EAST OSAGE RIVER

WATERSHED

INVENTORY AND ASSESSMENT

Prepared by

Alex L. S. Schubert

Missouri Department of Conservation

West Central Region-Fisheries Division

Clinton, MO

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Executive Summary

The East Osage River Basin is found in central Missouri in the Missouri counties of Osage, Maries, Cole, Pulaski, Miller, Camden, Morgan, Benton, and Hickory and encompasses 2,474.52 mi^2. This basin has been divided into two 8-digit hydrologic units (HUCs) and fourteen 11-digit HUCs. Lake of the Ozarks was formed in 1931 in the western half of the East Osage River Basin.

Geomorphology

This basin lies within a dissected plateau known as the Salem Plateau and is represented by four of Missouri's natural divisions. Karst features are common and soils are generally acidic with moderate to low fertility. Erosion rates are generally low although new housing developments, road construction, intensive confinement of livestock and overgrazing have denuded land causing locally-increased erosion and sediment pollution.

Land Use

The basin has undergone a major shift in land use during the last 300 years. Historically, the basin was occupied by the native Osage tribe. As European settlers moved into the basin, they degraded environmental quality and displaced the native people. European settlers cleared timber, overharvested fish and game, and plowed soil on steep hillsides. In the early days, people used the Osage River and its tributaries as a main mode of transportation and constructed wing dikes to control the flows of the river. In 1931, construction of Bagnell Dam was completed forming Lake of the Ozarks-a prime recreational and tourist destination. Harry S Truman Dam and Reservoir was completed in 1979. Bagnell Dam and Truman Dam both currently provide hydroelectric power generation. Agriculture in the basin has experienced a shift from a crop-based system in the earlier days of settlement to a livestock-based system today. Many concentrated animal feeding operations (CAFOs), gravel mining operations, waste water treatment plants, and urban construction projects currently exist within the basin. The Missouri Department of Natural Resources (MDNR), Environmental Protection Agency (EPA), U.S. Army Corps of Engineers (USACE), Missouri Department of Conservation (MDC), Natural Resources Conservation Service (NRCS), and county Soil and Water Conservation Districts have worked with landowners to protect natural resources in the basin.

Hydrology

Precipitation in the basin is typical of a mid-Missouri basin with an average of 40 inches per year. The U.S. Geological Survey (USGS) has maintained 16 gauging stations within the basin. Due to the karst topography of the basin, a number of losing streams and springs exist within the area. Truman Dam and Bagnell Dam on the Osage River have significantly impacted the hydrology of the region.

Water Use and Quality

Water of the basin is used for household use, commercial use, recreational use, and hydroelectric use. There are more than 85,000 residents of the basin served by public supplied surface water, public supplied groundwater, or private wells. Water quality is normally good, but pollution incidents occasionally occur, causing stream contamination and fish kills. The Clean Water Act requires each state to maintain a list of critically impaired streams. Currently, there are 1.9 miles of 303(d)-listed impaired streams and 50 impaired reservoir acres found within the basin. Sources of impairment include damming, riparian degradation, channel alteration, urbanization, flow alteration, sedimentation, low dissolved oxygen, point source pollution, and nonpoint source pollution. Hydroelectric power generation using the discharge of impounded water of the Osage River has caused considerable stream flow alteration and channel degradation to the Osage River below Bagnell Dam and has caused multiple fish kills below both Truman and Bagnell dams.

Habitat Conditions

Habitat conditions of the basin have been considerably altered in some areas. Logging, land clearing, burning, and overgrazing have degraded fish and wildlife habitats within the basin. Stream channels have become destabilized due to peaking-style discharge from dams, gravel mining, and channelization. Riparian corridors are in fair condition throughout the basin with an average of 61% riparian forest and 35% riparian grassland. There is only about 1% of the basin in riparian cropland and <1% in urban land-use. The Osage River below Bagnell Dam has the highest percentage of riparian cropland (20%) in the basin.

Biotic Community

The basin has a rich diversity of animal and plant species within its boundaries. Some species which historically occurred within the basin could not cope with the changes brought about by the European settlers. Other species such as the Niangua darter, lake sturgeon, and pink mucket mussel still exist, although their future is imperiled due to habitat changes, overharvest, introduction of exotic species, or water quality changes. The MDC has sampled the fish communities of the basin since 1940. Each subbasin hosts a different fish community structure depending on a variety of factors including interspecific competition, habitat availability, pollution events, or hydrologic characteristics.

Bagnell Dam has significantly changed the timing of water quantity discharged down the Osage River channel. This change in discharge rates and volume may have negatively affected the fish community found in the lower Osage River and its tributaries.

Management Goals, Objectives and Strategies

Six goals have been identified within the East Osage River Basin. The first of these is to protect and improve water quantity and quality in the East Osage River Basin so that all streams are capable of supporting native aquatic communities. The second is to protect and improve habitat conditions of the East Osage River Basin to meet the needs of native aquatic species while accommodating society's demands for water and agricultural production. The third is to maintain the diversity and abundance of aquatic communities and improve the quality of the sport fishery. The fourth is to increase public access within the East Osage River Basin. The fifth is to address informational and educational opportunities with the East Osage River Basin. The sixth is to manage the East Osage River Basin databases to provide accurate and up-to-date data, easy accessibility, and compatibility with other regions, divisions, and agencies. Management objectives and strategies are included under each goal.

TABLE OF CONTENTS

LOCATION

The East Osage River Basin lies in the central Missouri counties of Osage, Maries, Cole, Pulaski, Miller, Camden, Morgan, Benton, Laclede, and Hickory (Figure 1). Hereafter, the term "basin" shall refer to the East Osage River Basin as covered in this document, unless otherwise specified. The basin as described in this Watershed Inventory and Assessment starts at the Osage River-Missouri River confluence (River Mile (RM) 130.2) at T44N, R10W, Section 5 near Jefferson City, MO. It initially extends southwestward upstream along the Osage River to the basin's near center point at Bagnell Dam at T40N, R15W, Section 19. From this point, the basin extends both westward and southward. The western leg extends upstream on Lake of the Ozarks (LOZ) Reservoir and ends at Harry S Truman Reservoir (HST) at T40N, R23W, Section 17 near Warsaw, MO. The southern leg extends southward from Bagnell Dam along Wet Glaize and Dry Auglaize creeks and ends in the upper most reaches of Goodwin Hollow, a major tributary to Dry Auglaize Creek, near Lebanon, MO.

The basin encompasses 2,474.52 sq. mi^2 as outlined in this document and includes the Osage River and all tributary streams except the Niangua River and its tributaries and the Osage River upstream of Truman Dam. The Niangua River Basin and the West Osage River Basin are both tributary basins to the East Osage River Basin (Figure 2) and are covered in separate basin Inventory and Assessments.

The basin is divided into two 8-digit HUCs by the USGS; the Lake of the Ozarks HUC -10290109 (1,392.98 sq. mi^2) and the Lower Osage HUC -10290111 (1,081.54 sq. mi^2). These HUCs are further divided by the USGS into fourteen subunits or 11-digit HUCs (Figure 3) as a means of managing these basins and their basin-related information. Throughout this document the 14 USGS 11-digit HUCs will be referred to as subbasins to facilitate discussion of the large diverse basin area (Table 1). Hereinafter, each subbasin will be referred to by the name below of that subbasin.

1. Lower Osage River Subbasin
2. Lower Maries River Subbasin
3. Upper Maries River Subbasin
4. Little Maries River Subbasin
5. Tavern Creek Subbasin
6. Wet Glaize Creek Subbasin
7. Dry Auglaize Creek Subbasin
8. Lower LOZ Hills Subbasin
9. Deer Creek Subbasin
10. Turkey Creek Subbasin
11. Cole Camp Creek Subbasin
12. Upper LOZ Hills Subbasin
13. Gravois Arm Subbasin
14. Miller County Osage River Hills Subbasin

A major feature of the basin is Lake of the Ozarks. Construction of Bagnell Dam began in 1929. The dam began impounding water in 1931 to form Lake of the Ozarks. Lake of the Ozarks, Missouri's second largest reservoir, covers 55,000 acres and has over 1,300 miles of privately-owned shoreline. Bagnell Dam is owned and operated by AmerenUE.

Outside basins which surround the East Osage River Basin include: Lamine River Basin, Moreau River Basin, Missouri River Basin, Gasconade River Basin, Niangua River Basin, Pomme de Terre River Basin, West Osage River Basin, and South Grand River Basin.

Figure 1. Counties which include portions of the East Osage River Basin

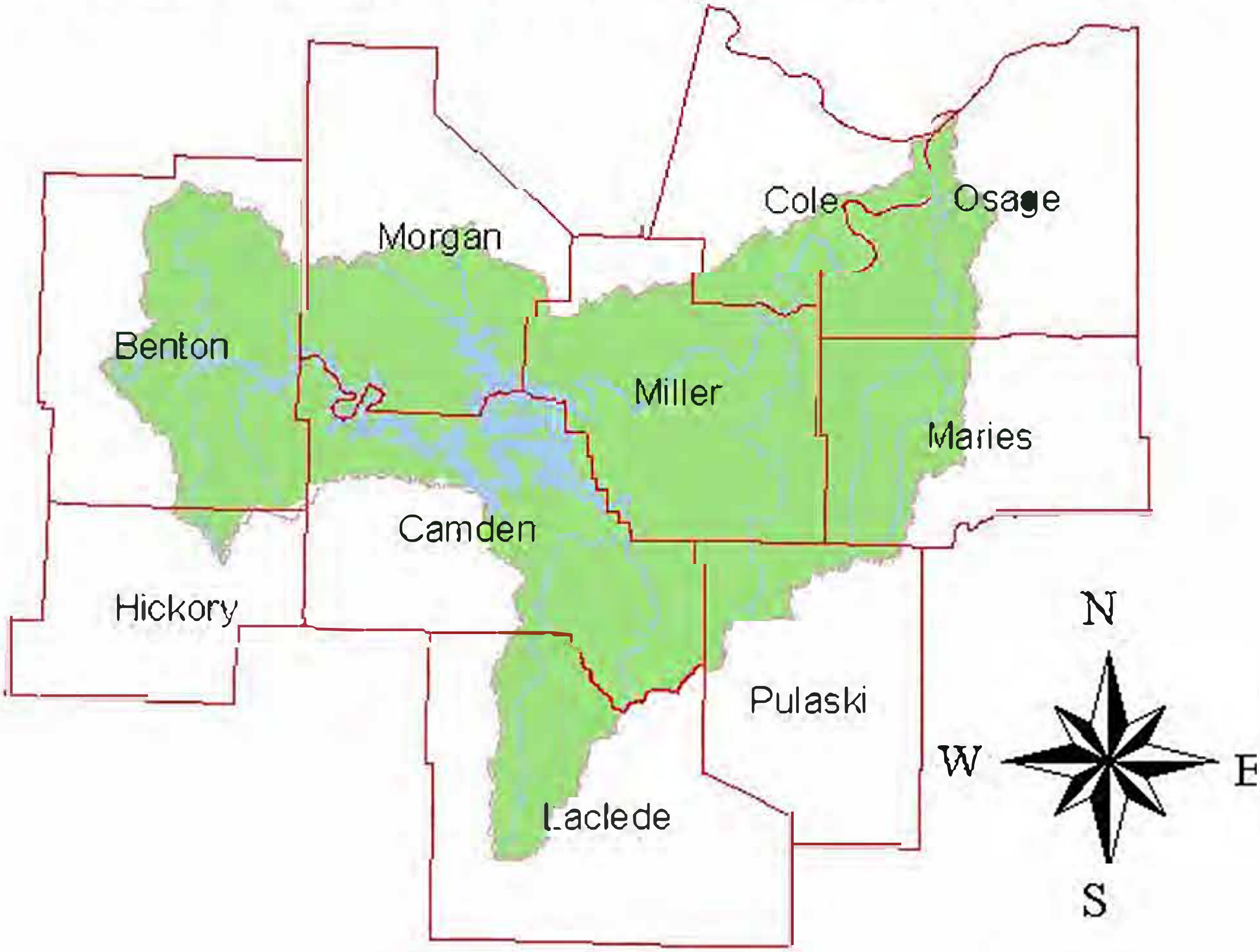

Figure 2. East Osage River Basin in relation to rivers of tributary basins

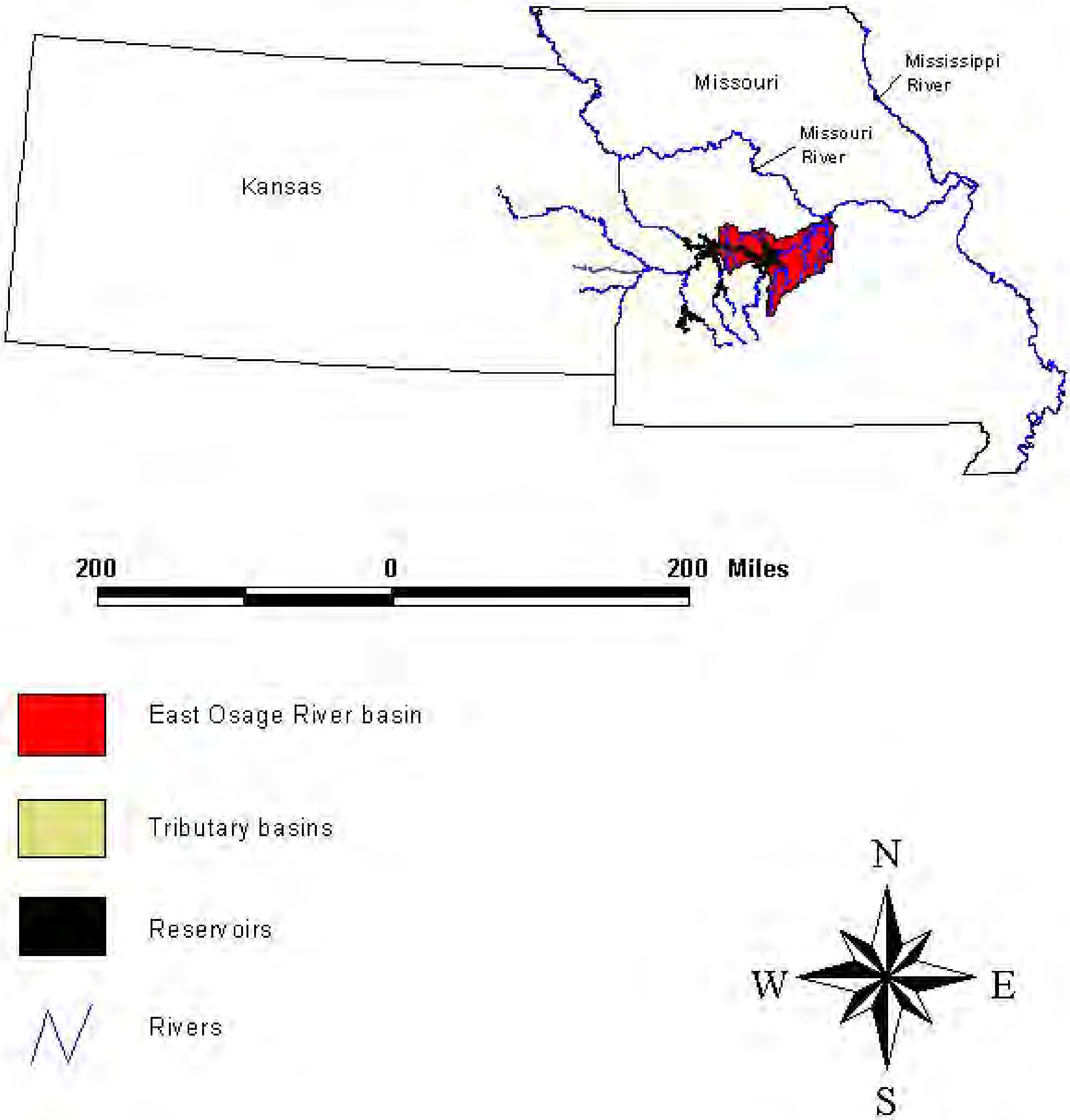

Figure 3. Subbasins of the East Osage River Basin

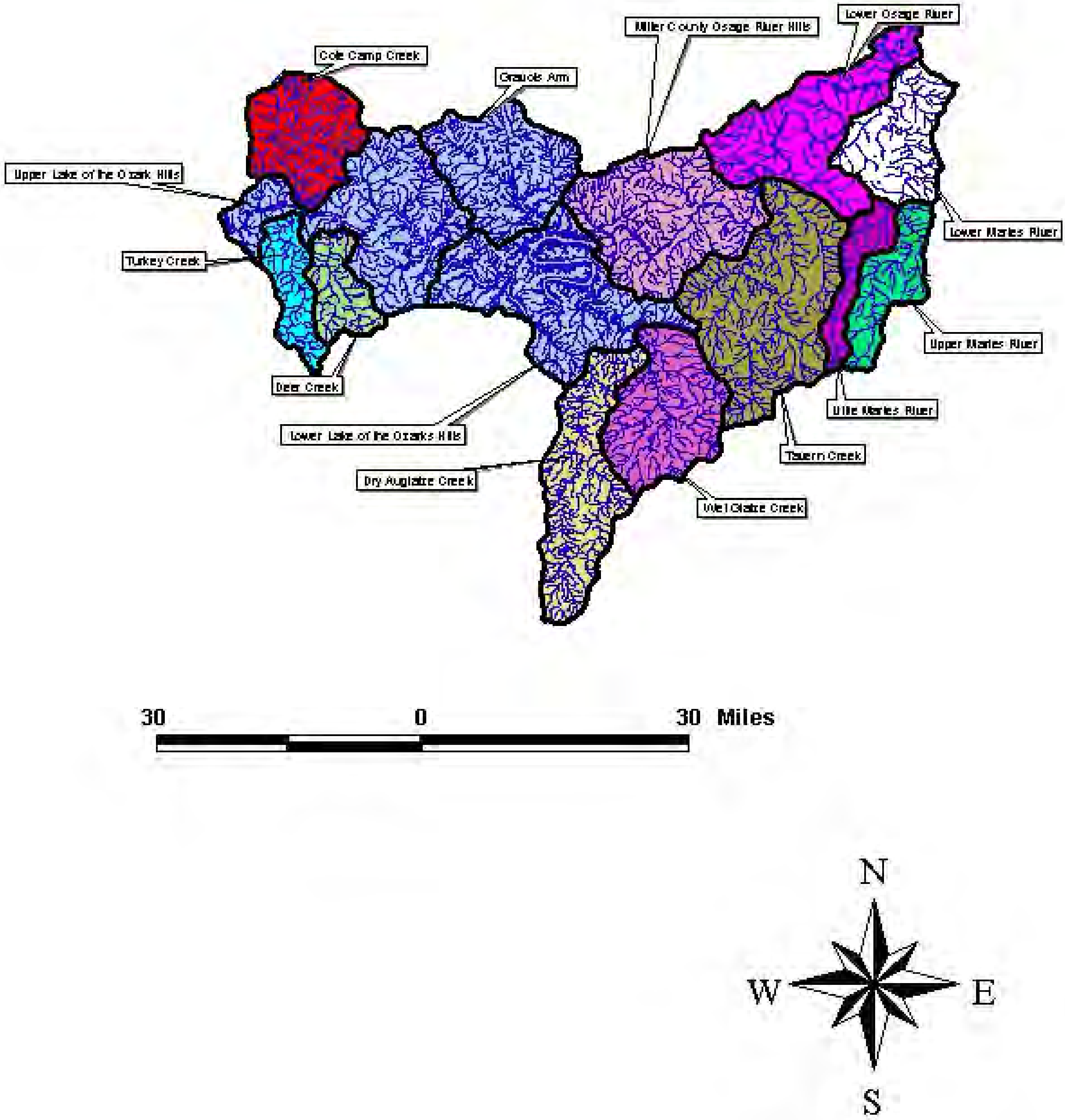

Table 1. 11-digit hydrologic units making up the East Osage River Basin.

Hydrologic unit name	11-digit number	Area (mi.^{2})	Area (acres)
Cole Camp Creek	10290109020	147	93,799.5
Upper Lake of the Ozark Hills	10290109040	265	169,755.4
Gravois Arm	10290109050	179	114,613.3
Miller County Osage River Hills	10290111020	252	161,071.9
Lower Osage River	10290111060	218	139,453.2
Lower Maries River	10290111050	133	84,942.2
Upper Maries River	10290111040	92	58,835.9
Little Maries River	10290111030	60	38,135.9
Tavern Creek	10290111010	314	200,629.0
Wet Glaize Creek	10290109070	180	115,110.5
Dry Auglaize Creek	10290109060	205	131,154.7
Lower Lake of the Ozarks Hills	10290109080	265	169,580.9
Deer Creek	10290109030	70	44,587.5
Turkey Creek	10290109010	72	46,021.9

Turkey Creek	**10290109010**	**72**	**46,021.9**

Table 2. Stream name, order, unimpounded length, impounded length, length influenced by Bagnell Dam discharge, and confluence for fourth-order and larger streams in the East Osage River Basin.

Name	Order	Unimpounded* Length (mi)	Length impounded by Lake of the Ozarks (mi)	Length ** influenced by Bagnell Dam Discharge (mi)	Confluence
Osage River	8	82	93	82	Missouri River
LOWER OSAGE RIVER SUBBASIN					
Sugar Creek	4	12.8	0	0	Osage River
Profits Creek	4	5.5	0	0	Osage River
LOWER MARIES RIVER SUBBASIN					
Maries River	6	37.5	0	0	Osage River
Little Maries Creek	5	13.7	0	0	Maries River
Loose Creek	4	5.6	0	0	Maries River
Unnamed Creek	4	4.9	0	0	Little Maries Creek
Unnamed Creek	4	3.7	0	0	Little Maries Creek
UPPER MARIES RIVER SUBBASIN					
Maries River	5	28.2	0	0	Maries River
Mag Creek	4	4.7	0	0	Maries River
Prairie Creek	4	3.6	0	0	Maries River
Rodgers Creek	4	5.6	0	0	Maries River
LITTLE MARIES RIVER SUBBASIN					
Little Maries River	4	25.5	0	0	Maries River
TAVERN CREEK SUBBASIN					
Tavern Creek	5	55.4	0	0	Osage River
Little Tavern Creek	5	17.9	0	0	Big Tavern Creek
Little Tavern Creek	4	10.5	0	0	Big Tavern Creek
Clinkingbeard Creek	4	5.8	0	0	Big Tavern Creek

Kenser Creek	**4**	**6.8**	**0**	**0**	**Big Tavern Creek**
Barren Fork	**4**	**13.3**	**0**	**0**	**Big Tavern Creek**

Table 2. Stream name, order, unimpounded length, impounded length, length influenced by Bagnell Dam discharge and confluence for fourth-order and larger streams in the East Osage River Basin.

Name	**Order**	**Unimpounded* Length (mi)**	**Length impounded by Lake of the Ozarks (mi)**	**Length ** influenced by Bagnell Dam Discharge (mi)**	**Confluence**
DRY AUGLAIZE CREEK SUBBASIN					
Dry Auglaize Creek	**5**	**44.7**	**0**	**0**	**Grand Glaize Creek**
Goodwin Hollow	**4**	**26.4**	**0**	**0**	**Dry Auglaize Creek**
WET GLAIZE CREEK SUBBASIN					
Grand Auglaize Creek (unimpounded section)	**6**	**7.8**	**0**	**0**	**Lake of the Ozarks**
Wet Glaize Creek	**5**	**11.7**	**0**	**0**	**Grand Auglaize Creek**
Deane Creek	**4**	**11.9**	**0**	**0**	**Grand Auglaize Creek**
Murphy’s Creek	**4**	**8.8**	**0**	**0**	**Wet Glaize Creek**
Conn’s Creek	**4**	**4.7**	**0**	**0**	**Wet Glaize Creek**
Sellars Creek	**5**	**9.0**	**0**	**0**	**Wet Glaize Creek**
Mill Creek	**4**	**5.5**	**0**	**0**	**Sellars Creek**
LOWER LAKE OF THE OZARK HILLS SUBBASIN					
Grand Auglaize Creek (impounded section)	**6**	**0**	**15.5**	**0**	**Lake of the Ozarks**
Linn Creek	**4**	**6.9**	**3.5**	**0**	**Lake of the Ozarks**
DEER CREEK SUBBASIN					
Deer Creek	**4**	**13.6**	**2.9**	**0**	**Lake of the Ozarks**

Little Deer Creek	**4**	**10.4**	**0**	**0**	**Deer Creek**
TURKEY CREEK SUBBASIN					
Turkey Creek	**4**	**24.2**	**2.4**	**0**	**Lake of the Ozarks**
COLE CAMP CREEK					
Cole Camp Creek	**5**	**23.5**	**4.8**	**0**	**Lake of the Ozarks**
Williams Creek	**4**	**11.2**	**0**	**0**	**Cole Camp Creek**
Duran Creek	**4**	**10.0**	**0**	**0**	**Cole Camp Creek**
Bauer Branch	**4**	**6.2**	**0**	**0**	**Cole Camp Creek**
Indian Creek	**4**	**10.1**	**0**	**0**	**Cole Camp Creek**

Table 2. Stream name, order, unimpounded length, impounded length, length influenced by Bagnell Dam discharge and confluence for fourth-order and larger streams in the East Osage River Basin.

Name	**Order**	**Unimpounded* Length (mi)**	**Length impounded by Lake of the Ozarks (mi)**	**Length ** influenced by Bagnell Dam Discharge (mi)**	**Confluence**
UPPER LAKE OF THE OZARK HILLS SUBBASIN					
Big Buffalo Creek	**5**	**11.1**	**2.5**	**0**	**Lake of the Ozarks**
Little Buffalo Creek	**4**	**7.6**	**2.1**	**0**	**Lake of the Ozarks**
Proctor Creek	**4**	**4.5**	**1.7**	**0**	**Lake of the Ozarks**
Feaster Creek	**4**	**3.4**	**1**	**0**	**Lake of the Ozarks**
Knobby Creek	**4**	**7.0**	**1.5**	**0**	**Lake of the Ozarks**
Rainy Creek	**4**	**6.9**	**2.5**	**0**	**Lake of the Ozarks**
GRAVOIS ARM SUBBASIN					
Big Gravois Creek	**4**	**12.4**	**10.4**	**0**	**Lake of the Ozarks**
Little Gravois Creek	**4**	**8.3**	**1.8**	**0**	**Lake of the Ozarks**
Indian Creek	**4**	**8.1**	**4.2**	**0**	**Lake of the Ozarks**

Mill Creek	**4**	**5.5**	**2.6**	**0**	**Lake of the Ozarks**
MILLER COUNTY OSAGE RIVER HILLS SUBBASIN					
Little Gravois Creek	**5**	**7.6**	**0**	**1.1**	**Osage River**
East Fork Little Gravois Creek	**4**	**7.4**	**0**	**0**	**Little Gravois Creek**
Big Saline Creek	**6**	**16.0**	**0**	**1**	**Osage River**
Little Saline Creek	**4**	**10.0**	**0**	**0**	**Big Saline Creek**
Dog Creek	**4**	**12.8**	**0**	**0**	**Osage River**
Cub Creek	**4**	**6.0**	**0**	**0**	**Osage River**
Jack Buster Creek	**5**	**7.0**	**0**	**0**	**Big Saline Creek**
Cattail Creek	**4**	**4.2**	**0**	**0**	**Osage River**
Bear Creek	**4**	**9**	**0**	**0.1**	**Osage River**
Unnamed Creek	**4**	**2.7**	**0**	**0**	**Jack Buster Creek**
Unnamed Creek	**4**	**3**	**0**	**0**	**Big Saline Creek**

[*] unimpounded stream length above Lake of the Ozarks normal pool (660'' elevation)

[**]distances taken from 7.5 minute topographic maps at 12-15,000 cfs approximate discharge

GEOLOGY

Physiography

The basin lies entirely within the Salem Plateau section of the Ozark Plateau, a portion of the larger Interior Highlands physiographic province. The Salem Plateau is a dissected plateau largely on Cambrian and Ordovician carbonate rocks with streams dissecting it in varying degrees. Along the drainage divides, the plateau has been best preserved as a rolling upland surface with a local relief of 100-200 feet. Karst features such as sinkholes, springs, and caves are locally prominent within the Salem Plateau (MDNR 1986).

The basin includes portions of four of Missouri's natural divisions (listed in descending order based on estimated basin percentages): Ozark division (85%), Ozark Border division (11%), Osage Plains division (3%), and Big River division (1%) (Figure 4) (Thom and Wilson 1980).

Geology

The majority of the basin's surface is covered in dolomites and sandstones of Ordivician and Cambrian age (Figure 5). The basin boundaries lie in Jefferson City-Cotter dolomite and the streams incise progressively older Roubidoux and Gasconade formations. Eminence dolomite is exposed in the Osage River valley near the Morgan-Camden county line. The Osage River and all of its major tributaries incise the Gasconade Formation. There are a few scattered exposures of Eminence dolomite along the Osage River and Tavern Creek in Miller County.

The geology of the basin creates conditions for a considerable amount of subsurface water movement. This subsurface water movement coupled with the presence of carbonate bedrock from the Paleozoic period provides an ideal environment for the development of karst topography. Caves, underground streams, and sinkholes are relatively abundant within the basin.

Dry Auglaize and Wet Glaize subbasins have unique geological and hydrological attributes. Both subbasins are underlain by numerous large faults, allowing a considerable amount of surface water to move underground within each subbasin as well as to adjacent subbasins. A good portion of the water in the Dry Auglaize Subbasin flows underground in a northwesterly direction crossing the subbasin divide to emerge in springs of the Niangua River Subbasin along the Niangua River or the Niangua Arm of Lake of the Ozarks. The Dry Auglaize Subbasin has no notable springs, while the Wet Glaize Subbasin has six. Four of these have discharges greater than 2 cubic feet per second (cfs). Four of the six, including the three largest, emerge from the Gasconade Formation (MDNR 1995).

Soil Types

Soils of the basin vary widely in character (Figure 6). Some soils are infertile stony-clay type soils, while others are fertile loess-capped types. Some soils are stone-free, while others may have a stone content exceeding 50 percent, and other areas may have no soil, exhibiting only exposed bedrock (STATSGO 1998).

The majority of the basin is dominated by stony, cherty soils found on steep slopes while soils of lower stone content are found on more level areas. Soils formed in the residuum from cherty limestone or dolomite, range from deep to shallow and contain a high percentage of chert in most places. Soils formed in a thin mantle of loess are found on the ridges and have fragipans, which restrict root penetration. Soils formed in loamy, sandy, and cherty alluvium are found in narrow bottomland areas, and are the most fertile soils in the basin (Allgood and Persinger 1979).

Soils in the basin are generally acidic and of moderate-to-low fertility. Productivity of the soils in the basin varies widely, with forest and grassland being the dominant land cover. A typical landscape of this basin consists of broad forested areas on moderately steep to very steep slopes and small pastures and cultivated fields on smoother ridge tops and valleys. The moisture holding capacity of most soil in the basin is limited, making many areas unsuitable for crop production.

Overall, erosion rates in the basin are relatively low as compared to those in the West Osage River Basin. The majority of the basin has annual erosion rates between 0-100 tons of sediment/mi.^{2}. Higher erosion rates (100-300 tons/year/mi.^{2}) may occur along the southeastern and western borders of the basin (USDA-SCS 1970). Heavy spring rains of three to eight inches, corresponding with poor land cover conditions, have the potential to cause severe erosion problems on sloping lands. Most erosion damage occurs in the form of sheet and rill erosion. Locally intensive land use practices may contribute to higher erosion rates. New housing developments, road construction, and overgrazing by livestock, may denude land causing increased erosion and sediment pollution (USDA-SCS 1970).

Stream channel erosion downstream of Bagnell Dam has been significant and has led to a number of studies. Erosion is greater near Bagnell Dam and decreases downstream (Belt 1983). UEC (1983) concluded that since Bagnell Dam was closed, the Osage River has caused approximately 10 acres of erosion per year and the average width of the Osage River channel has increased approximately 1 foot per year. Bank recession is occurring in varying degrees all along the Osage River below Bagnell Dam. The instream islands are also subject to erosive processes.

Below Bagnell Dam, the Osage River channel has experienced an increase in cross-sectional area caused by degradation, channel widening and base level lowering (Germanoski and Ritter 1988). Degradation appears to be the most important cause of tributary incision. Since the closure of Bagnell Dam in 1931, tributary streams have incised an average of 2.2 m and widened approximately 1.2 m at their mouths (Germanoski and Ritter 1988). Bank failure along the Osage River channel has occurred by two main processes, block gliding and slab failure. Block gliding is a slip process which involves large volumes of material moving on a planar surface as a single discrete block during periods of instability. Along the lower Osage River, sliding of this type involves portions of banks exceeding 5 feet in thickness and 20 feet in length. Block gliding results when high flows are followed by rapid drops of river stage to a level below the intermediate zone of the bank stratigraphy, and maintenance of that river level for several days. Slab failure is produced by lateral cutting at the surface of the Osage River into the bank materials. This incision engenders an overhanging slab which eventually falls when the overlying mass can no longer be supported. Slab failure is also significant because it is responsible for removal of the tree growth along the Osage River (Ritter 1983).

Stream Order and Gradient

Fourth order and larger streams and their respective subasins are listed in Table 2.

Subbasin Descriptions

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Lower Osage River Subbasin (HUC 10290111060)

This subbasin is located in eastern Cole, and extreme northeastern Miller counties. Major streams of this subbasin include the Osage River, Brule Creek, Profits Creek, and Sugar Creek. This subbasin contains portions of the Upper Ozarks, Missouri River, and Lower Missouri River physiographic regions. The Lower Osage River Subbasin covers the region from the Osage River/Tavern Creek confluence downstream to the Osage River/Missouri River confluence. The HUC drains 218 sq. mi^2.

Lower Maries River Subbasin (HUC 10290111050)

This subbasin is located in east central Osage County with a small portion of the headwaters located in northeastern Maries County. Major streams of the Lower Maries River Subbasin include the Maries River, Loose Creek, Little Maries Creek, Bear Creek, Brush Creek, Indian Creek, and a few unnamed creeks. The entire subbasin is located in the Missouri River physiographic section. The Lower Maries Subbasin originates 0.4 miles above the confluence of the Little Maries and Maries Rivers. The Maries River empties into the Osage River approximately 10 miles above the Osage River's confluence with the Missouri River. The Lower Maries River Subbasin drains 133 sq. mi^2.

Upper Maries River Subbasin (HUC 10290111040)

The Upper Maries River Subbasin is located in central Maries County with a very small portion of the headwaters in northeastern Pulaski County. The Maries River flows through the center of this subbasin. Major creeks of this subbasin include Rogers Creek, Prairie Creek, Mag Creek, and Fly Creek. These creeks are all major tributaries to the Maries River. The majority (about 95%) of this subbasin is in the Upper Ozarks physiographic section with a smaller part in the Missouri River physiographic section. The Maries River originates in the town of Dixon, MO in northeastern Pulaski County and joins with the Little Maries River in northern Maries County, 2 miles southeast of Argyle, MO. The Upper Maries River Subbasin drains an area of 92 sq. mi^2.

Little Maries River Subbasin (HUC 10200111030)

This subbasin covers a small portion of north central Pulaski County with the remainder found in western Maries County. The Little Maries River is the only major stream in this subbasin. The majority (about

95%) of this subbasin is in the Upper Ozarks physiographic section with a smaller part in the Missouri River physiographic section. The Little Maries River originates about 2.5 miles west of Dixon, MO in Pulaski County. This subbasin drains 60 sq. mi^2.

Tavern Creek Subbasin (HUC 10290111010)

The subbasin surrounding Tavern Creek covers portions of eastern Miller, western Maries, and northwestern Pulaski Counties. Major streams of this subbasin include Tavern Creek, Little Tavern Creek, Wiemer Creek, Barren Fork, and Brushy Fork. The Tavern Creek Subbasin is located entirely within the Upper Ozarks physiographic section. Tavern Creek originates about 6 miles west-southwest of Crocker, MO in Pulaski County and drains to the Osage River 31.0 miles below Bagnell Dam. The Tavern Creek Subbasin drains an area of 314 sq. mi^2.

Wet Glaize Creek Subbasin (HUC 10290109070)

This subbasin is located in southeast Camden County. Major streams of this subbasin include Grand Auglaize Creek, Wet Glaize Creek, Deane Creek, Murphy’s Creek, Conn’s Creek, Sellars Creek, and Mill Creek. This subbasin is located entirely within the Upper Ozarks physiographic section. Wet Glaize Creek originates northeast of Stoutland, MO in Laclede County and joins Dry Auglaize Creek near the Camden/Miller County line to form Grand Auglaize Creek. There are no inundated river miles in this subbasin. The Wet Glaize Creek Subbasin drains 180 sq. mi^2.

Dry Auglaize Creek Subbasin (HUC 102901090600)

The Dry Auglaize Creek Subbasin is located in north central Laclede County and southeast Morgan County. This subbasin is located entirely within the Upper Ozarks physiographic section. The subbasin’s namesake creek originates in the eastern edge of Lebanon, MO. Goodwin Hollow, Dry Auglaize Creek’s principle tributary, originates about 4 miles southwest of Lebanon, MO and is the southernmost stream in the basin. The Dry Auglaize Creek Subbasin drains 205 sq. mi^2.

Lower Lake of the Ozarks Hills Subbasin (HUC 10290109080)

This large subbasin is located in northeast Camden, southeast Morgan, and southwest Miller Counties. Major streams of this subbasin include Linn and Bollinger Creeks. This subbasin lies completely within the Upper Ozarks physiographic section. The Lower Lake of the Ozarks Hills Subbasin contains the lower half of the impounded portion of the Osage River (from the 48.5 mile marker to Bagnell Dam), the impounded length (15.5mi) of Grand Auglaize Creek and Linn Creek. Linn Creek has about 3.5 RMs impounded by Lake of the Ozarks. This subbasin drains 265 sq. mi^2.

Deer Creek Subbasin (HUC 10290109030)

The Deer Creek Subbasin lies mainly in southeastern Benton County. A small portion of the subbasin's headwaters are located in extreme northwestern Hickory County and extreme west central Camden County. The major streams of this subbasin include Deer Creek and Little Deer Creek. The majority of this subbasin lies in the Springfield Plateau physiographic section with about five percent in the Upper Ozarks physiographic section. Deer Creek and Little Deer Creek both originate in extreme northwestern Hickory County. Deer Creek flows into Lake of the Ozarks 19.1 miles below Truman Dam. The Deer Creek Subbasin covers 70 sq. mi^2. About 2.9 RMs of Deer Creek have been inundated by Lake of the Ozarks.

Turkey Creek Subbasin (HUC 10290109010)

The Turkey Creek Subbasin covers portions of south central Benton County and north central Hickory County. The only major stream of this subbasin is Turkey Creek. The Turkey Creek Subbasin is completely contained in the Springfield Plateau physiographic section. Turkey Creek originates near the town of Cross Timbers, MO and enters Lake of the Ozarks 12.5 miles below Truman Dam. The Turkey Creek Subbasin drains 72 sq. mi^2. About 2.4 RMs of Turkey Creek are inundated by Lake of the Ozarks.

Cole Camp Creek Subbasin (HUC 10290109020)

This subbasin lies in northeastern Benton County. The major streams of this subbasin include Cole Camp Creek, Williams Creek, Duran Creek, Bauer Creek, and Indian Creek. The upper reaches lie in the Osage Plains with a small northeast corner in the Missouri River and the majority in the Springfield Plateau. Cole Camp Creek has its headwaters due north of Cole Camp, MO. Cole Camp Subbasin drains 147 sq. mi^2 and drains into Lake of the Ozarks 13.7 miles below Truman Dam. About 4.8 RMs of Cole Camp Creek have been inundated due to the impoundment of the Osage River at Bagnell Dam.

Upper Lake of the Ozarks Hills Subbasin (HUC 10290109040)

The Upper Lake of the Ozarks Hills Subbasin is located in east central Benton, southwest Morgan, and northwest Camden Counties. The major water bodies found in this subbasin include Lake of the Ozarks, Big Buffalo Creek, Archer Creek, Little Buffalo Creek, Little Proctor Creek, Feaster Creek, and Knobby Creek. The western portion of this subbasin lies in the Springfield Plateau physiographic section. The eastern portion is in the Upper Ozarks physiographic section. A small northeastern section of this subbasin is in the Missouri River physiographic section. Approximately 11.3 miles of 4^{th} and 5^{th} order streams in this subbasin have been inundated by Lake of the Ozarks. The Upper Lake of the Ozarks Subbasin drains 265 sq. mi^2.

Gravois Arm Subbasin (HUC 10290109050)

This subbasin is located in southeastern Morgan County with a small section going into the western portion of Miller County. The major streams of this subbasin include Big Gravois Creek, the Little Gravois Creek, Indian Creek, and Mill Creek. The majority of this subbasin is in the Upper Ozarks physiographic section with the northern boundary in the Missouri River physiographic section. The headwaters of Big Gravois Creek originate about three miles due east of Versailles, MO, while Little Gravois Creek, the largest tributary to Big Gravois Creek, originates within the city limits of Versailles. This subbasin drains an area of 179 sq. mi^2. Approximately 10.4 RMs of Big Gravois Creek have been inundated by Lake of the Ozarks. An additional 8.6 RMs of 4^{th} order streams of this basin have been inundated in this subbasin as well.

Miller County Osage River Hills Subbasin (HUC 10290111020)

This river hills subbasin is located in central Miller County with small portions (<5% total) located in Morgan and Cole Counties. Major streams of this subbasin include the Osage River, Little Gravois Creek, Big Saline Creek, Blue Springs Creek, East Fork Little Gravois Creek, Little Saline Creek, Dog Creek, Cub Creek, Jack Buster Creek, Cattail Creek, Bear Creek, East Fork Creek, Coon Creek, and Wright's Creek. This subbasin covers a stretch of the Osage River (about 31 RMs) and all tributary streams from Bagnell Dam to the Osage River's confluence with Tavern Creek. The majority of this subbasin is located in the Upper Ozarks physiographic section with a narrow strip along the northern border located in the Missouri River physiographic section. This subbasin drains 252 sq. mi^2.

