakes and reservoirs. The fecal coliform count for primary contact water should not exceed a geometric mean of 200/100 mL nor more than 10 percent of total samples during any 30 day period exceed 400/100 mL between April 1 and September 30. The remainder of the year, these standards may be exceeded, but they should never exceed the standard for secondary contact water, which is 1,000/100 mL or 2,000/100 mL in a 10 percent sample over 30 days.

Water quality data

The data in this report were based on 17 different USGS sampling stations in Arkansas and Oklahoma where a long-term record was available. Three of these stations are in Arkansas, and three are on tributaries that originate in Arkansas. Ten of the stations are in Oklahoma on the main stem of the river with one station on a tributary. Figure 14 shows the location of these stations, which are also displayed in the water quality tables in appendix E. The years that each data set represent are quite varied. The data are also from various sources that were collected by different agencies and analyzed in different labs by different agencies. About 90 different publications describe in some way the water quality in the Illinois River that began with the collection of data in 1947 at Gore, Oklahoma (USEPA 1986). The stations in this report were selected because of a recent study cited in the USEPA reference. An analysis of the adequacy and accuracy of the data was completed in the development of the referenced report. The analysis evaluated the 17 stations as representing "good" data.

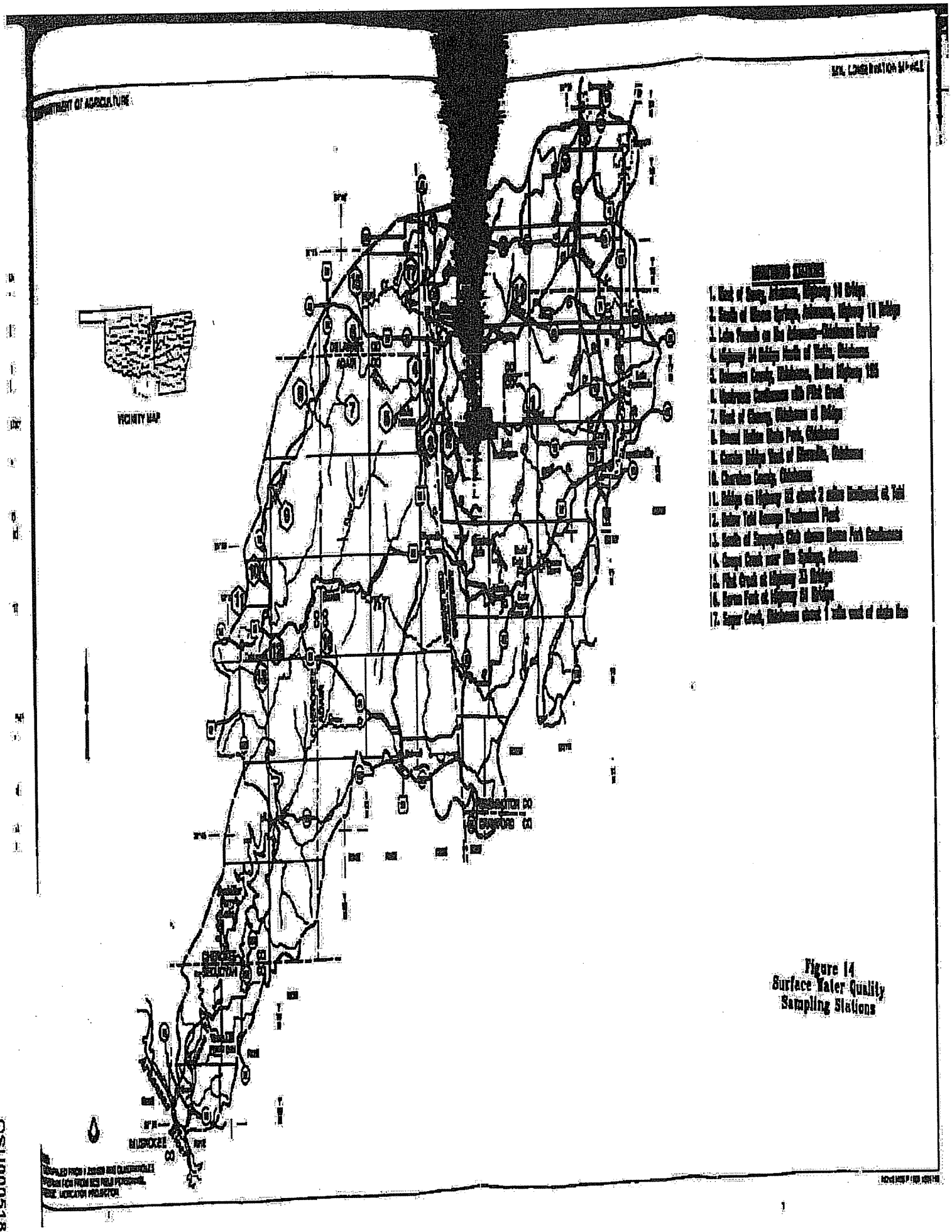

Figure 14
Surface Water Quality
Sampling Stations

Concerns are well justified and documented with the data represented in figure 15. The data shows that the entire Illinois River and many of the lakes on its tributaries are eutrophic from excessive nutrients. The total phosphorus concentrations on the mainstem of the river in Arkansas ranged from a mean value of 0.12 mg/L near the town of Savoy to 0.34 mg/L near the state line (USEPA 1986). Normal total phosphorus concentrations from uncontaminated rivers should average between 0.01 and 0.03 mg/L (USDA 1987). Maybeck (1982) estimated that clean rivers should average about 0.025 mg/L to avoid biological nuisances and eutrophication (USDA 1981). Kratzer (1979) estimated the trophic threshold at 0.04 mg/L for total phosphorus, while Vollenwelder estimated the threshold at 0.02 mg/L. The EPA recommends a guideline of 0.05 (USEPA 1985). All three mean concentrations in Arkansas greatly exceed these values. The average at Savoy is nearly five times the Maybeck guideline, and the concentrations are mean values, not maximums. The guidelines are strictly guides, however, and each river system has to be evaluated specifically in relation to the potential and impaired beneficial uses.

Tributaries in Arkansas exhibit similar phosphorus loading characteristics. Values ranged from a mean value of 1.082 mg/L on the Osage Creek tributary to a low of 0.08 mg/L on the Baron Fork (USEPA 1986). The Baron Fork value, however, is still three times the Maybeck guideline, while the Osage Creek value is 43 times the guideline.

Median values for the total phosphorus concentrations at mainstem stations in Arkansas were similar to mean values. The median did tend to be somewhat lower than the mean values, which would indicate the mean was skewed by high extremes of the data distribution. The mean of medians was lower than the mean of means as expected with both values exceeding guidelines (USEPA 1986).

Trends overall increased over the period of record. The largest annual increases were at the Lake Frances station with a reading of +0.134 mg/L/yr. One of the stations, Highway 16 near the Arkansas-Oklahoma state line, showed a decrease of -0.013 mg/L/yr. The mean trend for mainstem stations in Arkansas was +0.041 mg/L/yr, and tributaries averaged +0.03 mg/L/yr increase (USEPA 1986).

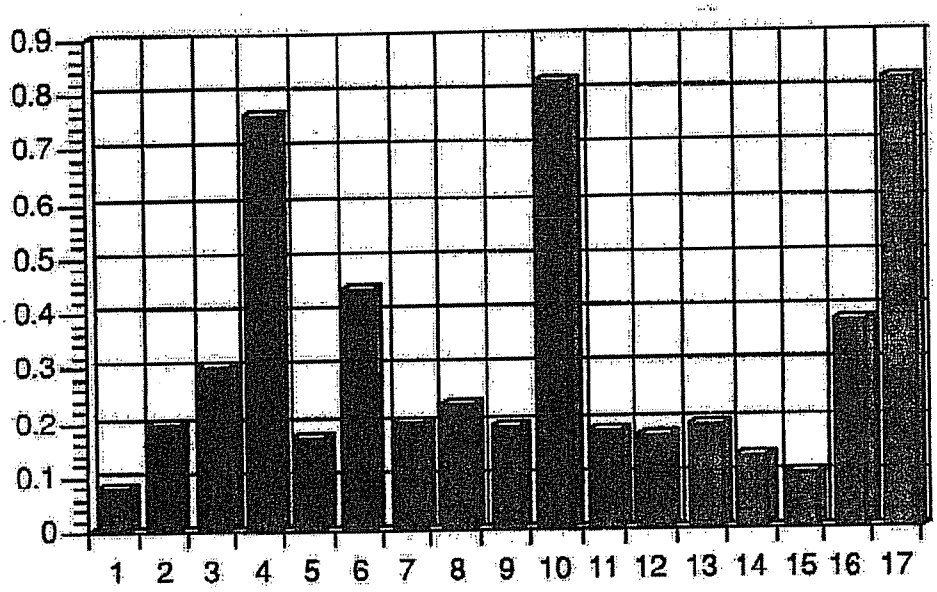

Figure 15. Mean values of total phosphorus in the Illinois River Basin.