Figure 4. Natural Divisions of the East Osage River Basin

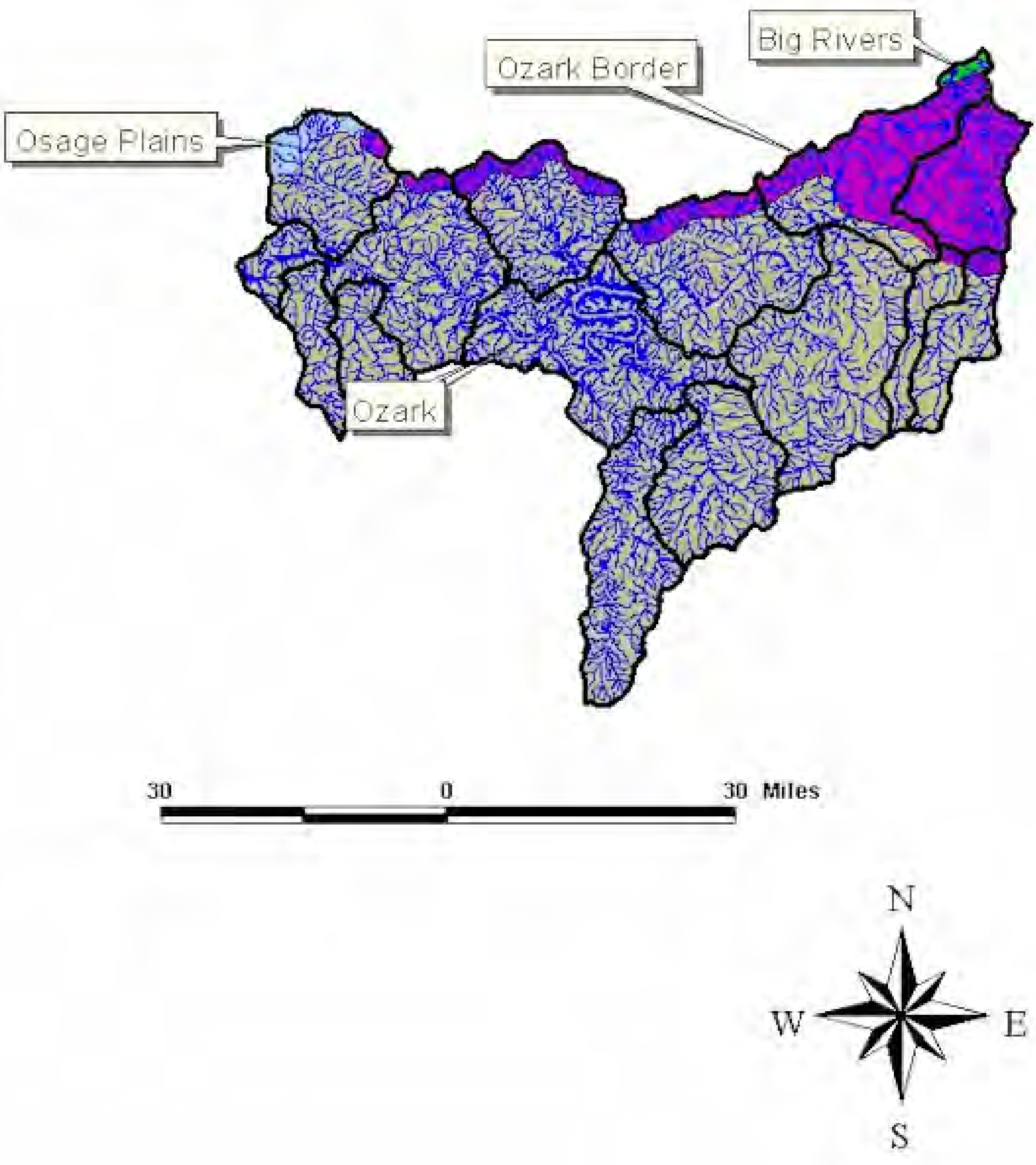

Figure 5. Geology of the East Osage River Basin

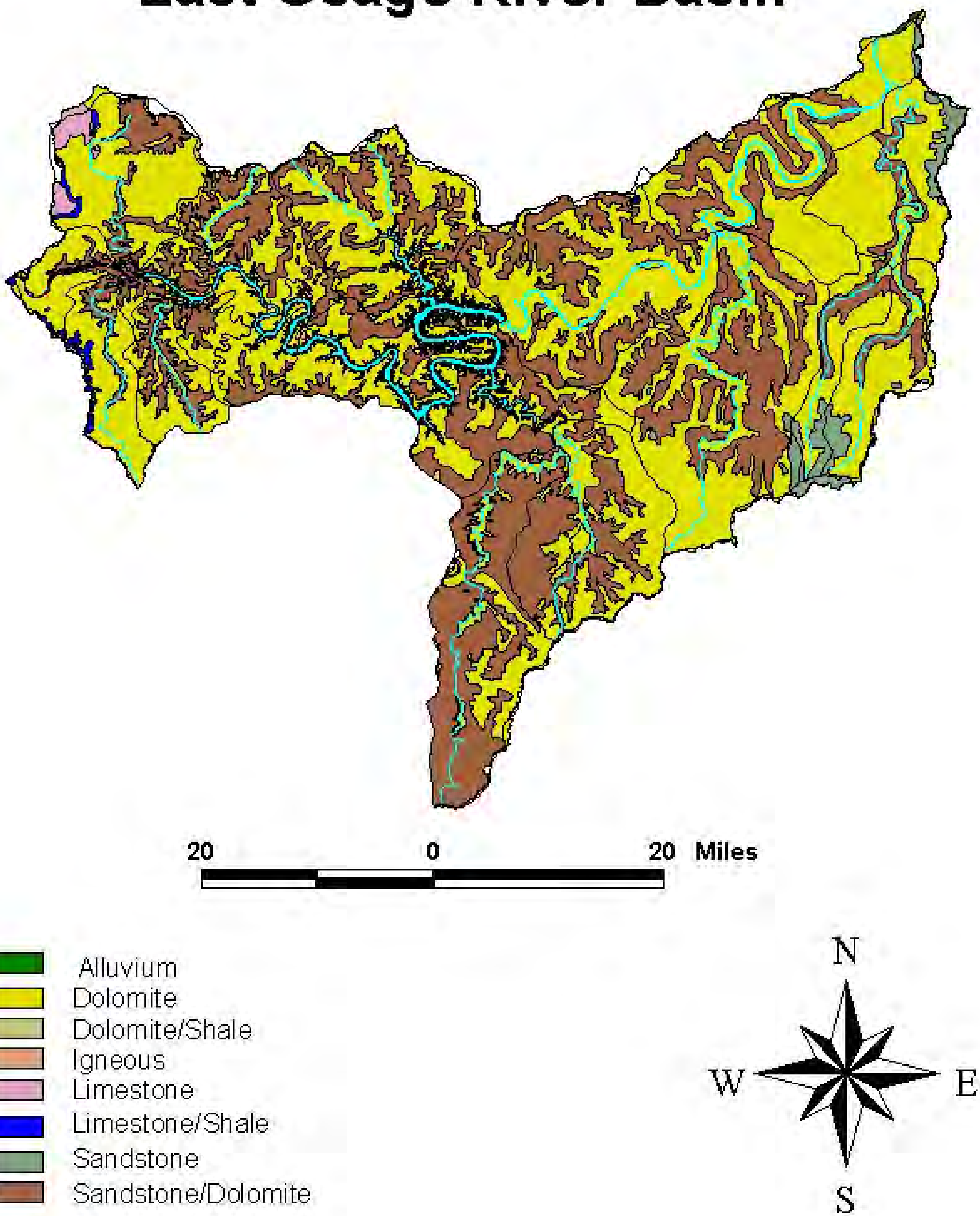

Figure 6. Soils of the East Osage River Basin

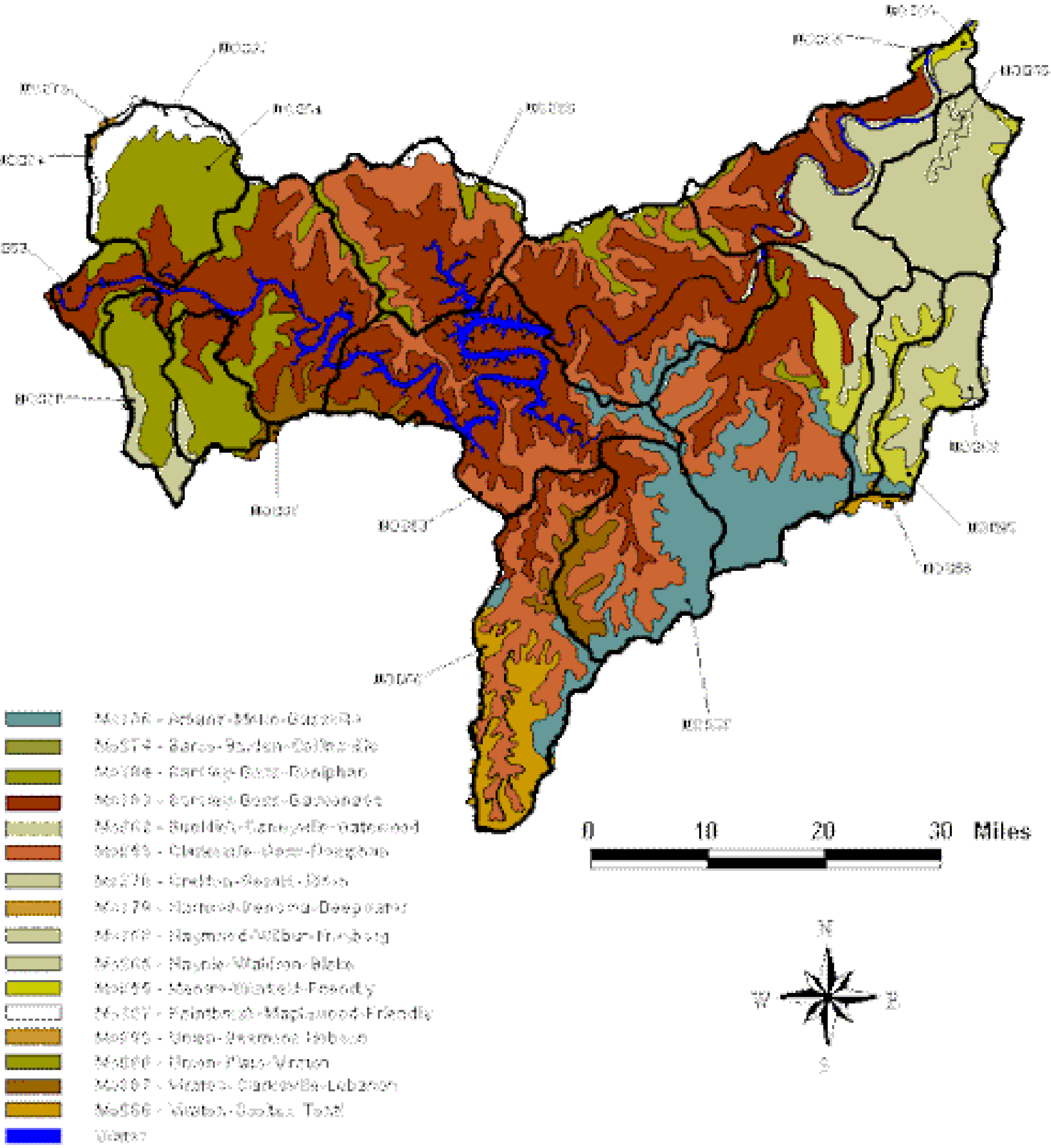

Table 2. Stream name, order, unimpounded length, impounded length, length influenced by Bagnell Dam discharge, and confluence for fourth-order and larger streams in the East Osage River Basin.

Name	Order	Unimpounded* Length (mi)	Length impounded by Lake of the Ozarks (mi)	Length ** influenced by Bagnell Dam Discharge (mi)	Confluence
Osage River	8	82	93	82	Missouri River
LOWER OSAGE RIVER SUBBASIN					
Sugar Creek	4	12.8	0	0	Osage River
Profits Creek	4	5.5	0	0	Osage River
LOWER MARIES RIVER SUBBASIN					
Maries River	6	37.5	0	0	Osage River
Little Maries Creek	5	13.7	0	0	Maries River
Loose Creek	4	5.6	0	0	Maries River
Unnamed Creek	4	4.9	0	0	Little Maries Creek
Unnamed Creek	4	3.7	0	0	Little Maries Creek
UPPER MARIES RIVER SUBBASIN					
Maries River	5	28.2	0	0	Maries River
Mag Creek	4	4.7	0	0	Maries River
Prairie Creek	4	3.6	0	0	Maries River

Rodgers Creek	**4**	**5.6**	**0**	**0**	**Maries River**
LITTLE MARIES RIVER SUBBASIN					
Little Maries River	**4**	**25.5**	**0**	**0**	**Maries River**
TAVERN CREEK SUBBASIN					
Tavern Creek	**5**	**55.4**	**0**	**0**	**Osage River**
Little Tavern Creek	**5**	**17.9**	**0**	**0**	**Big Tavern Creek**
Little Tavern Creek	**4**	**10.5**	**0**	**0**	**Big Tavern Creek**
Clinkingbeard Creek	**4**	**5.8**	**0**	**0**	**Big Tavern Creek**
Kenser Creek	**4**	**6.8**	**0**	**0**	**Big Tavern Creek**
Barren Fork	**4**	**13.3**	**0**	**0**	**Big Tavern Creek**

Table 2. Stream name, order, unimpounded length, impounded length, length influenced by Bagnell Dam discharge and confluence for fourth-order and larger streams in the East Osage River Basin.

Name	Order	Unimpounded* Length (mi)	Length impounded by Lake of the Ozarks (mi)	Length ** influenced by Bagnell Dam Discharge (mi)	Confluence
DRY AUGLAIZE CREEK SUBBASIN					
Dry Auglaize Creek	5	44.7	0	0	Grand Glaize Creek
Goodwin Hollow	4	26.4	0	0	Dry Auglaize Creek
WET GLAIZE CREEK SUBBASIN					
Grand Auglaize Creek (unimpounded section)	6	7.8	0	0	Lake of the Ozarks
Wet Glaize Creek	5	11.7	0	0	Grand Auglaize Creek
Deane Creek	4	11.9	0	0	Grand Auglaize Creek
Murphy's Creek	4	8.8	0	0	Wet Glaize Creek
Conn's Creek	4	4.7	0	0	Wet Glaize Creek
Sellars Creek	5	9.0	0	0	Wet Glaize Creek
Mill Creek	4	5.5	0	0	Sellars Creek
LOWER LAKE OF THE OZARK HILLS SUBBASIN					

Grand Auglaize Creek (impounded section)	**6**	**0**	**15.5**	**0**	**Lake of the Ozarks**
Linn Creek	**4**	**6.9**	**3.5**	**0**	**Lake of the Ozarks**
DEER CREEK SUBBASIN					
Deer Creek	**4**	**13.6**	**2.9**	**0**	**Lake of the Ozarks**
Little Deer Creek	**4**	**10.4**	**0**	**0**	**Deer Creek**
TURKEY CREEK SUBBASIN					
Turkey Creek	**4**	**24.2**	**2.4**	**0**	**Lake of the Ozarks**
COLE CAMP CREEK					
Cole Camp Creek	**5**	**23.5**	**4.8**	**0**	**Lake of the Ozarks**
Williams Creek	**4**	**11.2**	**0**	**0**	**Cole Camp Creek**
Duran Creek	**4**	**10.0**	**0**	**0**	**Cole Camp Creek**
Bauer Branch	**4**	**6.2**	**0**	**0**	**Cole Camp Creek**
Indian Creek	**4**	**10.1**	**0**	**0**	**Cole Camp Creek**

Table 2. Stream name, order, unimpounded length, impounded length, length influenced by Bagnell Dam discharge and confluence for fourth-order and larger streams in the East Osage River Basin.

Name	Order	Unimpounded* Length (mi)	Length impounded by Lake of the Ozarks (mi)	Length ** influenced by Bagnell Dam Discharge (mi)	Confluence
UPPER LAKE OF THE OZARK HILLS SUBBASIN					
Big Buffalo Creek	5	11.1	2.5	0	Lake of the Ozarks
Little Buffalo Creek	4	7.6	2.1	0	Lake of the Ozarks
Proctor Creek	4	4.5	1.7	0	Lake of the Ozarks
Feaster Creek	4	3.4	1	0	Lake of the Ozarks
Knobby Creek	4	7.0	1.5	0	Lake of the Ozarks
Rainy Creek	4	6.9	2.5	0	Lake of the Ozarks
GRAVOIS ARM SUBBASIN					
Big Gravois Creek	4	12.4	10.4	0	Lake of the Ozarks
Little Gravois Creek	4	8.3	1.8	0	Lake of the Ozarks
Indian Creek	4	8.1	4.2	0	Lake of the Ozarks
Mill Creek	4	5.5	2.6	0	Lake of the Ozarks
MILLER COUNTY OSAGE RIVER HILLS SUBBASIN					

Little Gravois Creek	**5**	**7.6**	**0**	**1.1**	**Osage River**
East Fork Little Gravois Creek	**4**	**7.4**	**0**	**0**	**Little Gravois Creek**
Big Saline Creek	**6**	**16.0**	**0**	**1**	**Osage River**
Little Saline Creek	**4**	**10.0**	**0**	**0**	**Big Saline Creek**
Dog Creek	**4**	**12.8**	**0**	**0**	**Osage River**
Cub Creek	**4**	**6.0**	**0**	**0**	**Osage River**
Jack Buster Creek	**5**	**7.0**	**0**	**0**	**Big Saline Creek**
Cattail Creek	**4**	**4.2**	**0**	**0**	**Osage River**
Bear Creek	**4**	**9**	**0**	**0.1**	**Osage River**
Unnamed Creek	**4**	**2.7**	**0**	**0**	**Jack Buster Creek**
Unnamed Creek	**4**	**3**	**0**	**0**	**Big Saline Creek**

*** unimpounded stream length above Lake of the Ozarks normal pool (660'' elevation)**

****distances taken from 7.5 minute topographic maps at 12-15,000 cfs approximate discharge**

LANDUSE

Historical Land Use

The first recorded inhabitants of the basin were Native Americans who called themselves the Osage (originally pronounced Wha-zha-zhe) which meant Little Ones of the Middle Waters. They were descendants of Asian people who came across the Bering Strait during the Ice Ages. The life of the Osage people followed a yearly cycle that depended on agriculture, food gathering, and hunting. Rivers, streams, and creeks were important factors in their lives. Family groups wintered in lowlands near rivers. They moved to the plains in the spring where they planted gardens of corn, beans, and pumpkins. In the summer, the families moved to the tall grass prairies, their hunting grounds, so the men could hunt and women could preserve the animals taken. In late summer, they returned to the plains to harvest their gardens. In the fall, they would return to their hunting grounds for another hunt. They would then return to their villages along the rivers for the winter. The native Osage people also supplemented their diets with wild fruits, walnuts, hazelnuts, pecan, acorns, grapes, plums, persimmons, and numerous roots.

It is estimated that there were approximately 5,000 people in the Osage tribe when the Europeans began entering the basin. The Osage people had little influence on their environment by today's standards with one exception. The Osage tribe, as did many plains tribes, used fire to combat their enemies, to drive wild game, and attract wild game. The burning of grasslands was used to scare animals to points of easy capture. Also the new succulent vegetation that would grow a few weeks after a fire had swept through an area would attract wildlife and increase the value of hunting grounds. Large scale burning was commonly practiced among the tribe. This burning had the major influence of suppressing the forest ecosystem and stimulating, expanding, and maintaining a prairie/savannah/glade based ecosystem over the areas of the basin where burning was practiced. At the time the Osage tribe occupied the area, prairies were located in the uplands of Cole Camp Creek, Turkey Creek, Dry Auglaize Creek and Wet Glaize Creek subbasins (Schroeder 1983).

The first Europeans to explore the area were the French. In 1714, The French explorer Etienne de Bourgmond explored the Missouri River and may have been one of the first Europeans to see the Osage River and parts of its basin. The French were primarily interested in trading furs and establishing fur trading routes. When the first settlers moved into the Osage Basin they found magnificent stands of timber inhabited by forest game. Furbearers were abundant, as were grassland birds and mammals. Buffalo and elk were common to the basin as were black bear, wolves, and mountain lions. Passenger pigeons inhabited the woodland areas. Many of these animals played an important role in the pioneer economy of the basin in the form of food to eat and fur to trade. Fur trading was a major economic activity in the basin. Some settlers trapped while others traded with the Osage people. Deer and beaver were the two most popular furs.

The East Osage River Valley was part of a larger land claim by the French in 1682.

At that time, it was called Louisiana in honor of King Louis XIV. In 1762, the basin was ceded from

France to Spain. During the 1700's the population of all of Missouri probably did not exceed 2,000 Europeans. These were congregated along the edges of rivers. In 1800, the Spanish ceded the basin back to France. In 1803, the United States of America purchased the basin from France. Zebulon Pike, in 1817, led the first recorded European exploration of the basin.

The early Europeans described the native Osage people as handsome, well-built, and striking. They were thought to be fierce-looking when tattooed. Heights over 6 feet were common. Generally, the native Osage people were cooperative with the Europeans and they did not slow the expansion of settlers into the basin. The Osage people signed treaties waving their claims and opening the way to westward expansion. Much of the basin as well as surrounding basins were ceded to the United States by the Osage people in 1808. For twenty more years, however, the Osage people continued to hunt over much of the basin.

In 1837, the first steamboat ascended the basin. However, low water hindered navigation by steamboats. In 1841, the U.S. Congress gave the state of Missouri funding to proceed with river navigation improvement projects. Some of these projects consisted of building dams of brush and stone and digging and scraping the river channel. These dams extended diagonally across the Osage River to confine the river channel to one bank.

In addition to the dams, snags were removed, overhanging trees were cut as a hazard to the high smokestacks of the steamboats. Maintenance of the river for navigation was costly. In less than twenty years, the river navigation program was taken over by the Federal Government and maintenance for navigation remains today the responsibility of the USACE.

Navigational projects were common on the river until the Civil War, after which the completed railroads began to become more important for travel in Missouri. The coming of the railroads signaled the beginning of the end for steamboat travel in Missouri.

Since the basin's first highways were its rivers and streams, early towns were typically built next to waterways. The towns of Linn Creek and Warsaw prospered as shipping terminals for steamboats. As settlers moved into the basin, they cut timber and delivered it downstream to larger towns. The basin was part of the largest timber producing region in the nation at the end of the 1800s.

Timber was cut for railroad ties and assembled into rafts and floated to the railhead at Bagnell, Missouri. Railroad ties were cut from as far back as 15 miles from the river. Tie squares were created by nailing 35 to 36 ties side by side to create a square eight feet wide. Some tie rafts were as much as 1,200 feet long, consisting of 35 or more tie squares. A raft of tie squares might be so large as to cover three bends in the river. It was in this fashion that the settlers moved the railroad ties down the river.

In 1906, a lock and dam was constructed on the Osage River to facilitate river travel. By the late 1920's, the forest of the basin had become exhausted of its resources. All that was left over much of the basin were rocky, barren hills. Cleared areas were used to grow a few crops, livestock were left to free-range, and settlers burned any remaining woods. Gravel had eroded from many of the hillsides and streams became choked with gravel.

With such an enormous amount of water in Missouri, it wasn't long before people began looking for ways to harness some of that potential energy for human use. In 1912, Ralph W. Street of Kansas City began to study the concept of damming the Osage River. In the fall of 1924, a preliminary permit was issued for the project. At this same time, the Missouri Hydro-Electric Power Company was also incorporated in

Missouri. Construction of Bagnell Dam began immediately after receiving the permit. Many facilities were created including an enormous mess hall, an administrative building, a large warehouse, and a power house. A road was built from the site of the dam to Bagnell, and the railroad from Bagnell to the dam site was mostly finished. The largest power contract to that date was negotiated, involving the sale of more than 150 million kilowatt hours to the St. Joseph Lead Company in the southeastern portion of Missouri.

Skeptics of the project abounded, saying that the project simply seemed impossible. The sheer scale of the dam itself was, after all, huge even by today's standards. Nevertheless, the local residents observed, gripped by excitement, as Union Electric began its initial clearing on August 6, 1929. Many thousands came seeking employment. Construction of Bagnell Dam provided more than 20,500 jobs at a time when the country was still in the grips of the Great Depression.

Bagnell Dam was completed in 1931. Electric service began on Christmas Eve of that year. With the completion of Bagnell Dam commodity transport on the upper river had come to an end. Bagnell Dam limited commercial navigation to the lower 82 miles of the Osage River. Bagnell Dam is 2,543 feet long, projects 148 feet above the bedrock, and creates a 55,000 acre reservoir with 1,300 miles of shoreline. The lake impounds 87 billion cubic feet of water. At the time the lake was built, Lake of the Ozarks was the largest man-made lake in the United States and one of the largest in the world (Pilkington 1989).

Recent Land Use

The current human population of the basin is larger than in previous years and is expected to increase in the foreseeable future (Table 3). The counties of Camden, Benton, Hickory, Morgan, and Pulaski are all expecting a greater than 5% increase per 5-year period based on population census records. The county which is expecting the most significant increase in population growth is Camden County with an expected 10-12% increase per 5-year period (Missouri State Office of Administration 1998).

Numerous communities exist within the basin (Figure 7). There are 10 communities in the basin with populations greater than 1000 (Table 4). The largest community is Lebanon found on the southernmost tip of the basin with a population that approached 10,000 in 1990. Other large communities found along the perimeter of the basin include Eldon, Crocker, Dixon, Richland, Warsaw, Cole Camp, and Versailles. The largest communities which are contained entirely within the basin are Camdenton and Osage Beach. Both of these resort communities are located adjacent to Lake of the Ozarks.

The majority of the current population growth of the basin can be attributed to the booming recreation and tourism industries. The recreation and tourism industry of this area centers around Lake of the Ozarks.

Recreation

Lake of the Ozarks has grown into the state’s largest resort development and is considered one of Missouri’s top tourist areas (MDNR 1985). Recreation is Lake of the Ozarks number one industry and a major retirement destination. Lake of the Ozarks offers ample opportunities for vacationing, fishing, boating, and waterskiing. Lake of the Ozarks was the first lake in Missouri to offer such activities on such a large scale. The recreational opportunities found at the lake have also led to the development of the shoreline and surrounding communities into a myriad of vacation homes, condominiums, hotels, restaurants, and shopping districts. With this growth has come a new emphasis on preserving the lake's unique environment for future generations.

Anglers account for nearly 1 million trips to Lake of the Ozarks per year, or about 14% of all fishing in Missouri (Stoner 2000). Fishing alone benefits the lake area economy by more than $70 million per year (Weithman 1991). Some of the more popular gamefish of Lake of the Ozarks include black bass, crappie, catfish, walleye, white bass, striped bass, striped bass x white bass hybrids, and paddlefish (Stoner 2000).

An average year will see at least 450 boating associated events including regattas, fishing tournaments, parades, and boat-shows on Lake of the Ozarks. Surrounding streams and rivers also provide a location for many boating, canoeing, sightseeing, and other passive leisure-time activities.

Other recreational activities that occur in the basin include swimming, hunting, camping, spelunking, golfing, and horseback riding. Camping takes place on some of the public areas where it is permitted and also at privately owned and operated campgrounds. Horseback riding is permitted on some designated trails of Lake of the Ozarks State Park.

Land Cover

Land cover within the basin is principally forest (54.8%) and grassland (39.7%) (Table 5, Figure 8). Open water makes up 2.5% of the basin while cropland makes up 1.6% and urban areas make up 1.4%. Most subbasins of the East Osage River Basin area are similar in that they are all principally made up of forest and grassland. The upper Lake of the Ozarks Hills Subbasin has the largest percentage of forest cover with 72% of this subbasin covered with forest. The Turkey Creek Subbasin has the largest percentage of grassland with 58.7% making up this Subbasin. The Lower Lake of the Ozarks Hills Subbasin has the largest percentage of open water with 19.7% or 30,332 acres open water. The Dry Auglaize Creek Subbasin has the largest percentage of urban land cover with 5.8% or 7,550 acres in urban areas.

Agriculture

Major current agricultural activities for counties in the basin are livestock production and crop production according to the Missouri Agricultural Statistics Service. Major grain crops produced in the basin include corn, soybeans, sorghum, and wheat. Benton County was the top grain crop producing county within the basin in 1998 with approximately 36,000 acres of grain crops, the majority of which were soybeans. The next top producing county for grain crops was Morgan County with approximately 10,000 acres of soybeans, 7,500 acres of corn, and 3,300 acres of sorghum. The lowest grain crop producing county in the basin was Camden County in 1998. It is clear that the counties within the basin have experienced a downward trend over time in crop production – an example of which is presented for Miller and Camden Counties (Figure 9). During the past century, Miller County corn production has dropped from almost 40,000 acres of corn produced in 1909 to only 1,300 acres in 1998. In Camden County, corn produced dropped from almost 34,000 acres to less than 500 acres in 1998. All other counties within the basin experienced similar declines in grain crop production (MASS data 2001).

Other important crops currently produced within the basin are fescue seed and hay. The top hay producing county of the basin was Laclede County with 58,100 acres of hay harvested in 1998. All counties of the basin produced significant amounts of hay. The average of amount of hay produced by a county of the basin was 37,540 acres.

Because of its high tolerance to stress, tall fescue (KY31 variety) is the main grass used for pastures and hay in the basin today. KY 31 fescue, however, has deleterious effects due to an associated endophyte present within the plant. The endophyte causes reduced weight gain of livestock as well as poor blood circulation, elevated temperature, and other health problems.

Tall fescue also can form a low-growing dense sod. In its sod-bound stage, it does not provide suitable habitat for some wildlife species including quail and other native grassland birds.

Native bunch grasses such as big bluestem, little bluestem, side oats grama, and Indian grass were more widespread throughout the basin before European settlement. These grasses are still found in prairie, glade, and savannah areas of the basin (Allgood and Porringer 1979).

Major livestock commodities within the basin are beef cattle, milk, and hogs. Beef cattle production consists primarily of cow-calf operations, stocker operations, concentrated feeding operations or a combination of these. Head of beef cows per county ranged from 12,700 head in Pulaski County to 33,400 head in Osage County in 1999. There was an average of 22,220 beef cows per county in the basin. Head of dairy cows per county ranged from 300 in Pulaski County to 2,250 head in Hickory County. Similarly all counties within the basin produced a significant number of pasture acres with 96,829 acres in Pulaski County to 206,829 acres in Laclede County. Hog numbers ranged widely from county to county with only 3,000 head in Laclede to 77,300 head in Osage.

Most counties within the basin have experienced an increase in cattle numbers over time (MASS data 2001) - an example of which is presented for Miller and Camden Counties (Figure 10). Total numbers of cattle in Miller County have steadily increased from only 5,174 in 1850 to 57,000 head in 1999. Similarly in Camden County, the number of cattle has increased from 14,100 head to 30,300.

Hog numbers have increased over time in Miller County but declined in Camden County (Figure 11). The increase in swine numbers in Miller County is in part due to a coinciding increase in CAFOs in that county in recent years. Swine numbers in Miller County have risen from 16,800 in 1940 to 98,600 in 1999. In Camden County where there are no swine CAFOs, swine numbers dropped from 19,237 in 1910 to 7,200 in 1999.

CAFOs

The MDNR issues permits and regulates activity of CAFOS within the basin. The MDNR recognizes 4 types of CAFOs based on the number of animal units. A facility with 7,000 or more animal unit equivalents is designated as class IA. Class IB facilities have 3,000-6,999 animal unit equivalents. Class IC facilities have 1,000-2,999 animal unit equivalents. Class II facilities are those with 300-999 animal unit equivalents. Class IA, IB, IC, and II facilities are considered point source pollution facilities. Only class IA, IB, and IC facilities are regulated by MDNR. Facilities with fewer than 300 animal units are considered non-point source pollution sources and are not regulated.

There are 70 different permitted CAFOS within the basin (Figure 12). The majority of these are located in the Miller County River Hills and the Tavern Creek Subbasins with 19 in each of these subbasins. Basin-wide there are 45 Swine CAFOS. This is more than any other type of CAFO within the basin. The other CAFO types within the basin are the turkey CAFOs (n=14), dairy CAFOs (n=8), and poultry boiler CAFOs (n=3). All of the poultry boiler CAFOs are located within the Cole Camp Creek Subbasin and this is the only type of CAFO located within this subbasin. Other subbasins with numerous CAFOs are the Lower Osage River Hills Subbasin and the Wet Glaize Creek Subbasin. Subbasins with only a few CAFOS include the Lower Maries River Subbasin, the Little Maries River Subbasin, Dry Auglaize Creek Subbasin, Lower Lake of the Ozark Hills Subbasin, the Gravois Arm Subbasin, and the Turkey Creek Subbasin. There are no Class IA CAFO facilities within the basin. Additional information on permitted CAFOs can be obtained from the Missouri Department of Natural Resources.

Gravel mining

Due to the rocky soil types and Ozark characteristics of the streams of this area, gravel is widely distributed throughout the basin. Gravel mining is widely practiced since gravel is easily obtained from stream gravel bars. The mining of gravel from streams is an ongoing, largely unregulated cumulative activity with serious natural resource consequences to biota and geomorphology. The majority of the gravel mining operations in the basin are non-commercial operations and therefore are not required by MDNR to have permits. Some commercial operations do currently exist however, and these are required to have current operating permits with the MDNR. The streams where these facilities are currently permitted to mine gravel are the East Fork Little Gravois Creek (Miller County River Hills Subbasin), Tavern Creek (Tavern Creek Subbasin), Turkey Creek (Turkey Creek Subbasin), and the Osage River (Lower Osage River Subbasin). Additional information on current gravel mining permits can be obtained from the Missouri Department of Natural Resources.

Hydroelectric power generation

Two hydroelectric power plants exist in the basin: Truman Dam near Warsaw, MO and Bagnell Dam (Lake of the Ozarks) near Bagnell, MO. Both projects impound the Osage River for the purpose of hydroelectric power generation.. Truman Dam is a public facility owned and operated by the USACE. It has an installed capacity of 160,000 kilowatts. Bagnell Dam is privately owned and operated by AmerenUE. It has an installed capacity of 215,000 kilowatts. Only the Bagnell Dam project is located entirely within the basin. Secondary uses of these dams are flood control and recreation.

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Soil Conservation Projects

Each county Soil and Water Conservation District in the basin has been active in promoting soil and water conservation projects (Table 6). Most of the funds for these projects have come from the Missouri State Parks, Soil and Water Conservation sales tax. The funds for soil and water conservation are administered through the MDNR Soil and Water Conservation Program Types of regular cost-share practices most commonly designed to address soil and water conservation concerns of the basin included the Permanent Vegetative Cover Establishment, Permanent Vegetative Cover Improvement, and the

Permanent Vegetative Cover Enhancement. Types and numbers of projects installed within counties of the basin can be found in Table 7.

In addition to the above regular cost-share projects, select Soil and Water Conservation districts have undertaken special conservation projects which address local soil and water conservation concerns. These projects are called Special Area Land Treatment (SALT) projects and are administered through the MDNR Soil and Water Conservation Program.

Completed SALT projects located within the basin include the Little Maries Creek SALT project of Osage County Soil and Water Conservation District and the Turkey Creek SALT project of Hickory County Soil and Water Conservation District (Table 8, Figure 13). These two SALT projects combined are saving an estimated 39,620 tons of soil and are serving 1,579 acres. An additional Agricultural Non-Point Source SALT (AgNPS SALT) project was approved for Deer Creek by the Benton County Soil and Water Conservation District.

Public Use Areas

The Missouri Department of Conservation and the Missouri Department of Natural Resources both own and manage public land within the basin. There are a total of 29,721 acres of state-owned public use areas in the basin. This is approximately 1.9% of all acres of the basin.

The MDC owns 19 stream accesses, 11 conservation areas, 11 tower sites, 1 fish hatchery, and 1 community lake within the basin (Table 9, Figure 14). Major MDC areas include Lost Valley Fish Hatchery (970 acres), Big Buffalo Creek Conservation Area (1,555 acres), Painted Rock Conservation Area (1,480 acres), and Saline Valley Conservation Area (4,782 acres). Additional information on all MDC owned public sites may be found at MDC’s website.

The MDNR, State Parks Division owns and operates Lake of the Ozarks State Park. This 17,302 acre park is the largest state park in Missouri and offers many recreational activities including fishing, boating, camping, horseback riding, bird watching, and much more.

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Corps of Engineers 404 Jurisdiction

The USACE has authority to oversee and regulate the waterways of the basin. This authority extends to regulation of gravel mining in streams and alteration of wetlands. Most in stream and some stream-side projects require 404 permits. Application for permits should be directed to the U.S. Army Corps of Engineers office in Kansas City, MO. The basin is under the jurisdiction of the Kansas City District of the Northwest Division.

Kansas City District USACE, 700 Federal Building, Kansas City, MO 64106 (816) 426-5357

Topographic Coverage

Figure 15 depicts 7.5 minute topographic map coverage of the basin.

Figure 7. Communities of the East Osage River Basin

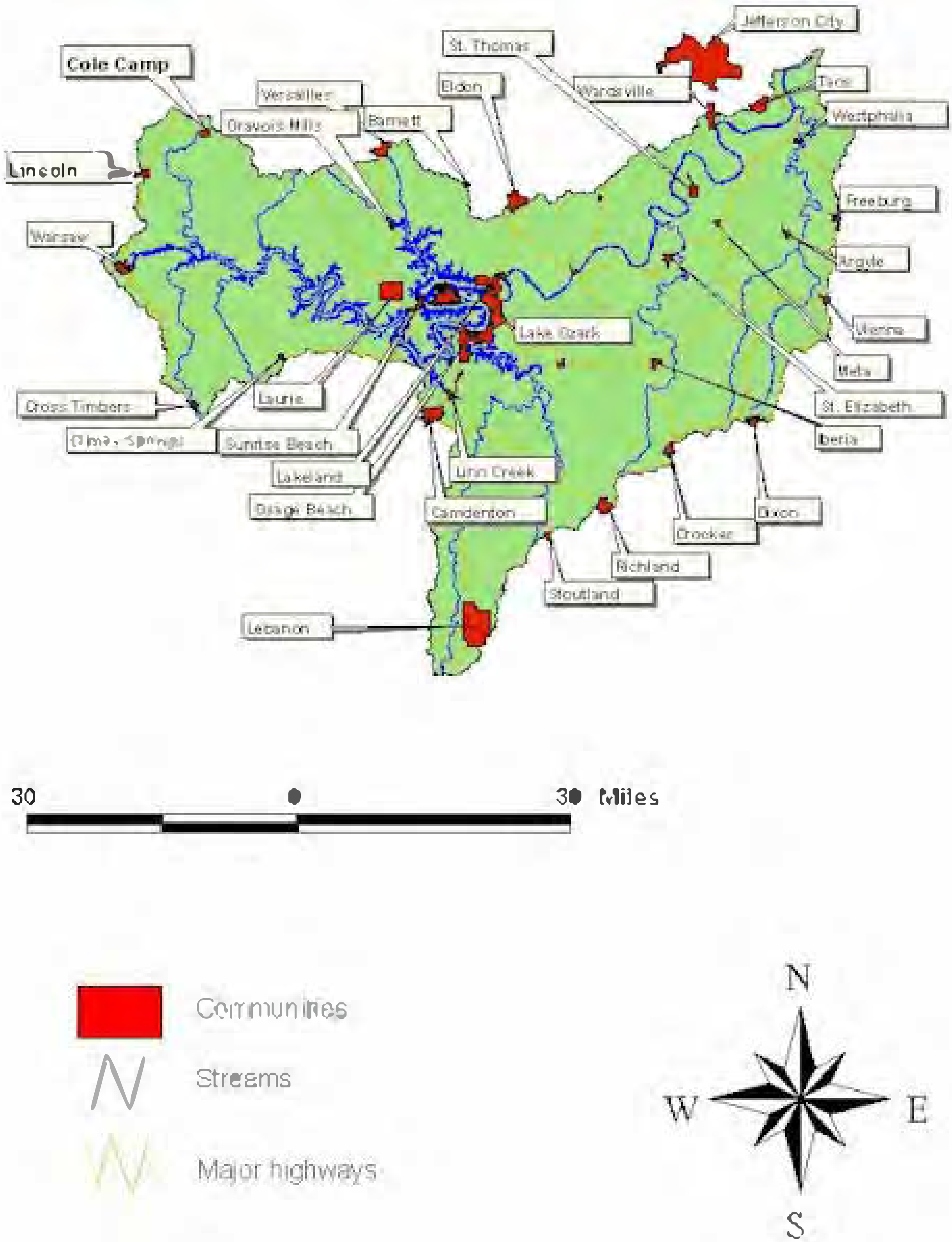


Figure 8. Landcover of the East Osage River Basin

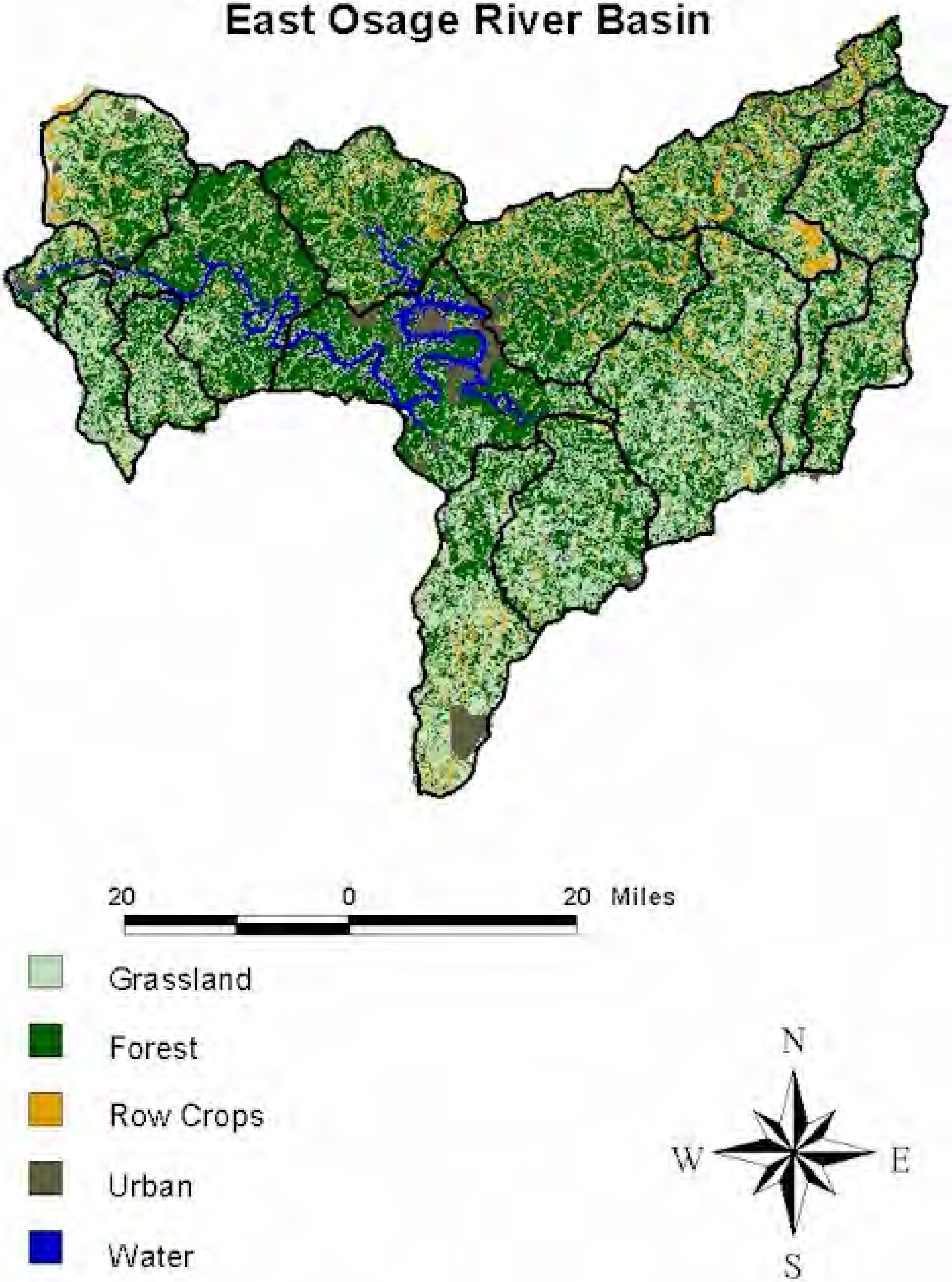


Figure 9. Corn harvested over time for Miller and Camden Counties

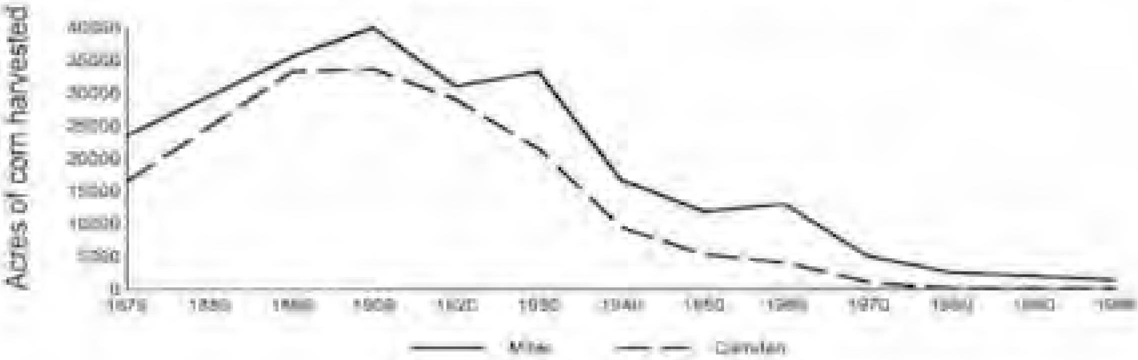


Figure 10. Cattle on farms over time for Miller and Camden Counties

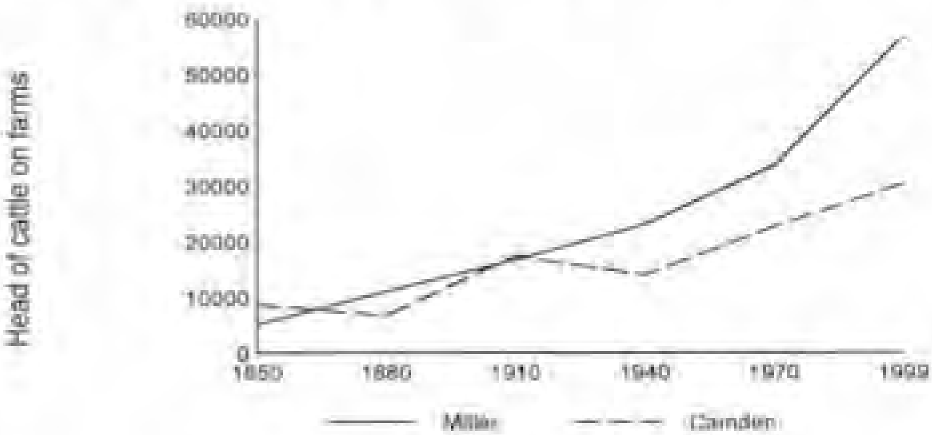


Figure 11. Swine on farms over time for Miller and Camden Counties

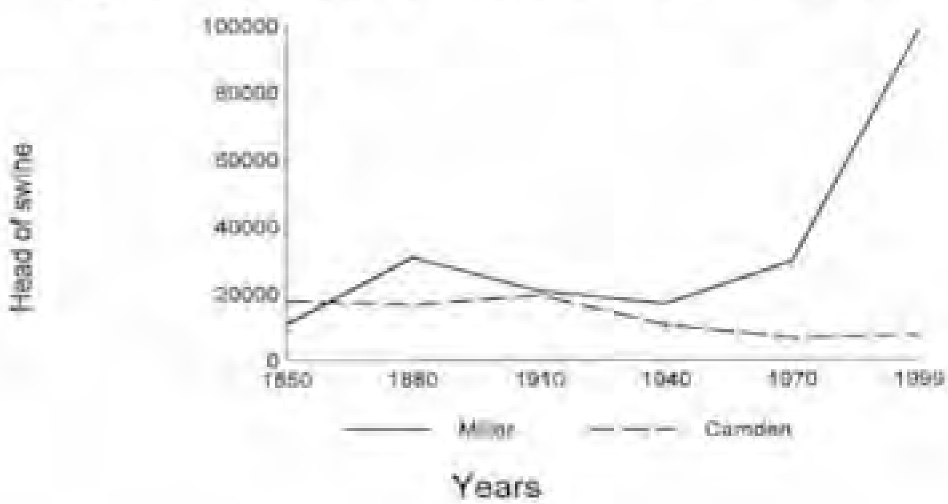


Figure 12. CAFOS of the East Osage River Basin

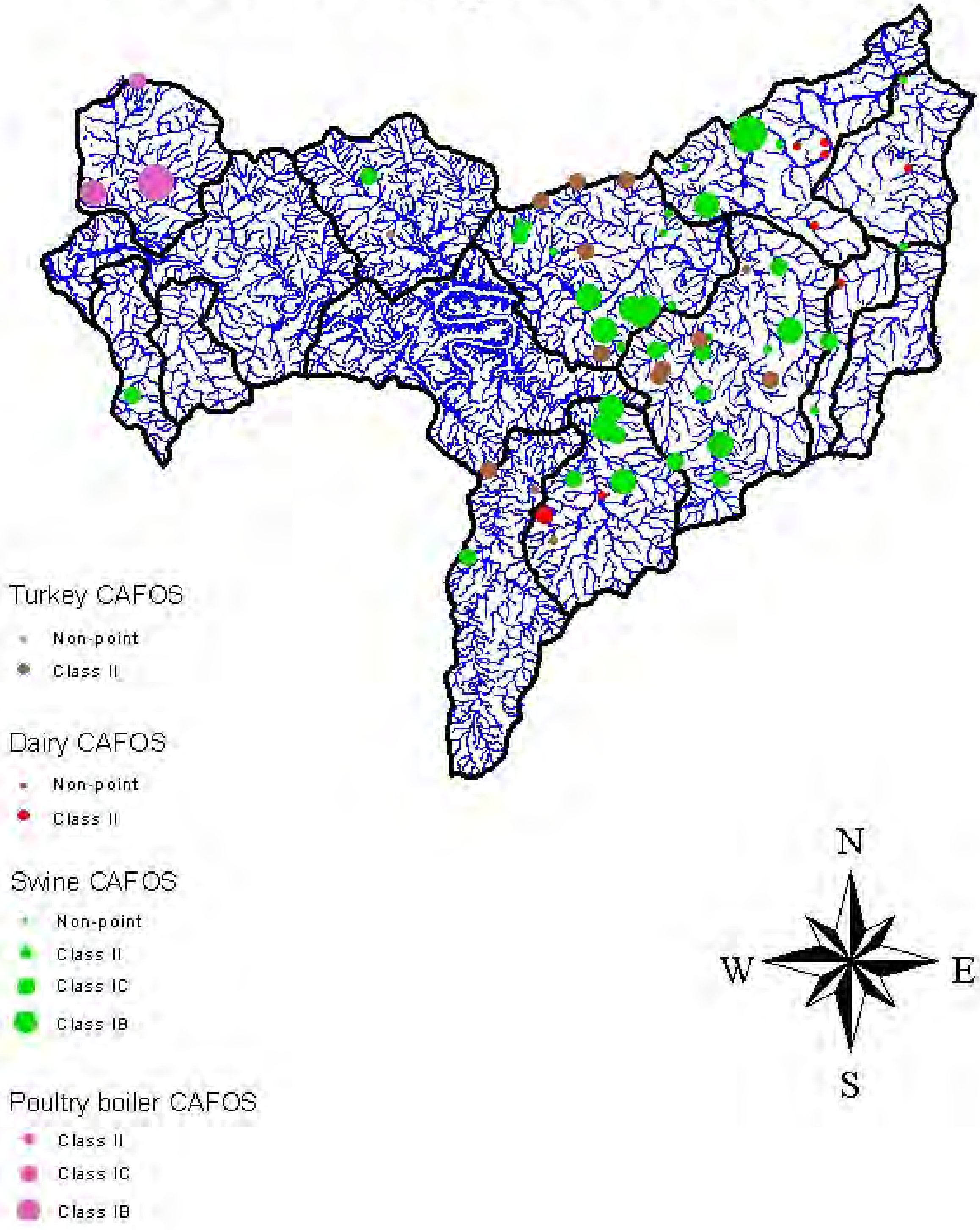


Figure 13. Completed SALT projects of the East Osage River Basin

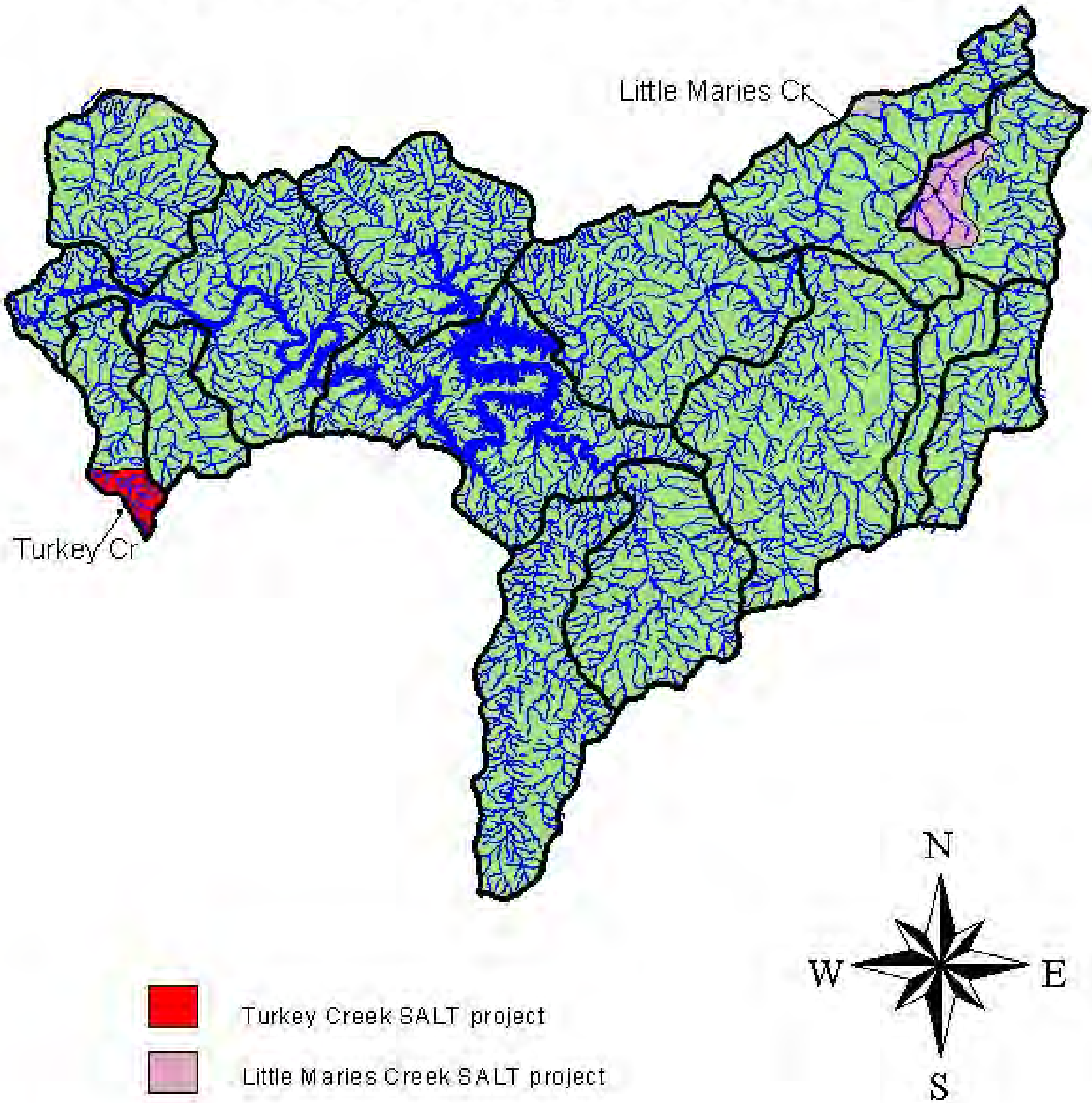


Figure 14. Public Use Areas in the East Osage River Basin

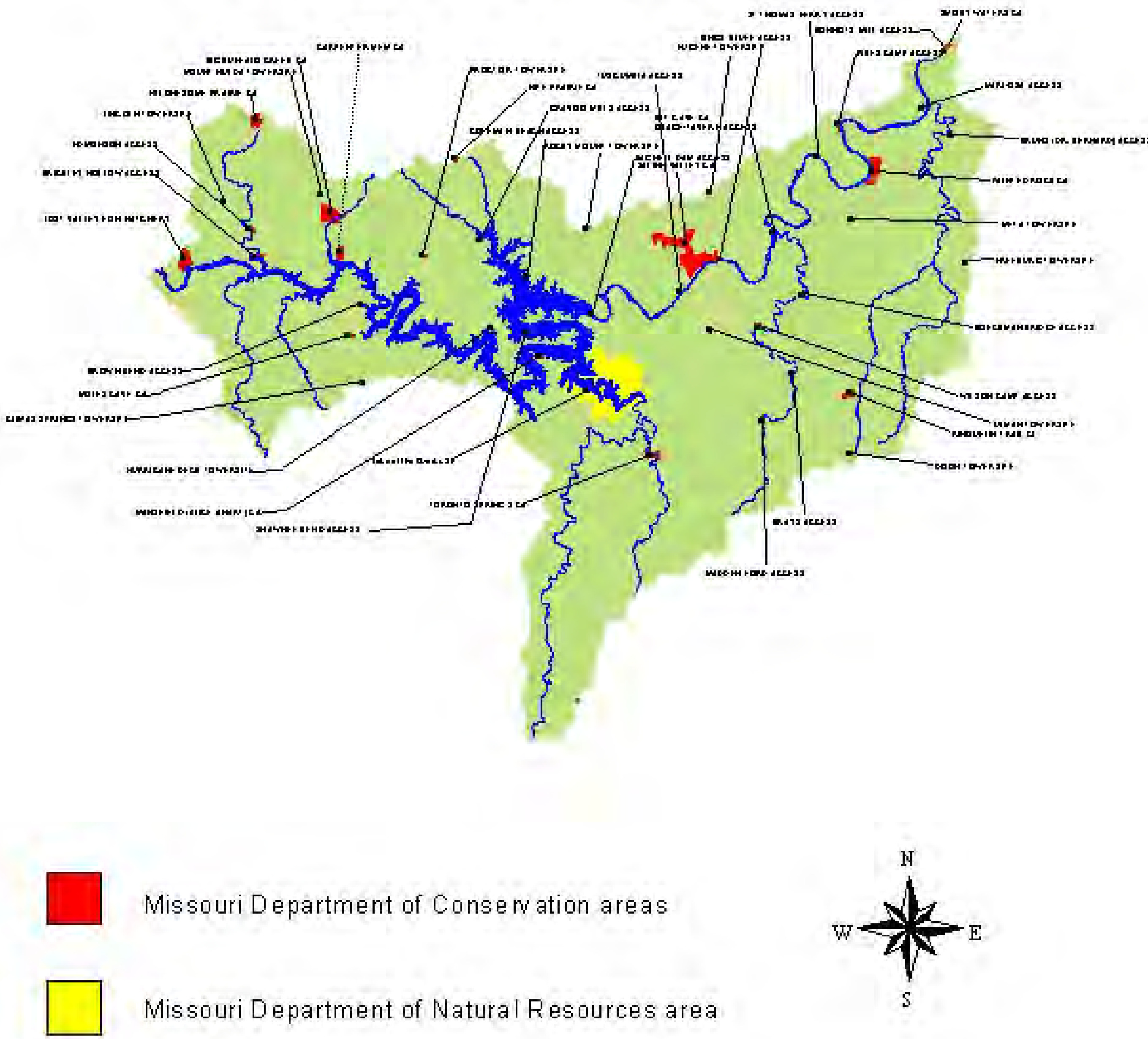


Figure 15. Topographic map coverage of the East Osage River Basin

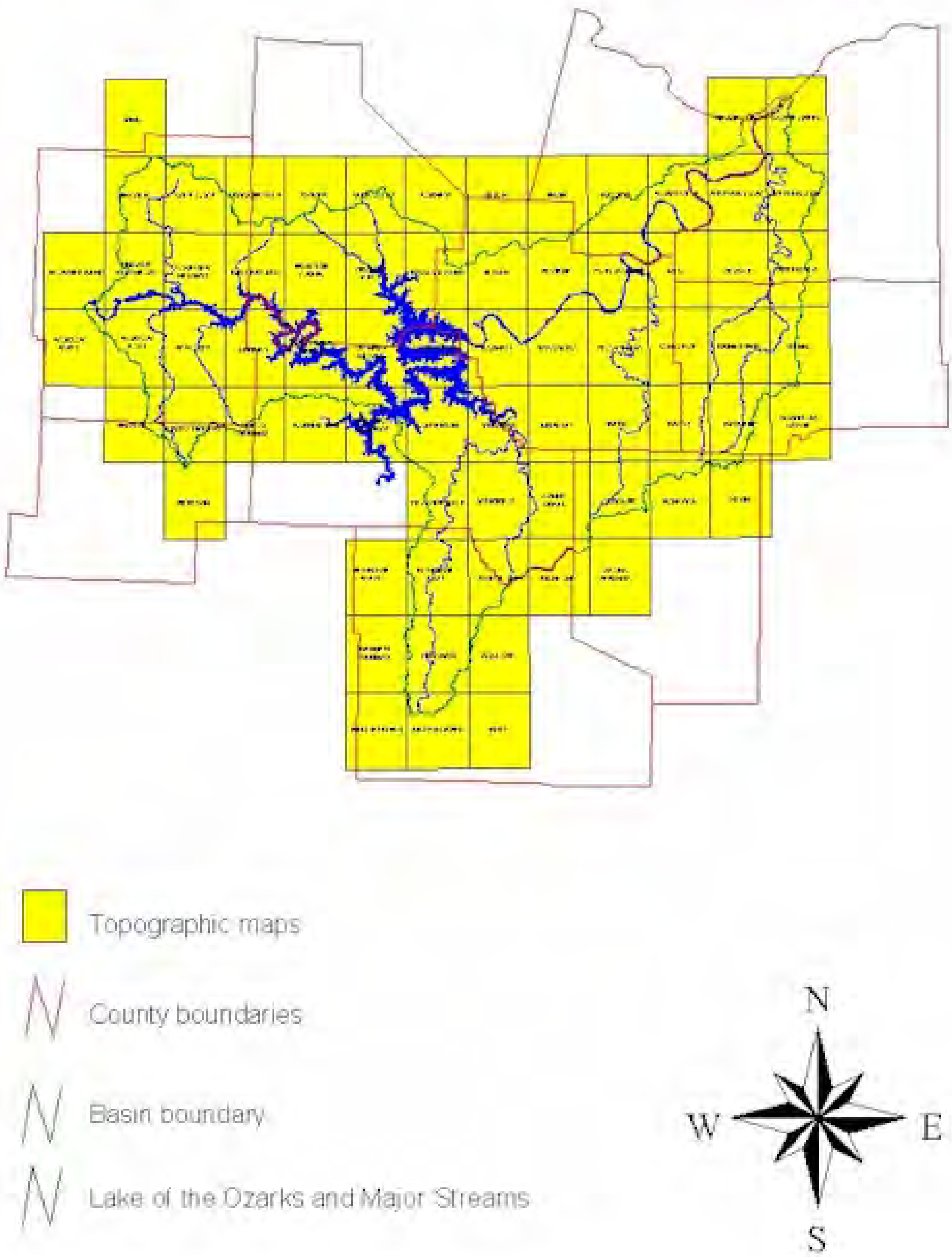


Table 3. Total county populations and estimated changes for Missouri counties that include portions of the East Osage River Basin.

County	1990 Pop.	1995 Pop.	2000 Est.	2005 Est.	2010 Est.	2015 Est.	2020 Est.
Benton	13,859	14,705	15,421	15,992	16,404	16,621	16,629
Camden	27,495	30,950	34,061	36,838	39,135	40,872	41,978
Cole	63,579	66,418	68,761	70,803	72,645	74,244	75,515
Hickory	7,335	7,758	8,103	8,345	8,475	8,499	8,429
Laclede	27,158	28,524	29,834	31,124	32,373	33,593	34,700
Maries	7,976	8,183	8,389	8,587	8,788	8,975	9,122
Miller	20,700	21,710	22,730	23,812	24,897	25,916	26,860
Morgan	15,574	16,433	17,197	17,883	18,456	18,883	19,145
Osage	12,018	11,979	11,929	11,912	11,914	11,923	11,920
Pulaski	41,307	43,816	46,322	48,994	51,836	54,742	57,634
Total	237,001	250,476	262,747	276,295	286,933	296,283	303,952

Source: Missouri State Office of Administration (1998).

Table 4. Largest communities (population >1,000), population*, county, and subbasin in which they are located for communities in the East Osage River Basin.

COMMUNITY	POPULATION	COUNTY	SUBBASIN	
Cole Camp	1054	Benton	Cole Camp Creek	10290109020
Crocker	1077	Pulaski	Tavern Creek	10290111010
Dixon	1585	Pulaski	Upper Maries River	10290111040
Warsaw	1696	Benton	Upper Lake of the Ozarks Hills	10290109040
Richland	2029	Pulaski	Upper Maries River	10290111040
Versailles	2365	Morgan	Gravois Arm	10290109050
Camdenton	2561	Camden	Dry Auglaize Creek	10290109060
Osage Beach	2599	Miller	Lower Lake of the Ozarks Hills	10290109080
Eldon	4419	Miller	Miller County Osage River Hills	10290111020
Lebanon	9983	Laclede	Dry Auglaize Creek	10290109060

*** based on 1990 Bureau of the Census, USDC figures. www.census.gov)**

Table 5. Land use/cover for the East Osage River Basin, by HUC (MoRAP 1997).		
Land Use/Cover	**Area (acres)**	**Percent by Land Use/Cover**
Cole Camp Creek HUC		
Forest	**45,526**	**48.5**
Grassland	**42,260**	**45.1**
Urban	**567**	**0.6**
Open Water	**804**	**0.9**
Cropland	**4,596**	**4.9**
Barren	**42**	**0.0**
TOTAL	**93,795**	**100**
Turkey Creek HUC		
Forest	**18,375**	**39.9**
Grassland	**27,016**	**58.7**
Urban	**250**	**0.5**
Open Water	**315**	**0.7**
Cropland	**67**	**0.0**
TOTAL	**46,022**	**100**

Deer Creek HUC		
Forest	**24,536**	**55.0**
Grassland	**19,597**	**43.9**
Open Water	**446**	**1.0**
Cropland	**14**	**0.0**
TOTAL	**44,592**	**100**
Upper Lake of the Ozark Hills HUC		
Forest	**113,793**	**72.1**
Grassland	**40,964**	**25.9**
Urban	**1,353**	**0.9**
Open Water	**1,330**	**0.8**
Cropland	**348**	**0.2**
TOTAL	**157,788**	**100**
Gravois Arm HUC		
Forest	**76,444**	**66.7**
Grassland	**30,789**	**26.9**
Urban	**1,893**	**1.7**

Open Water	**4,706**	**4.1**
Cropland	**786**	**0.7**
TOTAL	**114,618**	**100**
Lower Lake of the Ozarks Hills HUC		
Forest	**99,225**	**64.4**
Grassland	**24,079**	**15.6**
Urban	**9**	**0.0**
Open Water	**30,332**	**19.7**
Cropland	**471**	**0.3**
Barren	**9**	**0.0**
TOTAL	**154,125**	**100**
Miller County Osage River Hills HUC		
Forest	**100,419**	**63.2**
Grassland	**51,040**	**32.1**
Urban	**4,058**	**2.6**
Open Water	**229**	**0.1**
Cropland	**3,211**	**2.0**

Barren	**2**	**0.0**
TOTAL	**158,959**	**100**

Table 6. State Soil & Water Conservation Program efforts and accomplishments by county totaled for all years to date.

County	Total number of practices	Total Cost-share	Total Tons of Soil Saved over life span of practices	Acres Served
Benton	441	$767,680	249,070	4,848
Hickory	755	$1,243,535	292,308	21,205
Morgan	227	$364,653	140,948	5,142
Camden	337	$386,170	100,765	9,149
Miller	319	$540.698	117,243	5,895
Laclede	697	$813,347	344,447	17,644
Cole	322	$483,469	131,726	3,091
Pulaski	5,121	$7,288,044	2,582,651	111,677
Maries	1,049	$1,391,303	690,650	24,706
Osage	421	$621,041	197,129	6,143

HYDROLOGY

Precipitation

Precipitation for the basin averages 40 inches per year. The months with the highest precipitation are March-May, with an average of 13 inches for this three-month period. Evaporation averages about 54 inches per year for the basin. Runoff averages about 10 inches per year (MDNR 1986). The highest average runoff occurs in April-May and the lowest in December-January, coinciding with seasonal rainfall patterns.

USGS Gauging Stations

The USGS lists 13 discontinued and 3 active gauging stations operated to monitor stream flows and water quality in streams and rivers of the basin (Table 10). Seven of these gauges were located upstream of Bagnell Dam in HUC 10290109, within Benton, Laclede, and Morgan counties. Six of the gauging stations were located downstream of Bagnell Dam in HUC 10290111, within Cole, Maries, Miller, and Osage counties. Descriptions of the three active gauges are given below.

Gauging station number **06922450** is located on the Osage River 2,000 feet downstream of Truman Dam near Warsaw, Missouri. This gauge was installed after the construction of Harry S Truman Reservoir and measures flow from an area of 11,500 mi.^{2}. The available period of record is from 1981 to 2000, excluding October 1989 through September 1990. This station is important because it measures the majority (82% on average) of all water flowing into Lake of the Ozarks. Real-time river stage data for the Osage River below Harry S Truman Dam at Warsaw, MO are provided by the USGS.

Gauging station number **06926000** is located on the Osage River at the State Route 54 bridge, near Bagnell, Missouri. The station is 1.3 miles downstream of Bagnell Dam, which is located at Osage RM 81.7 and impounds Lake of the Ozarks. This gauge, which is jointly operated by USGS and AmerenUE, records flows from an area of 14,000 mi.^{2}. Mean monthly flow data are available for 1880-1925. Mean daily flow data are available from 1925 to 2000. This station is important because it provides information on the flow regime prior to impoundment of Lake of the Ozarks. It also continuously measures the discharge from Bagnell Dam, which controls most of the water flowing into the lower 82 miles of the Osage River. Real-time river stage and discharge data for the Osage River near Bagnell, MO are provided by the USGS.

Gauging station number **06926510** is located on the Osage River below St. Thomas, Missouri at Osage RM 34.5, about 47 miles downstream of Bagnell Dam. This station was installed in 1996 and replaced gauging station number 06926500, which was about 9 miles upstream. Station 06926510 below St. Thomas records flows from an area of 14,500 mi.^{2}. The available period of record is from 1931 to 2000. This station provides information on the combined discharge from Bagnell Dam and inflowing tributaries between Bagnell Dam and the station. Real-time river stage and discharge data for the Osage River below St. Thomas, MO are provided by the USGS.

Stream Order

Stream orders were assigned using 7.5 minute USGS topographic maps and methodology originally proposed by Horton (1932) and detailed by Gordon et al (1992). There are 59 streams 4th order and larger, totaling 855 stream miles, in the basin. Fourth order and larger streams and their mileages are outlined in Table 11.

Losing Streams

There are 22 identified losing streams within the basin (Table 12). These are primarily located in the center of the basin and the southward extending leg of the basin, with a few located in the eastern part of the basin (Figure 16). The longest losing stream is Dry Auglaize Creek which extends for 34 miles of the Dry Auglaize Creek Subbasin. Other subbasins with identified losing streams are the Wet Glaize Creek Subbasin, Lower Lake of the Ozarks River Hills Subbasin, Miller County River Hills Subbasin, and the Lower Maries River Subbasin.

Springs

One hundred and six (106) springs have been recorded throughout the basin (Table 13, Figure 17). Spring location information was gathered from USGS 7.5 minute topographic maps. The majority (87) of the springs are found in six of the basin's fourteen subbasins: Osage River Hills Subbasin (28 springs), Upper Lake of the Ozarks Hills Subbasin (28 springs), Tavern Creek Subbasin (12 springs), Deer Creek Subbasin (7 springs), Lower Lake of the Ozarks Hills Subbasin (6 springs), and Wet Glaize Creek Subbasin (6 springs).

The basin's 4 largest springs have average flows greater than 1 cubic foot per second (cfs). Three of the 4 largest springs are located in the center of the Wet Glaize Creek Subbasin. The largest is Armstrong East Spring with an average flow of 11.6 cfs. Blue Hole Spring is the second largest with an average flow of 7.16 cfs. Armstrong Spring is the fourth largest with an average flow of 1.18 cfs. Gravois Mills Spring in the Gravois Arm Subbasin is the third largest spring with an average flow of 1.36 cfs.

Dam and Hydropower Influences

Bagnell Dam and Harry S Truman Dam are located on the mainstem of the Osage River. Bagnell Dam impounds Lake of the Ozarks and was completed in 1931. Lake of the Ozarks is operated primarily for hydroelectric generation and recreation. Truman Dam is immediately upstream of Lake of the Ozarks, was completed in 1979, and is primarily operated for flood control and hydroelectric generation. Positive impacts of the dams and the reservoirs they create are ample water supply, electricity production, flood control, lake fishing and other recreation, and tourism.

Construction and operation of Bagnell Dam and Truman Dam have adversely affected 175 miles of river habitat in and along the Osage River within the basin. Lake of the Ozarks inundates a total of 93 miles of the Osage River. In addition, seventy years of Bagnell Dam operation have significantly changed the flow regime and habitats of the lower 82 miles of the Osage River, negatively affecting the river and its tributaries. Operation of Truman Dam also has affected hydrology and habitats of the lower Osage River by influencing water level and water quality in Lake of the Ozarks. Some of the known and suspected negative effects of construction and operation of Bagnell and Truman dams include rapid flow fluctuations, extended bankfull flows, frequent and unnaturally low flows, erosion and siltation in the Osage River and its tributaries, loss of riparian corridor, loss of wetlands, barriers to fish migration, limited spawning habitat for fish, lowered water temperatures, low dissolved oxygen, reduction of mussel populations, and fish kills due to low dissolved oxygen levels, impingement of fish on turbine intakes, and entrainment of fish through the turbines. Some problems have been addressed, but additional information is needed to implement strategies that improve habitat and water quality, prevent fish kills, and mitigate for the losses of fish and wildlife habitats.

Stream Flow

Flooding

Historically, major Osage River floods were caused by long periods of rainfall over large areas. Major floods most frequently occurred during April-June, but were not restricted to the spring season. Lake of the Ozarks has water storage of 1,927,000 acre-feet and only limited flood control capability. After construction of Bagnell Dam, floodwater from the Osage River still contributed to flooding along the lower Missouri River and portions of the Mississippi River. The highest flood stage at the gauging station at St. Thomas was recorded on May 20, 1943. The peak discharge at St. Thomas on that date was 216,000 cfs. To reduce flooding, the USACE constructed Harry S Truman Reservoir in the East Osage River Basin and 5 reservoirs upstream in the West Osage River Basin between 1961 and 1979 (Dent et al. 1997). Before Truman Dam was completed in 1979, there was still considerable flooding along Lake of the Ozarks and the lower Osage River. Since construction of Truman Dam and Reservoir, which has flood control storage of 5,209,000 acre-feet, destructive out-of-channel flooding along the lower Osage River downstream of Bagnell Dam is of much less concern. Flood control and hydropower generation reduce the peak flood flows downstream of Bagnell Dam but extend bankfull flow duration. Most floods since completion of Truman Dam have considerably lower peak flows but are weeks to even months longer in duration than floods that occurred in the years immediately prior to completion of Bagnell Dam.

Below Truman Dam

Other than flood control, the stream flow effects of Truman Dam are not as significant as those of Bagnell Dam because Truman Dam discharges directly into the impounded water of Lake of the Ozarks. However, a three-week long release of 4,000 cfs in the spring is needed to create adequate conditions for spawning of walleye and white bass downstream of Truman Dam. Although water discharged from Truman Dam spreads out as it travels 93 miles through Lake of the Ozarks, operation of Truman Dam does affect the water levels and water quality in Lake of the Ozarks and the Osage River downstream of Bagnell Dam.

Below Bagnell Dam

Impoundment of the Osage River by Bagnell and Truman dams has dramatically affected the hydrology of the lower Osage River. The timing, frequency, magnitude, duration, and fluctuation of flows have all been affected. Such changes can increase channel instability, decrease habitat availability, and limit diversity and abundance of aquatic and riparian biota.

Hydropower operations at Bagnell Dam have increased the frequency of both moderately high flows and very low flows. Hydropower operations at Bagnell Dam frequently produce bankfull flows when pulses of water are released through the generation turbines to meet peak demand for electricity. Between pulses, drought-like minimum flows (385-450 cfs) are released. Daily flow fluctuations are dramatic, with flows often varying between the minimum releases and hydropower releases of 30,000 cfs and higher.

Increased frequency of high flows can cause channel instability by increasing sediment transport and channel erosion, and can affect the amount and distribution of aquatic, riparian, and terrestrial habitats. Annual flow duration curves show that hydropower discharges cause mean daily flows between about 5,000-30,000 cfs to occur more frequently today than before Bagnell Dam. For example, a mean daily flow of 20,000 cfs was equaled or exceeded only 20% of the time before Bagnell Dam, but has occurred 26% of the time since 1980.

Frequent and persistent low flows can limit diversity and abundance of aquatic and riparian biota

by reducing habitat availability and affecting water quality. Due to the minimum releases between hydropower discharges, extremely low downstream flows occur more often now then before construction of Bagnell Dam. For example, a mean daily flow of 1,000 cfs flow in the Osage River near Bagnell, Missouri was equaled or exceeded about 90% of the time before Bagnell Dam, but only 75% of the time since 1980. In other words, flows less than 1,000 cfs now occur about 25% of the time compared to only 10% of the time before Bagnell Dam.

Low flows can have different harmful effects throughout the year. Low flows in the winter can reduce water temperatures. Springtime low flows can limit spawning of fish. Mussel spawning and fish nursery areas can be limited by low flows in the summer and fall. Although mean annual flows and average monthly flows in the Osage River since 1980 are comparable to flows before construction of Bagnell Dam, changes in low flow frequency due to operation of Bagnell Dam have occurred for most months. For October-June, the 75% and 95% monthly exceedance flows since 1980 are lower than those for water years 1926-1930 (October 1925 to September 1930), indicating that low mean daily flows now occur more often during the fall, winter, and spring. In particular, the unnatural minimum releases from Bagnell Dam during October-June cause mean daily flows less than 500 cfs to occur more often today than before the dam controlled flow. For example, 95% exceedance values for May show that flows less than 2,000 cfs occurred on about 5% of the days during May before Bagnell Dam. Since 1980, however, May daily flows less than 500 cfs occur 5% of the time. Table 16 shows monthly flow statistics for the entire pre-Bagnell Dam record of daily flows (June 1925-December 1931).

Hydropower operation of Bagnell Dam has caused mean daily and hourly flows to be much more variable today than before Bagnell Dam was built. Rapid increases in flow can disrupt feeding and spawning by fishes, displace aquatic insects, and initiate excessive transport of sediment. Rapid decreases in flow can result in bank erosion and stranding of fish, mussels, and aquatic insects. Frequent and rapid flow fluctuations can increase stream channel instability, change habitat availability, reduce ecological integrity, and interfere with recreational use of the lower Osage River.

Although mean daily flows show considerable flow fluctuations, hourly flow data reveal the true variability and extremes of flows and river levels (stage) due to hydropower peaking operation of Bagnell Dam. Mean daily flows do not show the rapid within- and between-day flow fluctuations that occurred during late summer and early fall of 2001. Flows often fluctuated from low flows to nearly 30,000 cfs over just a few hours, producing rapid changes of up to 12 feet in river stage. Stage fluctuations of 12 feet in stage on August 5-6, 2001 are shown as minimal changes by mean daily stage. Fluctuations in stage near Bagnell Dam were considerably higher than those for the nearby, unregulated Gasconade River near Rich Fountain, MO during fall 2001. Although the Gasconade River is smaller than the Osage River near Bagnell, standardized hourly flow data show the unnatural characteristics of flow fluctuations created by hydropower operation of Bagnell Dam. Standardized hourly flow data also indicate how unnaturally low the minimum flow releases from Bagnell Dam were during the fall of 2001.

Flow fluctuations at Bagnell Dam affect flows and water levels for many miles downstream. Although the magnitudes of flow and stage changes lessen as hydropower releases travel downstream, hourly and daily variability are still considerable. Standardized hourly stage data show releases from Bagnell Dam create substantial changes in river levels 42 miles downstream at St. Thomas, MO (Figure 45). A daily stage change of 13 feet at Bagnell Dam can equate to a daily change of 7 feet or more at St. Thomas. Hydropower releases from Bagnell Dam are still evident in the Missouri River at Hermann, Missouri, 114 miles downstream of Bagnell Dam, (Figures 46 & 47), and may affect water temperature, water quality, and availability of terrestrial habitats in and along the Missouri River when its flow is low.

Small Impoundments

According to the National Wetlands Inventory, there are an estimated 13,978 small water impoundments totaling 8,633 acres within the basin. These include small public and private lakes, ponds, and restored wetlands. Concern exists over the effects that these impoundments have on low-flow conditions of streams as they intercept runoff and allow little or no adjustment for maintenance of stream flows.

WATER USE AND QUALITY

Surface water and groundwater quality in the basin are generally good (Vandike 1995). The area covered by the basin is part of the Salem Plateau groundwater province, otherwise known as the Ozark aquifer. Streams draining from the Salem Plateau generally contain water that is calcium-magnesium-bicarbonate type with low sulfate and chloride levels (Vandike 1995). Sink holes and losing stream segments of the Ozark aquifer provide a direct conduit for surface water to enter groundwater. This allows for relatively quick groundwater recharge, and also provides a direct link for surface contamination to enter groundwater. This relatively quick recharge time is also responsible for great variations in the water quality of springs in the basin.

Water Use

There are over 85,000 people served in the basin by either public supplied surface water (9%), public supplied groundwater (39%), or private wells (52%) (Table 14). A greater proportion of people from the Lower Osage River HUC 10290111 below Bagnell Dam are served by public supplied surface water (19%) than are served by public supplied surface water in Lake of the Ozarks HUC 10290109 above Bagnell Dam (only 4%). A greater proportion of people (45%) above the dam are served by public supplied groundwater, whereas below the dam only 25% of the people are served by public supplied groundwater.

Throughout the basin, total water withdrawals equaled 11.32 million gallons per day (mgd). The majority of these withdrawals are from the HUC below Bagnell Dam (54% or 6.09 mgd). Above Bagnell Dam (HUC 10290109) has only 5.23 mgd or 46% of the total water withdrawals from the basin.

Total withdrawals from groundwater in the basin equaled 8.01 mgd whereas total withdrawals from surface water were only 7.61 mgd. There are more withdrawals from groundwater in the HUC above Lake of the Ozarks (56%) than below Bagnell Dam (45%). However there are more withdrawals from surface water (2.48 mgd) below the dam than in the HUC above Bagnell Dam (0.83 mgd). There are 10 public water supply districts in the basin (MDNR 1986).

Beneficial Use Attainment

The MDNR maintains a list of beneficial uses for classified waters of the basin. All classified waters have been assigned the beneficial uses of aquatic life protection, livestock and wildlife watering, and fish consumption by humans. In addition there are 298.5 miles of streams in the basin classified as supporting whole body contact. These streams are the Osage River (82 miles), Lake of the Ozarks (121 miles), Maries River (41.5 miles), Tavern Creek (37 miles), Grand Auglaize Creek (7 miles), and Wet Glaize Creek (10 miles)(MDNR 1986). Sections 303(d) and 305(b) of the Clean Water Act are a means for determining if beneficial uses are being attained.

Chemical Water Quality

Water quality of the basin is generally good. Ambient water quality data is monitored by the USGS at their gauging station on the Osage River near St. Thomas. For a detailed look at quarterly water quality constituents for the Osage River, see Table 15 for years 1984 and 1995. During those years, temperature ranged from 1.5 C to 27.5 C, pH ranged from 7.2-8, DO ranged from 3.9 to 12.8, fecal coliform ranged from <4 colonies/100ml in the spring of 1984 to 1,100 colonies/100ml in the spring of 1995, total nitrogen ranged from 0.12 mg/l to 0.8 mg/l (see Table 19 or Missouri Water Quality Assessment Report 47, Volume III, 1997).

Water quality problems associated with increased urban and commercial development are an ongoing concern in the area surrounding Lake of the Ozarks. Increases in population density and recreational use are the primary reason for elevated nitrification and algal growth in Lake of the Ozarks.

The MDNR noted several water quality concerns for the basin (MDNR 1994). The first concern dealt with the continued commercial and residential development along the shoreline of Lake of the Ozarks. This development has increased the amount of treated sewage discharged to the lake. Many coves have excess algal growth from nutrients discharged into the lake by sewage. A second concern is groundwater contamination by improperly functioning septic tanks, leaking storage tanks and agricultural runoff or wastewater discharges to losing streams. Poorly constructed wells also greatly increase the chance for groundwater contamination. The problem is especially severe where the human population center sits atop geologic strata, such as the Lebanon area, which allow high rates of infiltration of surface water to groundwater. A third concern is the increasing number of CAFOs which have the potential, if not properly managed, to discharge harmful amounts of animal waste into spring branches and streams thereby degrading the water quality of those water bodies.

Pesticides have been detected in wells and springs throughout the Ozark aquifer, including the basin. Recent studies have detected a higher level of pesticide occurrences in springs than in wells. Most occurrences of pesticides in this groundwater province are probably directly related to the land use of the area surrounding the spring or well sampled.

Nitrates were found in only about 5% of the wells tested in the Salem Plateau groundwater province. Land use practices such as the application of fertilizer and human and animal waste can contribute high levels of nitrates to groundwater. Data collected between 1972 and 1990 found that less than 15% of samples from this groundwater province contained phosphorus at concentrations above detection levels. Springs and shallow wells were found to have higher phosphorus levels on average than deeper wells.

Sections 305(b) and 303(d) of the Clean Water Act

The MDNR reports on the status of water quality in surface waters according to section 305(b) of the Clean Water Act. MDNR summarizes the quality of Missouri waters every two years in these reports. Significant improvements in water quality have been made over the past quarter century in controlling pollution from municipal sanitary wastes, but major problems still exist from non-point source pollution.

Section 303(d) of the Clean Water Act requires states to list waters not expected to meet established state water quality standards even after application of conventional technology-based controls for which total maximum daily load (TMDL) studies have not yet been completed. The impaired waters list is produced every four years by the MDNR and includes waters for which existing required pollution controls are not stringent enough to maintain state water quality standards.

There are approximately 1.9 miles of 303(d) listed impaired streams and 50 acres of impaired reservoir found within the basin. Sources of biological impairment include damming, riparian degradation, channel alteration, urbanization, flow alteration, sedimentation, point source pollution, and non-point source pollution.

Fifty acres of the upper section of Lake of the Ozarks, downstream from Truman Dam, is included in the 303(d) list due to periodic gas supersaturation, occasional low DO levels and fish kills due to physical trauma (MDNR 1996, MDNR 2000). Truman Dam is listed as the source of the problem. The priority for development of TMDL is medium priority for this section of Lake of the Ozarks.

For the Lower Osage River, two separate 0.2 mile sections of river are listed due to loss of aquatic habitat resulting from sand and gravel dredging operations (MDNR 1996, MDNR 2000). TMDL development for this section of the river is listed as high priority.

Dry Auglaize Creek near Lebanon, Missouri is also listed as an impaired stream on the 303(d) list. A 1.5 mile section of this stream downstream from the Lebanon Waste Water Treatment Plant has been repeatedly polluted by sewage. Major concerns listed in this reach of stream include biological oxygen demand (BOD) and non-filterable residue (NFR). TMDL development for this section of Dry Auglaize Creek has not been completed.

For more information, contact MDNR's Water Pollution Control Program at 1-800-361-4827 or (573) 751-1300.

Point Source Pollution

Several waste water treatment facilities of the basin have historically violated their discharge permits. As human population increases, these problems are likely to increase. Water quality concerns associated with point sources are listed in the Missouri Water Quality Basin Plan (MDNR 1996). The problems associated with point source discharges at this time include an increase in continued commercial and residential development at Lake of the Ozarks, which increases untreated sewage discharged to the lake. Many coves have excessive algal growth due to the nutrients in sewage.

The Clean Water Act requires wastewater dischargers to have a permit establishing pollution limits, and specifying monitoring and reporting requirements. The National Pollutant Discharge Elimination System (NPDES) regulates household and industrial wastes that are collected in sewers and treated at municipal wastewater treatment plants. These permits also regulate municipal and industrial point sources that discharge into other wastewater collection systems or that discharge directly into receiving water.

The EPA also issues permits and maintains lists of toxic release, regulated hazardous waste, and permitted compliance system water dischargers into the basin. Current lists of permitees and supplemental information can be accessed at EPA's Surf Your Watershed website (EPA 2001).

Non-Point Source Pollution

Significant forms of non-point source pollution which enter streams of the basin include untreated sewage, fertilizer, animal manure, and atmospheric deposition.

While much of the highly developed areas along Highway 54 have been sewered and their waste waters treated and discharged to the Osage River downstream of LOZ, sewage from thousands of lakeside homes is discharged to LOZ. The effects of this has been studied and to date this discharge source has not been recognized as a significant source of pollution. Although coves with high numbers of households do often have increased algae blooms associated with increased nutrients, there has not been sufficient documentation to warrant poor water quality conditions as a result of this form of nutrient input on Lake of the Ozarks.

A portion of the fertilizer which is applied to fields and lawns returns to the atmosphere as ammonia gas, and most of the rest is either taken up by plants or converted to nitrate in the soil. Consequently, most of the dissolved nitrogen that enters streams from runoff of fertilizer occurs as nitrate. Nitrate is a very mobile form of nitrogen. It is not readily retained by the soil and is highly soluble in water. Because of this mobility, nitrate is often applied in greater quantities than crops or lawns require. Also, given its high solubility, nitrate may be washed into adjacent streams by rain, or it may leach into the groundwater system (Pucket 1994)

The basin has a sizeable number of livestock operations. If not properly handled and disposed of, the accumulated manure from these operations can add nutrients to streams. Where livestock roam freely, large amounts of nutrients in the form of manure are distributed over the landscape and represent a true non-point source of pollution. However, where animals are confined to feedlots, barns, or sheds, they become more of a point-source pollution problem. In these situations, large quantities of manure commonly are concentrated in one location, and the nutrients that leach to ground and surface waters from storage areas may pose a water-quality problem (Pucket 1994).

When livestock waste enters a stream, nutrient contents of the stream rise and fecal coliform counts increase. Increases in nitrogen can result in dense algal growth which can deplete dissolved oxygen in the stream. Fish become stressed under these conditions, and in some cases fish kills occur. Also, cattle which drink the contaminated water may experience reduced weight gains. Increases in fecal coliform counts also make streams unsafe for human recreation.

Atmospheric deposition of nutrients such as nitrogen originates primarily from the combustion of fossil fuels, such as gas, coal, and oil. Atmospheric deposition of these nutrients often occurs with precipitation such as rain, snow, hail, or fog. The largest sources of these pollutants are coal and oil-burning electric facilities and large industries. However, automobiles, trucks, buses, and other forms of transportation can account for more than one-third of these sources. Even though these nutrients often come from point sources such as industrial plants, they still are called non-point source pollutants when they reach water bodies through precipitation. In the past, this type of non-point source pollution was largely ignored because it did not fit the traditional definition of a non-point source. This form of non-point source pollution can be significant. Over half of the nitrogen emitted from fossil-fuel-burning plants, vehicles, and other sources are deposited in watersheds (Pucket 1994).

Sediment input from construction sites which do not use best management practices can have serious negative impacts on streams and impoundments. Sediment input from crop fields is not as much of a concern throughout the basin, but can have localized negative impacts. Land use in the basin is listed as approximately 54.8% forest, 39.7% grassland, 2.5% open water, 1.6% cropland, and 1.6% urban. Sheet and rill erosion in the basin is estimated by the NRCS to be 2.5 tons/acre/year. Gully erosion is considerably less with 0-0.16 tons/acre/year. Since the majority of the land cover in this basin is forest and grassland, streams of the basin generally do not receive large amounts of sediment, and agricultural erosion is not considered to be a basin- wide problem. However, urbanization is continually increasing throughout the basin. With urbanization comes the destruction of vegetative cover and construction parking lots, buildings, shopping centers and residences, all impervious surfaces. With the steep hillsides and tremendous runoff effects of rainfall in the basin, if construction sites do not use best management practices to control erosion during their operations, sediment is transported and deposited in streams and reservoirs of the basin.

Prior to the construction of Truman Dam, the Upper Osage River carried significant amounts of sediment, as well as nitrogen and phosphorus into the basin. With the construction of Truman Dam, however, the sediment and nutrient inputs from the Upper Osage River have decreased.

Water Quality Studies and Concerns

A series of limnological studies have been conducted to monitor the water quality of Lake of the Ozarks.