Oklahoma mainstem stations had higher median values on total phosphorus concentrations and lower concentrations for the other parameters discussed. Ten stations on the mainstem of the river and one tributary in Oklahoma were analyzed in this report. Median total phosphorus concentrations on the 10 mainstem stations ranged from 0.1 mg/L near the Tahl Sewage Treatment Plant station to a high of 0.82 mg/L at the Chewey station. The mean of Oklahoma station median values equalled 0.26 mg/L compared to a value of 0.192 mg/L in Arkansas. The tributary of Sager Creek near the Arkansas-Oklahoma state line had a median value of 0.82 mg/L. The trends for total phosphorus in Oklahoma were on the increase at a rate of 0.021 mg/L/year. This rate was approximately half the increasing rate for Arkansas stations (USEPA 1986).

Orthophosphates were similar to total phosphate concentrations (fig, 16). Two guidelines for maximum orthophosphate concentrations were proposed by Sawyer in 1947 and Vollenweider in 1968. They proposed that the trophic state threshold should be about .001 mg/L. Median orthophosphate concentration values for the mainstem of the Illinois River in Arkansas exceeded this guideline. Concentrations in Arkansas increased downstream beginning with a median concentration of 0.04 mg/L and increasing to 0.18 mg/L at the stateline. Tributaries exhibited a great range in orthophosphate concentrations. Sager Creek contained the largest concentration at 0.69 mg/L for a median, while Baron Fork was the lowest at 0.022 mg/L. Trends generally have been on the increase. Only one value declined while the remainder increased. The largest increasing trend was at the Lake Frances site near the state line with a rate of +0.205 mg/L/year (USEPA 1986).

Orthophosphate concentrations at stations on the mainstem of the Illinois River in Oklahoma ranged from a median of 0.286 mg/L near the Tahl STP station to a low of .071 mg/L at the Tahl station. The mean of median values for the mainstem Oklahoma stations was 0.124 mg/L compared to 0.124 mg/L in Arkansas. The Sager Creek tributary concentrations for orthophosphate had a median value of 0.69 mg/L. Trends in Oklahoma indicated an increasing rate of 0.054 mg/L/year, which is only slightly lower than the trend for Arkansas (USEPA 1986).

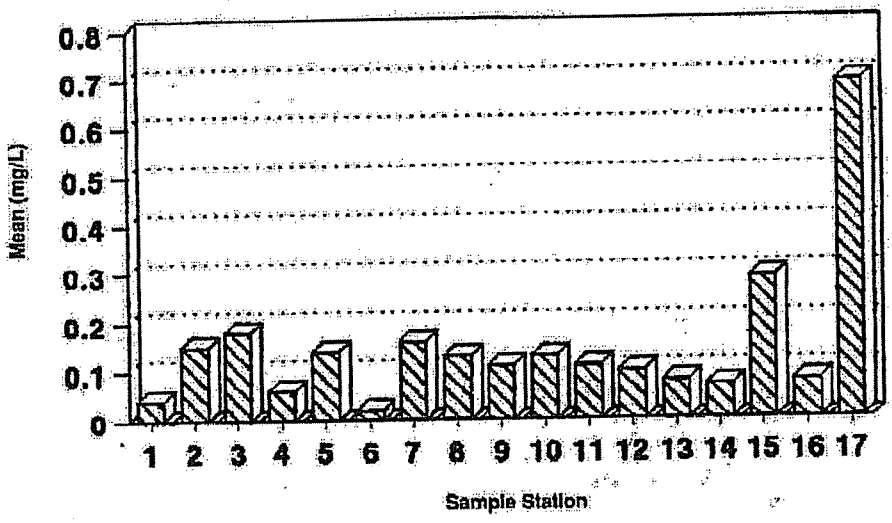

Figure 16. Mean values of orthophosphate in the Illinois River Basin. Vollenwalder guideline is .001 mg/L (1968).