Initially the studies were designed to evaluate the effect of Truman Dam on Lake of the Ozarks (Jones and Novak 1981, Jones and Kaiser 1988). Sampling was continued to monitor and evaluate any changes in water quality over time (Jones 1993, Kaiser and Jones 1999). Jones and Kaiser (1988) found decreased loading of total phosphorus and suspended solids, and increased levels of chlorophyll, suggesting that Lake of the Ozarks had increased in productivity. Indirect evidence suggested that conditions were more favorable for algal growth after the construction of Truman Dam because of increased water clarity in Lake of the Ozarks. The water which entered Lake of the Ozarks had lower amounts of dissolved solids since these were now settling out in Truman Reservoir.

Water quality concerns associated with increased urban development will need to be addressed in the future for Lake of the Ozarks and streams around Lebanon, Missouri. The lower part of Lake of the Ozarks receives substantial nutrient inputs associated with development. Point source discharges, septic tanks, and lawn maintenance are causing localized, high levels of suspended algae in some coves.

Bacterial contamination in coves of lower Lake of the Ozarks is a continuing concern. However, studies in the past have shown that all coves tested had low levels of fecal coliform bacteria well within state water quality standards for whole body contact recreation (MDNR 1996).

Mitzelfelt (1985) studied Lake of the Ozarks to determine if urbanization and development was affecting water quality. Small but consistent differences in trophic state of near shore waters were found as development of the adjacent shoreline increased. Data based on nutrient levels, chlorophyll a levels, and secchi disk readings categorized the lower Lake of the Ozarks as mesotrophic although chlorophyll a and secchi readings bordered on eutrophic. Fecal coliform data showed large increases with increased development particularly over summer weekends and holidays. Many of the samples exceeded standards for whole body contact recreation. The high levels of fecal coliform bacteria were attributed to inadequate septic systems and occasional pleasure boat discharges of untreated sewage. Mitzelfelt (1985) also suggested it was unlikely that urbanization and development would have a major impact on Lake of the Ozarks water quality because of dilution and flushing effects of the reservoir.

The Missouri Department of Health (MDOH) and MDNR continue to monitor the water quality of Lake of the Ozarks to ensure that adequate wastewater and stormwater management are undertaken. Study results indicate that there is an increase in fecal coliform counts after heavy rainfall, suggesting the waste load is a result of runoff. Acknowledging this fact, state water quality regulations stipulate that the standard for fecal coliform bacteria does not apply during periods of stormwater runoff (10 CSR20-7.031(4)(c)).

Mitzelfelt (1985) also found that Lake of the Ozarks becomes temperature stratified during the summer months. The cold, lower layer of water, termed the hypolimnion, has very little or no dissolved oxygen (DO). Each summer, leakage and release of this hypolimnetic water through the turbines causes many miles of the Osage River downstream from the Bagnell Dam to have unnaturally low DO. Many fish kills have occurred in dam's tailwater as a result.

AmerenUE and MDC jointly developed and agreed upon operational changes to increase tailwater DO and reduce the likelihood of fish kills due to low DO. To increase DO of hydropower generation releases, AmerenUE allows more air to mix with the water by opening vents on all main turbines when DO is less than 3 mg/l at the turbine intakes. From June 1 to July 14, the DO of minimum releases (455 cfs; 25% gate setting) is improved by operating the house turbines with vents open. From July 15 to September 30, the house turbines are operated at 16% gate setting with vents open, which increases DO but reduces the flow to 385 cfs. In addition, when DO about 2,000 feet downstream near the MDC boat ramp is less than 2.5 mg/l, one main turbine is operated for one hour on and one hour off from 8:00 P.M. to 8:00 A.M. each night. Since implementation of the operating agreement in 1996, no fish kills have been reported due to low DO problems below Bagnell Dam.

Even with the operating agreement, summer DO levels still remain below the MDNR standard of 5 mg/l for many miles downstream of Bagnell Dam. During minimum flow conditions (385-455 cfs), DO can be 1 mg/l in some locations near the dam and can remain below 5 mg/l for up to 10 miles downstream. DO can remain below 5 mg/l for up to 70 miles downstream during peak generation. Although fish kills have been prevented since implementation of the 1996 agreement, DO levels below the 5 mg/l standard can stress fish, mussels, and aquatic insects, likely reducing growth, spawning, distribution, and diversity of aquatic biota.

The effects of gravel mining (the removal of gravel from streambeds) can be disastrous to a stream and the surrounding stream corridor as well as upstream and downstream stream reaches. Water quality problems associated with gravel mining in the basin include: increased turbidity downstream from mining, increase in gradient, increased water temperatures due to a disruption in the stream flow, and increased sedimentation. Little information on the extent of past or present gravel mining is known for the basin.

In recent years, there has been a relaxing of the rules and case laws concerning instream gravel mining operations in the United States. From 1995-1998, the USACE regulated instream removal of gravel from streams in the basin. Currently, there are no permits required for non-commercial gravel mining operations. Permits are required for commercial gravel mining operations. These are handled through the MDNR’s Land Reclamation Division.

In the past, large commercial gravel operations have caused major upstream and downstream erosion within the basin. Linn Creek is one such example. A commercial gravel mining operation adjacent to the town of Linn Creek, Missouri mined considerable quantities of gravel from the adjacent streambed causing a 5-10 foot deep headcut to move upstream (Greg Stoner, MDC, personal communication). The effects of this operation were documented upstream for miles on Linn Creek and into two tributaries. A grade control structure built to protect one bridge later failed due to further incision. Other infrastructure damage along Linn Creek required $20,000 worth of repairs for telephone poles, cables, and phone lines and $19,000 worth of repairs for a sewer line. Up to 100 ft of lateral bank erosion occurring over a nine year period undermined nine residences and two businesses, resulting in an $875,000 buyout of those properties in 1994 by the Federal Emergency Management Agency. Numerous structures are still in jeopardy. It is estimated that the damages caused by this gravel mining operation alone may exceed $1 million dollars before the streambed re-stabilizes. Sellar’s Creek and Tavern Creek are two more examples where gravel removal has severely damaged habitat, water quality, and caused fish kills.

The majority of the gravel removal operations are non-commercial and presently not regulated. These mining operations are typically operated by landowners or local road districts to remove gravel from streams for use on farm roads. Landowners also rearrange gravel bars in an attempt to alleviate stream bank erosion. The cumulative effects of this small-scale but widespread gravel removal and streambed alteration are unknown at this time.

Although the cumulative effects of non-commercial gravel removal have not been well documented, they are considered to be a significant concern and possible source of habitat and water quality degradation.

Between 1993-1998, the USACE regulated all instream gravel mining operations including non-commercial operations. The extent that gravel mining was permitted both commercially and non-commercially in the basin was extensive and is shown in Figure 32. Since the USACE now has limited involvement regulating this activity, the extent that these operations are currently removing gravel in most cases may be going unmonitored and having severe local impacts on streambeds, streambanks, riparian vegetation, and the species that rely on them.

Volunteer Water Quality Monitoring and Stream Clean-up

Volunteer water quality monitoring in the basin is conducted by both the Missouri Stream Teams program and the Lakes of Missouri Volunteer Program. The Missouri Stream Teams program was initiated by MDC, MDNR, and the Conservation Federation of Missouri. The Lakes of Missouri Volunteer Program is coordinated by the University of Missouri-Columbia, School of Natural Resources and funded by the EPA through MDNR.

Missouri Stream Team sampling sites for the basin are depicted in Figure 50. These volunteers participate in various projects such as litter cleanup, macroinvertebrate sampling, tree planting for bank stabilization, stream inventories, and educational exhibits. For a complete listing of the Missouri Stream Teams and to obtain the data that they have collected, please see the official Missouri Stream Team website.

Fish Consumption Advisories

The MDOH issues fish consumption advisories for Missouri. MDC collects fish annually for use in consumption advisories. The most current consumption advisory information is available from the MDOH.

During 2001 the MDOH issued a statewide advisory regarding the consumption of largemouth bass in Missouri. The advisory targets pregnant women, nursing mothers, and children advising that they not consume largemouth bass. It also advises consumption of no more than a specified amount of bass by the remainder of the population. This advisory was issued due to a reduction in EPA’s action level for mercury in fish tissue from 1,000 ppb to 200-300 ppb. Missouri’s largemouth bass population has for many years had fish with mercury levels in the 200-300 ppb range. In 2001, 100% of the bass collected in Missouri and analyzed for metals contained mercury. Of those samples approximately 32% exceeded 200 ppb. The primary source of mercury to the environment is through air emissions. In Missouri, coal burning boilers account for 90% of mercury emissions.

Fish Kills

MDC maintains a listing of all reported fish kills within the basin and a list of pollution occurrences where no fish kill was reported but may have in fact been detrimental to aquatic populations. The earliest reported fish kill on record was in April of 1960 on a creek near Gravois Mills. Unfortunately, there is no record of the number killed or the cause of that fish kill. The most recent fish kill to date occurred in Lake of the Ozarks in October of 2001. An estimated 70 paddlefish were killed after becoming impinged on turbine intakes on the front of the dam.

The causes of recorded fish kills in the basin have included: low dissolved oxygen, sludge, petroleum, diesel fuel, sewage, gas bubble disease, temperature, parasites, physical injury from turbines, impingement on the face of Bagnell dam, detergent, hog manure, dairy cattle manure, molasses, severe siltation, stream habitat destruction, channelization, and herbicide. The estimated numbers of fish killed per incident range from as few as 3 fish killed in Lake of the Ozarks due to herbicide application to as many as 421,785 in Lake of the Ozarks due to a gas supersaturation in the water resulting from to the operation of Truman Dam.

Figure 16. Losing streams of the East Osage River Basin

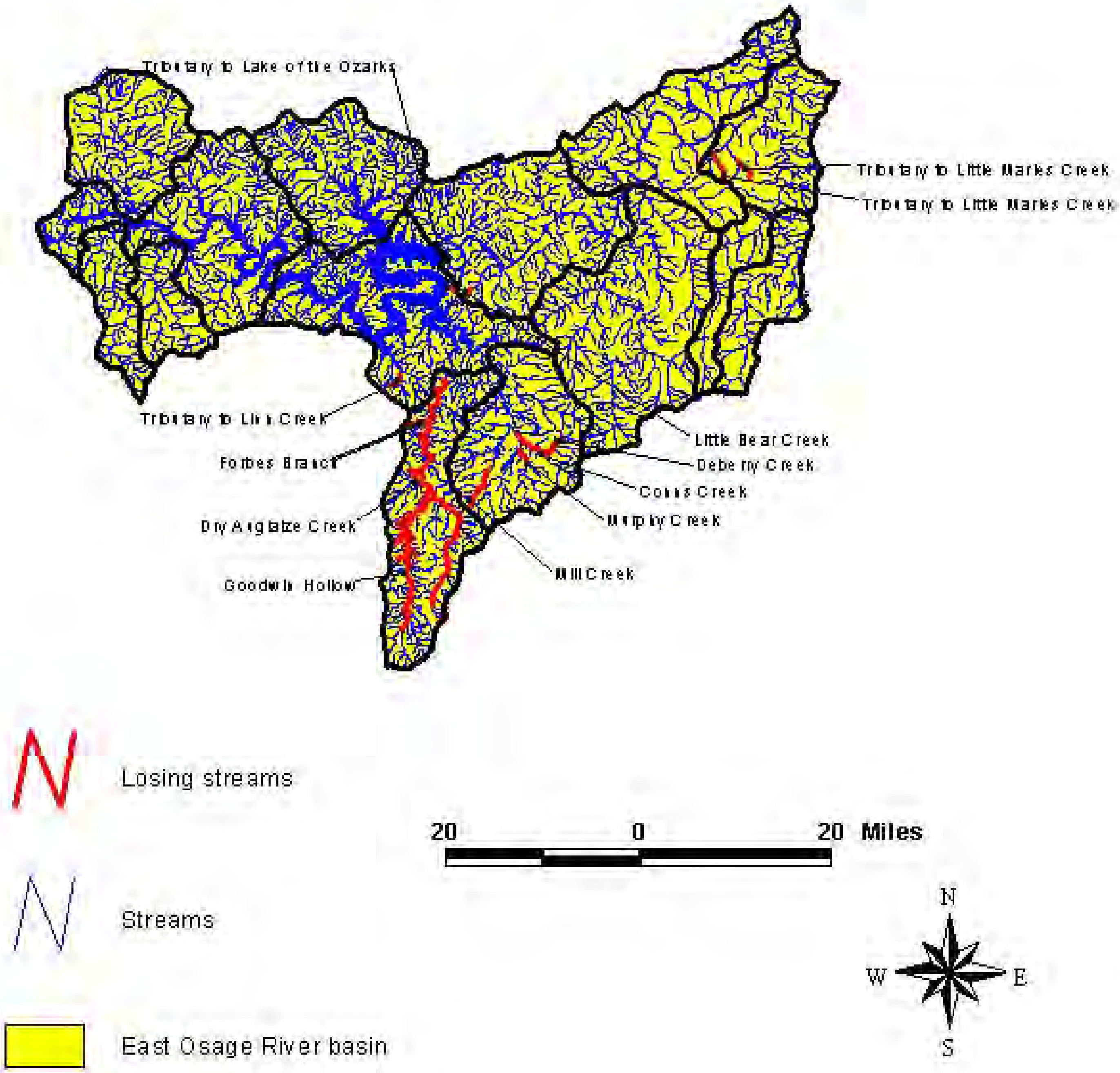


Figure 17. Springs of the East Osage River Basin

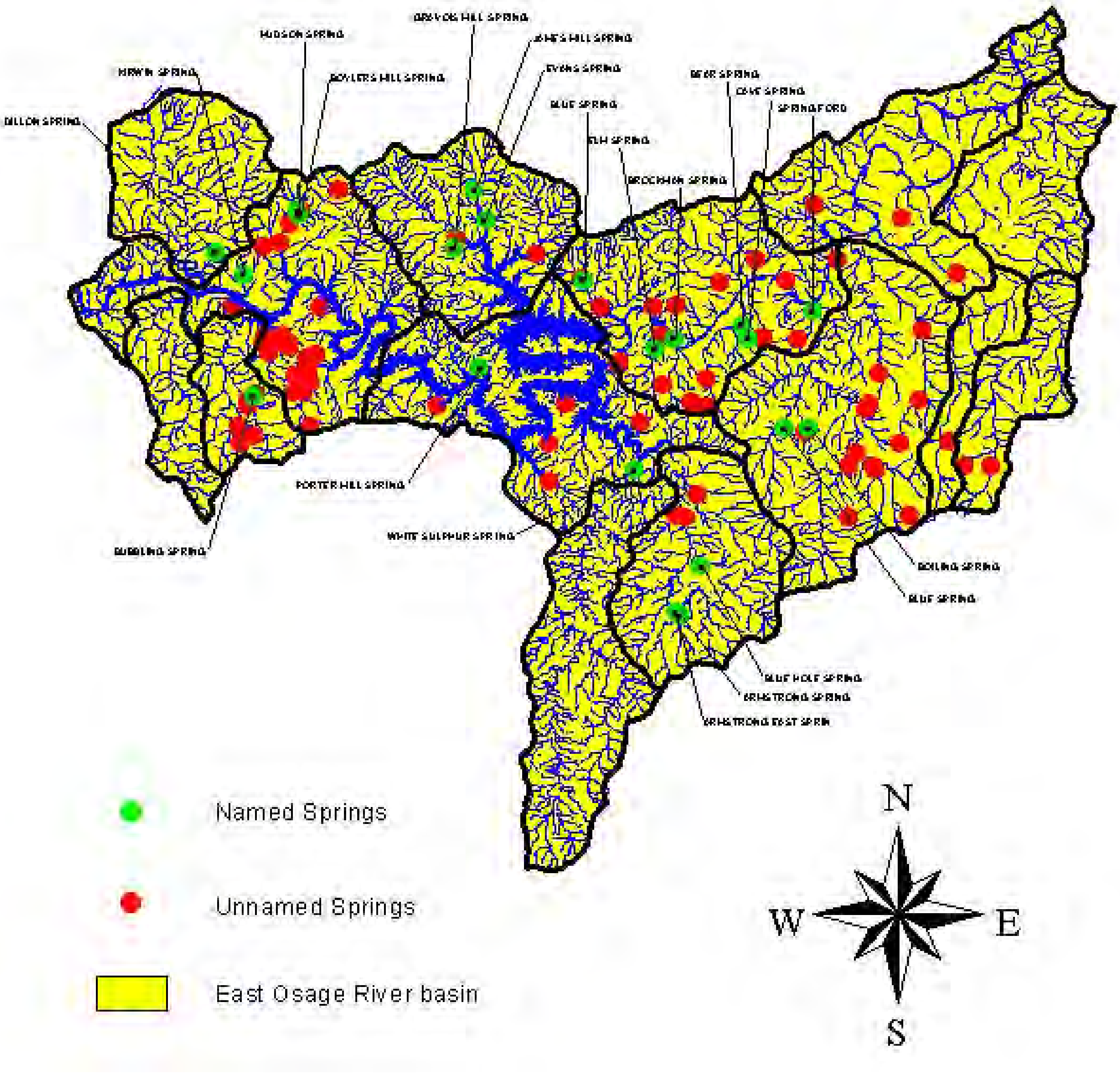


Table 10. Gauging stations operated in the East Osage River Basin (bold indicates active station).

Gauge Number	Station Name	County	Years of Record
06922450	Osage River below Truman Dam at Warsaw, Missouri	Benton	1981-2000 minus Oct. 1989-Sept. 1990
06922500	Osage River at Warsaw, Missouri	Benton	1925-1931
06922600	Little Turkey Creek Tributary near Warsaw, Missouri	Benton	1959-1979
06922700	Chub Creek near Lincoln, Missouri	Benton	1958-1979
06922800	Big Buffalo Creek near Stover, Missouri	Benton	1965-1967 1968-1977
06925270	Dry Auglaize Creek Tributary near Lebanon, Missouri	Laclede	1955-1970
06925300	Prairie Branch near Decaturville, Missouri	Laclede	1955-1979
06925450	Little Gravois Creek near Versailles, Missouri	Morgan	1955-1979
06910430	Dickerson Creek Tributary near Jefferson City, Missouri	Cole	1970-1979
06926150	Jack Buster Creek at Eugene, Missouri	Cole	1961-1979

06926500	Osage River near St. Thomas, Missouri	Cole	1931-1996
06926510	Osage River below St. Thomas, Missouri	Cole	1996-2000
06926000	Osage River near Bagnell, Missouri	Miller	1925-1998
16926200	Van Cleve Branch near Meta, Missouri	Maries	1956-1972
06926800	Long Branch near Vienna, Missouri	Maries	1957-1979
06927000	Maries River at Westphalia, Missouri	Osage	1948-1970

Table 11. Number of streams 4th order and larger and stream mileage by subbasin for the East Osage River Basin.

Subbasin	Number of streams $\geq$ 4th order	Total stream miles
Lower Osage River	3	69.3
Lower Maries River	3	65.4
Upper Maries River	4	42.1
Little Maries River	1	25.5
Tavern Creek	6	109.7
Wet Glaize Creek	7	60.8
Dry Auglaize Creek	2	71.1
Deer Creek	2	24
Turkey Creek	1	24.2
Cole Camp Creek	5	61
Upper Lake of the Ozark Hills	7	88.2
Gravois Arm	4	37.4
Lower Lake of the Ozarks Hills	2	59.9
Miller County Osage River Hills	12	116.7

Table 12. Known losing streams of the East Osage River Basin.

Stream Name	County	Length (miles)	Start T R S	End T R S
Trib. to Linn Creek	Camden	2.4	38N 16W 19	38N 16W 17
Murphy Creek	Camden	1.8	37N 14W 33	37N 14W 29
Conns Creek	Camden	4.3	37N 14W 26	37N 14W 17
Deberry Creek	Camden	3.3	37N 14W 13	37N 14W 22
Mill Creek	Camden	4.5	36N 15W 28	37N 15W 35
Trib. to LOZ	Camden	0.9	39N 15W 06	39N 15W 06
Little Bear Creek	Miller	1.5	39N 15W 05	39N 15W 04
Dry Auglaize Creek	Camden/Laclede	34.4	34N 16W 11	38N 15W 18
Forbes Branch	Camden	3.1	37N 16W 09	37N 16W 11
Trib. to Dry Auglaize Creek	Laclede	0.6	36N 16W 03	36N 16W 03
Trib. to Dry Auglaize Creek	Laclede	1.2	36N 16W 04	36N 16W 03
Goodwin Hollow	Laclede	20.0	34N 16W 20	36N 16W 14

Trib. to Goodwin Hollow	**Laclede**	**0.8**	**36N 16W 33**	**36N 16W 33**
Trib. to Goodwin Hollow	**Laclede**	**0.6**	**36N 16W 32**	**36N 16W 33**
Trib. to Goodwin Hollow	**Laclede**	**1.1**	**36N 16W 32**	**36N 16W 33**
Trib. to Goodwin Hollow	**Laclede**	**2.1**	**35N 16W 10**	**35N 16W 04**
Trib. to Goodwin Hollow	**Laclede**	**2.2**	**35N 16W 18**	**35N 16W 08**
Trib. to Goodwin Hollow	**Laclede**	**1.4**	**35N 16W 22**	**35N 16W 16**
Trib. to Goodwin Hollow	**Laclede**	**1.2**	**35N 16W 20**	**35N 16W 21**
Trib. to Goodwin Hollow	**Laclede**	**0.6**	**35N 16W 22**	**35N 16W 21**
Trib. to Little Maries	**Osage**	**3.1**	**41N 11W 01**	**42N 11W 26**
Trib. to Little Maries	**Osage**	**2.6**	**41N 10W 05**	**42N 10W 30**

Source: MDNR (1986a).

Table 13. Known springs within the East Osage River Basin.

Spring Name	County	Topographic Map	Twp	Rng	Sec	Average Flow (cfs)
Unnamed	Benton	Edwards	40N	20W	17	--
Unnamed	Benton	Edwards	39N	20W	9	--
Unnamed	Benton	Edwards	38N	20W	17	--
Unnamed	Benton	Edwards	39N	20W	17	--
Unnamed	Benton	Knobby	40N	20W	26	--
Unnamed	Benton	Knobby	40N	20W	36	--
Unnamed	Benton	Knobby	39N	20W	12	--
Unnamed	Benton	Knobby	39N	20W	12	--
Unnamed	Benton	Knobby	39N	20W	1	--
Unnamed	Benton	Knobby	40N	20W	35	--
Unnamed	Benton	Knobby	40N	20W	34	--
Unnamed	Benton	Knobby	40N	20W	35	--
Unnamed	Benton	Knobby	39N	20W	1	--
Unnamed	Benton	Knobby	40N	20W	36	--
Unnamed	Benton	Knobby	40N	20W	36	--
Unnamed	Benton	Knobby	40N	20W	25	--

Unnamed	Benton	Knobby	40N	20W	27	--
Unnamed	Benton	Cross Timbers	39N	20W	30	--
Unnamed	Benton	Cross Timbers	39N	20W	31	--
Unnamed	Benton	Cross Timbers	39N	20W	33	--
Unnamed	Benton	Boylers Mill	41N	20W	22	--
Unnamed	Benton	Boylers Mill	41N	20W	23	--
Unnamed	Benton	Boylers Mill	41N	20W	12	--
Bubbling Spring	Benton	Edwards	39N	20W	8	0.08
Kirwin Spring	Benton	Lakeview Heights	41N	20W	32	--
Dillon Spring	Benton	Lakeview Heights	41N	20W	25	0.031
Unnamed	Camden	Knobby	40N	19W	16	--
Unnamed	Camden	Knobby	40N	19W	16	--
Unnamed	Camden	Knobby	40N	19W	32	--
Unnamed	Camden	Knobby	39N	19W	6	--
Unnamed	Camden	Climax Springs	39N	19W	30	--
Unnamed	Camden	Camdenton	39N	16W	29	--
Unnamed	Camden	Camdenton	38N	16W	8	--
Unnamed	Camden	Conns Creek	37N	14W	21	--

Unnamed	**Camden**	**Knobby**	**30N**	**19W**	**16**	**--**
Unnamed	**Camden**	**Montreal**	**38N**	**15W**	**30**	**--**
Unnamed	**Camden**	**Montreal**	**38N**	**15W**	**30**	**--**
Blue Hole Spring	**Camden**	**Conns Creek**	**37N**	**14W**	**17**	**7.16**
Armstrong East Spring	**Camden**	**Montreal**	**36N**	**14W**	**6**	**11.6**
Armstrong Spring	**Camden**	**Montreal**	**36N**	**15W**	**1**	**1.18**
Unnamed	**Camden**	**Sunrise Beach**	**39N**	**18W**	**14**	**--**
Porter Mill Spring	**Camden**	**Sunrise Beach**	**39N**	**17W**	**5**	**--**
White Sulphur Spring	**Camden**	**Toronto**	**38N**	**15W**	**9**	**--**
Unnamed	**Camden**	**Lake Ozark**	**39N**	**16W**	**9**	**--**
Unnamed	**Cole**	**St. Elizabeth**	**42N**	**13W**	**25**	**--**
Unnamed	**Maries**	**Big Bend**	**38N**	**11W**	**2**	**--**
Unnamed	**Maries**	**Big Bend**	**39N**	**11W**	**27**	**--**
Unnamed	**Maries**	**Argyle**	**41N**	**11W**	**23**	**--**
Unnamed	**Maries**	**Van Cleve**	**39N**	**11W**	**6**	**--**
Unnamed	**Maries**	**Van Cleve**	**40N**	**11W**	**16**	**--**
Unnamed	**Maries**	**Big Bend**	**38N**	**11W**	**6**	**--**

Bear Spring	**Miller**	**Tuscumbia**	**40N**	**14W**	**13**	**--**
Blue Spring	**Miller**	**Iberia**	**39N**	**13W**	**21**	**--**
Boiling Spring	**Miller**	**Iberia**	**39N**	**13W**	**23**	**--**
Cave Spring	**Miller**	**Tuscumbia**	**40N**	**13W**	**19**	**--**
Unnamed	**Miller**	**Lake Ozark**	**40N**	**15W**	**7**	**--**
Unnamed	**Miller**	**Rocky Mount**	**41N**	**16W**	**35**	**--**
Unnamed	**Miller**	**Bagnell**	**40N**	**15W**	**11**	**--**
Unnamed	**Miller**	**Bagnell**	**40N**	**15W**	**11**	**--**
Brockman Spring	**Miller**	**Bagnell**	**40N**	**14W**	**19**	**--**
Unnamed	**Miller**	**Bagnell**	**40N**	**15W**	**24**	**--**
Unnamed	**Miller**	**Bagnell**	**40N**	**14W**	**6**	**--**
Blue Spring	**Miller**	**Rocky Mount**	**41N**	**16W**	**35**	**--**
Unnamed	**Miller**	**Iberia**	**39N**	**13W**	**22**	**--**
Unnamed	**Miller**	**Tuscumbia**	**39N**	**14W**	**7**	**--**
Unnamed	**Miller**	**Tuscumbia**	**39N**	**14W**	**5**	**--**
Unnamed	**Miller**	**Bagnell**	**39N**	**15W**	**2**	**--**
Unnamed	**Miller**	**Bagnell**	**40N**	**15W**	**32**	**--**
Unnamed	**Miller**	**Bagnell**	**40N**	**15W**	**32**	**--**

Elm Spring	**Miller**	**Bagnell**	**40N**	**15W**	**26**	**0.09**
Unnamed	**Miller**	**Tuscumbia**	**40N**	**13W**	**20**	**--**
Spring Ford	**Miller**	**St. Anthony**	**40N**	**13W**	**12**	**--**
Unnamed	**Miller**	**St. Anthony**	**40N**	**13W**	**23**	**--**
Unnamed	**Miller**	**St. Elizabeth**	**41N**	**12W**	**20**	**--**
Unnamed	**Miller**	**St. Elizabeth**	**41N**	**13W**	**28**	**--**
Unnamed	**Miller**	**Eugene**	**41N**	**14W**	**27**	**--**
Unnamed	**Miller**	**Eugene**	**41N**	**13W**	**19**	**--**
Unnamed	**Miller**	**Brays**	**38N**	**12W**	**3**	**--**
Unnamed	**Miller**	**Brays**	**38N**	**12W**	**3**	**--**
Unnamed	**Miller**	**Brays**	**39N**	**12W**	**9**	**--**
Unnamed	**Miller**	**Brays**	**39N**	**12W**	**9**	**--**
Unnamed	**Miller**	**Brays**	**39N**	**12W**	**25**	**--**
Unnamed	**Miller**	**Van Cleve**	**39N**	**12W**	**9**	**--**
Unnamed	**Miller**	**Van Cleve**	**39N**	**12W**	**3**	**--**
Unnamed	**Miller**	**Toronto**	**39N**	**15W**	**21**	**--**
Unnamed	**Miller**	**Brumley**	**38N**	**14W**	**17**	**--**
Unnamed	**Miller**	**Brumley**	**39N**	**14W**	**17**	**--**
Unnamed	**Miller**	**Brumley**	**39N**	**14W**	**9**	**--**

Unnamed	**Miller**	**Brumley**	**39N**	**14W**	**17**	**--**
Unnamed	**Miller**	**Iberia**	**38N**	**12W**	**5**	**--**
Unnamed	**Miller**	**Iberia**	**39N**	**12W**	**32**	**--**
Unnamed	**Miller**	**Tuscumbia**	**40N**	**13W**	**20**	**--**
Unnamed	**Miller**	**Tuscumbia**	**40N**	**13W**	**20**	**--**
Boylers Mill Spring	**Morgan**	**Boylers Mill**	**41N**	**19W**	**6**	**1.36**
Gravois Mill Spring	**Morgan**	**Gravois Mills**	**41N**	**17W**	**19**	**--**
James Mill Spring	**Morgan**	**Versailles**	**42N**	**17W**	**28**	**--**
Unnamed	**Morgan**	**Boylers Mill**	**42N**	**17W**	**6**	**--**
Unnamed	**Morgan**	**Rocky Mount**	**41N**	**16W**	**20**	**--**
Hudson Spring	**Morgan**	**Boylers Mill**	**42N**	**19W**	**6**	**--**
Unnamed	**Morgan**	**Gravois Mills**	**41N**	**17W**	**18**	**--**
Unnamed	**Morgan**	**Crockerville**	**42N**	**19W**	**27**	**--**
Evans Spring	**Morgan**	**Gravois Mills**	**41N**	**17W**	**3**	**--**
Unnamed	**Morgan**	**Rocky Mount**	**41N**	**16W**	**20**	**--**
Unnamed	**Osage**	**Meta**	**42N**	**11W**	**31**	**--**
Unnamed	**Pulaski**	**Hancock**	**38N**	**11W**	**30**	**–**

– = No data recorded

Table 14. Water use in the East Osage River Basin .

Category	10290109 Lake of the Ozarks	10290111 Lower Osage	Total
POPULATION SERVED			
Number of People Served by Public Supplied Surface Water	2,210 (4 %)	5,730 (19 %)	7,940 (9 %)
Number of People Served by Public Supplied Groundwater	25,350 (45%)	7,630 (25%)	32,980 (39%)
Total Number of People Served by Public Water Supply	27,560	13,360	40,920
Total Number of People Served by Private Wells	28,500 (51%)	16,170 (56 %)	44,670 (52 %)
Total Number of People Served in Area	56,060 (65% of total)	29,530 (35 % of total)	85,590 (100 %)
GROUNDWATER WITHDRAWALS (Million Gallon/Day (mgd))			
Groundwater Withdrawals for Commercial Use	0.54	0.18	0.72
Groundwater Withdrawals for Livestock Use	0.28	0.27	0.55
Groundwater Withdrawals for Public Water Supply	1.72	2.04	3.76
Groundwater Withdrawals for Irrigation	0.04	0	0.04
Private Well Withdrawals	1.71	0.96	2.87
SURFACE WATER WITHDRAWALS (mgd)			

Private Surface-water Withdrawals	**0**	**0**	**0**
Surface Water Withdrawals for Public Water Supply	**0.15**	**1.53**	**1.68**
Surface Water Withdrawals for Livestock Use	**0.04**	**0.85**	**0.89**
Surface Water Withdrawals for Commercial Use	**0**	**0**	**0**
Surface Water Withdrawals for Irrigation	**0.07**	**0.05**	**0.12**
TOTAL WITHDRAWALS (mgd)			
Total Groundwater Withdrawals	**4.4**	**3.61**	**8.01**
Total Surface Water Withdrawals	**0.83**	**2.48**	**3.31**
Total Withdrawals for Public Water Supply	**1.87**	**3.57**	**4.44**
Total Withdrawals for Livestock Use	**0.91**	**1.12**	**2.03**
Total Withdrawals	**5.23 (46 % of total)**	**6.09 (54 % of total)**	**11.32 (100%)**

Table 15. Quarterly water quality data from the Osage River near St. Thomas, Missouri, 1984 and 1995. (Data source USGS, 1985, and 1996).

CONSTITUENT	FALL		WINTER		SPRING		SUMMER	
	1984	1995	1984	1995	1984	1995	1984	1995
Instanteneous discharge, (ft3/second)	20,400	12,300	6,730	21,600	35,100	52,700	2,020	31,600
Temperature, (Celcius)	12.0	15.5	1.5	3	16.5	19	25	27.5
Specific Conductance, (Fs/cm)	28	272	251	254	255	281	283	248
pH, whole water, field measurement	8	7.7	7.8	7.2	7.9	7.7	7.6	7.5
Oxygen, dissolved (mg/l)	8.2	9	12.8	12.6	9.2	9.7	6	3.9
Fecal coliform, (colonies/100 ml)	96	1	10	13	<4	1,100	39	5
Fecal streptococci, (colonies/100 ml)	220	475	52	115	80	1,260	22	205
Alkalinity, (mg/l as $CaCO_3$)	106	102	106	83	91	105	123	90
Bicarbonate, dissolved (mg/l)	–	125	–	99	–	126	–	109
Nitrate + Nitrite, total as N (mg/l)	0.33	0.12	0.56	0.47	0.8	0.24	0.45	0.17
Phosphorus, dissolved (mg/l)	0.01	0.03	0.02	0.03	<0.02	0.09	0.02	0.02

Calcium, dissolved (mg/l)	**39**	**0.4**	**37**	**33**	**33**	**34**	**40**	**34**
Magnesium, dissolved (mg/l)	**11**	**9.8**	**11**	**7.9**	**7.7**	**10**	**8.8**	**6.9**
Sodium, dissolved (mg/l)	**5.5**	**4.3**	**5.2**	**5.7**	**7.9**	**4.5**	**5.4**	**8.2**
Potassium, dissolved (mg/l)	**2.9**	**2.8**	**3.2**	**3.4**	**2.4**	**2.3**	**2.6**	**3.2**
Sulfate, dissolved (mg/l)	**26**	**18**	**27**	**22**	**29**	**20**	**26**	**17**
Chloride, dissolved (mg/l)	**5.2**	**8.9**	**6.3**	**8.4**	**5.1**	**5.4**	**4.9**	**3.7**
Flouride, dissolved (mg/l)	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**<0.1**	**0.2**	**0.1**
Total solids, dissolved (mg/l)	**159**	**155**	**170**	**216**	**159**	**158**	**153**	**142**
Aluminum, dissolved (Fg/l)	**<10**	**<10**	**30**	**–**	**20**	**80**	**20**	**–**
Iron, dissolved (Fg/l)	**14**	**6**	**21**	**13**	**18**	**93**	**9**	**<3**
Manganese, dissolved (Fg/l)	**8**	**6**	**8**	**69**	**6**	**7**	**22**	**6**
Nickel, dissolved (Fg/l)	**11**	**<1**	**4**	**<1**	**<1**	**<1**	**10**	**1**
Strontium, dissolved (Fg/l)	**120**	**97**	**110**	**89**	**110**	**83**	**130**	**120**

WATER QUALITY

Surface water and groundwater quality in the basin are generally good (Vandike 1995). The area covered by the basin is part of the Salem Plateau groundwater province, otherwise known as the Ozark aquifer. Streams draining from the Salem Plateau generally contain water that is calcium-magnesium-bicarbonate type with low sulfate and chloride levels (Vandike 1995). Sink holes and losing stream segments of the Ozark aquifer provide a direct conduit for surface water to enter groundwater. This allows for relatively quick groundwater recharge, and also provides a direct link for surface contamination to enter groundwater. This relatively quick recharge time is also responsible for great variations in the water quality of springs in the basin.

Water Use

There are over 85,000 people served in the basin by either public supplied surface water (9%), public supplied groundwater (39%), or private wells (52%) (Table 14). A greater proportion of people from the Lower Osage River HUC 10290111 below Bagnell Dam are served by public supplied surface water (19%) than are served by public supplied surface water in Lake of the Ozarks HUC 10290109 above Bagnell Dam (only 4%). A greater proportion of people (45%) above the dam are served by public supplied groundwater, whereas below the dam only 25% of the people are served by public supplied groundwater.

Throughout the basin, total water withdrawals equaled 11.32 million gallons per day (mgd). The majority of these withdrawals are from the HUC below Bagnell Dam (54% or 6.09 mgd). Above Bagnell Dam (HUC 10290109) has only 5.23 mgd or 46% of the total water withdrawals from the basin.

Total withdrawals from groundwater in the basin equaled 8.01 mgd whereas total withdrawals from surface water were only 7.61 mgd. There are more withdrawals from groundwater in the HUC above Lake of the Ozarks (56%) than below Bagnell Dam (45%). However there are more withdrawals from surface water (2.48 mgd) below the dam than in the HUC above Bagnell Dam (0.83 mgd). There are 10 public water supply districts in the basin (MDNR 1986).

Beneficial Use Attainment

he MDNR maintains a list of beneficial uses for classified waters of the basin. All classified waters have been assigned the beneficial uses of aquatic life protection, livestock and wildlife watering, and fish consumption by humans. In addition there are 298.5 miles of streams in the basin classified as supporting whole body contact. These streams are the Osage River (82 miles), Lake of the Ozarks (121 miles), Maries River (41.5 miles), Tavern Creek (37 miles), Grand Auglaize Creek (7 miles), and Wet Glaize Creek (10 miles)(MDNR 1986). Sections 303(d) and 305(b) of the Clean Water Act are a means for determining if beneficial uses are being attained.

Chemical Water Quality

Water quality of the basin is generally good. Ambient water quality data is monitored by the USGS at their gauging station on the Osage River near St. Thomas. For a detailed look at quarterly water quality constituents for the Osage River, see Table 15 for years 1984 and 1995. During those years, temperature ranged from 1.5 C to 27.5 C, pH ranged from 7.2-8, DO ranged from 3.9 to 12.8, fecal coliform ranged from <4 colonies/100ml in the spring of 1984 to 1,100 colonies/100ml in the spring of 1995, total nitrogen ranged from 0.12 mg/l to 0.8 mg/l (Missouri Water Quality Assessment Report 47, Volume III, 1997).

Water quality problems associated with increased urban and commercial development are an ongoing concern in the area surrounding Lake of the Ozarks. Increases in population density and recreational use are the primary reason for elevated nitrification and algal growth in Lake of the Ozarks.

The MDNR noted several water quality concerns for the basin (MDNR 1994). The first concern dealt with the continued commercial and residential development along the shoreline of Lake of the Ozarks. This development has increased the amount of treated sewage discharged to the lake. Many coves have excess algal growth from nutrients discharged into the lake by sewage. A second concern is groundwater contamination by improperly functioning septic tanks, leaking storage tanks and agricultural runoff or wastewater discharges to losing streams. Poorly constructed wells also greatly increase the chance for groundwater contamination. The problem is especially severe where the human population center sits atop geologic strata, such as the Lebanon area, which allow high rates of infiltration of surface water to groundwater. A third concern is the increasing number of CAFOs which have the potential, if not properly managed, to discharge harmful amounts of animal waste into spring branches and streams thereby degrading the water quality of those water bodies.

Pesticides have been detected in wells and springs throughout the Ozark aquifer, including the basin. Recent studies have detected a higher level of pesticide occurrences in springs than in wells. Most occurrences of pesticides in this groundwater province are probably directly related to the land use of the area surrounding the spring or well sampled.

Nitrates were found in only about 5% of the wells tested in the Salem Plateau groundwater province. Land use practices such as the application of fertilizer and human and animal waste can contribute high levels of nitrates to groundwater. Data collected between 1972 and 1990 found that less than 15% of samples from this groundwater province contained phosphorus at concentrations above detection levels. Springs and shallow wells were found to have higher phosphorus levels on average than deeper wells.

Sections 305(b) and 303(d) of the Clean Water Act

The MDNR reports on the status of water quality in surface waters according to section 305(b) of the Clean Water Act. MDNR summarizes the quality of Missouri waters every two years in these reports. Significant improvements in water quality have been made over the past quarter century in controlling pollution from municipal sanitary wastes, but major problems still exist from non-point source pollution.

Section 303(d) of the Clean Water Act requires states to list waters not expected to meet established state water quality standards even after application of conventional technology-based controls for which total maximum daily load (TMDL) studies have not yet been completed. The impaired waters list is produced every four years by the MDNR and includes waters for which existing required pollution controls are not stringent enough to maintain state water quality standards.

There are approximately 1.9 miles of 303(d) listed impaired streams and 50 acres of impaired reservoir found within the basin. Sources of biological impairment include damming, riparian degradation, channel alteration, urbanization, flow alteration, sedimentation, point source pollution, and non-point source pollution.

Fifty acres of the upper section of Lake of the Ozarks, downstream from Truman Dam, is included in the 303(d) list due to periodic gas supersaturation, occasional low DO levels and fish kills due to physical trauma (MDNR 1996, MDNR 2000). Truman Dam is listed as the source of the problem. The priority for development of TMDL is medium priority for this section of Lake of the Ozarks.

For the Lower Osage River, two separate 0.2 mile sections of river are listed due to loss of aquatic habitat resulting from sand and gravel dredging operations (MDNR 1996, MDNR 2000). TMDL development for this section of the river is listed as high priority.

Dry Auglaize Creek near Lebanon, Missouri is also listed as an impaired stream on the 303(d) list. A 1.5 mile section of this stream downstream from the Lebanon Waste Water Treatment Plant has been repeatedly polluted by sewage. Major concerns listed in this reach of stream include biological oxygen demand (BOD) and non-filterable residue (NFR). TMDL development for this section of Dry Auglaize Creek has not been completed.

For more information, contact MDNR's Water Pollution Control Program at 1-800-361-4827 or (573) 751-1300.

Point Source Pollution

Several waste water treatment facilities of the basin have historically violated their discharge permits. As human population increases, these problems are likely to increase. Water quality concerns associated with point sources are listed in the Missouri Water Quality Basin Plan (MDNR 1996). The problems associated with point source discharges at this time include an increase in continued commercial and residential development at Lake of the Ozarks, which increases untreated sewage discharged to the lake. Many coves have excessive algal growth due to the nutrients in sewage.

The Clean Water Act requires wastewater dischargers to have a permit establishing pollution limits, and specifying monitoring and reporting requirements. The National Pollutant Discharge Elimination System (NPDES) regulates household and industrial wastes that are collected in sewers and treated at municipal wastewater treatment plants. These permits also regulate municipal and industrial point sources that discharge into other wastewater collection systems or that discharge directly into receiving water.

The EPA also issues permits and maintains lists of toxic release, regulated hazardous waste, and permitted compliance system water dischargers into the basin. Current lists of permitees and supplemental information can be accessed at EPA's Surf Your Watershed website (EPA 2001).

Non-Point Source Pollution

Significant forms of non-point source pollution which enter streams of the basin include untreated sewage, fertilizer, animal manure, and atmospheric deposition.

While much of the highly developed areas along Highway 54 have been sewered and their waste waters treated and discharged to the Osage River downstream of LOZ, sewage from thousands of lakeside homes is discharged to LOZ. The effects of this has been studied and to date this discharge source has not been recognized as a significant source of pollution. Although coves with high numbers of households do often have increased algae blooms associated with increased nutrients, there has not been sufficient documentation to warrant poor water quality conditions as a result of this form of nutrient input on Lake of the Ozarks.

A portion of the fertilizer which is applied to fields and lawns returns to the atmosphere as ammonia gas, and most of the rest is either taken up by plants or converted to nitrate in the soil. Consequently, most of the dissolved nitrogen that enters streams from runoff of fertilizer occurs as nitrate. Nitrate is a very mobile form of nitrogen. It is not readily retained by the soil and is highly soluble in water. Because of this mobility, nitrate is often applied in greater quantities than crops or lawns require. Also, given its high solubility, nitrate may be washed into adjacent streams by rain, or it may leach into the groundwater system (Pucket 1994)

The basin has a sizeable number of livestock operations. If not properly handled and disposed of, the accumulated manure from these operations can add nutrients to streams. Where livestock roam freely, large amounts of nutrients in the form of manure are distributed over the landscape and represent a true non-point source of pollution. However, where animals are confined to feedlots, barns, or sheds, they become more of a point-source pollution problem. In these situations, large quantities of manure commonly are concentrated in one location, and the nutrients that leach to ground and surface waters from storage areas may pose a water-quality problem (Pucket 1994).

When livestock waste enters a stream, nutrient contents of the stream rise and fecal coliform counts increase. Increases in nitrogen can result in dense algal growth which can deplete dissolved oxygen in the stream. Fish become stressed under these conditions, and in some cases fish kills occur. Also, cattle which drink the contaminated water may experience reduced weight gains. Increases in fecal coliform counts also make streams unsafe for human recreation.

Atmospheric deposition of nutrients such as nitrogen originates primarily from the combustion of fossil fuels, such as gas, coal, and oil. Atmospheric deposition of these nutrients often occurs with precipitation such as rain, snow, hail, or fog. The largest sources of these pollutants are coal and oil-burning electric facilities and large industries. However, automobiles, trucks, buses, and other forms of transportation can account for more than one-third of these sources. Even though these nutrients often come from point sources such as industrial plants, they still are called non-point source pollutants when they reach water bodies through precipitation. In the past, this type of non-point source pollution was largely ignored because it did not fit the traditional definition of a non-point source. This form of non-point source pollution can be significant. Over half of the nitrogen emitted from fossil-fuel-burning plants, vehicles, and other sources are deposited in watersheds (Pucket 1994).

Sediment input from construction sites which do not use best management practices can have serious negative impacts on streams and impoundments. Sediment input from crop fields is not as much of a concern throughout the basin, but can have localized negative impacts. Land use in the basin is listed as approximately 54.8% forest, 39.7% grassland, 2.5% open water, 1.6% cropland, and 1.6% urban. Sheet and rill erosion in the basin is estimated by the NRCS to be 2.5 tons/acre/year. Gully erosion is considerably less with 0-0.16 tons/acre/year. Since the majority of the land cover in this basin is forest and grassland, streams of the basin generally do not receive large amounts of sediment, and agricultural erosion is not considered to be a basin- wide problem. However, urbanization is continually increasing throughout the basin. With urbanization comes the destruction of vegetative cover and construction parking lots, buildings, shopping centers and residences, all impervious surfaces. With the steep hillsides and tremendous runoff effects of rainfall in the basin, if construction sites do not use best management practices to control erosion during their operations, sediment is transported and deposited in streams and reservoirs of the basin.

Prior to the construction of Truman Dam, the Upper Osage River carried significant amounts of sediment, as well as nitrogen and phosphorus into the basin. With the construction of Truman Dam, however, the sediment and nutrient inputs from the Upper Osage River have decreased.

Water Quality Studies and Concerns

A series of limnological studies have been conducted to monitor the water quality of Lake of the Ozarks. Initially the studies were designed to evaluate the effect of Truman Dam on Lake of the Ozarks (Jones and Novak 1981, Jones and Kaiser 1988). Sampling was continued to monitor and evaluate any changes in water quality over time (Jones 1993, Kaiser and Jones 1999). Jones and Kaiser (1988) found decreased loading of total phosphorus and suspended solids, and increased levels of chlorophyll, suggesting that Lake of the Ozarks had increased in productivity. Indirect evidence suggested that conditions were more favorable for algal growth after the construction of Truman Dam because of increased water clarity in Lake of the Ozarks. The water which entered Lake of the Ozarks had lower amounts of dissolved solids since these were now settling out in Truman Reservoir.

Water quality concerns associated with increased urban development will need to be addressed in the future for Lake of the Ozarks and streams around Lebanon, Missouri. The lower part of Lake of the Ozarks receives substantial nutrient inputs associated with development. Point source discharges, septic tanks, and lawn maintenance are causing localized, high levels of suspended algae in some coves.

Bacterial contamination in coves of lower Lake of the Ozarks is a continuing concern. However, studies in the past have shown that all coves tested had low levels of fecal coliform bacteria well within state water quality standards for whole body contact recreation (MDNR 1996).

Mitzelfelt (1985) studied Lake of the Ozarks to determine if urbanization and development was affecting water quality. Small but consistent differences in trophic state of near shore waters were found as development of the adjacent shoreline increased. Data based on nutrient levels, chlorophyll a levels, and secchi disk readings categorized the lower Lake of the Ozarks as mesotrophic although chlorophyll a and secchi readings bordered on eutrophic. Fecal coliform data showed large increases with increased development particularly over summer weekends and holidays. Many of the samples exceeded standards for whole body contact recreation. The high levels of fecal coliform bacteria were attributed to inadequate septic systems and occasional pleasure boat discharges of untreated sewage. Mitzelfelt (1985) also suggested it was unlikely that urbanization and development would have a major impact on Lake of the

Ozarks water quality because of dilution and flushing effects of the reservoir.

The Missouri Department of Health (MDOH) and MDNR continue to monitor the water quality of Lake of the Ozarks to ensure that adequate wastewater and stormwater management are undertaken. Study results indicate that there is an increase in fecal coliform counts after heavy rainfall, suggesting the waste load is a result of runoff. Acknowledging this fact, state water quality regulations stipulate that the standard for fecal coliform bacteria does not apply during periods of stormwater runoff (10 CSR20-7.031(4)(c)).

Mitzelfelt (1985) also found that Lake of the Ozarks becomes temperature stratified during the summer months. The cold, lower layer of water, termed the hypolimnion, has very little or no dissolved oxygen (DO). Each summer, leakage and release of this hypolimnetic water through the turbines causes many miles of the Osage River downstream from the Bagnell Dam to have unnaturally low DO. Many fish kills have occurred in dam's tailwater as a result.

AmerenUE and MDC jointly developed and agreed upon operational changes to increase tailwater DO and reduce the likelihood of fish kills due to low DO. To increase DO of hydropower generation releases, AmerenUE allows more air to mix with the water by opening vents on all main turbines when DO is less than 3 mg/l at the turbine intakes. From June 1 to July 14, the DO of minimum releases (455 cfs; 25% gate setting) is improved by operating the house turbines with vents open. From July 15 to September 30, the house turbines are operated at 16% gate setting with vents open, which increases DO but reduces the flow to 385 cfs. In addition, when DO about 2,000 feet downstream near the MDC boat ramp is less than 2.5 mg/l, one main turbine is operated for one hour on and one hour off from 8:00 P.M. to 8:00 A.M. each night. Since implementation of the operating agreement in 1996, no fish kills have been reported due to low DO problems below Bagnell Dam.

Even with the operating agreement, summer DO levels still remain below the MDNR standard of 5 mg/l for many miles downstream of Bagnell Dam. During minimum flow conditions (385-455 cfs), DO can be 1 mg/l in some locations near the dam and can remain below 5 mg/l for up to 10 miles downstream. DO can remain below 5 mg/l for up to 70 miles downstream during peak generation. Although fish kills have been prevented since implementation of the 1996 agreement, DO levels below the 5 mg/l standard can stress fish, mussels, and aquatic insects, likely reducing growth, spawning, distribution, and diversity of aquatic biota.

The effects of gravel mining (the removal of gravel from streambeds) can be disastrous to a stream and the surrounding stream corridor as well as upstream and downstream stream reaches. Water quality problems associated with gravel mining in the basin include: increased turbidity downstream from mining, increase in gradient, increased water temperatures due to a disruption in the stream flow, and increased sedimentation. Little information on the extent of past or present gravel mining is known for the basin.

In recent years, there has been a relaxing of the rules and case laws concerning instream gravel mining operations in the United States. From 1995-1998, the USACE regulated instream removal of gravel from streams in the basin. Currently, there are no permits required for non-commercial gravel mining operations. Permits are required for commercial gravel mining operations. These are handled through the MDNR's Land Reclamation Division.

In the past, large commercial gravel operations have caused major upstream and downstream erosion within the basin. Linn Creek is one such example. A commercial gravel mining operation adjacent to the town of Linn Creek, Missouri mined considerable quantities of gravel from the adjacent streambed causing a 5-10 foot deep headcut to move upstream (Greg Stoner, MDC, personal communication). The effects of this operation were documented upstream for miles on Linn Creek and into two tributaries. A grade control structure built to protect one bridge later failed due to further incision. Other infrastructure damage along Linn Creek required $20,000 worth of repairs for telephone poles, cables, and phone lines and $19,000 worth of repairs for a sewer line. Up to 100 ft of lateral bank erosion occurring over a nine year period undermined nine residences and two businesses, resulting in an $875,000 buyout of those properties in 1994 by the Federal Emergency Management Agency. Numerous structures are still in jeopardy. It is estimated that the damages caused by this gravel mining operation alone may exceed $1 million dollars before the streambed re-stabilizes. Sellar’s Creek and Tavern Creek are two more examples where gravel removal has severely damaged habitat, water quality, and caused fish kills.

The majority of the gravel removal operations are non-commercial and presently not regulated. These mining operations are typically operated by landowners or local road districts to remove gravel from streams for use on farm roads. Landowners also rearrange gravel bars in an attempt to alleviate stream bank erosion. The cumulative effects of this small-scale but widespread gravel removal and streambed alteration are unknown at this time.

Although the cumulative effects of non-commercial gravel removal have not been well documented, they are considered to be a significant concern and possible source of habitat and water quality degradation. Between 1993-1998, the USACE regulated all instream gravel mining operations including non-commercial operations. The extent that gravel mining was permitted both commercially and non-commercially in the basin was extensive and is shown in Figure 32. Since the USACE now has limited involvement regulating this activity, the extent that these operations are currently removing gravel in most cases may be going unmonitored and having severe local impacts on streambeds, streambanks, riparian vegetation, and the species that rely on them.

Volunteer Water Quality Monitoring and Stream Clean-up

Volunteer water quality monitoring in the basin is conducted by both the Missouri Stream Teams program and the Lakes of Missouri Volunteer Program. The Missouri Stream Teams program was initiated by MDC, MDNR, and the Conservation Federation of Missouri. The Lakes of Missouri Volunteer Program is coordinated by the University of Missouri-Columbia, School of Natural Resources and funded by the EPA through MDNR.

Missouri Stream Team sampling sites for the basin are depicted in Figure 18. These volunteers participate in various projects such as litter cleanup, macroinvertebrate sampling, tree planting for bank stabilization, stream inventories, and educational exhibits. For a complete listing of the Missouri Stream Teams and to obtain the data that they have collected, please see the official Missouri Stream Team website.

Fish Consumption Advisories

The MDOH issues fish consumption advisories for Missouri. MDC collects fish annually for use in consumption advisories. The most current consumption advisory information is available from the MDOH.

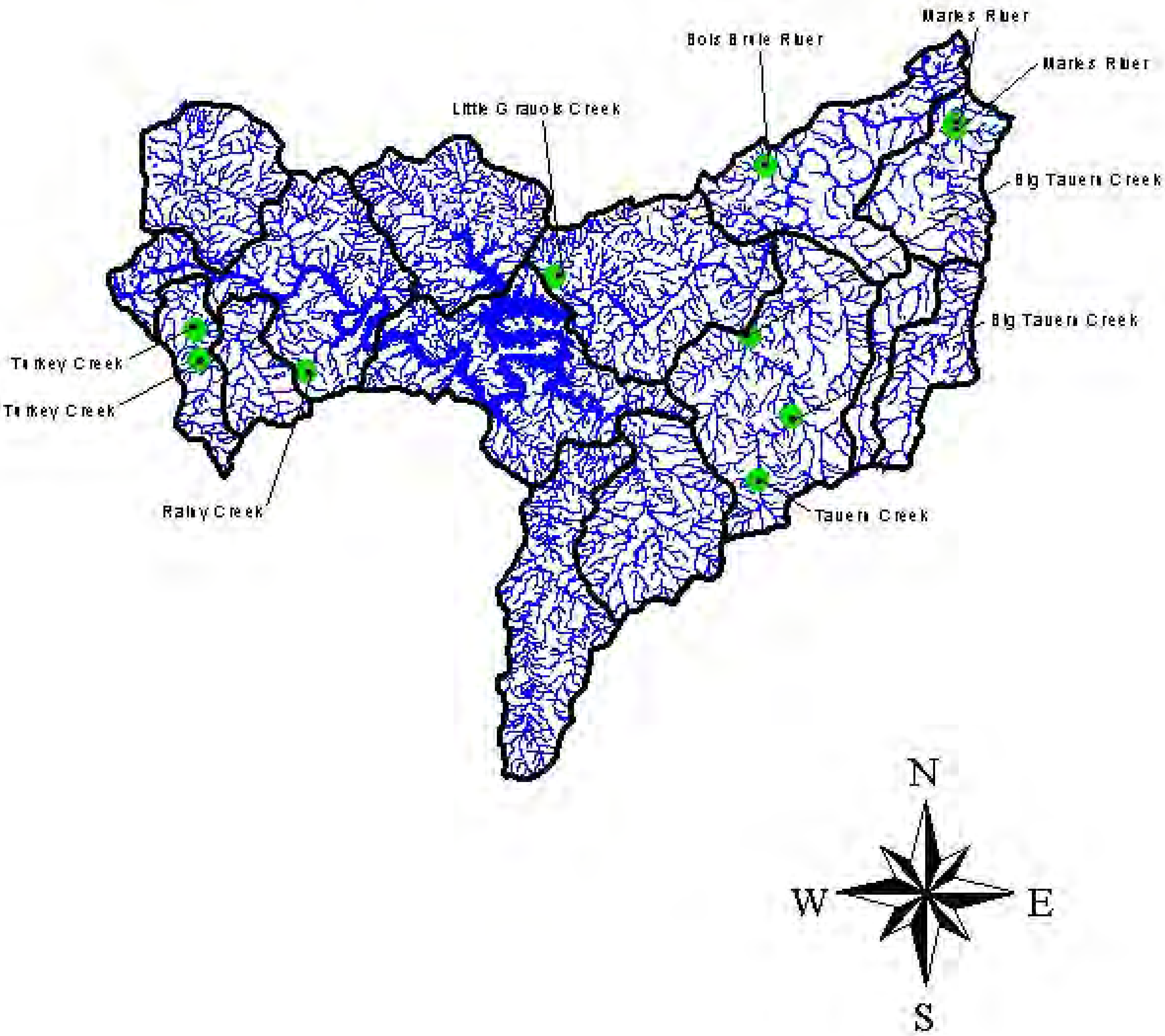
During 2001 the MDOH issued a statewide advisory regarding the consumption of largemouth bass in Missouri. The advisory targets pregnant women, nursing mothers, and children advising that they not consume largemouth bass. It also advises consumption of no more than a specified amount of bass by the remainder of the population. This advisory was issued due to a reduction in EPA's action level for mercury in fish tissue from 1,000 ppb to 200-300 ppb. Missouri's largemouth bass population has for many years had fish with mercury levels in the 200-300 ppb range. In 2001, 100% of the bass collected in Missouri and analyzed for metals contained mercury. Of those samples approximately 32% exceeded 200 ppb. The primary source of mercury to the environment is through air emissions. In Missouri, coal burning boilers account for 90% of mercury emissions.

Fish Kills

MDC maintains a listing of all reported fish kills within the basin and a list of pollution occurrences where no fish kill was reported but may have in fact been detrimental to aquatic populations. The earliest reported fish kill on record was in April of 1960 on a creek near Gravois Mills. Unfortunately, there is no record of the number killed or the cause of that fish kill. The most recent fish kill to date occurred in Lake of the Ozarks in October of 2001. An estimated 70 paddlefish were killed after becoming impinged on turbine intakes on the front of the dam.

The causes of recorded fish kills in the basin have included: low dissolved oxygen, sludge, petroleum, diesel fuel, sewage, gas bubble disease, temperature, parasites, physical injury from turbines, impingement on the face of Bagnell dam, detergent, hog manure, dairy cattle manure, molasses, severe siltation, stream habitat destruction, channelization, and herbicide. The estimated numbers of fish killed per incident range from as few as 3 fish killed in Lake of the Ozarks due to herbicide application to as many as 421,785 in Lake of the Ozarks due to a gas supersaturation in the water resulting from to the operation of Truman Dam.

Figure 18. Stream Team Water Quality Monitoring Sites for the East Osage River Basin



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Number of People Served by Public Supplied Groundwater	25,350 (45%)	7,630 (25%)	32,980 (39%)
Total Number of People Served by Public Water Supply	27,560	13,360	40,920
Total Number of People Served by Private Wells	28,500 (51%)	16,170 (56 %)	44,670 (52 %)
Total Number of People Served in Area	56,060 (65% of total)	29,530 (35 % of total)	85,590 (100 %)
GROUNDWATER WITHDRAWALS (Million Gallon/Day (mgd))			
Groundwater Withdrawals for Commercial Use	0.54	0.18	0.72
Groundwater Withdrawals for Livestock Use	0.28	0.27	0.55
Groundwater Withdrawals for Public Water Supply	1.72	2.04	3.76
Groundwater Withdrawals for Irrigation	0.04	0	0.04
Private Well Withdrawals	1.71	0.96	2.87
SURFACE WATER WITHDRAWALS (mgd)			

Private Surface-water Withdrawals	**0**	**0**	**0**
Surface Water Withdrawals for Public Water Supply	**0.15**	**1.53**	**1.68**
Surface Water Withdrawals for Livestock Use	**0.04**	**0.85**	**0.89**
Surface Water Withdrawals for Commercial Use	**0**	**0**	**0**
Surface Water Withdrawals for Irrigation	**0.07**	**0.05**	**0.12**
TOTAL WITHDRAWALS (mgd)			
Total Groundwater Withdrawals	**4.4**	**3.61**	**8.01**
Total Surface Water Withdrawals	**0.83**	**2.48**	**3.31**
Total Withdrawals for Public Water Supply	**1.87**	**3.57**	**4.44**
Total Withdrawals for Livestock Use	**0.91**	**1.12**	**2.03**
Total Withdrawals	**5.23 (46 % of total)**	**6.09 (54 % of total)**	**11.32 (100%)**

Table 15. Quarterly water quality data from the Osage River near St. Thomas, Missouri, 1984 and 1995. (Data source USGS, 1985, and 1996).

CONSTITUENT	FALL		WINTER		SPRING		SUMMER	
	1984	1995	1984	1995	1984	1995	1984	1995
Instanteneous discharge, (ft3/second)	20,400	12,300	6,730	21,600	35,100	52,700	2,020	31,600
Temperature, (Celcius)	12.0	15.5	1.5	3	16.5	19	25	27.5
Specific Conductance, (Fs/cm)	28	272	251	254	255	281	283	248
pH, whole water, field measurement	8	7.7	7.8	7.2	7.9	7.7	7.6	7.5
Oxygen, dissolved (mg/l)	8.2	9	12.8	12.6	9.2	9.7	6	3.9
Fecal coliform, (colonies/100 ml)	96	1	10	13	<4	1,100	39	5
Fecal streptococci, (colonies/100 ml)	220	475	52	115	80	1,260	22	205
Alkalinity, (mg/l as $CaCO_3$)	106	102	106	83	91	105	123	90
Bicarbonate, dissolved (mg/l)	–	125	–	99	–	126	–	109
Nitrate + Nitrite, total as N (mg/l)	0.33	0.12	0.56	0.47	0.8	0.24	0.45	0.17
Phosphorus, dissolved (mg/l)	0.01	0.03	0.02	0.03	<0.02	0.09	0.02	0.02

Calcium, dissolved (mg/l)	**39**	**0.4**	**37**	**33**	**33**	**34**	**40**	**34**
Magnesium, dissolved (mg/l)	**11**	**9.8**	**11**	**7.9**	**7.7**	**10**	**8.8**	**6.9**
Sodium, dissolved (mg/l)	**5.5**	**4.3**	**5.2**	**5.7**	**7.9**	**4.5**	**5.4**	**8.2**
Potassium, dissolved (mg/l)	**2.9**	**2.8**	**3.2**	**3.4**	**2.4**	**2.3**	**2.6**	**3.2**
Sulfate, dissolved (mg/l)	**26**	**18**	**27**	**22**	**29**	**20**	**26**	**17**
Chloride, dissolved (mg/l)	**5.2**	**8.9**	**6.3**	**8.4**	**5.1**	**5.4**	**4.9**	**3.7**
Flouride, dissolved (mg/l)	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**<0.1**	**0.2**	**0.1**
Total solids, dissolved (mg/l)	**159**	**155**	**170**	**216**	**159**	**158**	**153**	**142**
Aluminum, dissolved (Fg/l)	**<10**	**<10**	**30**	**–**	**20**	**80**	**20**	**–**
Iron, dissolved (Fg/l)	**14**	**6**	**21**	**13**	**18**	**93**	**9**	**<3**
Manganese, dissolved (Fg/l)	**8**	**6**	**8**	**69**	**6**	**7**	**22**	**6**
Nickel, dissolved (Fg/l)	**11**	**<1**	**4**	**<1**	**<1**	**<1**	**10**	**1**
Strontium, dissolved (Fg/l)	**120**	**97**	**110**	**89**	**110**	**83**	**130**	**120**

Table 16. Estimated riparian corridor conditions* for 11-digit, 9-digit, and combined hydrologic units of the East Osage River Basin. (Note: Lower Osage River HUC and Miller County River Hills HUC do not have data on the Osage River channel itself included in percentages.)

Hydrologic Unit Name	Hydrologic Unit Number	Riparian Forest	Riparian Grassland	Riparian Cropland	Riparian Urban
Lower Osage River	10290111060	54 %	40 %	5 %	< 1 %
Lower Maries River	10290111050	55 %	37 %	7 %	< 0.01 %
Upper Maries River	10290111040	52 %	47 %	< 1 %	< 1 %
Little Maries River	10290111030	45 %	54 %	< 1 %	0
Tavern Creek	10290111010	60 %	38 %	1 %	< 1 %
Wet Glaize Creek	10290109070	56 %	43 %	< 1 %	< 1 %
Dry Auglaize Creek	10290109060	42 %	56 %	1 %	1 %
Deer Creek	10290109030	64 %	35 %	< 0.1 %	0
Turkey Creek	10290109010	54 %	45 %	< 1 %	0
Cole Camp Creek	10290109020	54 %	40 %	5 %	< 0.01 %
Upper LOZ Hills	10290109040	75 %	24 %	< 1 %	< 1 %
Gravois Arm	10290109050	73 %	25 %	1 %	< 0.1 %
Lower LOZ Hills	10290109080	82%	17 %	< 1 %	< 1 %
Miller County Osage River Hills	10290111020	65 %	32 %	2 %	< 1 %
LOZ HUC	10290109	63 %	35 %	1 %	< 1 %
Lower Osage River HUC	10290111	58 %	38 %	3 %	< 0.1 %
All Above Subbasins Combined		61 %	36 %	2 %	< 1 %
Lower Osage River	10290111060	46 %	24 %	19%	< 1 %
Miller County Osage River Hills	10290111020	42 %	21 %	22 %	< 1 %

*** riparian corridor conditions estimated by summation of satellite image pixels adjacent to streams depicted on satellite images.**

Estimated riparian corridor is 90 meters wide (extends for 45 meters on either side of the center of each stream).

Table 19. Fish present in MDC fish community samples sampled by seining or visual observation in the East Osage River Basin by subbasin and most recent time period collected*

Common Name	Lower Osage R.	Lower Maries R.	Upper Maries R.	Little Maries R.	Tavern Cr.	Wet Glaize Cr.	Dry Auglaize Cr.	Deer Cr.	Turkey Cr.	Cole Camp Cr.	Upper LOZ Hills	Gravois Arm	Lower LOZ Hills	Miller Co Osg R Hills
Chestnut lamprey		B			C									C
Shovelnose sturgeon														C
Lake sturgeon														A
Longnose gar	B				D					D				C
Shortnose gar	B				D									C
American eel														C
Gizzard shad	D	D			D			C	D	A		A		D
Skipjack herring														C
Mooneye					B									
Goldeye	B													C
Largescale stoneroller	D	D	D	D	D	D	D	D	D	D	D	D		D

Central stoneroller	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**C**	**D**		**D**
Red shiner	**B**	**D**	**A**	**A**	**D**	**D**	**D**			**A**		**A**		**C**
Common carp	**B**				**D**	**D**	**D**	**D**	**D**	**D**				**D**
Goldfish						**D**								**D**
Gravel chub	**B**				**D**									**C**
Bleeding shiner	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Redfin shiner	**A**	**D**	**A**	**A**	**D**		**D**		**D**	**D**				**C**
Wedgespot shiner		**D**	**A**	**D**	**D**	**D**								**C**
Hornyhead chub	**D**	**D**	**D**	**D**	**D**	**D**	**A**	**D**	**B**	**A**	**C**	**D**		**D**
Mimic shiner														**D**
Emerald shiner	**B**													**C**
Golden shiner					**C**	**D**	**D**			**D**		**D**		**D**
Ghost shiner		**A**												**D**
Blacknose shiner			**A**	**A**			**D**							
Sand shiner	**B**	**D**	**A**		**D**	**D**	**D**			**D**		**A**		**C**
Ozark minnow	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**

Western silvery minnow	**B**	**A**			**C**									
Rosyface shiner	**D**	**D**			**D**	**D**	**D**							**D**
Striped shiner														**D**
Suckermouth minnow	**B**	**C**			**C**					**A**				**A**
Southern redbelly dace	**D**		**D**	**D**	**D**	**D**	**D**	**D**			**D**	**D**		**D**
Bluntnose minnow	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**		**D**
Fathead minnow			**D**			**D**	**C**			**D**		**A**		**D**
Gravel chub	**B**	**C**			**D**									**C**
Creek chub	**D**	**C**	**D**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Speckled chub														**C**
White sucker					**D**	**D**	**D**							**D**
Blue sucker														**C**
Highfin carpsucker														**C**
Northern hogsucker	**D**	**D**	**C**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Bigmouth buffalo														**C**

Smallmouth buffalo	**D**													**C**
Black buffalo														**C**
Quillback	**B**					**D**								**C**
Black redhorse	**D**	**D**	**C**	**C**	**D**	**D**	**D**	**D**	**D**	**D**				**D**
Golden redhorse	**D**	**D**	**A**		**D**	**D**	**D**	**D**	**C**	**D**				**D**
Shorthead redhorse		**B**			**C**									**C**
Silver redhorse					**D**									**C**
River redhorse														**C**
Black bullhead	**A**			**C**	**C**		**D**							**C**
Yellow bullhead	**D**	**C**	**C**	**C**	**D**	**C**	**D**	**D**	**D**	**D**	**C**	**D**		**D**
Channel catfish					**D**					**A**				**C**
Flathead catfish														**C**
Blue catfish														**C**
Freckled madtom					**A**									

Slender madtom	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Stonecat					**D**									
Northern studfish	**D**	**D**		**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Blackspotted topminnow	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**A**		**D**
Plains topminnow	**A**	**C**	**D**	**D**	**D**			**B**		**D**	**D**	**D**		**D**
Western mosquitofish		**D**			**D**	**D**	**D**							**D**
Brook silverside	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**A**		**D**
Mottled sculpin	**D**				**D**	**D**		**D**						**D**
Banded sculpin						**D**				**C**	**D**	**A**		
Ozark sculpin					**D**						**D**	**D**		**D**
White bass					**D**									**C**
Rock bass		**B**	**C**	**C**										**D**
River carpsucker	**B**									**A**				**C**
Green sunfish	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Warmouth		**D**												

Orangespotted sunfish		**A**			**C**		**A**			**B**				**A**
Bluegill	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Longear sunfish	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**		**D**
Smallmouth bass	**D**	**D**	**D**	**D**	**D**	**D**	**A**	**D**	**B**	**D**	**D**	**D**		**D**
Spotted bass	**C**	**D**		**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Largemouth bass	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**C**	**D**		**D**
White crappie					**D**		**D**							**C**
Black crappie	**B**													**D**
Greenside darter	**D**	**D**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**A**		**D**
Rainbow darter	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Fantail darter		**D**		**D**		**D**	**D**	**D**	**D**	**D**		**D**		**D**
Least darter								**B**		**D**		**A**		
Niangua darter		**D**			**D**									
Johnny darter	**D**	**A**	**A**		**D**									**C**
Stippled darter	**C**	**C**	**C**	**D**		**D**				**D**	**D**	**A**		**D**

Orangethroat darter		**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Banded darter		**D**			**D**	**D**				**A**				**C**
Missouri saddled darter	**C**	**D**			**D**	**D**								**C**
Slenderhead darter					**D**									**D**
Gilt darter														**C**
Logperch		**D**			**D**	**D**	**D**	**D**	**C**	**D**		**D**		**D**
Northern pike														**C**
Walleye														**C**
Sauger	**B**													**C**
Freshwater drum	**B**				**C**				**D**	**D**				**D**

Time period collected: A = 1931-1946, B = 1947-1973, C = 1974-1990, D = 1991-2001

[1]The most recent collection period for Lower Osage R. was B (1947-1973).

[2]The most recent collection period for Upper LOZ Hills was C (1974-1990).

HABITAT CONDITIONS

Aquatic Community Classification

The majority of the basin lies within the Ozark faunal region (Pflieger 1997). This region is essentially an elevated plain that was uplifted near the beginning of the Pleistocene ice age. It has since been eroded by the streams that drain it. Limestone laid down by an ancient sea underlies most of the region. The limestone contains large quantities of chert that remain as coarse, angular rock fragments when the surrounding limestone dissolves away. The thin, stony soil derived from limestone does not favor intense crop production. Instead, large areas of the region are forested or devoted to pasture. The time span over which the region evolved created very physiographically diverse habitats.

Many streams of the basin occupy narrow, steep-sided valleys, and in places are bordered by sheer limestone bluffs. Streams typically consist of a series of short pools and well-defined riffles. Chert gravel washed down from the surrounding slopes is the most abundant streambed type. Cobble, boulders, and bedrock are also fairly common. The streams found in the basin are some of the clearest in the state. Most of the water that enters them is first filtered through unconsolidated deposits of chert. The basin also has a number of springs which contribute additional clear water to the streams and rivers into which they empty (Pflieger 1997).

Approximately 30 miles of the Lower Osage River are included in the big-river faunal region (Pflieger 1997). This region supports a distinct aquatic species assemblage which sets it apart from the Ozark faunal region. In its original condition, the rivers of the big-river faunal region occupied relatively wide braided channels with many islands and backwaters. Since European settlement, these areas have been subject to channel modification in an attempt to better facilitate river navigation. These modifications have increased velocities in the center of most channels and reduced the number of backwaters.

Several types of aquatic plants occur in the basin. Water cress (*Nasturtium sp.*) is often found near springs. Water willow (*Justicia sp.*) often occurs in riffle areas and along rocky shores and gravel bars. Other plants that are common along rocky areas are spatterdock or yellow pond lily (*Nuphar sp.*). Plants that prefer backwater areas include: coontail (*Ceratophyllum sp.*), water milfoil (*Myriophyllum sp.*), spatterdock or yellow pond lily (*Nuphar sp*.), and pond weeds (*Potamogeton sp.*).

Disturbances Caused by Land Use

Disturbances associated with logging, land clearing, burning, and overgrazing affected stream habitats of the basin and their fish faunas in the late 1800s and the early 1900s, though these changes went largely undocumented. These disturbances increased the bedload of gravel and finer sediments carried by the streams, resulting in higher turbidity, channel instability, and the filling of stream pools and backwaters (Pflieger 1997).

Channel Alterations and Their Effects on Habitat

In most streams and rivers, habitat quality is strongly linked to the stability of channel beds and banks. Unstable streams are less inhabitable to many aquatic species. Factors that increase or decrease sediment supply often destabilize streambeds and banks and result in dramatic channel readjustments (Roell 1999). Since unconsolidated chert is unstable, any disturbance of either a stream basin or its channel may cause accelerated movement of bedload during floods. This moving material tends to fill pools and cover rubble substrates which reduces the both the quantity and quality of fish habitat.

Channelization and Navigational Structures

In upper stream reaches, channelization has been small scale and widely scattered throughout the basin. The effects of these small scale channelization projects can have significant negative localized effects. Channelization increases the slope of the stream which leads to increase stream velocities and increased streambed erosion. Headcuts and bank scour are other negative effects of channelization. Overall the smaller order streams in the uplands of the basin are in relatively good condition and the majority of these streams have not undergone channelization.

On the Osage River, navigational structures have historically changed the shape and stream habitat of the river. MDC has identified 23 wingdike complexes and 10 back channel diversions along the lower Osage River channel. These navigational structures were constructed in the late 1800's and early 1900's to confine the river to a narrower, deeper river channel. These structures have trapped considerable quantities of gravel and sediment behind them and now offer a greater diversity of habitat types to the river.

Dams

Two large hydroelectric projects influence the aquatic habitat of the basin; Truman Dam and Bagnell Dam. These projects have significantly impacted stream habitat in the basin in the last 70 years. The fish faunas of the impounded reaches of these reservoirs (Table 3) has been drastically altered (Pflieger 1997). Aquatic species requiring flowing waters have been replaced by those preferring standing waters.

Impacts of these hydroelectric projects have included impoundment of streams hundreds of miles of flowing streams, bank erosion, siltation, instream flow problems, poor water quality, modified colder temperature regime, loss of riparian corridor, loss of invertebrate habitats, and reduction and/or elimination of spawning habitat. Scouring of the channel bed and banks of the lower Osage River is more apparent below Bagnell Dam than below Truman Dam. Truman Dam discharges soon meet the impounded waters of Lake of the Ozarks thereby dissipating the majority of their energy. Effects from the rapid high flow to low flow transition created by hydropower peaking operation below Bagnell Dam can be seen in streams confluencing with the Osage River below Bagnell Dam in the form of headcutting, steep eroding streambanks, and sediment deposition in stream channels. Bank stabilization procedures such as tree plantings along the Osage River have been tried but with unsatisfactory results. The unpredictability of the timing and volume of water discharged from Bagnell Dam did not allow the establishment of the tree plantings at any of the study sites (AmerenUE 1999).

The effects of the hydroelectric operations extend beyond the impounded stream reaches. Many species have had their life cycles disrupted as they can no longer ascend the river to ancestral spawning areas.

The American eel, paddlefish, sturgeon species, and walleye once ascended the Osage River but now have been denied accessed to necessary upstream habitats above Bagnell and Truman dams.

Many smaller aquatic species are dependent on periodic dispersal to maintain their populations. Populations of these species are maintained by dispersal from one tributary stream to another via larger rivers and streams. These species now occur in small isolated populations in small streams. Historically, small isolated populations of these species were occasionally eliminated by long droughts or other environmental extremes. Replenishment of these populations by upstream migration occurred before large rivers were impounded. Following impoundment, as tributary populations have been eliminated, they can not be replaced by recolonization since the reservoir acts as a dispersal barrier. The Niangua darter is one fish which has been negatively impacted by hydroelectric projects. The Niagua darter's long-term status is in jeopardy over its entire range (Pflieger 1997).

Gravel Mining

Removal of gravel from stream channels is commonly practiced in the basin and significantly degrades the quality of stream ecosystems. Instream gravel mining results in increased sedimentation rates and turbidity, shallower and larger pools downstream, and fewer downstream riffles. Gravel mining is often preceded by removal of riparian vegetation, large woody debris, and large substrate particles. According to a study by Brown and Lyttle (1992), the combined effects of gravel mining resulted in invertebrates and fish of a smaller body size at disturbed and downstream sites.

The most widespread impacts of instream gravel mining on aquatic habitats are bed degradation and sedimentation (Roell 1999). Bed degradation can be caused by pit excavation or bar skimming. Excavation of gravel in an active stream channel lowers the stream bed. This creates a nick point that locally steepens the channel slope and increases the energy locally carried by the stream. At high flows, this nick point becomes a point of bed erosion that moves upstream to form a headcut. Headcuts mobilize the sediments of the streambed sending the eroded sediment and bedload downstream. Headcut will often move considerable distances upstream into tributaries, fields, and eventually threaten bridges, ponds, and buildings. The gravel mined stream bed will incise and become wider. Characteristics of wider/shallower streams include higher temperatures, slower stream flows, less deep water habitat, and lower stream energies causing sediments that were eroded upstream to be deposited at the gravel mined site.

Deposited sediments caused by gravel mining operations can have substantial negative impacts on fish, benthic macroinvertebrates, and mussels (Brown and Lyttle 1992, Grace and Buchanan 1981). Every benthic invertebrate species is adapted to specific substrate particle sizes and bed morphology. Mayflies (*Ephemoptera*), stoneflies (*Plecoptera*), and caddisflies (*Trichoptera*) are the benthic invertebrates most readily available to foraging fishes. These groups are typically most abundant where streambed substrates are a mixture of cobbles, pebbles, and gravels. Cobble-pebble-gravel substrate mixtures are highly susceptible to alteration and encasement by deposited sediments. Once the preferred substrates are encased and covered with sediment, the benthic invertebrate species diversity, abundance, and productivity are reduced (Roell 1999). A reduction in macroinvertebrates available as fish forage in turn cause a decrease in fish numbers, diversity, and productivity. Sedimentation directly affects the ability of freshwater mussel species to feed and maintain their populations.

As discussed in the Water Quality Section, Linn Creek has undergone considerable gravel mining activity. A commercial gravel mining operation adjacent to the town of Linn Creek, Missouri mined considerable quantities of gravel from the adjacent streambed causing a 5-10 foot deep headcut to move upstream (Greg Stoner, MDC, unpublished study). The effects of this operation have been felt upstream for miles and into two tributaries and have disturbed aquatic habitat. Fortunately, a low water bridge below the gravel mining site has acted as a grade control structure which has prevented streambed lowering and degradation downstream of the site.

Riparian Corridor Assessment

Riparian corridors are defined as the stream channel and that portion of the terrestrial landscape from the high water mark towards the uplands where vegetation may be influenced by elevated water tables or flooding, and by the ability of soils to hold water (Naiman et al. 1993). Riparian corridors are some of the most biologically diverse terrestrial habitats. The riparian vegetation also has many environmental effects on stream habitat as well as the biotic community. Riparian vegetation regulates light and temperature regimes, provides nourishment to aquatic as well as terrestrial life, acts as a source of large woody debris (which significantly influences sediment routing, channel morphology and instream habitat), and regulates the flow of water and filters nutrients and pollutants from uplands to the stream. They are also the sites for chemical transformation of certain compounds.

Riparian corridor conditions of the basin were estimated by the summation of satellite image pixels adjacent to streams depicted on satellite images (Table 16). The majority of the riparian corridor is forested in all subbasins except the Little Maries River (45% forested) and the Dry Auglaize Creek (42% forested) Subbasins. The largest portion of forested riparian corridor is found in the Lower Lake of the Ozark Hills (82%) and the upper Lake of the Ozarks Hills (75%). The proportion of riparian corridor in grass cover ranged from 17% in the Lower Lake of the Ozarks Hills to 56% in Dry Auglaize Creek. Most subbasins had 1% or less of the riparian corridor currently in cropland. Exceptions included the Lower Osage River (5%), the Lower Maries River (7%), Cole Camp Creek (5%), and Miller County River hills (2%) subbasins with more of the riparian corridor in crops. Also the Osage River below Bagnell Dam averaged near 20% riparian cropland.

Stream Habitat Assessment Methods

Aerial Photos

In order to document the current state of the Osage River channel below Bagnell Dam, MDC took a series of aerial photos of the channel during low flow conditions during the month of August 2001. Fifty-seven points were selected (approximately 1.5 miles apart) along the channel and photographed while hovering over the channel by helicopter. A number of habitat types including riffles, runs, pools, islands, and gravel bars were observed and photographed. The lock and dam #1 at RM 12.1 as well as the gravel mining operation at Tuscumbia were also photographed. These photos will be part of an MDC archive collection. It is hoped that similar photos can be taken in the future to document any changes to the channel which are occurring from gravel mining, riparian corridor removal, water level fluctuations or excessive discharge from Bagnell Dam.

<u>Onsite Stream Habitat Assessment</u>

Many streams in the basin have problems with cattle access and non-existent or poor quality riparian corridors. Symptoms of excessive cattle grazing include bank erosion, poorly vegetated riparian corridors, and nutrient enrichment from cattle wastes. There are some areas with good forested streamside corridors present. These areas are often affected by lack of upstream and/or downstream corridor which create a patchy and ineffective stream corridor. The headwaters of many streams in the basin are forest or grazed pasture. Stream channels that are frequented by cattle are generally eroded.

The following observations for individual streams are based on information recorded at specific locations during fish collections in September and October 1996. Onsite stream habitat assessment were not representative of the conditions along the entire stream or subbasin. The amount of time required to sample the entire stream or subbasin in this fashion made this method of habitat description time-prohibitive. Therefore, only a few sites were described in this manner.

<u>Onsite Stream Habitat Descriptions</u>

Cole Camp Creek Site #1 (T42N, R21W, Sec. 2) - This reach had 45% of the stream shaded. The bank stability was good with the riparian corridor extending to the stream's edge with some trees in the water. There were no visible signs of bank erosion except for one section of unprotected cut bank near the bridge. The bank vegetation was estimated to be 35% trees, 25% shrubs, 30% non-woody herbaceous, and 5% without vegetation. Beyond the riparian corridor, the land cover was 25% forest, 25% pasture, and 50% row crops. The width of the tree corridor on the left bank was 1-10 meters, on the right bank, the riparian corridor was 50% 1-10 meters and 50% was greater than 100 meters. All pool habitat had a depth of at least 6 ft. The site was too deep to adequately sample substrate. There were large boulders directly above the bridge and some woody debris in the stream.

Cole Camp Creek Site #2 (T42N, R21W, Sec. 28) - This reach had 20% of the stream shaded. The bank stability was poor with a large portion of vertical cut bank both at the site and below the site. A very large gravel bar with no vegetation was disturbed by gravel removal. The bank vegetation was estimated to be 20% trees, 30% shrubs, 30% non-woody vegetation, and 20% without vegetation. Beyond the riparian corridor, the land cover was 50% forest and 50% ungrazed pasture. The width of the tree corridor on the left bank was greater than 50 meters. On the right bank, the riparian corridor was greater than100 meters. There was a thin layer of silt deposited on substrate particles. The substrate composition was 10% silt, 5% sand, 20% fine gravel, 25% coarse gravel, 20% pebble, 15% cobble, and 5% boulder. Some water willow (*Justicea americana*) was observed at the site.

Cole Camp Creek Site #3 (T42N, R21W, Sec. 8) - This reach had 60% of the stream shaded. The bank stability was poor with a large portion of vertical cut bank with exposed bedrock at the base. The bank vegetation was estimated to be 35% trees, 15% shrubs, 25% non-woody vegetation, and 25% without vegetation. Beyond the riparian corridor, the land cover was 100% ungrazed pasture. The width of the tree corridor on the left bank was 50% <10 meters and 50% 25-50 meters. On the right bank, the riparian corridor was 25-50 meters. The substrate composition was 5% sand, 5% fine gravel, 10% coarse gravel, 10% pebble, 15% cobble, and 5% boulder and 50% bedrock. This site was a good mixture of riffles, runs, and pools.

Turkey Creek Site #1 (T39N, R21W, Sec. 5) - This reach had 85% of the stream shaded. Bank stability was poor with vertical cut banks about 3m high on both sides of the stream. The right bank was protected by trees and a rock bluff. The left bank has a small riparian corridor with scattered trees. Cattle have eaten or trampled most of the understory of the left bank. The bank vegetation was estimated to be 30% trees, 10% shrubs, 40% non-woody vegetation, and 20% without vegetation. Beyond the riparian corridor, the land cover was 50% forest and 50% grazed pasture. The width of the riparian corridor on the left bank was about 1-10 meters. On the right bank, the riparian corridor was over 100 meters wide. The substrate composition was 5% silt, 5% sand, 25% fine gravel, 25% coarse gravel, 35% pebble, and 5% cobble. Cattle had open access to the stream from the left bank. Habitat was simple with one long wide shallow (1 ft deep) pool with a few deep (3 ft) areas. Algae was present both at the surface and attached to the bottom. There was a small amount of simple riffle-run habitat, some woody debris, and one large (est. 70 m) gravel bar.

Turkey Creek Site #2 (T39N, R21W, Sec. 28) - This reach had 25% of the stream shaded. The bank stability was poor. The left bank has a large unprotected cut bank about 3 m high and 40 m long. The corridor has been heavily trampled by cattle on both sides of the stream. There is one stable gravel bar. The bank vegetation was estimated to be 25% trees, 5% shrubs, 40% non-woody vegetation, and 30% without vegetation. Beyond the riparian corridor, the land cover was 50% grazed forest and 50% grazed pasture. The width of the tree corridor on the left bank was about 1-10 meters. On the right bank, the riparian corridor was over 100 meters wide. The substrate composition was 5% silt, 3% sand, 10% fine gravel, 20% coarse gravel, 35% pebble, 25% cobble, and 2% bedrock. There was a small amount of aquatic vegetation (*Justicea*) but limited fish cover. There were small riffles separating pools with a small amount of woody debris. The pools were 1-5 ft deep.

Deer Creek Site # 1 (T39N, R20W, Sec. 21) - This reach had 20% of the stream shaded. The bank stability was poor. The majority of the bank was in good shape but there were some areas of cut bank. The lower left bank was protected by trees and a rock bluff. The right bank was narrow with a grazed corridor. The bank vegetation was estimated to be 30% trees, 40% shrubs, 20% non-woody vegetation, and 10% without vegetation. Beyond the riparian corridor, the land cover was 50% forest and 50% grazed pasture. The width of the tree corridor on the left bank was over 100 meters wide. On the right bank, the riparian corridor was > 10 meters wide. The substrate composition was 3% silt, 15% sand, 17% fine gravel, 10% coarse gravel, 20% pebble, 20% cobble, and 5% boulder, and 10% bedrock. There was aquatic vegetation (*Justicea*) providing some cover. There was open access to cattle on both sides of the stream with large amounts of algae on the bottom. There was a good mix of habitat types with some deep pools, some backwater habitat, and some areas fairly wide and shallow.