Nitrate and nitrite values were higher than might be expected in streams, but were much lower than the 10 mg/L safe drinking water standard (fig. 17). Median values as nitrogen on the mainstem-Arkansas stations ranged from 1.7 mg/L at the Highway 16 station on the state line to 1.3 mg/L at the Savoy station. Kratzer (1979) proposed that a concentration of more than 0.9 mg/L for total nitrogen as N would be great enough to cause eutrophic conditions. Tributary values in Arkansas ranged from 4.081 mg/L on Osage creek to 0.914 mg/L on Baron Fork of the Illinois. All Arkansas median values exceeded the Kratzer guideline (USEPA 1986).

Median NO_2 & NO_3 concentrations as nitrogen ranged from a high of 1.8 mg/L at station #5 to a low of 0.8 mg/L at the Tahl station #11. The mean of station medians was lower in Oklahoma than in Arkansas. Trend data showed an increase of 0.136 mg/L/year for Oklahoma stations and 1.542 in Arkansas. The Oklahoma tributary had a median value of 2.25 mg/L (USEPA 1986).

Median total dissolved solids concentrations in the Illinois River in Arkansas ranged from a high of 32.5 mg/L at the Lake Frances station to 10 mg/L at Savoy and State Highway 16 near the Oklahoma-Arkansas border (fig. 18). The mean of station medians was 17.5 mg/L. Arkansas tributaries ranged from 2 mg/L to 9 mg/L with a mean of station medians of 4.67mg/L. The long-term trends for Savoy and the Highway 16 stations showed a slight decrease in concentrations, while the Lake Frances station had an increase of 126 mg/L.(USEPA 1986)

Oklahoma median values for total dissolved solids and turbidity were generally lower than those for the Arkansas stations. Median values ranged from 21 mg/L at the Watts station to 4 mg/L at the Chewey station. The average median value for all Oklahoma mainstem stations was 8.6 mg/L. Trends for Oklahoma stations were increasing at the rate of 6.06 mg/L/yr. The Oklahoma tributary median value was 5 mg/L.(USEPA 1986)

Turbidity values were generally less than 30 Jackson Turbidity Units (JTU). Arkansas mainstem median values ranged from 22 JTU on the Lake Frances station to 6 JTU at the Savoy station (fig. 19). The mean of medians for Arkansas mainstem stations was 14 JTU. Tributary values ranged from 4 JTU on Osage Creek to as little as 1 JTU on Flint Creek and the Baron Fork. Trends for the period of record indicated a large increase in the Lake Frances station (USEPA 1986).

klahoma stations averaged 11.4

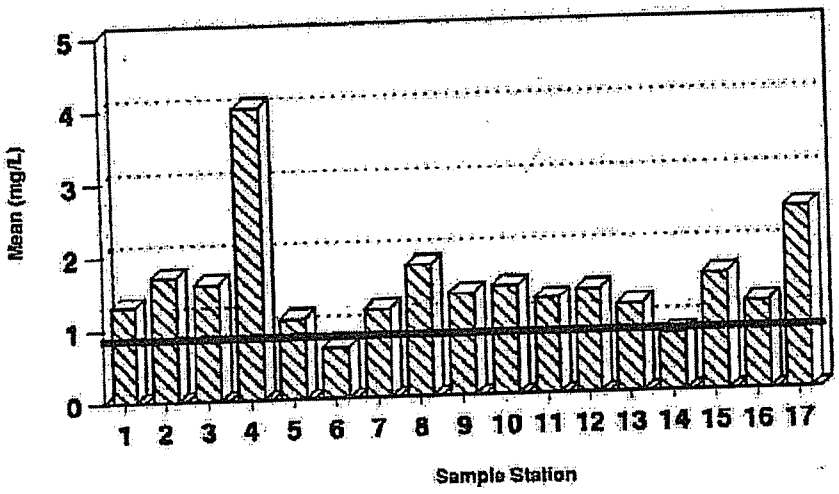

Figure 17. Nitrate and nitrite values in the Illinois River Basin. Kratzer guideline is 0.9 mg./L (1979).