Deer Creek Site #2 (T40N, R20W, Sec. 19) - This reach had 45% of the stream shaded. The bank stability was good. The banks were stable on both sides with the exception of one unstable gravel bar. The bank vegetation was estimated to be 35% trees, 10% shrubs, 40% non-woody vegetation, and 15% without vegetation. Beyond the riparian corridor, the land cover was 75% forest and 25% ungrazed pasture. The width of the tree corridor on both banks was over 100 meters wide with the exception of one small area without trees. The substrate composition was 10% silt, 5% sand, 20% fine gravel, 30% coarse gravel, 30% pebble, and 5% cobble. There was aquatic vegetation (*Justicea*) and water cress in some pools providing some cover. Woody debris also provided good cover. There was a good mix of habitat types with some deep pools, some backwater habitat, and stable gravel bars.

Big Buffalo Creek (Site #1) (T41N, R19W, Sec. 7) -This reach had 55% of the stream shaded. The bank stability was poor with one long cut bank. The bank vegetation was estimated to be 15% trees, 40% shrubs, 30% non-woody vegetation, and 15% without vegetation. Beyond the riparian corridor, the land cover was 50% forest and 50% ungrazed pasture. The width of the tree corridor on the left bank was over 100 meters wide. On the right bank, the tree corridor was < 10 meters wide. The substrate composition was 10% sand, 25% fine gravel, 20% coarse gravel, 20% cobble, and 5% bedrock. This site had a good mix of riffle, run, and pool habitat.

Big Buffalo Creek (Site #2) (T41N, R20W, Sec. 23) - This reach had 65% of the stream shaded. The bank stability was poor with one long cut bank on the right side. The left bank had a large amount of unstable gravel bars. The bank vegetation was estimated to be 15% trees, 10% shrubs, 35% non-woody vegetation, and 40% without vegetation. Beyond the riparian corridor, the land cover was 100% forest. The width of the tree corridor on both banks was over 100 meters wide. The substrate composition was 3% sand, 17% fine gravel, 30% coarse gravel, 30% pebble, 15% cobble, and 5% boulder. There was no aquatic vegetation present at this site. This site had a good mix of riffle, run, and pool habitat. The maximum pool depth was more than 3 ft. There was a small amount of cover provided by root wads and cobble.

Unique Habitats

Natural Features Inventories have been completed for the basin. These inventories are ongoing efforts by M to identify and rank outstanding examples of natural communities, rare or endangered species habitat, and other significant features of interest. Several natural communities/features in the basin are listed in the MDC Natural Heritage Database. These features include: dolomite glades, caves, dry-mesic chert prairie, acid seeps, deep muck fens, dry limestone/dolomite cliffs, creeks and small rivers, mesic bottomland forests, hardpan prairies, dry chert forests, sandstone glades, large Ozark rivers, Ozark sloughs, and springs (for more information, contact the MDC Natural History Division).

Lake of the Ozarks Habitat

The upper parts of Lake of the Ozarks various arms are stream-like with a defined channel and continuous current and a fair amount of woody debris. Moving downstream, the stream characteristics are delta-like with a poorly defined stream channel and sluggish currents. These areas are typically wide and shallow, and also contain a fair amount of woody structure. Areas downstream from deltas are typical lake habitats. The majority of the banks in the area are steeply sloping and covered with coarse gravel, rock, or boulders. The depth of Lake of the Ozarks channel ranges from 8 to more than 100 feet deep. The majority of the standing timber below elevation 660' was removed prior to filling the lake. In an effort to increase woody fish habitat, many individuals as well as the Camdenton Chamber of Commerce have placed hundreds of dead trees into the lake to serve as fish habitat.

The MDC also places these woody structures at MDC accesses in an effort to provide better aquatic habitat (Stoner 2000). Additionally, trees have washed into the lake from surrounding tributaries or have fallen into the water along the shore to provide better aquatic habitat.

Instream Habitat/Bank Stabilization Projects

Tavern Creek Subbasin

There have been two stream improvement project completed on private land in the Tavern Creek Subbasin. A cedar tree revetment was installed and a 100 foot riparian corridor was planted to complete this project. This project took place on Little Tavern Creek in Maries County (Rob Pullium, MDC, personal communication).

The second of these projects took place along Tavern Creek in Miller County directly across from Brays Access. The site consisted of a 10-12 foot tall vertical actively eroding bank approximately 800-850 feet in length located on the outside of a bend on the right descending bank. Sand content in the bank soil was very high. The site contained no riparian corridor. The left bank was a large gravel bar that was in the early stages of stabilization. Many small sycamores had become established on the gravel bar. Streambank erosion was addressed by installation of a cedar tree revetment approximately 550 feet in length. Restoration of the 100 foot riparian corridor was attempted by planting 200 green ash trees. Problems ensued soon thereafter. The trees used in the revetment were too small. The sandy soil and inadequate bank coverage by the revetment led to further erosion during flood events. The willow stakes planted on the eroding bank and many of the ash trees planted in the corridor died.

Wet Glaize Creek Subbasin

Two streambank stablization projects were undertaken adjacent to Wet Glaize Creek on the Toronto Springs Conservation Area. Both involved cedar tree revetments with willow staking.

The first site was a 600 foot long bank at the downstream (northwest) end of the conservation area. About 400 feet of the bank was actively eroding. The 10 foot vertical bank was experiencing undercutting and sloughing. Large trees in the channel were aggravating the bank erosion. The second site was a 200 foot long section of bank near the middle of the area. Woody vegetation had been removed from the riparian zone and the 8 foot high vertical banks were eroding in the adjacent pasture.

At the first site, tops of trees were removed from the middle of the channel. Cedar trees were used to construct cedar revetments at both sites. Trees were planted in the riparian area at the first site. At the second site, the streambank was planted with willows during the dormant season. Hardwoods were planted to re-establish trees along the riparian corridor. The stabilization project at site one was later inspected and found to be in poor condition and not working well. The second site met with better results. The second site was found to be intact and working well.

Maries River Subbasin

There are two stream improvement projects currently underway on private land in the basin besides the previously mentioned SALT and EARTH projects. For the first project, tow rock and four hardpoints were installed to control erosion on the Maries River. There was a resulting 700 feet of stream bank protected. The corridor along the river and a drainage into the river were replanted to trees to a width of

100 feet. Additionally, this landowner plans to implement an alternative watering system for cattle, exclude cattle from the stream, remove a levee, and plant trees and warm season grasses for 1/4 mile along the stream.

Another project is being implemented along Little Maries Creek and the Maries River near Westphalia. In this project, a landowner has 400 feet of eroding streambank that was treated with 3 hardpoints. Additionally, the landowner will plant 10.1 acres of cropland to trees while reestablishing the riparian corridor to a width of 100 ft.

Upper Lake of the Ozarks Hills Subbasin

The MDC has completed several studies on the Big Buffalo Creek Conservation Area which involved stream habitat improvement. MDC purchased this area in 1963. During the 1940's, a section of Big Buffalo Creek was channelized together with a section of Pole Hollow Creek. The combined creeks were directed into one 0.8 mile long nearly straight channel. This was the result of attempts by the previous landowner to speed up the movement of flood flows through the property and thus minimize flooding of low lying cropland. The straightening of the stream resulted in a poorly defined, unstable, shallow channel practically devoid of fish cover. MDC planned to dechannelize this stream and sampled the fish community before restoration efforts were undertaken. In 1965, MDC separated the two channels totaling 1.8 miles in length. This was similar to the lengths of the streams prior to channelization. Also, log, rock, and gabion structures were installed to stop bank erosion and provide fish cover. It was determined that restoration efforts were successful and that fish populations did increase along the restored streams (Fajen 1975).

The MDC manages the aquatic habitat of the Saline Valley Conservation Area. During the period from 1983-1986, MDC attempted to alter the stream flow of Saline Creek on the Saline Valley Conservation Area using earthen berms. The purpose of the berm construction was to increase the sinuosity of the stream channel. Instream habitat improvement structures were also installed on Little Saline Creek to create deep pool habitat. More recently, management efforts on the area have focused on stabilizing stream erosion sites and reestablishing woody riparian corridors to a width of 200 ft along 3rd order and larger portions of the Osage River, Saline Creek, Little Saline Creek, Jack Buster Creek, and Jim Henry Creek within the area boundaries. Efforts are also underway to establish a similar corridor of 100 ft on 1st and 2nd order streams of the area.

Table 3. Total county populations and estimated changes for Missouri counties that include portions of the East Osage River Basin.

County	1990 Pop.	1995 Pop.	2000 Est.	2005 Est.	2010 Est.	2015 Est.	2020 Est.
Benton	13,859	14,705	15,421	15,992	16,404	16,621	16,629
Camden	27,495	30,950	34,061	36,838	39,135	40,872	41,978
Cole	63,579	66,418	68,761	70,803	72,645	74,244	75,515
Hickory	7,335	7,758	8,103	8,345	8,475	8,499	8,429
Laclede	27,158	28,524	29,834	31,124	32,373	33,593	34,700
Maries	7,976	8,183	8,389	8,587	8,788	8,975	9,122
Miller	20,700	21,710	22,730	23,812	24,897	25,916	26,860
Morgan	15,574	16,433	17,197	17,883	18,456	18,883	19,145
Osage	12,018	11,979	11,929	11,912	11,914	11,923	11,920
Pulaski	41,307	43,816	46,322	48,994	51,836	54,742	57,634
Total	237,001	250,476	262,747	276,295	286,933	296,283	303,952

Source: Missouri State Office of Administration (1998).

BIOTIC COMMUNITIES

The East Osage River Basin hosts a diverse biotic community including many aquatic species. Fauna was first categorized, recorded, and named as early explorers moved up into the basin and into surrounding areas. Over time many of the earlier records of certain faunal collections have become obscure or unobtainable. This is unfortunate as these records were some of the only means to accurately describe the regions faunal composition prior to and during the early days of settlement.

Since settlement of the basin by European settlers and their descendants, numerous changes to the habitat have prompted coinciding shifts in aquatic as well as terrestrial fauna. As the backwater areas were drained to be used as farmland, steep slopes were plowed for crop production, and the timber harvested for various uses, many of the species which depended on these habitats either persisted as best as they could or dropped out of the picture all together. Bison, elk, wolves, mountain lions, and passenger pigeons are just a few of the more spectacular species which could not cope with the habitat changes and/or hunting pressure brought about by European settlement and disappeared from the basin entirely. Numerous species have persisted although in reduced numbers. Sturgeon were once plentiful in the Osage Riveras were paddlefish and walleye.

Smaller fishes such as the Niangua darter presently have their existence in peril due to degraded water quality and their inability to replenish depleted populations due to impoundment of the larger reaches of streams and rivers which they once used as dispersal corridors (Pflieger 1997). Numerous freshwater mussel species are similarly in jeopardy due to overharvest, degradation of habitat from gravel dredging and siltation, manipulation of river levels and temperature regime by dams, and competition with exotic species.

Despite the human-induced impacts to the fauna of the region, high species diversity and population levels persist for those species which have adapted well to the changes. Populations of sportfish and game animals provide ample recreational opportunities. The Missouri Department of Conservation regulates the taking and possessing of Missouri fauna.

MDC Fish Community Samples

Fish community data of the basin were first recorded and archived by MDC in the 1930s. Since that time, numerous population monitoring efforts have resulted in a substantial database of fish community samples. The species composition of the more abundant gamefish, large non-game fish, and small non-game fish per subbasin is presented below (Table 17). For ease of discussion, the periods of fish community collections by MDC have been separated into four distinct time periods: Period A (prior to 1946), Period B (1946-1973), Period C (1974-1990), and Period D (1991-2001)(Tables 18, 19, 20, 21). By comparing the four time periods, shifts in fish community structure can be more easily discerned.

Fish communities have been sampled in the basin by MDC using kick seines, drag seines, electrofishing equipment with DC current, rotenone, and visual observation (Table 22). There have been a total of 178 fish community samples collected by MDC within the basin. These samples represent 113 unique sampling locations (Figure 19). A total of 131,154 fish make up the samples basin-wide with 102 species represented. The fish community samples of each subbasin are described below. The early fish collections were made by W. Pflieger. More recent fish collections have been made by M.. Bayless, S. Bruenderman, T. Groshens, H.. Mattingly, M.. Smith, M.. Boyer, and M.. Winston.

Cole Camp Creek Subbasin Fish Community Samples

Within this subbasin, MDC has made 10 samples representing five unique sites. One sample was taken in 1940. Two samples were taken in 1962. Two samples were taken in 1976 and the remainder were taken after 1994. All samples were taken using seining equipment with one sample supplemented with visual observations. Six thousand and fifty-four fish make up the samples of this subbasin, representing forty-five species.

The most abundant game fishes captured within the subbasin were green sunfish (1.5%), longear sunfish (0.99%), bluegill (0.76%), and largemouth bass (0.45%). The most abundant large non-game fish species captured within the basin were the golden redhorse (0.38%) and black redhorse (0.28%). The most abundant small non-game fish species present in the samples were Ozark minnow (38.0%), bleeding shiner (9.4%), northern orangethroated darter (8.8%), and brook silverside (6.4%). There was a higher percentage of Ozark minnows and orangethroat darters collected in the Cole Camp Creek Subbasin than in any other subbasin.

The least abundant fish species captured within this subbasin were banded darter, banded sculpin, channel catfish, common carp, freshwater drum, gizzard shad, and hornyhead chub with only one specimen each of these species present within the samples. The species which have not been collected by MDC during fish community sampling efforts within this subbasin since 1940 include: gizzard shad, red shiner, hornyhead chub, suckermouth minnow, channel catfish, river carpsucker, and banded darter. The orangespotted sunfish has not been collected since 1962. The banded sculpin has not been collected since 1976. Fish species of conservation concern present within this subbasin include plains topminnow and least darter.

Upper Lake of the Ozarks Hills Subbasin Fish Community Samples

Within this subbasin, MDC has made 10 fish community samples representing seven unique sites. Three samples were taken using electrofishing equipment. One was taken in 1964 and two were taken in 1976. Samples using seining equipment were taken in the following years: one in 1940, one in 1976, one in 1979, and four in 1995. Three thousand eight hundred and fifty fish make up the samples of this subbasin representing twenty-nine species.

The most abundant game fishes captured within the subbasin were green sunfish (13.2%), smallmouth bass (9.9%), and bluegill (5.3%). The most abundant small non-game fish species present in the samples were bleeding shiner (20.2%), central and largescale stonerollers (8.1%), creek chub (7.9%), and southern redbelly dace (6.8%). There was a greater percentage of green sunfish, creek chubs, smallmouth bass, yellow bullheads, and northern hogsucker collected in this subbasin than in any other.

The least abundant fish species captured within this subbasin were banded sculpin, channel catfish, longear sunfish, Ozark sculpin, spotted bass, and stippled darter with only one specimen each of these species present within the samples. The species which have not been collected by MDC during fish community sampling efforts within this subbasin since 1964 include channel catfish and longear sunfish. The hornyhead chub, yellow bullhead, and largemouth bass has not been present in MDC fish community samples in this subbasin since the 1970's.

Gravois Arm Subbasin Fish Community Samples

Within this subbasin, MDC collected six samples representing four unique sites. Three samples were taken in 1940. One sample was taken in each of the years 1996, 1999, and 2000. All samples of this subbasin were taken using seining equipment with one sample supplemented with visual observations. One thousand and ten fish, representing 35 species, comprise the samples collected within this subbasin.

The most abundant game fishes represented within the samples of this subbasin were longear sunfish (5%), largemouth bass (3%), and smallmouth bass (2.2%). The only large non-game fish species present was northern hogsucker (1.3%). The most abundant small non-game fish species present were bleeding shiner (25%), northern studfish (14.6%), and Ozark minnow (11.3%). There was a greater percentage of largemouth bass and northern studfish collected in the Gravois Arm than in any other subbasin.

The least abundant fish species captured within this subbasin were banded sculpin, brook silverside, fathead minnow, golden shiner, greenside darter, least darter, Ozark sculpin, plains topminnow, sand shiner, southern redbelly dace, spotted bass, and yellow bullhead with only one specimen each of these species present within the samples. Since 1940 gizzard shad, red shiner, sand shiner, fathead minnow, blackspotted topminnow, brook silverside, banded sculpin, greenside darter, least darter, and stippled darter have not been collected by MDC. Species of conservation concern present within this subbasin include plains topminnow and least darter.

Miller County Osage River Hills Subbasin Fish Community Samples

Within this subbasin, MDC collected 24 samples representing 15 unique sites. One sample was taken in 1937, three in 1940, eight in the mid-70s, and seven samples have been collected since 1994. All samples of this subbasin were taken using seining equipment with three samples supplemented with visual observations. Thirty-three thousand, two hundred and twenty-seven fish make up the samples of this subbasin. This is the most diverse subbasin in the basin with eighty-nine species represented.

The most abundant gamefishes were bluegill (5.5%), longear sunfish (1.5%), channel catfish (1.3%), spotted bass (0.6%), and white crappie (0.5%). The most abundant large non-game fish species present were river carpsucker (1.5%), longnose gar (1%), common carp (0.32%), and smallmouth buffalo (0.31%). The most abundant small non-game fish species present were emerald shiner (17%) and gravel chub (14.1%). White crappie dominated this and the Dry Auglaize Creek samples. A higher percentage of bluegill, spotted bass, channel catfish, river carpsuckers, longnose gar, gravel chubs, emerald shiners, bluntnose minnows, and brook silversides were collected in the Miller County Osage River Hills than in any other basin.

The black bullhead, greenside darter, lake sturgeon, northern pike, orangespotted sunfish, river redhorse, shovelnose sturgeon, speckled chub, and the striped shiner were the least abundant species captured with only one specimen of each of these species collected. Since 1940, the lake sturgeon, suckermouth minnow, and orangespotted sunfish have not been collected by MDC. An additional thirty-eight fish species have not been collected in this subbasin since the mid-70s (Table 25). However, no fish community samples have been collected from the Osage River in this subbasin since that time period. Species of conservation concern present within this subbasin include the plains topminnow, lake sturgeon, blue sucker, paddlefish, ghost shiner, highfin carpsucker, and least darter.

Lower Osage River Subbasin Fish Community Samples

Within this subbasin, MDC has collected nine samples representing six unique sites. Seining was used as the method of capture during 1940, 1962, 1963, 1976, and 1996. Two seining samples also were supplemented with visual observations. Two additional samples were taken in 1962 and 1963. In the 1962 sample, seining, shocking, and cyanide were used as methods of capture. In the 1963 sample, only electrofishing was used. Six thousand one hundred and one fish make up the samples of this subbasin.

The most abundant game fishes represented within the samples of this subbasin were bluegill (4.6%), longear sunfish (3.1%), and spotted bass (1.4%). The most abundant large non-game fish species present were shorthead redhorse (0.8%) and black redhorse (0.7%). The most abundant small non-game fish species present in the samples were Ozark minnow (29.9%) and bleeding shiner (15.5%). This subbasin had a greater percentage of shorthead redhorse collected than any other subbasin.

The least abundant fish species captured within this subbasin were black crappie, flathead catfish, greenside darter, mottled sculpin, northern pike, sauger, shortnose gar, silver chub, silver redhorse, silverband shiner, slenderhead darter, and smallmouth buffalo with only one specimen of each of these species present within the samples. The redfin shiner has not been collected by MDC during fish community sampling efforts within this subbasin since 1940. An additional ten fish species have not been collected in this subbasin since 1963 (Table 25) because there have been no fish community samples taken from this subbasin since then. Species of conservation concern captured within this subbasin include plains topminnow, western silvery minnow, silver chub, ghost shiner, and Alabama shad.

Lower Maries River Subbasin Fish Community Samples

Within this subbasin, MDC has made 12 samples at six sites. Seining was used only during 1940, 1964, 1976, and 1996. Samples using only visual observations were taken in 1975 and 1996. In 1994, an additional sample was taken using seining and electrofishing. Seven thousand eight hundred and seventy-seven fish were sampled in this subbasin.

The most abundant game fishes sampled in this subbasin were longear sunfish (4.0%), bluegill (1.1%), spotted bass (0.51%), and smallmouth bass (0.5%). The most abundant large non-game fish species present were black redhorse (0.7%), common carp (0.5%), and golden redhorse (0.5%). The most abundant small non-game fish species present in the samples were Ozark minnow (22.1%), bleeding shiner (20.4%), wedgespot shiner (9.8%) and striped fantail darter (5.1%). This subbasin had a greater percentage of common carp, golden redhorse, largescale stoneroller, and wedgespot shiner collected than any other subbasin.

The least abundant fish species captured within this subbasin were ghost shiner, johnny darter, orange spotted sunfish, silver redhorse, warmouth, and white bass with only one specimen each of these species present within the samples. The chestnut lamprey has not been collected by MDC during fish community sampling efforts within this subbasin since 1964. Species of conservation concern present within this subbasin include plains topminnow, western silvery minnow, and Niangua darter.

Upper Maries River Subbasin Fish Community Samples

Within this subbasin, MDC has made seven samples representing five unique sites all by seining. Three samples were taken in 1976. One sample was taken in each of the years 1940, 1964, and 1995. Seven thousand two hundred and ninety-nine fish were sampled representing 36 species.

The most abundant game fishes represented in this subbasin were longear sunfish (0.8%), bluegill (0.4%), yellow bullhead (0.3%) and smallmouth bass (0.3%). Only two individual large non-game fishes were captured within this subbasin, a golden redhorse and a black redhorse. This subbasin had a greater percentage of southern redbelly dace captured than any other subbasin. The least abundant fish captured within this subbasin were black redhorse, fathead minnow, golden redhorse, northern pike, red shiner, and wedgespot shiner with only one specimen of each of these species present within the samples. Since 1940, MDC has not collected red shiners, redfin shiners, or wedgespot shiners. Species of conservation concern present within this subbasin include plains topminnow and blacknose shiner.

Little Maries River Subbasin Fish Community Samples

Within this subbasin, MDC collected nine samples at four sites. One sample was taken in 1940 and 1964, four samples in the mid 70's, and three samples were taken in 1995. Seining was the sole sampling method. Five thousand, eight hundred and twelve fish were collected in this subbasin representing thirty-three fish species.

The most abundant game fishes represented were longear sunfish (1.6%), smallmouth bass (1.1%), and bluegill (0.8%). The only species of large non-game fish captured was black redhorse (0.03%) The most abundant small non-game fish species sampled were bleeding shiner (30%), Ozark minnow (13.6%), central stoneroller (10.2%), and striped fantail darter (9.9%). This subbasin had a greater percentage of striped fantail darters collected than any other subbasin.

The least abundant fish species captured within this subbasin were black bullhead, greenside darter, and spotted bass with only one specimen of each of these species present within the samples. The red shiner and redfin shiner have not been collected by MDC during fish community sampling efforts since 1940. Species of conservation concern present within this subbasin include blacknose shiner and plains topminnow.

Tavern Creek Subbasin Fish Community Samples

Within this subbasin, MDC collected 48 samples at 31 unique sites. Four samples were taken in 1940 and four samples in 1964. Twenty-nine samples were taken in the mid-70s and the remainder were taken since 1994. Forty-four samples were taken using seining with visual observations supplementing nine of these. Four samples were taken by visual observation only. Thirty-four thousand, three hundred and eighty-one fish make up the samples of this subbasin representing sixty-eight species.

The most abundant game fishes represented within the samples of this subbasin were longear sunfish (1.6%), smallmouth bass (1%), and bluegill (0.8%). The most abundant large non-game fish species present were black redhorse (0.4%) and northern hogsucker (0.2%). The most abundant small non-game fish species present in the samples were bleeding shiner (27%) and Ozark minnow (14.8%).

The least abundant fish species captured within this subbasin were common carp, emerald shiner, freckled madtom, mooneye, Ozark sculpin, western silvery minnow, and white bass with only one individual of each of these captured. The mooneye has not been collected by MDC during fish community sampling within this subbasin since 1964. The chestnut lamprey has not been collected since 1975. Species of conservation concern within this subbasin include Niangua darter, plains topminnow, and western silvery minnow.

Wet Glaize Creek Subbasin Fish Community Samples

Within this subbasin, MDC collected 13 samples at 9 unique sites. One sample was taken in 1967 using seining and electrofishing. One sample was taken in 1975 using visual observation only. The remaining samples were taken in the years 1962, 1975, 1998, and 1999 by seining with three of these remaining samples supplemented with visual observations. Six thousand, seven hundred and thirty-seven fish were collected in this subbasin. Fifty-seven species are represented within the samples.

The most abundant game fishes represented within the samples of this subbasin were green sunfish (0.9%) and longear sunfish (0.34%). The most abundant large non-game fish species present was northern hogsucker (0.5%). The most abundant small non-game fish species present in the samples were bleeding shiner (29%), Ozark minnow (12.3%) and fathead minnow (8.8%). This subbasin had a greater percentage of fathead minnows collected than any other subbasin possibly due to the continued incidental introduction of this species into the streams by fish hatcheries in the basin.

The quillback, river carpsucker, and walleye were the least abundant fish species with only one specimen collected. Since 1967, chestnut lamprey, longnose gar, and gizzard shad have not been collected by MDC. However, there have been no collections made with electrofishing in this subbasin since then. There were no species of conservation concern collected within this subbasin.

Dry Auglaize Creek Subbasin Fish Community Samples

Within this subbasin, MDC has collected 24 samples representing 17 sites. One sample was taken in 1931 using a seine. A second sample was taken in 1975 using seine and visual observations. The remaining twenty-two samples were taken 1996-2000 using seines with one of these samples supplemented with visual observations. Sixteen thousand six hundred and ninety-five individuals were collected in this subbasin representing forty-one species.

The most abundant game fishes represented within the samples of this subbasin were green sunfish (2.5%) and bluegill (2.3%). The most abundant large non-game fish species present were white sucker

(0.9%) and black redhorse (0.4%). The most abundant small non-game fish species present in the samples were central stoneroller (28.6%), Ozark minnow (13.9%), and bluntnose minnow (7.5%). Along with the Miller County River Hills Subbasin, this subbasin had a higher percentage of white crappie collected than any of the other subbasins. The Dry Auglaize Creek Subbasin also had the greatest percentage of white suckers and central stonerollers collected than any other subbasin.

The least abundant fish species' captured within this subbasin were spotted bass and black bullhead with only three specimens of each of these species present within the samples. Since 1931, hornyhead chub has not been collected by MDC. The blacknose shiner was the only fish species of conservation concern captured within the Dry Auglaize Creek Subbasin.

Lower Lake of the Ozarks Hills Subbasin Fish Community Samples

MDC has not taken fish community samples within this subbasin.

Deer Creek Subbasin Fish Community Samples

Within this subbasin, MDC collected four samples at two unique sites. Samples were taken in 1966, 1975, 1995, and 2000. All samples of this subbasin were taken using seining supplemented with visual observations. One thousand two hundred and thirteen fish were collected representing thirty-two species.

The most abundant game fishes collected in this subbasin were bluegill (5.3%), longear sunfish (5.3%), smallmouth bass (2%), and green sunfish (1.9%). The most abundant large non-game fish species present were golden redhorse (1%), northern hogsuckers (0.9%), and black redhorse (0.8%). The most abundant small non-game fish species present in the samples were bleeding shiner (36%), rainbow darter (10.1%), and Ozark minnow (9.3%). The Deer Creek Subbasin had a greater percentage of longear sunfish, black redhorse, bleeding shiners, and rainbow darters collected than any other subbasin.

The least abundant fish species captured within this subbasin were blackspotted topminnow, hornyhead chub, mottled sculpin, Ozark logperch, slender madtom, spotted bass, and yellow bullhead with only one specimen collected. Gizzard shad have not been collected by MDC since 1975. Species of conservation concern captured within this subbasin include plains topminnow and least darter.

Turkey Creek Subbasin Fish Community Samples

Within this subbasin, MDC has taken four samples representing four unique sites. Samples were taken in 1966, 1975, and 1995. All samples of this subbasin were taken using seining equipment with one sample being supplemented with visual observations. One thousand nine hundred fish were collected representing thirty-three species.

The most abundant game fishes collected in this subbasin were longear sunfish (2.3%) and bluegill (0.8%). The most abundant large non-game fish species present was northern hogsucker (0.8%). The most abundant small non-game fish species collected were Ozark minnow (23%) and bleeding shiner (21.7%).

The least abundant fish species captured within this subbasin were black redhorse, creek chub, longnose gar, redfin shiner, and smallmouth bass with only one specimen of each of these collected. Since 1966, hornyhead chub has not been collected by MDC within this subbasin. Species of conservation concern captured within this subbasin include plains topminnow and least darter.

AmerenUE Fish Community Collections

AmerenUE has taken yearly fish community samples in the Lower Osage River from 1980-2000 using electrofishing equipment with AC current. AmerenUE's samples represent 6 unique sampling sites and contain sixty species totaling 45,444 specimens (Table 23).

The most abundant game fishes represented within these samples were bluegill (8.9%), white crappie (6.5%), spotted bass (4.3%), largemouth bass (2.6%), and white bass (2.4%). The most abundant large non-game fish present were freshwater drum (6.2%), common carp (3.9%), and river carpsucker (1.9%). The most abundant small non-game fish species present in the samples was gizzard shad (45%) and brook silverside (0.1%).

The least abundant fish species captured by AmerenUE in the Lower Osage River were banded sculpin, northern studfish, silver carp, silver lamprey, black bullhead, red shiner, southern redbelly dace, and sauger with only one specimen of each species collected. The banded sculpin has not been collected by AmerenUE during fish community sampling efforts in the Lower Osage River since 1980. The southern redbelly dace has not been captured since 1981. Species of conservation concern captured by AmerenUE within the Lower Osage River include paddlefish, highfin carpsucker, blue sucker, and mooneye.

When compared with MDC fish community samples taken by electrofishing, AmerenUE has made considerably more samples in the Lower Osage River than MDC. Whereas AmerenUE took yearly samples for 20 years (1980-2000), MDC fish collections made on the Osage River below Bagnell Dam with electrofishing equipment consist of only two samples taken in 1963: one sample southeast of Taos and one sample north of St. Thomas. The electrofishing equipment used by the two organizations may have differed substantially since MDC's collections consisted of more small non-game fish species than the samples of AmerenUE.

The two MDC collections made on the Lower Osage River using electrofishing consisted of 951 fish representing 25 species. Species that were collected by MDC electrofishing in 1963 but not collected by AmerenUE from 1980-2000 included: northern pike, gravel chub, johnny darter, bleeding shiner, ghost shiner, sand shiner, Ozark minnow, channel shiner, bluntnose minnow, fantail darter, Missouri saddled darter, mimic shiner, and slenderhead darter. The most abundant game species in MDC's 1963 samples were spotted bass (3.7%) and bluegill (1.7%). Although large non-game fish species were observed during at least one of these MDC samples, none were captured or counted. The most abundant small non-game fish species collected by MDC were channel shiner (39%), emerald shiner (17.7%), and bluntnose minnow (13.2%). In the samples of AmerenUE taken in the 1980-2000, gizzard shad comprised 45% of the samples. However, in the collections made by MDC in 1963, no gizzard shad were captured. The gizzard shad is a common, prolific, widely-distributed generalist species over its entire range. It has been known to increase in abundance in other rivers such as the Missouri River following the construction of upstream reservoirs (Pflieger 1997).

The Osage River below Bagnell Dam may have undergone shifts in species presence and abundance possibly from the peaking-style discharges currently and historically released by AmerenUE at Bagnell Dam or possibly emigration of eggs, larval, YOY, or adult gizzard shad through the turbines of Bagnell Dam. Adult gizzard shad are currently very abundant in the Osage River below Bagnell Dam and grow to sizes which make them essentially immune to predation and able to compete for food and space with more desirable species. It would appear from the current samples obtained that gizzard shad may have increased in abundance and possibly have replaced or out competed other small non-game fish species such as the once abundant channel shiners, emerald shiners, and bluntnose minnows in the Lower Osage River. Further sampling in the Osage River below Bagnell Dam will be necessary to confirm if these species shifts are real.

MDC Fish Samples and Management of Lake of the Ozarks

Lake of the Ozarks fishery is made up of many key gamefish species which support over 1 million fishing trips per year. Stoner (2000) lists largemouth bass, spotted bass, crappie, blue, flathead, and channel catfishes, walleye, white bass, striped bass, striped bass ^{x} white bass hybrids, and paddlefish as the key gamefishes found in Lake of the Ozarks. A detailed description of the stocking and management of these fishes can be found in Lake of the Ozarks Management Plan. Gizzard shad populations in the lake are normally high and provide the bulk of prey for all gamefishes in Lake of the Ozarks with the exception of the paddlefish (Stoner 2000).

Amphibians and Reptiles

There is a diverse assemblage of amphibians and reptiles found in the East Osage River Basin (Johnson 2000) (Table 24). Amphibian species of conservation concern include the green treefrog, ringed salamander, four-toed salamander, and the grotto salamander. Reptile species of conservation concern include the eastern collared lizard and the northern scarlet snake.

Aquatic Invertebrates

Aquatic Macroinvertebrates

The USACE conducted a study of macroinvertebrates within the basin to describe the possible impacts of Truman Dam on these organisms (Kersh 1989). Numerous macroinvertebrates were sampled from 5 sites on Lake of the Ozarks from Truman Dam to Lake of the Ozarks River Mile 17 as well as from the following tributary streams to Lake of the Ozarks: Turkey Creek, Deer Creek, Big Buffalo Creek, Little Buffalo Creek, and Rainy Creek.

Overall, benthic communities sampled within Lake of the Ozarks were characterized by limited diversity and tolerant organisms. Diversity of organisms decreased as one went downstream within the lake. The benthic communities in the Truman outlet channel and Upper Osage Arm of Lake of the Ozarks were similar with more than 40 taxa observed. Midges (Chironomidae) and the phantom midge (Chaoborus) were the dominant taxa observed. Oligochaetes, the burrowing mayfly (Hexagenia), sphaeriid clams, leeches, (Hirudinea), and dipterans were also observed.

The study concluded there was no significant change in benthic diversity within Lake of the Ozarks for 11 years after Truman Dam began operation. However, it appeared that a tributary stream to Lake of the Ozarks, Little Buffalo Creek, where it was influenced by Truman Dam discharges had experienced a slight downward trend in benthic diversity.

The study also concluded that benthic macroinvertebrate densities within Lake of the Ozarks had changed based on the 11 years of record. There were significantly lower benthic densities in the outlet area directly below Truman Dam downstream to Lake of the Ozarks RM 87 in 1987 than eleven years previous. Evidence suggested that the lower benthic diversities observed were a reflection of the degree of substrate alteration in the reach caused by the discharge of Truman Dam. It appeared that discharges at or above 35,000 cfs from Truman Dam resulted in substantial bed erosion and significantly lower benthic macroinvertebrate densities (Kersh 1989).

Finni (1982) and Finni and Kubb (1982) sampled benthic macroinvertebrate communities within Lake of the Ozarks to determine if residential and commercial development affected the diversity or density of these organisms. Similar to the study of Kersh (1989), midges (chironimidae), worms (Oligochaeta), and the phantom midge (Chaoborus) were the dominant taxa. Leeches (Hirudinea), caddisflies (Tricoptera), mayflies (Ephemeroptera), damselflies (Odonata), snails and clams (Mollusca) were also observed. The level of cove development or numbers of boat docks, ramps, and retaining walls did not appear to affect the diversity or density of benthic macroinvertebrates in this study.

Union Electric, now AmerenUE conducted a study of benthic macroinvertebrates below Bagnell Dam. Sixty taxa were identified from three shallow riffle areas 4 to 21 miles downstream from the dam. Midges were the dominant taxa identified comprising 45% of the samples. Other taxa identified included isopods, Oligochaetes, flatworms, caddisflies, mayflies, amphipods, hydroids, gastropods, and Corbicula clams (UEC 1982).

Duchrow (1984) studied invertebrates of the Lower Osage River and the major mainstem tributaries of the Lower Osage River. Taxa of invertebrates were collected, identified, and categorized as to their degree of pollution tolerance. Pollution intolerant invertebrate species (those found in areas of good water quality) were found in the Maries River, Tavern Creek, Gravois Creek, Dry Auglaize Creek, Wet Glaize Creek, Deer Creek, Turkey Creek, and Big Buffalo Creek. These areas were thus classified as unpolluted. Moderately polluted streams were designated based on the presence of moderately pollution tolerant species at those sites. Moderately polluted streams included Cole Camp Creek, the Osage River eleven miles below Bagnell Dam, the Osage River 4 miles above the mouth of the Osage River, and below Ozark Fisheries, Inc. on Mill Creek in the Wet Glaize Creek Subbasin. Only pollution tolerant species were collected 4 miles below Bagnell Dam. This section of the Osage River therefore was classified as polluted. The presence of only pollution tolerant invertebrate species at that site was due to poor water quality discharged through Bagnell Dam.

Mussels

Freshwater mussels were plentiful in the basin prior to the boom of the commercial button industry in the 1880's. Thousands of tons of mussels were taken from rivers of the basin using long tongs, rakes, hand picking, and dredging. Mussels were loaded into tanks and boiled or steamed for up to 30 minutes. The flesh was carefully checked for pearls and then often thrown back in the river or buried to avoid the stench it created. Occasionally the mussel meat was used to feed hogs or chickens. Cleaned shells were then shipped to button factories for processing (Oesch 1995).

Freshwater mussel populations were soon depleted and concern over the future of this resource heightened. Attempts were made to artificially propagate mussels but these attempts met with little success. After World War II, plastic buttons began replacing those made from mussel shells. Mussel harvest was banned from Missouri's waters in 1976 (Oesch 1995). Mussel populations continue to decline however. Depletion of fish stocks, changes in water quality, habitat degradation (gravel mining, urbanization, stream channelization, and dam construction), and introduction exotic species are all possible contributors to the mussel's decline.

There are 39 species of freshwater mussels in the basin. All species have been collected since 1965 (Table 25). The pink mucket mussel is a federally and state endangered species. The elephant-ear mussel is state endangered.

The scale shell was recently collected in the basin and should soon be listed as endangered. Other freshwater mussel species of conservation concern found in the basin are the hickorynut, black sandshell, spectaclecase, rock-pocketbook, and giant floater. All freshwater mussel species of conservation concern within the basin are found in the Miller County River Hills and Lower Osage River Subbasins (Table 26).

Species of Conservation Concern, Threatened, or Endangered

A number of plant, invertebrate, fish, amphibian, reptile, bird, and mammal species of the basin have become imperiled due to habitat loss, overharvest, competition with exotic species, or other human-induced influences. Both the Missouri State Government and U.S. Federal Government have recognized certain imperiled species and protected them as necessary. All federally endangered species are protected by the Endangered Species Act of 1973 and by Missouri Endangered Species Law 252.240. The State designated endangered species of the basin include: running buffalo clover, Mead's milkweed, pink mucket mussel, elephant-ear mussel, lake sturgeon, Niangua darter, bald eagle, greater prairie chicken, gray bat, and the Indiana bat. In addition, species of conservation concern have been ranked according to their susceptibility to extirpation or extinction (Table 26). Table 27 shows the MDC designated species of conservation concern of the East Osage River Basin by subbasin.

Niangua Darter

The Niangua darter is only found in Missouri and is considered critically imperiled in Missouri because of its rarity and its vulnerability to extirpation. It is federally listed as threatened and by Missouri as endangered. A recovery plan was finalized (Pflieger 1989), and a recovery team was established in 1991 (Mattingly and Galat 1998). Optimal habitat for this species is shallow clear pools in medium-size streams having gravel or rocky bottoms. This species can not live in silt-laden water. Niangua darters forage along the stream bottom for aquatic insects, crustaceans, and snails. Reproduction occurs in shallow riffles in mid-spring (Pflieger 1997).

Reservoir construction has been a significant factor leading to the decline of the Niangua darter (Pflieger 1997). Reservoirs eliminate Niangua darter populations through destruction of habitat and by range fragmentation, resulting in small, isolated populations that are more vulnerable to local extirpations. Destabilization of stream channels by gravel mining and channelization, and nutrient enrichment of streams as a result of livestock production or municipal sewage treatment, are other threats to its long-term survival.

In the basin, the Niangua darter is found in Lower Maries, Upper Maries and Tavern Creek Subbasins (Figure 20). It is found in 3.3 miles of Little Maries Creek in Lower Maries Subbasin, and 27.2 miles of the Maries River in the Lower Maries and Upper Maries Subbasins. In the Tavern Creek Subbasin, Niangua darters are found in 3.9 miles of Barren Fork, 3.2 miles of Brushy Fork, 1.6 miles of Little Tavern Creek, and 34.6 miles of Tavern Creek (Table 27). All in-stream activities within these areas should be coordinated with MDC and the U.S. Fish and Wildlife Service. Special conditions apply March 15-June 15 annually. All areas are within State Critical Habitat, most of these areas are also federally designated Critical Habitat.

Lake Sturgeon

The lake sturgeon is a primitive fish found in larger rivers of northcentral and northeastern North America. They are covered with several lengthwise rows of bony plates, or scutes, and their cone-shaped snout is long and prominent with four large barbels which dangle from the underside of the snout. The lake sturgeon is reported to reach a length of eight feet and a weight of 310 pounds.

Lake sturgeon were very abundant in Missouri before the mid-1800's. Commercial harvest began in 1860 and harvest peaked in 1890. The population was decimated by the early 1900's. The basin was known for large harvests of lake sturgeon suggesting that this area may have supported a spawning population prior to decimation of the populations and construction of Lake of the Ozarks (Carlson and Pflieger 1981).

Missouri considers the lake sturgeon to be endangered in the state and especially vulnerable to extirpation. Globally, the species is considered to be rare or uncommon but not presently in danger of extinction.

Lake sturgeon are a long-lived species. They mature slowly and begin reproducing when 20 years old when they will be four feet long and weigh around 25 pounds. They spawn at 2-6 year intervals rather than annually. A slow maturation rate and an infrequent spawning interval contributes to slow recovery after its populations have been depleted. The maximum age reported for a lake sturgeon was 152 years old.

To aid lake sturgeon populations' recovery, MDC artificially-reared and released 45,000 young lake sturgeon into Missouri waters from 1984-1990. These fish have and are continuing to be incidentally captured in Missouri's larger rivers. Given the slow maturation rate, these stocked fish should soon begin to reach sexual maturity and presumably will establish a more stable naturally reproducing population in future years.

It is presumed that overharvest was the principal cause of the decline of the lake sturgeon. However, blockage of spawning runs by dams, destruction of spawning habitat by siltation, pollution, and drainage, and decline in the food supply (mollusks) may have been contributing factors and will hinder recovery of this species in future years.

Thirteen other fish species are listed as species of conservation concern in the basin (Table 34). Species which are imperiled because of rarity or because some factor makes them very vulnerable to extirpation include blacknose shiner, ghost shiner, western silvery minnow, Alabama shad, mooneye, highfin carpsucker, southern cavefish, least darter, and bluestripe darter. Species which are considered rare or uncommon include paddlefish and plains topminnow. The northern pike is considered widespread, abundant, and apparently secure in Missouri but of long-term concern (MDC Natural History Database 2001).

Exotic Species

Fish Exotics

There are 10 fish species known from the basin which are not presumed to have been present prior to European settlement of the region. The presence of these exotics within the basin is the result of stocking or introduction. The bighead carp, common carp, goldfish, spotted bass, and western mosquitofish now have established naturally reproducing populations within the basin. The brown trout, rainbow trout, striped bass, grass carp, and muskellunge are present in the basin only as stocked individuals with no documented natural reproduction.

The influence that these exotics have had on native populations is unknown. Exotic species are often more competitive than native species and can cause decline or extirpation of native fauna.

Mussel Exotics

The Asiatic clam (Corbicula fulminea) was introduced into the United States in the late 1930's. It currently occupies the southeast half of Missouri and is expected to spread across the entire state within a decade. Unlike the mussels indigenous to the United States, the Asiatic clam produces a free-swimming larval form known as a veliger. The rapid expansion of the range of the essentially non-mobile Asiatic clam is most likely caused by incidental transportation of the free-swimming veliger from river to river in the water of angler's bait buckets.

The zebra mussel (Dreissena polymorpha) is a small native to the Caspian Sea in Europe. The zebra mussel like the Asiatic clam has a free swimming larval form which facilitates rapid range expansion. The zebra mussel spread throughout Europe in the 1800's and now is rapidly expanding into northern

Asia as well as into the Eastern United States. This highly invasive, damaging species threatens populations of native mussels and other benthic aquatic species. Zebra mussels clog water intake pipes and attach to boat hulls in densities as high as 700,000 individuals per square meter. Zebra mussels were first documented from the Northeastern United States in 1986. By 1991, zebra mussels had spread through the Great Lakes, down the Illinois River, and down the Mississippi River to the waters of Missouri. MDC produces a brochure describing how to prevent the further expansion of the zebra mussel to Missouri waters.

Some pictures courtesy of Native Fish Conservancy.

Figure 19. MDC Fish Community Sampling Sites for the East Osage Basin

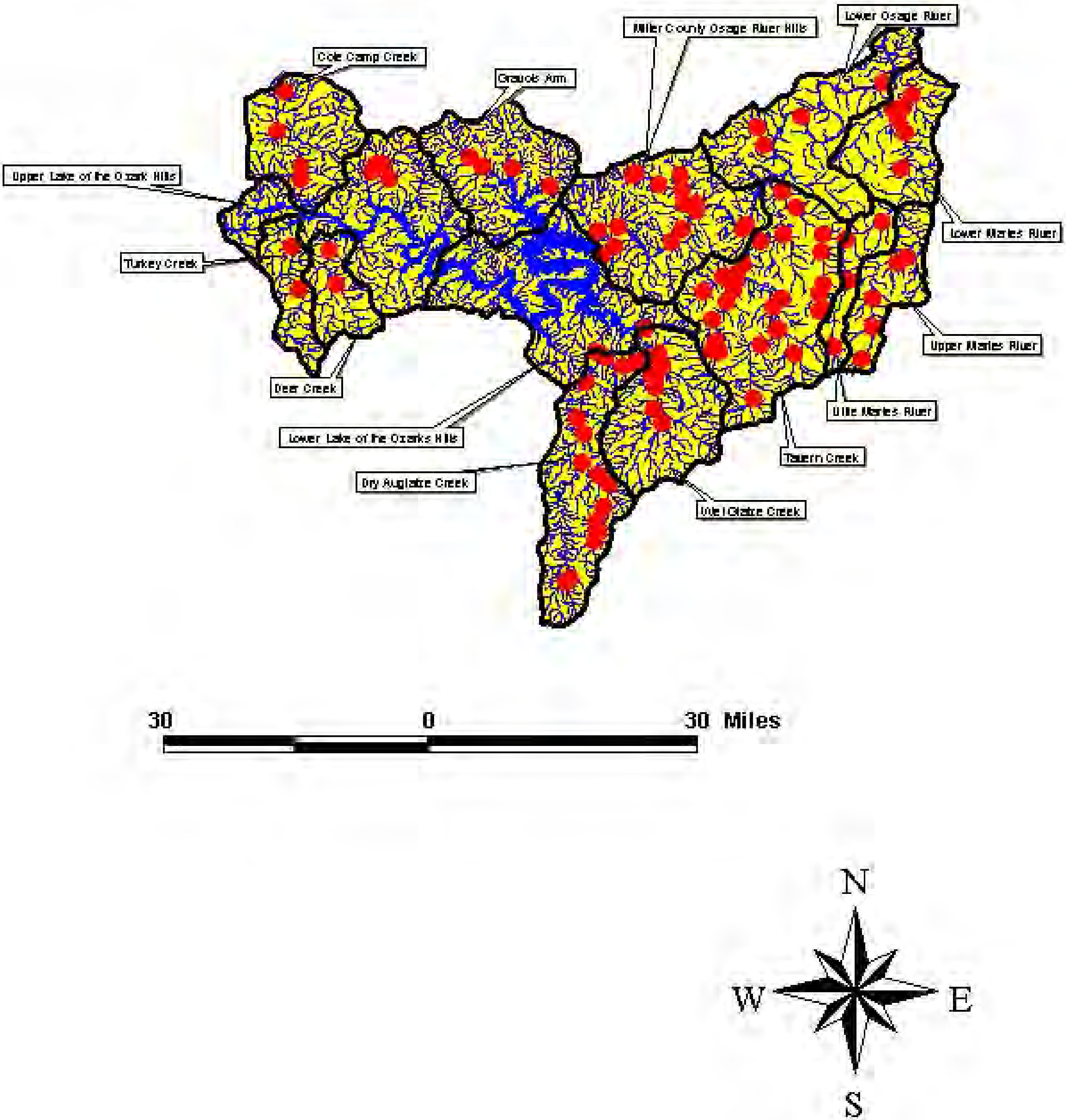

Figure 20. Niangua Darter Range in the East Osage River Basin

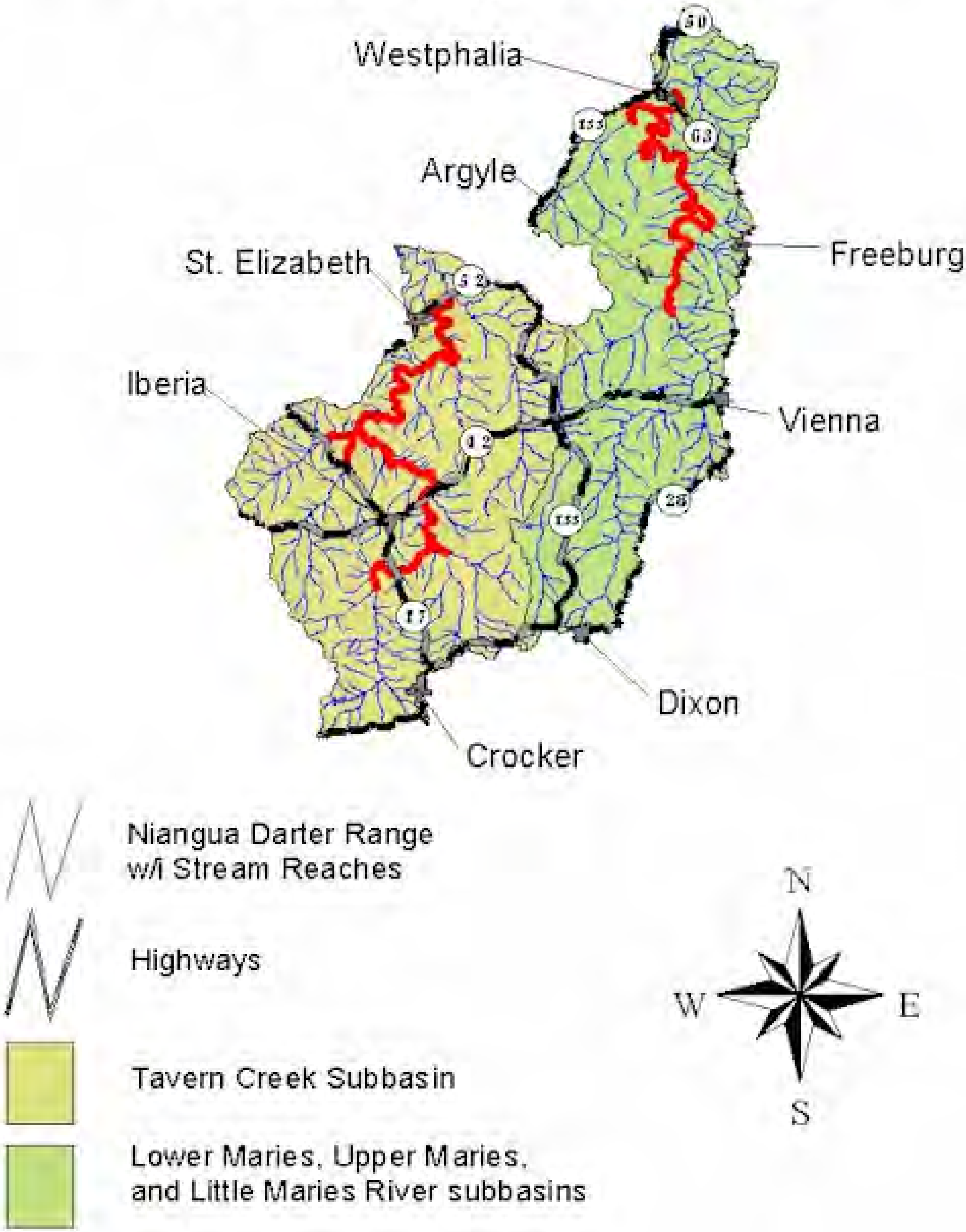

Table 17. Species composition of more abundant gamefish, large non-game fish, and small non-game fish in MDC community fish samples for each subbasin based on all MDC samples from the basin to date. Note: Values in bold represent the greatest percentage of that species.

Common Name	Lower Osage R.	Lower Maries R.	Upper Maries R.	Little Maries R.	Tavern Cr.	Wet Glaize Cr.	Dry Auglaize Cr.	Deer Cr.	Turkey Cr.	Cole Camp Cr.	Upper LOZ Hills	Gravois Arm	Lower LOZ Hills	Miller Co Osg R Hills
GAMEFISH														
Green sunfish	1.16	0.36	0.23	0.15	0.66	0.87	2.53	1.98	0.21	1.55	13.2	0.40	-	0.06
Bluegill	4.67	1.05	0.35	0.81	0.81	0.03	2.28	5.28	0.79	0.76	5.32	0.99	-	5.47
Longear sunfish	3.08	3.97	0.79	1.58	1.16	0.34	0.17	5.28	2.26	0.99	0.44	5.05	-	1.45
Smallmouth bass	0.43	0.47	0.31	1.10	0.95	0.06	0	2.14	0.05	0.10	9.90	2.18	-	0.15
Spotted bass	1.34	0.51	0	0.02	0.15	0.04	0.02	0.33	0.53	0.21	0.13	0.10	-	0.55
Largemouth bass	0.62	0.30	0.08	0.12	0.11	0.06	0.35	1.15	0.47	0.45	1.01	2.97	-	0.20
White crappie	0	0	0	0	0.01	0	0.46	0	0	0	0	0	-	0.46
Channel catfish	0.46	0.05	0	0	0.01	0	0	0	0	0.02	0.13	0	-	1.32
Yellow bullhead	0.03	0.15	0.32	0.15	0.04	0	0.14	0.32	0.16	0.03	1.01	0.10	-	0.01

LARGE NON-GAME FISH														
Common carp	**0.05**	**0.50**	**0**	**0**	**0.002**	**0.03**	**0.02**	**0.16**	**0**	**0.02**	**0**	**0**	**-**	**0.33**
White sucker	**0**	**0**	**0**	**0**	**0.06**	**0.21**	**0.89**	**0**	**0**	**0**	**0**	**0**	**-**	**0.01**
Northern hogsucker	**0.15**	**0.10**	**0**	**0.05**	**0.24**	**0.50**	**0.10**	**0.91**	**0.80**	**0.05**	**8.16**	**1.29**	**-**	**0.01**
Black redhorse	**0.73**	**0.66**	**0.01**	**0.03**	**0.43**	**0.34**	**0.38**	**0.82**	**0.05**	**0.28**	**0**	**0**	**-**	**0.34**
Golden redhorse	**0.07**	**0.48**	**0.01**	**0**	**0.17**	**0.21**	**0.03**	**1.00**	**0**	**0.40**	**0**	**0**	**-**	**0.15**
Shorthead redhorse	**0.84**	**0.05**	**0**	**0**	**0.01**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**-**	**0.21**
River carpsucker	**0.03**	**0**	**0**	**0**	**0**	**0.01**	**0**	**0**	**0**	**0.03**	**0**	**0**	**-**	**1.48**
Longnose gar	**0.15**	**0.01**	**0**	**0**	**0.01**	**0**	**0**	**0**	**0.05**	**0**	**0**	**0**	**-**	**0.97**
SMALL NON-GAME FISH														
Largescale stoneroller	**1.77**	**4.21**	**3.73**	**1.17**	**3.73**	**0.34**	**0.83**	**3.30**	**0**	**3.12**	**0.03**	**1.58**	**-**	**0.43**
Central stoneroller	**2.67**	**1.17**	**13.9**	**10.2**	**8.08**	**3.35**	**28.6**	**2.06**	**0.37**	**5.07**	**0.52**	**4.75**	**-**	**1.98**
Gravel chub	**1.34**	**0.23**	**0**	**0**	**0.10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**-**	**14.1**
Creek chub	**0.26**	**0.05**	**2.12**	**2.03**	**0.59**	**0.71**	**4.41**	**0.66**	**0.05**	**0.81**	**7.95**	**2.48**	**-**	**0.38**
Bleeding shiner	**15.6**	**20.4**	**19.3**	**29.5**	**27.1**	**29.1**	**6.5**	**36.7**	**21.7**	**9.4**	**20.2**	**25.3**	**-**	**3.4**

Wedgespot shiner	**0**	**9.83**	**0.01**	**0.03**	**3.42**	**3.06**	**0**	**0**	**0**	**0**	**0**	**0**	**-**	**0.02**
Emerald shiner	**5.56**	**0**	**0**	**0**	**0.003**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**-**	**17.0**
Ozark minnow	**24.9**	**22.1**	**14.7**	**13.6**	**14.8**	**12.3**	**13.9**	**9.3**	**23.1**	**38.1**	**0.28**	**11.3**	**-**	**3.64**
Southern redbelly dace	**0**	**0**	**7.28**	**1.72**	**4.76**	**0.42**	**0.34**	**0.08**	**0**	**0**	**6.86**	**1.29**	**-**	**0.78**
Bluntnose minnow	**2.56**	**1.88**	**0.48**	**0.36**	**1.41**	**1.42**	**7.47**	**0.16**	**6.63**	**5.07**	**0**	**1.09**	**-**	**9.66**
Fathead minnow	**0**	**0**	**0.01**	**0**	**0**	**8.80**	**0.12**	**0**	**0**	**0.86**	**0**	**0.10**	**-**	**0.03**
Northern studfish	**3.18**	**1.35**	**13.1**	**8.14**	**4.6**	**3.89**	**0.66**	**6.92**	**8.21**	**0.71**	**1.19**	**14.6**	**-**	**3.81**
Brook silverside	**1.26**	**5.94**	**1.52**	**1.86**	**1.64**	**0.33**	**0.89**	**3.30**	**4.58**	**6.39**	**0**	**1.49**	**-**	**8.12**
Rainbow darter	**1.87**	**8.66**	**3.41**	**4.01**	**6.19**	**5.52**	**1.40**	**10.1**	**3.42**	**5.32**	**2.00**	**2.87**	**-**	**0.60**
Striped fantail darter	**2.11**	**5.05**	**5.82**	**9.86**	**4.55**	**7.01**	**0.51**	**1.40**	**5.05**	**2.46**	**2.72**	**0.89**	**-**	**0.78**
Orangethroat darter	**7.61**	**1.22**	**8.33**	**6.73**	**3.70**	**3.10**	**4.36**	**2.80**	**0.26**	**8.84**	**3.04**	**3.56**	**-**	**1.97**

Table 18. Fish present in MDC fish community samples of the East Osage River Basin by subbasin and most recent time period collected*

Common Name	Lower Osage R.	Lower Maries R.	Upper Maries R.	Little Maries R.	Tavern Cr.	Wet Glaize Cr.	Dry Auglaize Cr.	Deer Cr.	Turkey Cr.	Cole Camp Cr.	Upper LOZ Hills	Gravois Arm	Lower LOZ Hills	Miller Co Osg R Hills
Chestnut lamprey		B			C	B								C
Shovelnose sturgeon														C
Lake sturgeon														A
Longnose gar	B	D			D	B				D				C
Shortnose gar	B	D			D									C
American eel	B													C
Alabama shad	B													
Gizzard shad	D	D			D	B		C	D	A		A		D
Skipjack herring														C
Mooneye					B									
Goldeye	B													C

Largescale stoneroller	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Central stoneroller	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Red shiner	**B**	**D**	**A**	**A**	**D**	**D**	**D**			**A**		**A**		**C**
Common carp	**B**	**D**			**D**	**D**	**D**	**D**	**D**	**D**				**D**
Goldfish						**D**								**D**
Gravel chub	**B**				**D**									**C**
Bleeding shiner	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Redfin shiner	**A**	**D**	**A**	**A**	**D**		**D**		**D**	**D**				**C**
Wedgespot shiner		**D**	**A**	**D**	**D**	**D**								**C**
Hornyhead chub	**D**	**D**	**D**	**D**	**D**	**D**	**A**	**D**	**B**	**A**	**C**	**D**		**D**
Mimic shiner	**B**													**D**
Emerald shiner	**B**													**C**
Golden shiner					**C**	**D**	**D**			**D**		**D**		**D**
Ghost shiner	**B**	**A**												**D**
Blacknose shiner			**A**	**A**			**D**							
Channel shiner	**B**													

Sand shiner	**B**	**D**	**A**		**D**	**D**	**D**			**D**		**A**		**C**
Silverband shiner	**B**													
Ozark minnow	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Western silvery minnow	**B**	**A**			**C**									
Rosyface shiner	**D**	**D**			**D**	**D**	**D**							**D**
Striped shiner														**D**
Suckermouth minnow	**B**	**C**			**C**	**C**				**A**				**A**
Southern redbelly dace	**D**		**D**	**D**	**D**	**D**	**D**	**D**			**D**	**D**		**D**
Bluntnose minnow	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**		**D**
Fathead minnow			**D**			**D**	**C**			**D**		**A**		**D**
Gravel chub	**B**	**C**			**D**									**C**
Creek chub	**D**	**C**	**D**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Speckled chub														**C**
Silver chub	**B**													
White sucker					**D**	**D**	**D**							**D**

Blue sucker														**C**
Highfin carpsucker														**C**
Northern hogsucker	**D**	**D**	**C**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Bigmouth buffalo		**D**												**C**
Smallmouth buffalo	**D**													**C**
Black buffalo														**C**
Quillback	**B**					**D**								**C**
Black redhorse	**D**	**D**	**C**	**C**	**D**	**D**	**D**	**D**	**D**	**D**				**D**
Golden redhorse	**D**	**D**	**A**		**D**	**D**	**D**	**D**	**C**	**D**				**D**
Shorthead redhorse	**B**	**D**			**C**	**B**								**C**
Silver redhorse	**D**	**D**			**D**	**B**								**C**
River redhorse														**C**
Black bullhead	**A**			**C**	**C**		**D**							**C**
Yellow bullhead	**D**	**C**	**C**	**C**	**D**	**C**	**D**	**D**	**D**	**D**	**C**	**D**		**D**

Channel catfish	**B**	**D**			**D**					**A**	**B**			**C**
Flathead catfish	**B**	**D**												**C**
Blue catfish														**C**
Freckled madtom	**B**				**A**									
Slender madtom	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Stonecat	**B**				**D**									
Northern studfish	**D**	**D**		**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Blackspotted topminnow	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**A**		**D**
Plains topminnow	**D**	**C**	**D**	**D**	**D**			**B**		**D**	**D**	**D**		**D**
Western mosquitofish		**D**			**D**	**D**	**D**							**D**
Brook silverside	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**A**		**D**
Mottled sculpin	**D**				**D**	**D**		**D**						**D**
Banded sculpin	**B**					**D**				**C**	**D**	**A**		
Ozark sculpin					**D**						**D**	**D**		**D**
White bass		**D**			**D**	**B**								**C**

Rock bass		**D**	**C**	**C**										**D**
River carpsucker	**B**					**B**				**A**				**C**
Green sunfish	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Warmouth		**D**												
Orangespotted sunfish		**A**			**C**		**A**			**B**				**A**
Bluegill	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Longear sunfish	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**B**	**D**		**D**
Smallmouth bass	**D**	**D**	**D**	**D**	**D**	**D**	**A**	**D**	**B**	**D**	**D**	**D**		**D**
Spotted bass	**C**	**D**		**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Largemouth bass	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**C**	**D**		**D**
White crappie					**D**	**B**	**D**							**C**
Black crappie	**B**	**D**				**B**								**D**
Greenside darter	**D**	**D**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**A**		**D**
Rainbow darter	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Fantail darter				**D**		**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Least darter								**B**		**D**		**A**		

Niangua darter		**D**			**D**									
Johnny darter	**D**	**A**	**A**		**D**									**C**
Stippled darter	**D**	**C**	**C**	**D**		**D**				**D**	**D**	**A**		**D**
Orangethroat darter		**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Banded darter	**B**	**D**			**D**	**D**				**A**				**C**
Missouri saddled darter	**C**	**D**			**D**	**D**								**C**
Slenderhead darter	**B**				**D**									**D**
Gilt darter	**B**													**C**
Logperch	**B**				**D**	**D**	**D**	**D**	**C**	**D**		**D**		**D**
Northern pike	**B**													**C**
Walleye						**B**								**C**
Sauger	**B**	**D**												**C**
Freshwater drum	**B**	**D**			**C**	**B**			**D**	**D**				**D**

A = 1931-1946 collections

B = 1947-1973 collections

C = 1974-1990 collections

D = 1991-2001 collections

Table 19. Fish present in MDC fish community samples sampled by seining or visual observation in the East Osage River Basin by subbasin and most recent time period collected*

Common Name	Lower Osage R.	Lower Maries R.	Upper Maries R.	Little Maries R.	Tavern Cr.	Wet Glaize Cr.	Dry Auglaize Cr.	Deer Cr.	Turkey Cr.	Cole Camp Cr.	Upper LOZ Hills	Gravois Arm	Lower LOZ Hills	Miller Co Osg R Hills
Chestnut lamprey		B			C									C
Shovelnose sturgeon														C
Lake sturgeon														A
Longnose gar	B				D					D				C
Shortnose gar	B				D									C
American eel														C
Gizzard shad	D	D			D			C	D	A		A		D
Skipjack herring														C
Mooneye					B									
Goldeye	B													C
Largescale stoneroller	D	D	D	D	D	D	D	D	D	D	D	D		D

Central stoneroller	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**C**	**D**		**D**
Red shiner	**B**	**D**	**A**	**A**	**D**	**D**	**D**			**A**		**A**		**C**
Common carp	**B**				**D**	**D**	**D**	**D**	**D**	**D**				**D**
Goldfish						**D**								**D**
Gravel chub	**B**				**D**									**C**
Bleeding shiner	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Redfin shiner	**A**	**D**	**A**	**A**	**D**		**D**		**D**	**D**				**C**
Wedgespot shiner		**D**	**A**	**D**	**D**	**D**								**C**
Hornyhead chub	**D**	**D**	**D**	**D**	**D**	**D**	**A**	**D**	**B**	**A**	**C**	**D**		**D**
Mimic shiner														**D**
Emerald shiner	**B**													**C**
Golden shiner					**C**	**D**	**D**			**D**		**D**		**D**
Ghost shiner		**A**												**D**
Blacknose shiner			**A**	**A**			**D**							
Sand shiner	**B**	**D**	**A**		**D**	**D**	**D**			**D**		**A**		**C**
Ozark minnow	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**

Western silvery minnow	**B**	**A**			**C**									
Rosyface shiner	**D**	**D**			**D**	**D**	**D**							**D**
Striped shiner														**D**
Suckermouth minnow	**B**	**C**			**C**					**A**				**A**
Southern redbelly dace	**D**		**D**	**D**	**D**	**D**	**D**	**D**			**D**	**D**		**D**
Bluntnose minnow	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**		**D**
Fathead minnow			**D**			**D**	**C**			**D**		**A**		**D**
Gravel chub	**B**	**C**			**D**									**C**
Creek chub	**D**	**C**	**D**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Speckled chub														**C**
White sucker					**D**	**D**	**D**							**D**
Blue sucker														**C**
Highfin carpsucker														**C**
Northern hogsucker	**D**	**D**	**C**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Bigmouth buffalo														**C**

Smallmouth buffalo	**D**													**C**
Black buffalo														**C**
Quillback	**B**					**D**								**C**
Black redhorse	**D**	**D**	**C**	**C**	**D**	**D**	**D**	**D**	**D**	**D**				**D**
Golden redhorse	**D**	**D**	**A**		**D**	**D**	**D**	**D**	**C**	**D**				**D**
Shorthead redhorse		**B**			**C**									**C**
Silver redhorse					**D**									**C**
River redhorse														**C**
Black bullhead	**A**			**C**	**C**		**D**							**C**
Yellow bullhead	**D**	**C**	**C**	**C**	**D**	**C**	**D**	**D**	**D**	**D**	**C**	**D**		**D**
Channel catfish					**D**					**A**				**C**
Flathead catfish														**C**
Blue catfish														**C**
Freckled madtom					**A**									

Slender madtom	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Stonecat					**D**									
Northern studfish	**D**	**D**		**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Blackspotted topminnow	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**A**		**D**
Plains topminnow	**A**	**C**	**D**	**D**	**D**			**B**		**D**	**D**	**D**		**D**
Western mosquitofish		**D**			**D**	**D**	**D**							**D**
Brook silverside	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**A**		**D**
Mottled sculpin	**D**				**D**	**D**		**D**						**D**
Banded sculpin						**D**				**C**	**D**	**A**		
Ozark sculpin					**D**						**D**	**D**		**D**
White bass					**D**									**C**
Rock bass		**B**	**C**	**C**										**D**
River carpsucker	**B**									**A**				**C**
Green sunfish	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Warmouth		**D**												

Orangespotted sunfish		**A**			**C**		**A**			**B**				**A**
Bluegill	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Longear sunfish	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**		**D**
Smallmouth bass	**D**	**D**	**D**	**D**	**D**	**D**	**A**	**D**	**B**	**D**	**D**	**D**		**D**
Spotted bass	**C**	**D**		**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Largemouth bass	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**C**	**D**		**D**
White crappie					**D**		**D**							**C**
Black crappie	**B**													**D**
Greenside darter	**D**	**D**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**A**		**D**
Rainbow darter	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Fantail darter		**D**		**D**		**D**	**D**	**D**	**D**	**D**		**D**		**D**
Least darter								**B**		**D**		**A**		
Niangua darter		**D**			**D**									
Johnny darter	**D**	**A**	**A**		**D**									**C**
Stippled darter	**C**	**C**	**C**	**D**		**D**				**D**	**D**	**A**		**D**

Orangethroat darter		**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Banded darter		**D**			**D**	**D**				**A**				**C**
Missouri saddled darter	**C**	**D**			**D**	**D**								**C**
Slenderhead darter					**D**									**D**
Gilt darter														**C**
Logperch		**D**			**D**	**D**	**D**	**D**	**C**	**D**		**D**		**D**
Northern pike														**C**
Walleye														**C**
Sauger	**B**													**C**
Freshwater drum	**B**				**C**				**D**	**D**				**D**

Time period collected: A = 1931-1946, B = 1947-1973, C = 1974-1990, D = 1991-2001

[1]**The most recent collection period for Lower Osage R. was B (1947-1973).**

[2]**The most recent collection period for Upper LOZ Hills was C (1974-1990).**

Table 20. Fish present in MDC fish community samples sampled by electrofishing in East Osage River Basin by subbasin and most recent time period collected*

Common Name	Lower Osage R[1]	Lower Maries R.	Upper Maries R.	Little Maries R.	Tavern Cr.	Wet Glaize Cr.	Dry Auglaize Cr.	Deer Cr.	Turkey Cr.	Cole Camp Cr.	Upper LOZ Hills[2]	Gravois Arm	Lower LOZ Hills	Miller Co Osg R Hills
Longnose gar		D												
Shortnose gar		D												
Gizzard shad	B	D												
Largescale stoneroller	B													
Red shiner	B													
Common carp	B	D												
Gravel chub	B													
Bleeding shiner	B													
Hornyhead chub											C			
Mimic shiner	B													

Emerald shiner	**B**													
Ghost shiner	**B**													
Channel shiner	**B**													
Sand shiner	**B**													
Ozark minnow	**B**													
Bluntnose minnow	**B**													
Gravel chub	**B**													
Creek chub											**C**			
Northern hogsucker		**D**									**C**			
Bigmouth buffalo		**D**												
Black redhorse		**D**												
Golden redhorse	**B**	**D**												
Shorthead redhorse	**B**	**D**												
Silver redhorse		**D**												

Yellow bullhead											**C**			
Channel catfish		**D**									**B**			
Flathead catfish		**D**												
Brook silverside	**B**													
White bass		**D**												
Rock bass		**D**												
Green sunfish	**B**										**C**			
Bluegill	**B**	**D**									**C**			
Longear sunfish	**B**	**D**									**B**			
Smallmouth bass	**B**										**C**			
Spotted bass	**B**	**D**												
Largemouth bass	**B**	**D**									**C**			
Black crappie		**D**												
Fantail darter	**B**													

Johnny darter	**B**													
Missouri saddled darter	**B**													
Logperch	**B**	**D**												
Sauger		**D**												
Northern pike	**B**													
Freshwater drum		**D**												

Time period collected: B = 1947-1973, C = 1974-1990, D = 1991-2001

Table 21. Fish species of the East Osage River Basin.		
Common Name	***Scientific Name***	**Status***
LARGE FISH		
Alabama shad	***Alosa alabamae***	**B**
American eel	***Anguilla rostrata***	**A, B, C, D**
Bighead carp	***Hypophthalmichthys nobilis***	**D**
Bigmouth buffalo	***Ictiobus cyprinellus***	**B, C, D**
Black crappie	***Pomxis nigromaculatus***	**B, C, D**
Black redhorse	***Moxostoma erythrurum***	**A, B, C, D**
Black bullhead	***Ameiurus melas***	**A, B, C, D**
Black buffalo	***Ictiobus niger***	**C**
Blue catfish	***Ictalurus furcatus***	**B, C, D**
Blue sucker	***Cycleptus elongatus***	**B, C**
Bluegill	***Lepomis cyanellus***	**A, B, C, D**
Brown trout	***Salmo trutta***	**K**

Channel catfish	***Ictalurus punctatus***	**A, B, C, D**
Chestnut lamprey	***Ichthyomyzon castaneus***	**B, C, D**
Common carp	***Cyprinus carpio***	**A, B, C, D**
Flathead catfish	***Pylodictis olivaris***	**A, B, C, D**
Freckled madtom	***Noturus nocturnus***	**A, B**
Freshwater drum	***Aplodinotus grunniens***	**A, B, C, D**
Gizzard shad	***Dorosoma cepedianum***	**A, B, C, D**
Golden redhorse	***Moxostoma erythrurum***	**A, B, C, D**
Goldeye	***Hiodon alsoides***	**B, C, D**
Goldfish	***Carassius auratus***	**A, B, C, D**
Grass carp	***Ctenopharyngodon idella***	**D**
Common Name	***Scientific Name***	**Status***
Green sunfish	***Lepomis cyanellus***	**A, B, C, D**
Highfin carpsucker	***Carpiodes velifer***	**B, C**
Lake sturgeon	***Acipenser fulvescens***	**A, D**
Largemouth bass	***Micropterus salmoides***	**A, B, C, D**

Longear sunfish	***Lepomis megalotis***	**A, B, C, D**
Longnose gar	***Lepisosteus osseus***	**A, B, C, D**
Mooneye	***Hiodon tergisus***	**B**
Muskellunge	***Esox masquinongy***	**K**
Northern brook lamprey	***Ichthyomyzon fossor***	**K**
Northern pike	***Esox lucius***	**B, C, D**
Northern hogsucker	***Hypentelium nigricans***	**A, B, C, D**
Orangespotted sunfish	***Lepomis humilis***	**A, B, C**
Paddlefish	***Polyodon spathula***	**K, D**
Quillback	***Carpiodes cyprinus***	**A, B, C, D**
Rainbow Trout	***Oncorhynchus mykiss***	**K**
River carpsucker	***Carpiodes carpio***	**A, B, C**
River redhorse	***Moxostama carinatum***	**A, B, C, D**
Rock Bass	***Ambloplites rupestris***	**B, C, D**
Sauger	***Stizostedion canadense***	**A, B, C, D**
Shorthead redhorse	***Moxostoma macrolepidotum***	**A, B, C, D**

Shortnose gar	***Lepisosteus platostomus***	**B, C, D**
Shovelnose sturgeon	***Scaphirhynchus platorynchus***	**B, C**
Silver redhorse	***Moxostoma anisurum***	**B, C, D**
Skipjack herring	***Alosa chrysochloris***	**B, C**
Common Name	***Scientific Name***	**Status***
Smallmouth buffalo	***Ictiobus bubalus***	**A, B, C, D**
Smallmouth bass	***Micropterus dolomieui***	**A, B, C, D**
Southern brook lamprey	***Ichthyomyzon gagei***	**K**
Striped bass	***Morone saxatilis***	**K**
Spotted bass	***Micropterus punctulatus***	**A, B, C, D**
Walleye	***Stizostedion vitreum***	**A, B, C, D**
Warmouth	***Lepomis gulosus***	**B, D**
White Crappie	***Pomoxis annularis***	**A, B, C, D**
White sucker	***Catostomus commersoni***	**A, B, C, D**
White bass	***Morone chrysops***	**B, C, D**

Yellow bullhead	***Ictalurus natalis ameiurs***	**A, B, C, D**
NEKTONIC FISH		
Blacknose shiner	***Notropis heterolepis***	**A, C, D**
Blackspotted topminnow	***Fundulus oluvaceus***	**A, B, C, D**
Bleeding shiner	***Notropis zonatus***	**A, B, C, D**
Bluntnose minnow	***Pimephales notatus***	**A, B, C, D**
Brook silverside	***Labidesthes sicculus***	**A, B, C, D**
Central Stoneroller	***Campostoma Anomalum***	**A, B, C, D**
Channel shiner	***Notropis wickliffi***	**B**
Creek chub	***Semotilus atromaculatus***	**A, B, C, D**
Emerald shiner	***Notropis atherinoides***	**A, B, C, D**
Fathead minnow	***Pimephales promelas***	**A, B, C, D**
Ghost shiner	***Notropis buchanani***	**A, B, C, D**
Golden shiner	***Notemigonus crysoleucas***	**A, B, C, D**
Common Name	***Scientific Name***	**Status***

Hornyhead chub	***Nocomis biguttatus***	**A, B, C, D**
Largescale stoneroller	***Campostoma oligolepis***	**A, B, C, D**
Mimic shiner	***Notropis volucellus***	**A, B, C, D**
Northern studfish	***Fundulus catenatus***	**A, B, C, D**
Ozark minnow	***Notropis nubilus***	**A, B, C, D**
Plains topminnow	***Fundulus sciadicus***	**A, B, C, D**
Red shiner	***Notropis lutrensis***	**A, B, C, D**
Redfin shiner	***Lythrurus umbratilis***	**A, B, C, D**
Rosyface shiner	***Notropis rubellus***	**A, B, C, D**
Sand shiner	***Notropis stramineus***	**A, B, C, D**
Southern redbelly dace	***Phoxinus erythrogaster***	**A, B, C, D**
Silverband shiner	***Notropis shumardi***	**B**
Silver Chub	***Macrhybopsis storeriana***	**B**
Speckled chub	***Macrhybopsis aestivalis***	**B**
Striped shiner	***Luxilus chrysocephalua***	**B, D**
Studfish	***Fundulus Catenatus***	**A, B, C, D**

Wedgespot shiner	***Notropis greenei***	**A, B, C, D**
Western silvery minnow	***Hybognathus argyritis***	**B, C**
Western mosquitofish	***Gambusia affinis***	**A, C, D**
BENTHIC FISH		
Banded darter	***Etheostoma zonale***	**A, B, C, D**
Banded sculpin	***Cottus carolinae***	**A, B, C, D**
Fantail darter	***Etheostoma flabellare ssp.***	**A, B, C, D**
Gravel chub	***Erimystax x-punctatus***	**A, B, C, D**
Common Name	***Scientific Name***	**Status***
Gilt darter	***Percina evides***	**B, C**
Greenside darter	***Etheostoma blennioides***	**A, B, C, D**
Johnny darter	***Etheostoma nigrum***	**A, B, C, D**
Least darter	***Etheostoma microperca***	**A, B, C**
Logperch	***Percina caprodes***	**B, D**
Missouri saddled darter	***Etheostoma tetrazonum***	**A, B, C, D**
Mottled sculpin	***Cottus bairdi***	**B, D**

Niangua darter	***Etheostoma nianguae***	**A, B, C, D**
Northern orangethroat darter	***Etheostoma s spectabile***	**A, B, C, D**
Ozark logperch	***Percina c fulvitaenia***	**A, B, C, D**
Ozark sculpin	***Cottus hypselurus***	**A, B, C, D**
Rainbow darter	***Etheostoma caeruleum***	**A, B, C, D**
Slender madtom	***Noturus exilis***	**A, B, C, D**
Slenderhead darter	***Percina phoxocephala***	**A, B, C, D**
Speckled chub	***Macrhybopsis aestivalis***	**C**
Southern cavefish	***Typhlichthys subterraneus***	**K**
Stonecat	***Noturus flavus***	**A, B, C, D**
Stippled darter	***Etheostoma punctulatum***	**A, B, C, D**
Suckermouth minnow	***Phenacobius mirabilis***	**A, B, C**
Tadpole madtom	***Noturus gyrinus***	**K**

A=collected before 1946

B=collected between 1946 and 1973

C=collected from 1974-1990

D=collected from 1990-2001

K=known or probable occurrence within basin though species not represented in MDC community samples based on ineffective sampling methods for that species or rarity of species.

Table 22. Fish community sampling methods by subbasin

Method	Lower Osage R.	Lower Maries R.	Upper Maries R.	Little Maries R.	Tavern Cr.	Wet Glaize Cr.	Dry Auglaize Cr.	Deer Cr.	Turkey Cr.	Cole Camp Cr.	Upper LOZ Hills	Gravois Arm	Lower LOZ Hills	Miller Co Osg R Hills
Electrofishing	X	X									X			
Kick seine	X	X	X	X	X	X	X	X	X	X	X	X		X
Drag seine	X	X	X	X	X	X	X	X	X	X	X	X		X
Rotenone	X													
Visual	X	X			X	X	X	X	X	X	X	X		

Table 23. Fish species present in the samples of AmerenUE (1980-2000) and MDC (1963)taken by electrofishing in the Osage River below Bagnell Dam.

Common Name	AmerenUE # of each species	MDC # of each species	AmerenUE % of each species	MDC % of each species
Chestnut lamprey	49	-	0.11	-
Silver lamprey	1	-	<0.01	-
Longnose gar	263	-	0.58	-
Shortnose gar	517	-	1.14	-
Paddlefish	113	-	0.25	-
American eel	24	-	0.05	-
Gizzard shad	20,621	-	45.38	-
Skipjack herring	10	-	0.02	-
Mooneye	10	-	0.02	-
Goldeye	131	-	0.29	-
Largescale stoneroller	6	20	0.01	2.1
Central stoneroller	2	12	<0.01	1.26

Red shiner	**1**	**10**	**<0.01**	**1.05**
Common carp	**1,793**	**-**	**3.96**	**-**
Grass carp	**165**	**-**	**0.36**	**-**
Bighead carp	**83**	**-**	**0.18**	**-**
Silver carp	**1**	**-**	**<0.01**	**-**
Gravel chub	**-**	**15**	**-**	**1.58**
Bleeding shiner	**-**	**10**	**-**	**1.05**
Hornyhead chub	**2**	**-**	**<0.01**	**-**
Mimic shiner	**-**	**2**	**-**	**0.21**
Emerald shiner	**12**	**168**	**0.03**	**17.67**
Golden shiner	**7**	**-**	**0.01**	**-**
Ghost shiner	**-**	**81**	**-**	**8.52**
Channel shiner	**-**	**374**	**-**	**39.33**
Sand shiner	**-**	**23**	**-**	**2.42**
Ozark minnow	**-**	**2**	**-**	**0.21**
Southern redbelly dace	**1**	**-**	**<0.01**	**-**
Bluntnose minnow	**-**	**126**	**-**	**13.25**
White sucker	**2**	**-**	**<0.01**	**-**

Blue sucker	3	-	<0.01	-
Highfin carpsucker	32	-	0.07	-
Northern hogsucker	8	-	0.02	-
Bigmouth buffalo	661	-	1.45	-
Smallmouth buffalo	1,081	-	2.38	-
Black buffalo	60	-	0.13	-
Quillback	123	-	0.27	-
Black redhorse	214	-	0.47	-
Golden redhorse	598	-	1.31	-
Shorthead redhorse	525	-	1.15	-
Silver redhorse	40	-	0.09	-
River redhorse	69	-	0.15	-
Black bullhead	1	-	<0.01	-
Yellow bullhead	4	-	0.01	-
Channel catfish	966	-	2.12	-
Flathead catfish	28	-	0.06	-
Blue catfish	915	-	2.01	-
Northern studfish	1	-	<0.01	-

Brook silverside	**55**	**31**	**0.12**	**3.26**
Banded sculpin	**1**	**-**	**<0.01**	**-**
White bass	**1,092**	**-**	**2.40**	**-**
Striped bass	**40**	**-**	**0.09**	**-**
Rock bass	**17**	**-**	**0.04**	**-**
River carpsucker	**889**	**-**	**1.96**	**-**
Green sunfish	**127**	**4**	**0.28**	**0.42**
Warmouth	**2**	**-**	**<0.01**	**-**
Bluegill	**4,048**	**16**	**8.91**	**1.68**
Longear sunfish	**391**	**9**	**0.86**	**0.94**
Redear sunfish	**13**	**-**	**0.03**	**-**
Smallmouth bass	**21**	**4**	**0.05**	**0.42**
Spotted bass	**1,977**	**35**	**4.35**	**3.7**
Largemouth bass	**1,201**	**2**	**2.64**	**0.21**
White crappie	**2,959**	**-**	**6.51**	**-**
Black crappie	**588**	**-**	**1.29**	**-**
Fantail darter	**-**	**1**	**-**	**0.11**
Johnny darter	**-**	**1**	**-**	**0.11**

Missouri saddled darter	**-**	**2**	**-**	**0.21**
Slenderhead darter	**-**	**1**	**-**	**0.11**
Logperch	**29**	**1**	**0.64**	**0.11**
Northern pike	**-**	**1**	**-**	**0.11**
Walleye	**25**	**-**	**0.06**	**-**
Sauger	**1**	**-**	**<0.01**	**-**
Freshwater drum	**2,825**	**-**	**6.22**	**-**
Total	**45,444**	**951**	**100.00**	**100.00**

Table 24. Amphibians and Reptiles of the East Osage River Basin.		
Common name	**Scientific name**	**Missouri County***
Hellbender	***Cryptobranchus alleganiensis***	**B, H, Ca, Mi, P, Co, O, Ma, L**
Ringed salamander	***Ambystoma annulatum***	**All**
Spotted salamander	***Ambystoma maculatum***	**All**
Marbled salamander	***Ambystoma opacum***	**L, O, Ma, P, Mi**
Smallmouth salamander	***Ambystoma texanum***	**O, Co**
Eastern tiger salamander	***Ambystoma tigrinum tigrinum***	**All**
Central newt	***Notophthalmus viridescens louisianensis***	**All**
Longrail salamander	***Eurycea longicauda***	**All**
Cave salamander	***Eurycea lucifuga***	**All**
Graybelly salamander	***Eurycea multiplicata griseogaster***	**Pa, La**
Four-toed salamander	***Hemidactylium scutatum***	**Ca, Mi, L, P, Ma**
Slimy salamander	***Plethodon glutinosus glutinosus***	**All**
Southern redback salamander	***Plethodon serratus***	**All**
Grotto salamander	***Typhlotriton spelaeus***	**B, H, Mo, Ca, L, P, Mi, Ma**
Mudpuppy	***Necturus maculosus***	**All**
Plains spadefoot	***Scaphiopus bombifrons***	**Co, O**

Eastern american toad	***Bufo americanus***	**All**
Great plains toad	***Bufo cognatus***	**Co, O**
Woodhouse’s toad	***Bufo woodhousei***	**All**
Blanchard’s cricket frog	***Acris crepitans blanchardi***	**All**
Green treefrog	***Hyla cinerea***	**Ca, L, Mi**
Northern spring peeper	***Hyla crucifer crucifer***	**All**
Gray treefrog	***Hyla chrysoscelis***	**All**
Western chorus frog	***Pseudacris triseriata***	**All**
Eastern narrowmouth toad	***Gastrophryne carolinensis***	**All**
Great plains narrowmouth toad	***Gastrophryne olivacea***	**O, Co**
Northern crawfish frog	***Rana areolata circulosa***	**Mi, Mo, Co**
Plains leopard frog	***Rana blairi***	**Co, O**
Bullfrog	***Rana catesbeiana***	**All**
Green frog	***Rana clamitans***	**All**
Pickerel frog	***Rana palustris***	**All**
Common name	**Scientific name**	**Missouri County***
Southern leopard frog	***Rana sphenocephala***	**All**
Wood frog	***Rana sylvatica***	**Os**

Common snapping turtle	***Chelydra serpentina serpentina***	**All**
Stinkpot	***Sternotherus odoratus***	**All**
Western painted turtle	***Chrysemys picta bellii***	**All**
Map turtle	***Graptemys geographica***	**All**
Mississippi map turtle	***Graptemys kohnii***	**All**
False map turtle	***Graptemys pseudogeographica pseudogeographica***	**All**
Missouri river cooter	***Pseudemys concinna metteri***	**All**
Three-toed box turtle	***Terrapene carolina triunguis***	**All**
Ornate box turtle	***Terrapene ornata ornata***	**All**
Red-eared slider	***Trachemys scripta elegans***	**All**
Midland smooth softshell	***Trionyx muticus vuticus***	**All**
Eastern spiny softshell	***Trionyx spinifer spinifer***	**All**
Northern fence lizard	***Sceloporus undulatus hyacinthinus***	**All**
Southern coal skink	***Eumeces anthracinus pluvialis***	**All**
Five-lined skink	***Eumeces fasciatus***	**All**
Broadhead skink	***Eumeces laticeps***	**All**
Ground skink	***Scincella lateralis***	**All**
Six-lined racerunner	***Cnemidophorus sexlineatus***	**All**

Western slender glass lizard	***Ophisaurus attenuatus attenuatus***	**All**
Western worm snake	***Carphophis amoenus vermis***	**All**
Northern scarlet snake	***Cemophora coccinea copei***	**Ca, Mi, Ma, Pu**
Eastern yellowbelly racer	***Coluber constrictor flaviventris***	**All**
Prairie ringneck snake	***Diadophis punctatus arnyi***	**All**
Great plains rat snake	***Elaphe guttata emoryi***	**All**
Black rat snake	***Elaphe obsoleta obsoleta***	**All**
Eastern hognose snake	***Heterodon platyrhinos***	**All**
Prairie kingsnake	***Lampropeltis calligaster calligaster***	**All**
Speckled kingsnake	***Lampropeltis getulus holbrooki***	**All**
Common name	**Scientific name**	**Missouri County***
Red milk snake	***Lampropeltis triangulum syspila***	**All**
Eastern Coachwhip	***Masticophis fagellum flagellum***	**All**
Northern water snake	***Nerodia sipedon sipedon***	**All**
Rough green snake	***Opheodrys aestivus***	**All**
Bullsnake	***Pituophis melanoleucus sayi***	**All**
Midland brown snake	***Storeria dekayi wrightorum***	**All**
Northern redbelly snake	***Storeria occipitamaculata occipitomaculata***	**All**

Flathead snake	***Tantilla gracilis***	**All**
Western ribbon snake	***Thamnophis proximus proximus***	**All**
Eastern garter snake	***Thamnophis sirtalis sirtalis***	**All**
Central lined snake	***Tropidoclonion lineatum annectens***	**Ma, Mi, Ca, Mo, Co**
Rough earth snake	***Virginia striatula***	**All**
Osage copperhead	***Agkistrodon contortrix phaeogaster***	**All**
Western cottonmouth	***Agkistrodon piscivorus leucostoma***	**Hi, La, Pu, Ma, Mi, Ca**
Timber rattlesnake	***Crotalus horridus***	**All**

Note*: B-Benton, H-Hickory, Mo-Morgan, C-Camden, L-Laclede, P-Pulaski, Mi-Miller, Ma-Maries, C-Cole, O-Osage

Table 25. Mussels of the East Osage River Basin.	
Common Name	**Scientific Name**
Mucket	***Actinonaias ligamentina carinata***
Three-ridge	***Amblema plicata***
Paper floater	***Anodonta imbecilis***
Flat floater	***Anodonta suborbiculata***
Giant floater	***Anodonta grandis grandis***
Rock pocketbook	***Arcidens confragosus***
Asiatic clam	***Corbicula fulminea***
Spectacle case	***Cumberlandia monodonta***
Purple pimpleback	***Cyclonaias tuberculata***
Butterfly	***Ellipsaria lineolata***
Elephant's ear	***Elliptio crassidens crassidens***
Lady-finger	***Elliptio dilatata***
Ebony shell	***Fusconaia***
Wabash pig-toe	***Fusconaia flava***
Yellow sand shell	***Lampsilis teres anodotoides***

Fat mucket	***Lampsilis radiata luteola***
Common Name	**Scientific Name**
Pink mucket	***Lampsilis orbiculata***
Pocketbook	***Lampsilis ventricosa***
Britt’s mussel	***Lampsilis reeviana brittsi***
White heel-splitter	***Lasmigona complanata***
Fluted shell	***Lasmigona costata***
Scale shell	***Leptodea leptodon***
Fragile paper shell	***Leptodea fragilia***
Black sand shell	***Ligumia recta***
Washboard	***Megalonaias nervosa***
Three-honed warty-back	***Obliquaria reflexa***
Hickory-nut	***Obovaria olivaria***
Round pig-toe	***Pleurobema sintoxia***
Pink heel-splitter	***Potamilus alatus***
Pink paper shell	***Potamilus ohioensis***
Monkey-face	***Quadrula metanevra***

Pimple-back	***Quadrula pustulosa***
Maple leaf	***Quadrula quadrula***
Squaw foot	***Strophitus undulatus undulatus***
Liliput shell	***Toxolasma parvus***
Pistol-grip	***Tritogonia verrucosa***
Fawn’s foot	***Truncilla donaciformis***
Deer-toe	***Truncilla truncata***
Pond-horn	***Uniomerus tetralasmus***
Ellipse	***Venustaconcha ellipsiformis ellipsiformis***

Table 26. Species of Conservation Concern found in the East Osage River Basin and conservation status and rank.

Common Name	Scientific Name	Federal Status	State Status	State Rank	Global Rank
PLANTS					
Shaggy moss	*Rhytidiadelphus triquetrus*				G5
Tussock sedge	*Carex stricta*				G5
Hairy-fruited sedge	*Carex trichocarpa*			S1	G4
Brown bog sedge	*Carex buxbaumii*			S2	G5
Smooth sheath sedge	*Carex laevivaginata*			S3	G5
Type of sedge	*Carex fissa* var. *fissa*			S1	G3G4
Broadwing sedge	*Carex alata*			S2S3	G4
Sharp-scaled manna grass	*Glyceria acutiflora*			S3	G5
Bald grass	*Sporobolus ozarkanus*			S4	
Type of liverwort	*Preissia quadrata*				G5
Waterwort	*Elatine triandra*				G5
Buffalo clover	*Trifolium reflexum*			S3S4	G5

Running buffalo clover	***Trifolium stoloniferum***	**E**	**E**	**S1**	**G3**
Heart-leaved plantain	***Plantago cordata***			**S3S4**	**G4**
Yellow-flowered leafcup	***Smallanthus uvedalius***			**S4**	**G4G5**
Royal catchfly	***Silene regia***			**S3**	**G3**
Butternut	***Juglans cinerea***			**S2**	**G3G4**
Type of wild hyacinth	***Camassia angusta***			**S3**	**G5**
Mead's Milkweed	***Asclepias meadii***	**T**	**E**	**S2**	**G2**
Yellow-flowered horse gentian	***Triosteum angustifolium* var *eamesii***			**S1**	**G5**
Pale avens	***Geum virginianum***			**S1**	**G5**
Shining ladies' tresses	***Spiranthes lucida***			**S3**	**G5**
Northern rein orchid	***Platanthera flava* var *herbiola***			**S2**	**G4**
Tradescant aster	***Aster dumosus* var *strictior***			**S2**	**G5**
Queen of the prairie	***Filipendula rubra***			**S2**	**G4G5**
Wild sweet William	***Phlox maculata* ssp *pyramidalis***			**S2**	**G5**

INVERTEBRATES					
Hickorynut	***Obovaria olivaria***			**S2S3**	**G4**
Black sandshell	***Ligumia recta***			**S1S2**	**G5**
Pink mucket	***Lampsilis abrupta***	**E**	**E**	**S2**	**G2**
Spectaclecase	***Cumberlandia monodanta***			**S3**	**G2G3**
Elephant-ear	***Elliptio crassidens***		**E**	**S1**	**G5**
Rock-pocketbook	***Arcidens confragosus***			**S3**	**G4**
Giant floater	***Pyganodon grandis corpulenta***			**S3S4**	**G5**
Prairie mole cricket	***Gryllotalpa major***			**S3**	**G3**
Type of winter stonefly	***Allocapnia pygmaea***			**S3**	**G5**
Gray petaltail	***Tachopteryx thoreyi***				**G4**
Regal fritillary	***Speyeria idalia***			**S3**	**G3**
FISH					
Lake sturgeon	***Acipenser fulvescens***		**E**	**S1**	**G3**
Blacknose shiner	***Notropis heterolepis***			**S2**	**G5**

Ghost shiner	***Notropis buchanani***			**S2**	**G5**
Western silvery minnow	***Hybognathus argyritis***			**S2**	**G5**
Paddlefish	***Polyodon spathula***			**S3**	**G4**
Northern pike	***Esox lucius***			**S4**	**G5**
Alabama shad	***Alosa alabamae***	**C**		**S2**	**G3**
Mooneye	***Hiodon tergisus***			**S2**	**G5**
Blue sucker	***Cycleptus elongatus***			**S3**	**G3**
Highfin carpsucker	***Carpiodes velifer***			**S2**	**G4G5**
Southern cavefish	***Typhlichthys subterraneus***			**S1S2**	**G3**
Plains topminnow	***Fundulus sciadicus***			**S3**	**G3**
Least darter	***Etheostoma microperca***			**S2**	**G5**
Niangua darter	***Etheostoma nianguae***	**T**	**E**	**S2**	**G2**
Bluestripe darter	***Percina cymatotaenia***			**S2**	**G2**
AMPHIBIANS					
Green treefrog	***Hyla cinerea***			**S3S4**	**G5**

Ringed salamander	***Ambystoma annulatum***			**S3**	**G4**
Four-toed salamander	***Hemidactylium scutatum***			**S4**	**G5**
Grotto salamander	***Typhlotriton spelaeus***			**S3**	**G4**
REPTILES					
Eastern collared lizard	***Crotaphytus collaris collaris***			**S4**	**G5**
Northern scarlet snake	***Cemophora coccinea copei***			**S2S3**	**G5T5**
BIRDS					
Bald eagle	***Haliaeetus leucocephalus***	**T**	**E**	**S2**	**G4**
Sharp-shinned hawk	***Accipiter striatus***			**S2**	**G5**
Red-shouldered hawk	***Buteo lineatus***			**S3**	**G5**
Cooper's hawk	***Accipiter cooperi***			**S3**	**G5**
Henslow's sparrow	***Ammodramus henslowii***			**S2**	**G4**
Greater prairie chicken	***Tympanuchus cupido***		**E**	**S1**	**G4**
Upland sandpiper	***Bartramia longicauda***			**S3**	**G5**

Great blue heron	***Ardea herodias***			**S5**	**G5**
MAMMALS					
Gray bat	***Myotis grisescens***	**E**	**E**	**S3**	**G3**
Indiana bat	***Myotis sodalis***	**E**	**E**	**S1**	**G2**
Black-tailed jackrabbit	***Lepus californicus***			**S1**	**G5**
Eastern woodrat	***Neotoma floridana***			**S3S4**	**G5**
Cotton mouse	***Peromyscus gossypinus***			**S2**	**G5**

E=Endangered

T=Threatened

C=Candidate for listing

S1=Critically imperiled in Missouri because of exterme rarity or because some factor(s) make it especially vulnerable to extirpation

S2=Imperiled in Missouri because of rarity or because some factor(s) make it very vulnerable to extirpation

S3=Rare or uncommon in Missouri

S4=Widespread, abundant, and apparently secure in Missouri, but of long-term concern

S5=Demonstrably widespread, abundant, and secure in Missouri, and essentially ineradicable under present conditions

G1-G5=Relative endangerment for the species worldwide. Numerical categories are similar to S1-S5 above.

Table 27. Species of Conservation Concern in East Osage River Basin by subbasin (MDC Natural History database).														
Common Name (if available)	Lower Osage R.	Lower Maries R.	Upper Maries R.	Little Maries R.	Tavern Cr.	Wet Glaize Cr.	Dry Auglaize Cr.	Deer Cr.	Turkey Cr.	Cole Camp Cr.	Upper LOZ Hills	Gravois Arm	Lower LOZ Hills	Miller Co Osg R Hills
<u>PLANTS</u>														
Heart-leaved plaintain	x										x			x
Yellow-flowered leaf	x													
Purple loosestrife				x										
Tussock sedge					x									
Hairy-fruited sedge					x									
Brown bog sedge													x	
Smooth sheath sedge					x						x	x	x	
Bald grass					x									
(*Carex fissa*)						x								
(*Panicum acuminatum*)						x							x	

Royal catchfly						**x**	**x**						**x**	**x**
Butternut													**x**	
(*Preissia quadrata*)							**x**							
Waterwort							**x**							
Sharp-scaled manna grass							**x**							
Broadwing sedge							**x**							
(*Camassia angusta*)										**x**				
Mead’s milkweed										**x**				
Yellow-flowered horse gentian										**x**				
Pale avens										**x**				
Shining ladies’ tresses											**x**	**x**	**x**	
Northern rein orchid												**x**		
Shaggy moss												**x**		
Tradescant aster											**x**			
Buffalo clover													**x**	

Running buffalo clover											**x**			
Queen of the prairie											**x**			
Wild sweet william											**x**			
INVERTEBRATES														
Hickorynut	**x**													**x**
Black sandshell	**x**	**x**			**x**									**x**
Pink mucket	**x**													**x**
Spectaclecase	**x**													**x**
Elephant ear	**x**													**x**
Rock pocketbook	**x**													**x**
Giant floater	**x**													**x**
Prairie mole cricket										**x**				
(*Allocapnia pygmaea*)														**x**
Gray petaltail													**x**	
Regal fritillary										**x**				
FISH														

Alabama shad	**x**													
Northern pike	**x**		**x**											**x**
Ghost shiner	**x**	**x**												**x**
Plains topminnow	**x**	**x**	**x**	**x**	**x**					**x**	**x**			**x**
Blacknose shiner			**x**	**x**			**x**							
Niangua darter					**x**									
Southern cavefish						**x**								
Mooneye														**x**
Paddlefish														**x**
Highfin carpsucker														**x**
Lake sturgeon														**x**
Blue sucker														**x**
Least darter								**x**		**x**		**x**		
AMPHIBIANS														
Green treefrog						**x**								
Ringed salamander							**x**							
Four-toed salamander											**x**			

Grotto salamander													x	
REPTILES														
Eastern collared lizard	x				x									
Northern scarlet snake												x	x	x
BIRDS														
Great blue heron	x				x	x		x		x	x			x
Bald eagle	x							x			x		x	x
Cooper’s hawk		x			x						x			
Sharp-shinned hawk					x									
Henslow’s sparrow					x					x				
Greater prairie chicken										x				
Upland sandpiper										x				
Red-shouldered hawk											x		x	
MAMMALS														
Gray bat	x					x		x		x	x	x	x	x
Indiana bat						x								

Black-tailed jackrabbit										**x**				
Eastern woodrat												**x**	**x**	
Cotton mouse											**x**			

MANAGEMENT PROBLEMS AND OPPORTUNITIES

The management objectives and strategies for the East Osage River Basin Watershed Inventory and Assessment were developed to address the problems and opportunities for conserving and enhancing the aquatic resources within the basin. The MDC Strategic Plan, the Fisheries Division Operational Plan, the Lake of the Ozarks Fisheries Management Plan, the MDC Stream Areas Program Plan, the MDC Stream Access Acquisition Plan, and the MDC West Central Regional Management Guidelines indicate areas of future expanded resource management, public awareness, and access needs, and helped guide development of these objectives and strategies.

The following text describes the management objectives and strategies under six major goals: water quantity and quality, habitat, biotic community, public access and recreational use, informational and educational opportunities, and data inventory and maintenance. Completion of these objectives will depend upon their status in overall Department, Division, and Regional priorities and the availability of personnel and funds. Many of the objectives rely on interagency coordination. Revision of any and all of these objectives will occur as needed. In particular, ongoing and future studies associated with the Federal Energy Regulatory Commission's relicensing of the Osage Project (Bagnell Dam) will provide substantial amounts of new information that will be used to evaluate and revise objectives.

GOAL I: PROTECT AND IMPROVE WATER QUANTITY AND QUALITY IN THE EAST OSAGE RIVER BASIN SO THAT ALL STREAMS ARE CAPABLE OF SUPPORTING NATIVE AQUATIC COMMUNITIES.

Status: Data were compiled for all known potential sources of water-related degradation in the basin. The beneficial uses and classifications of most third order and greater streams were evaluated, and numerous streams were recommended for upgraded classification in 1996 and 2001. Osage River discharge data were compiled from pre- and post-Bagnell Dam records maintained by the USGS. Information on discharge, river stage, water chemistry, water temperature, and aquatic communities is currently being collected and analyzed through contractual studies required of AmerenUE in the Federal Energy Regulatory Commission (FERC) relicensing process. Additional contractual studies and information are anticipated in 2002-2004, with a new Osage Project license scheduled to be issued in 2006.

Water Quantity

Objective I.1: Work with AmerenUE, USACE and other basin water regulators, during and following the FERC relicensing process, to improve aquatic habitat and recreational use by changing Osage Project operation to natural run-of-river (non-peaking) operation, or obtain mitigation measures which will result in equivalent or more benefits to natural resources and recreation.

Bagnell Dam

Problem/Opportunity: Bagnell Dam was constructed in 1931 for hydropower generation. AmerenUE operates the Osage Project plant under the auspices of the FERC, and the current license which expires in 2006. A new license is scheduled to be issued in 2006, and will be for at least a 30-year period. The Osage Project is a peaking plant with generation discharges usually occurring in the late morning through the evening, Monday- Friday, when power demand is at a peak. A minimum flow of about 455 cfs occurs 24 hours per day from a small "house" generator or turbine. The peaking operation creates rapid flow fluctuations, with low, drought-like flows followed by bankfull flows. As a result of the peaking and low flows, aquatic habitat and biota, and recreational use on the river have been negatively impacted. These impacts include: erosion of the river channel and islands, erosion and siltation of tributaries, loss of riparian habitat, channel widening and loss of depth at low flows - which strands aquatic life, sedimentation and loss of backwaters, changes in river flow that alter fish movement and spawning success, and cold water discharges from the lake that alter temperature and contain low levels of dissolved oxygen, and killing of fish going through the turbines (termed entrainment). Recreational use is affected by both low flows and high discharge rates, particularly the rapid changes in water levels and flow velocities. Fish kills have occurred due to low oxygen levels in the tailwater of Bagnell Dam. Some improvements have been made by cooperative efforts to increase oxygen by simple modifications in existing generation equipment and operational changes. However, DO still needs to be improved and other problems related to entrainment and fluctuating flows have not been adequately addressed. In addition, AmerenUE has requested amendments to the current license to upgrade four turbines. Increased discharge rates and potential problems with dissolved oxygen or entrainment of Lake of the Ozarks sport fishes must be addressed during the amendment comment period that is scheduled for late 2001 and early 2002. The relicensing process offers a rare opportunity to improve the Osage River for the next 30 years for fish, wildlife, and recreational use by balancing the need for hydro-power with the outstanding fisheries and tourism / recreational boon that Lake of the Ozarks offers. Guidelines can be developed to take advantage of opportunities to operate the dam in the best interests of Lake of the Ozarks, the Osage River, and the demand for power.

MDC should participate in the FERC relicensing effort by attending stakeholder and subcommittee meetings.

MDC should take the lead with other fish and wildlife and environmental agencies to work through the FERC relicensing effort under the 10J provision of the Federal Power Act to develop conditions to the new license which will develop Osage Project operations in ways which will enhance, protect, and mitigate for aquatic resources.

MDC should work with AmerenUE and other stakeholders to compare upgraded operation of the Osage Project with run-of-river (non-peaking) and other operational alternatives and evaluate effects on aquatic habitats and native aquatic and riparian communities. Measurement or modeling of habitat conditions and diversity provided by operational alternatives will be needed for comparing operational alternatives, as required by FERC in the relicensing of the Osage Plant.

MDC should inform other stakeholders of our vision for the continued maintenance of the quality fishery and recreational / tourism offered by Lake of the Ozarks and the improvement of the Osage River offered during and following the relicensing period.

Stream Teams and other stakeholders should be encouraged to adopt streams in the basin particularly below Bagnell Dam to help with monitoring biota, water quality, and habitat.

MDC should provide guidance in the development of standardized sampling methods for fish and macroinvertebrates and mussels in the Osage River to document improvements in habitat as changes in operation of Bagnell Dam are implemented under the new license. MDC should seek mitigation for habitat losses along MDC areas along the river and tributary streams impacted by the operation of Bagnell Dam.

MDC should provide guidance in the monitoring of entrainment of fish through Bagnell Dam with the upgrades of any new turbines.

MDC should provide guidance in the monitoring of discharge from Bagnell Dam to ensure that minimum flows and other flow regime changes are followed as outlined in the FERC license to be issued in 2006. Report violations of the license to AmerenUE, FERC, MDNR, and the Public Service Commission.

Objective I.2: Support the enactment of a State Water Law and other rules that will prevent negative downstream impacts from single or cumulative withdrawals.

Problem/Opportunity: Since there are inadequate water-use policies in Missouri, downstream users and government agencies have little recourse to regulate upstream water users and prevent them from withdrawing water that may impact aquatic organisms.

Cooperate with and support MDNR in preparing a Missouri Water Policy which restricts water removal from streams for upstream uses.

Work with MDNR and USACE, to protect or enhance stream flows through oversight and enforcement of existing water withdrawal permits.

Work with federal/state entities toward interstate compact.

Water Quality

Bagnell Dam

Problems and Opportunities: Low dissolved oxygen and rapid temperature changes are common below Bagnell Dam. Some improvements have been made by AmerenUE in cooperative efforts to increase oxygen by simple modifications in existing generation equipment and operational changes. Additional improvements are possible with new technologies and with the turbine upgrades described in the water quantity objectives section. Low temperatures may be a continual problem as the depth of the intake structure on Bagnell Dam is below the thermocline and cold water discharged from the lake during the summer when LOZ is thermally stratified can impact fish and mussels.

> Recommend potential changes in the operation of Bagnell Dam during the FERC relicensing to increase dissolved oxygen and moderate temperature changes in the Osage River. Data for these changes will be forthcoming in the contractual water quality sampling and analysis slated for 2002 and 2003 by AmerenUE. Modeling of the water quality conditions using the collected data would be beneficial under the 401 certification required by MDNR and for comparing operational alternatives, as required by FERC in the relicensing of the Osage Plant.
>
> MDC should continue to work with AmerenUE to monitor dissolved oxygen levels with the new turbine upgrades.

Pollution Sources

Objective I.3: Continue to identify potential pollution sources within the basin and within the recharge areas of springs; evaluate their potential impacts on water quality and aquatic communities, and implement management strategies to monitor the potential impacts and reduce these threats.

Sewage Treatment Plants

Problem/Opportunity: Sewage treatment facilities of the Lebanon WWTP are chronically discharging poorly treated wastewater to the basin.

> Encourage MDNR to monitor compliance with permit limitations, and comment on plans to upgrade

these facilities.

Ensure that receiving streams are appropriately classified for protection of aquatic resources.

Encourage Stream Teams to monitor sites below these facilities.

Sludge Application

Problem/Opportunity: Wastewater sludge stored in lagoons or applied to farmland can pose a threat to water quality. Application sites for sludge storage seem to be adequately monitored by the MDNR and 18 problems have been reported in the basin. Private haulers have only recently been required to obtain licenses and file reports, so limited information is available. There are a large number of private treatment systems in the basin, especially around LOZ, that depend on private haulers for sludge disposal. Locations of disposal sites within the watershed need to be determined.

Obtain records for private haulers from MDNR, create a database, and plot sites on 7.5 minute topographic maps.

Obtain annual reports each year and evaluate whether haulers are in compliance.

Non-POTWs (Non-public owned treatment works)

Problem/Opportunity: There are large numbers of these systems in the LOZ area that handle considerable amounts of waste. They pose a significant threat to water quality if they are not monitored and properly maintained. The number of these systems is expected to increase with continuing development around the lake because many sites will not meet the requirements of the new regulations for conventional septic systems.

Recommend strict permit review and compliance monitoring for these facilities by MDNR.

Animal Waste Point Source

Problem/Opportunity: Most of the permitted animal waste facilities in the watershed are hog confinement facilities. However, there are at least 14 large poultry operations and eight dairies within the basin.

Encourage Stream Teams to monitor water quality and aquatic communities in the receiving streams below large facilities.

Support legislation that reduces potential pollution of the surface and groundwater resources from the application of poultry, hog, and cattle waste.

Landfills

Problem/Opportunity: The Lebanon Sanitary Landfill occasionally discharges leachate to Goodwin Hollow, a losing stream that is hydrologically connected to Niangua Darter habitat in the adjacent subbasin.

Recommend that the MDNR inspect this facility, and ensure maximum water quality protection.

Agricultural Runoff

Problem/Opportunity: Wastewater of greater than 300 animal units from dairies and hog and poultry confinement facilities and dairies are regulated by the MDNR as point sources. They must meet minimum standards, and operations within the watershed appear to be gradually coming into compliance. Livestock in pasture are non-point sources that are less tangible and may represent a considerable source of contaminants. The amount of stream contamination can be reduced by good pasture management, erosion control, and providing filter strips in riparian corridors.

Promote good pasture management, erosion control, revegetation of corridors, and livestock exclusion throughout the watershed.

Cooperate with NRCS to implement alternative water systems incentive agreements throughout the watershed.

Utilize other state and cost share programs such as AgNPS, EQIP, WHIP, and CRP to address non-point agriculture pollution problems in the watershed.

Water Quality Monitoring

Objective I.4: Ensure that water quality and aquatic communities are monitored adequately to provide early detection of stream and lake degradation and to evaluate possible effects of watershed and stream improvement projects.

Problem/Opportunity:

Support continued water quality monitoring efforts in the Wet Glaize, Tavern Creek, Little Maries River, Lower Maries River, Lower Osage River, Miller County Osage River Hills, Gravois Mills, Cole Camp Creek, Turkey Creek, and Dry Auglaize Creek Subbasins to document improvements from animal waste treatment facilities and from continuing efforts to reduce agricultural runoff.

Encourage Stream Teams to adopt strategic sampling sites in the basin.

Fish Kills

Problem/Opportunity: Several fish kills have been documented in the basin. Most have been associated with either the operation of Harry S Truman Dam and Bagnell Dam or sewage discharge from a number of municipal and non-municipal sources sewage treatment facilities within the basin.

Assist state and federal agencies with enforcement of water pollution laws by cooperating with pollution and fishkill investigations.

Cooperate with the Truman Project Office of the USACE to set spillway outflow limits and turbine use guidelines and minimize releases harmful fish below Truman Dam.

Cooperate with MDNR to minimize future threats from Truman Dam or Bagnell Dam due to the addition of new turbines or discharge manipulation.

Cooperate with MDNR to minimize future threats from municipal and non-municipal sewage treatment plants within the watershed and spring recharge areas.

Fish Contamination

Problem/Opportunity: During the previous sample periods, largemouth bass collected from the basin have shown elevated levels of mercury.

Continue to collect fish for contaminant and heavy metal analysis by MDOH from Lake of the Ozarks and selected tributary streams every year per MDOH guidelines.

Cooperate with MDOH in informing the public about health advisories and the impacts of fish contamination.

Fish Contaminant Sampling

Problem/ Opportunity: MDC cooperates with the MDOH to sample fish for contaminant and heavy metals in public waters around the state. Increases in the heavy metal mercury have occurred in waters in the basin. In addition, recent changes related to fish advisory levels for mercury were adopted by EPA. In June 2001 a statewide advisory was issued for all waters for pregnant or nursing women, and children under the age of 12 who eat largemouth bass greater than 12 inches.

Beneficial Use Attainment

Objective I.5: Evaluate all classified streams to ensure that appropriate beneficial uses are being attained and recommend upgraded classifications as necessary.

Problem/Opportunity: Some third-order streams in the watershed remain unclassified.

> Identify appropriate classifications and beneficial uses for remaining unclassified streams and recommend upgraded classification to MDNR.

Problem/Opportunity: Efforts to protect Niangua darter habitat with a special classification have failed to win Clean Water Commission approval. Classification could be used to require stricter limitations in NPDES Permits that discharge to streams within critical habitat. "Outstanding State Resource" classification would also provide better protection for these streams.

> Propose, once again, that Niangua darter known range be given special classification "Critical Habitat for Rare and Endangered Aquatic Species," or alternatively, "Outstanding State Resource."

Objective I.6: Promote programs that enhance groundwater recharge in the watershed and spring recharge areas.

Springs

Problem/Opportunity: Springs are the main source of sustained flow in streams during periods of low precipitation. Since aquatic communities can experience great stress under these conditions (low dissolved oxygen and high temperatures), adequate flow and good water quality are essential. Springs in the watershed have not been monitored sufficiently to determine current conditions or detect change over time.

> Compile existing data on springs within the watershed.
>
> Cooperate with the USGS and MDNR to develop a plan to monitor strategic springs.

Watershed Projects

Problem/Opportunity: The amount of rainfall that percolates through the soil to recharge aquifers and maintain base flows is affected by land use and the amount of vegetation. Ungrazed, uneven-aged, woodland allows optimal percolation, and well-managed pastures improve the quality of runoff events.

> Promote watershed practices that improve groundwater recharge, including cattle exclusion from woodlands, good pasture management, timber stand improvement, and conversion of pasture and open fields to woodland.
>
> Support current and future Special Area Land Treatment Projects (SALT) as administered by the county Soil and Water Conservation Districts and the Missouri Department of Natural Resources.

GOAL II: PROTECT AND IMPROVE AQUATIC HABITAT CONDITIONS OF THE EAST OSAGE RIVER BASIN WATERSHED TO MEET THE NEEDS OF NATIVE AQUATIC SPECIES WHILE ACCOMMODATING SOCIETY'S DEMANDS FOR WATER AND AGRICULTURAL PRODUCTION.

Objective II.1: Ensure that instream projects within the watershed do not interfere with natural stream processes.

Osage Lock and Dam at RM 12.1

Problem / Opportunity: During the late 1890's the USACE developed a navigation plan to improve the Osage River for barge traffic. In this plan the USACE identified a series of Lock and Dams to be constructed at various intervals along the entire stretch of the Osage River. Only one lock and dam was constructed in the early 1900's by the USACE at RM 12.1. This lock and dam now has the lock removed but the dam serves as an impediment to fish migration during some parts of the year. When the Missouri River is low and no generation occurs, fish cannot get over the dam, or if the Missouri River is low and generation flows are not high enough to over top the lock and dam, the velocities in the narrow opening to the lock exceed the swimming ability of many sportfish, preventing them from migrating upstream. The Osage Lock and Dam is currently under private ownership as the USACE deeded the property back to the landowner. The lock and dam also presents a hazard to boaters and canoeists. A large amount of gravel and silt is present above the dam.

Work with the landowner who owns the land where the Osage Lock and Dam is located and federal and other state agencies to investigate the feasibility of modifying the existing structure to improve the passage of fish at a variety of river flows and reduce hazards to recreational users.

Work with AmerenUE in the FERC relicensing to evaluate Osage Project operational alternatives that would improve fish passage during fish and mussel spawning seasons

Channel Alterations

Problem/Opportunity: Many landowners and county and city governments still believe that channelization is an appropriate solution to bank erosion and flooding problems. Although some short-term reduction in bank erosion may be achieved, the negative side effects can be severe, including loss of habitat diversity, accelerated upstream and downstream erosion, headcutting upstream, and channel destabilization.

Meet with landowners and local government officials who propose channelization projects to discuss their concerns and inform them about stream processes and the negative impacts of channel alterations, and recommend more appropriate remedies.

Disseminate MDC literature and other information that describe alternative techniques to channelization.

404 Activities

Problem/Opportunity: A large number of Section 404 applications for instream construction and excavation are submitted for streams within basin.

Review all 404, gravel excavation, bridge construction and other development projects that may impact streams and recommend appropriate action to maintain, improve or protect aquatic habitats.

Recommend denial of 404 permits that require repeated stream crossing or recommend conditions that include installation of a temporary crossing under MDC supervision.

Encourage Stream Teams to comment on 404 permits.

Problem/Opportunity: The permitting process for sand and gravel removal has become greatly simplified within recent years. The simplification of the application and approval process for applicants has reduced a very important component which has been beneficial in the past - direct contact between landowners or permittees and government employees from MDC, USACE, or MDNR. These contacts provided opportunities to inform the interested parties about stream processes and the meaning and justification for the permit conditions; learn about their experiences, techniques, and concerns; and otherwise establish a cooperative, mutually beneficial relationship. In addition, greater involvement by USACE, MDNR, or MDC employees provided opportunity to make site visits and document pre-permit conditions, monitor compliance, and observe possible impacts. Now, when a general permit is issued, the MDC is usually not consulted and frequently the USACE makes no site inspection. Nationwide permits are usually issued with inadequate conditions to protect aquatic resources and without MDC input.

Review 404 applications and inspect proposed sites whenever possible.

Encourage the USACE to provide opportunities for regional fisheries personnel to comment on 404 applications that include requests for variances, crossing streams, or channelizations.

Recommend that MDC Policy Coordination request changes in procedures to USACE General and Nationwide Permits. Include careful scrutiny of locations of proposed activities, onsite inspections where violations have occurred, and MDC notification of proposed activities.

Recommend that MDC Policy Coordination continue to work with the Clean Water Commission and MDNR to control gravel mining through 401 certification.

Objective II.2: Determine flows necessary to sustain native communities of fish and other aquatic life, and to provide adequate spawning habitat for white bass, walleye, and other species.

Problem/Opportunity: Truman Dam prevents migration of LOZ white bass, walleye, paddlefish and other species to historic spawning sites upstream. White bass spawn below Truman Dam and Bagnell Dam on the Osage River. While some walleye may spawn below Truman Dam, the contribution to the LOZ fishery is speculative. Sauger are found in the Osage River below Bagnell Dam. Suitable spawning conditions for paddlefish are not available below Truman Dam. Spawning areas for paddlefish below Bagnell Dam are useless.

> Provide guidance in the development of fish sampling and spawning habitat assessment techniques on the Osage River for walleye and sauger.
>
> Develop recommendations for maintaining adequate flows below hydropower dams for white bass, walleye, sauger, and paddlefish using approved instream flow methodologies as recommended by Fisheries personnel. Such flows might also enhance paddlefish migration and susceptibility to anglers on the Osage River and Upper Lake of the Ozarks.

Objective II.3: Implement habitat improvement projects on public and private land.

Habitat Improvement Projects on Private Land

Problem/Opportunity: Riparian corridors are in poor condition on many watershed streams and cattle frequently have access to corridors and streams. The vast majority of stream frontage in the watershed is in private ownership.

> Implement landowner incentive programs through existing or new state or federal incentive program or assist county SWCDs to obtain federal or state grant money through: 319 Environmental Protection Agency grants, Rural Clean Water Program, Water Quality Improvement Practices (WQIP), AgNPS projects and MDC stream private land programs.
>
> Develop landowner cooperative projects (LCPs) in the basin. Target Maries River and Tavern Creek for promoting cost shares.
>
> Promote the adoption of streambank erosion control and riparian corridor establishment or protection practices for approval by the county Agriculture Executive Committee of FSA or the SWCD administered through the MDNR Soil and Water Conservation Program.
>
> Encourage landowners and urban residents to form watershed committees.

Provide technical assistance and information to all landowners who request assistance and on-site consultation to those willing to establish and maintain stream corridors guidelines.

Problem/Opportunity: Promotional and educational efforts are necessary to inform landowners about cost-share programs and encourage participation.

Promote and advertise stream improvement projects on Department areas and LCPs for demonstration purposes using Neighbor to Neighbor or SWCD Field Day events.

Advertise and promote available stream habitat improvement cost-share programs through traditional and agricultural media; emphasize word-of-mouth advertising by neighbors.

Sponsor a stream and watershed workshop for landowners, NRCS, FSA, USACE, and city and county officials which highlights problems and strategies for correcting them.

Increase landowner awareness of MDC private stream programs through SWCD and Farm Bureau cooperative programs at the county level. Emphasize the economic benefits of well-managed streams.

Cooperate with the MDC Outreach and Education Division to develop stream habitat improvement materials for use by local Vocational Agricultural instructors, FFA chapters, and 4-H clubs.

Habitat Improvement Projects on Public Lands

Problem/Opportunity: Area Plans are prepared periodically for MDC conservation areas.

Inspect these areas and recommend corridor expansion or bank stabilization projects as necessary to correct problems and serve as demonstrations sites.

Include monitoring and habitat improvement strategies for streams on these areas to correct problems.

Problem/Opportunity: The Saline Valley Conservation Area provides an excellent opportunity for managing aquatic resources.

Inspect this area and recommend corridor expansion, bank stabilization projects, and fish habitat improvements to correct problems and serve as demonstrations sites.

Problem/Opportunity: Develop habitat improvement projects as demonstration areas on selected MDC lands in the basin.

Develop several stream demonstration areas in the basin.

Continue to monitor these projects and complete maintenance as necessary.

Use these projects to demonstrate good stream management to the general public and agency personnel as appropriate.

Unique Habitat

Objective II.4: Identify and protect unique habitat in the watershed

Problem/Opportunity: Very little high quality bottomland forest was identified in the Natural Features Inventory of the basin. This is the result of one or more of the following common practices: clearing of bottomlands up to the stream edge; allowing cattle to graze the intact forests; and repeated logging of forests and excessive erosion along the Osage River from Bagnell Dam discharges. These forests are important and necessary components of the stream ecosystem. They provide essential habitat, help prevent streambank erosion, filter surface runoff and groundwater flow, reduce water temperatures by shading streams, and contribute woody debris and organic matter.

Encourage landowners in the basin with bottomland forests or sites naturally suited for bottomland forests to protect and manage them.

Encourage AmerenUE to work with landowners along the Osage River to mitigate for land lost as a result of discharges from Bagnell Dam. (Note that MDC is also a landowner along the river.)

Protect the remaining bottomland hardwoods and look for ways of establishing bottomland hardwoods on MDC's Saline Valley, Smokey Waters and other MDC CAs.

Problem/Opportunity: Very few high quality wetlands were identified in the Natural Features Inventory. Wetlands were probably always a scarce resource in the watershed historically and many have been developed for pasture or cropland or suffered from changes in hydrology resulting from downcutting of the streambed of the Osage River due to releases from Bagnell Dam.

Identify, protect, and enhance wetland habitat through purchases, easements, or other agreements.

Recommend wetland creation at suitable sites on public lands.

Implement management strategies outlined in the MDC Guidelines for Promoting Fishery Resources in Missouri Wetlands on all public areas and privately owned wetlands.

Assist the West Central Region Wildlife personnel with workshops for other agency staff and landowners on the importance of managing wetlands for fish and other aquatic organisms.

Assist MDC West Central Region personnel with workshops for loggers and landowners regarding proper methods of logging timber from riparian corridors and bottomland forests.

Problem/Opportunity: Two of the eight extant Niangua darter populations occur in the watershed. Habitat degradation is apparently still negatively impacting the Niangua darter. Nutrification and sedimentation are believed to be the most serious threats to the darter, as well as the rest of the natural fauna.

Support continued habitat and water quality monitoring efforts in the Lower Maries River, Upper Maries River, Little Maries River, and Tavern Creek subbasins.

Encourage Stream Teams to adopt monitoring sites in Niangua darter range.

Identify, protect, and enhance Niangua darter habitat through purchases, easements, or other agreements.

Habitat Assessment

Objective II.5: Inventory aquatic habitat throughout the basin to provide descriptions of habitat conditions in representative reaches, and quantify various parameters to allow for comparisons between subbasins and with other Missouri watersheds.

Problem/Opportunity: Insufficient numbers of SHADs were conducted to adequately characterize the entire watershed. Most of the SHADs were completed during the 1990's, so it would be desirable to repeat them if surveys are conducted at additional sites. The Habitat Assessment Committee investigated possible alternatives to the SHAD that would provide more useful quantitative data from a watershed wide perspective. Analyses of remote sensing data, including aerial photography, digital orthophotography, and satellite imagery, are promising alternatives, however, current data on a sufficiently large scale is not readily available. A method for evaluating riparian corridors has been developed by several MDC personnel using aerial photographs, aerial videos, and other methods. Photographs were on hand for only a small portion of the watershed, so this method was not pursued for this plan.

Another emerging method is digital image analysis of high quality helicopter videos or low altitude digital photographs.

Implement the current habitat assessment methodology within the watershed.

Incorporate site specific habitat observations on all Niangua darter snorkeling trips as determined from criteria developed by MDC’s Rare Threatened & Endangered Species Fisheries Biologist.

GOAL III. MAINTAIN THE DIVERSITY AND ABUNDANCE OF AQUATIC COMMUNITIES AND IMPROVE THE QUALITY OF THE SPORT FISHERY.

Objective III.1: Protect and improve the status of threatened and endangered species, and implement state or federal recovery plans.

Problem/Opportunity: Niangua darter populations appear to be fairly stable in the Maries River but declining in Tavern Creek. Sampling in both subbasins needs to be expanded and compared to Mattingly's (UMC) sampling. No thorough, comparable survey has been conducted throughout Niangua darter range since Pflieger's in the 1970s and recent sampling procedures have been inconsistent.

Conduct a thorough search of the Upper Maries, Lower Maries, Little Maries, and Tavern Creek subbasins for the Niangua darters distribution.

Recommend to the MDNR that all known range of the Niangua darter be classified as "Critical Habitat for Rare and Endangered Aquatic Species," or failing that, as "State Outstanding Resource Waters."

Conduct a multi-district survey of known range to evaluate current status and consider elevation of federal status to "Endangered."

Target the Lower Maries River, Upper Maries River, Little Maries River, and Tavern Creek subbasins for intensive promotion of stream incentive programs and SSA.

Identify, protect, and enhance Niangua darter habitat through purchases, easements, and cost shares. Highlight expansion priorities of MDC area plans as they are developed.

Carry out recommendations in the Niangua Darter Recovery Plan and actively participate on the Niangua Darter Recovery Team.

Adopt a standardized monitoring plan for Niangua darters and maintain a statewide database.

Sturgeon

Problems and Opportunities: Lake sturgeon and shovelnose sturgeon have historically been found in the basin (Pflieger 1970). Lake sturgeon have been documented by MDC biologists from both Lake of the Ozarks and below Bagnell Dam as late as 1998 (Stoner 2000). Opportunities may exist for managing this species in the Osage River below Bagnell Dam (MDC Lake Sturgeon Plan 1992).

Conduct standardized sampling for sturgeon in the Osage River below Bagnell Dam as outlined in the MDC Monitoring Evaluation Study (Gemming, 2001).

Determine suitable habitat and river flows that are conducive to spawning success for lake and shovelnose sturgeon, and recommend these flows be discharged from Bagnell Dam during the spawning season.

Sauger / Walleye

Problems and Opportunities: Sauger are primarily found in the Mississippi and Missouri rivers, however, sauger are frequently caught by anglers in the Osage River below Bagnell Dam. Several state record sauger from the Osage River have been recorded in the past ten years. Walleye are found in the Osage River, Lake of the Ozarks and some of the tributary streams. Walleye and sauger are frequently found below the Lock and Dam on the Osage River. Opportunities exist for managing these two species in the Osage River. Continuous water flow is needed to stimulate walleye gonadal development as determined in an MDC study conducted below Truman Dam (DiStefano 1994).

> Provide guidance in the development of sampling techniques for sauger in the Osage River during late January thru early March as sauger spawn at cooler water temperatures than walleye.
>
> Provide guidance in the development of management strategies for these two species such as recommending water flows for Bagnell Dam that enhance spawning habitat and gonadal development of mature adults and harvest regulations as needed.

Problem/Opportunity: Thorough fish community samples have not been conducted in all subbasins of the East Osage River Basin.

> Conduct periodic, thorough fish community sampling at historic collection sites as well as new sites for subbasins which have not historically been well sampled.

Problem/Opportunity: Comprehensive invertebrate sampling has not been conducted in the basin. Sampling is scheduled for summer and fall 2001 on the Osage River in conjunction with the FERC relicensing of Bagnell Dam.

> Encourage Stream Teams to assist with sampling.

Problem/Opportunity: A diverse mussel community historically occupied the basin. In consideration of mussel decline throughout the Midwest and the lack of recent watershed sampling, a thorough mussel survey is warranted.

Mussels

> Evaluate the results of the mussel survey planned by AmerenUE in conjunction with FERC relicensing and recommend periodic sampling be conducted as required.
>
> Special considerations should be given to the federally endangered pink mucket and efforts made to restore it to its original habitat.

Problem/Opportunity: All subbasins offer opportunities for producing high quality fisheries.

> Identify and prioritize the native sportfish most suitable for increased management and implement a plan for sampling.

Develop strategies for managing selected sportfish species such as: paddlefish, walleye, sauger, smallmouth bass and catfish on the Osage River and tributary streams.

Assess the impacts to sportfish of Truman Dam and Bagnell Dam operations and to Lake of the Ozarks and streams within the basin.

Problem/Opportunity: Management actions targeting one or more game species can have unexpected negative impacts on non-game fishes and invertebrates. Several listed rare, threatened, and endangered species are found in limited number in the watershed.

Evaluate the potential impacts of sportfish management activities on non-game fishes and invertebrates before and after implementation.

Avoid special management areas in designated critical habitat for state or federally listed rare, threatened or endangered species.

Problem/Opportunity: All tributaries streams are important components of the fisheries and aquatic ecosystems of the basin.

Implement all strategies of the LOZ Management Plan and this plan so they compliment one another.

Be aware of problems which arise in the Osage River and LOZ which may negatively impact the basin (exotic species introductions; distributional changes of zebra mussels, bighead carp, black carp, or spined water fleas; etc.)

GOAL IV. INCREASE ACCESS AND MDC OWNERSHIP WITHIN THE EAST OSAGE RIVER BASIN.

Objective IV.1: Provide additional MDC owned access to the Osage.

Problem/Opportunity: There is a demand for at least one stream access on the Lower Osage River to increase user convenience and encourage more uniform use throughout the basin.

Priority should be given to land acquisitions in the basin that include stream frontage for access development and corridor protection/development.

Objective IV.2: Enhance accessibility at all MDC access and frontage areas within the watershed.

Problem/Opportunity: Area Plans have been or are being developed for five stream areas. There are no disabled user facilities at MDC stream areas in the watershed.

Include public use objectives, including some disabled user facilities, in MDC area plans for public lands along streams in the basin.

Objective IV.3: Implement expansion plans as outlined in MDC area plans; focus on key expansions at Saline Valley, CA and Smokey Waters, CA.

Problem/Opportunity: Area Plans have been or are being developed for several stream areas.

Highlight expansion needs and stress the need to fund these expansion areas.

Objective IV.4: Work with other divisions and agencies to address problems associated with increased public use in the basin.

Work with other divisions to minimize vandalism and improper public use of MDC areas by improving designs and patrolling areas during heavy public use periods.

GOAL V: ADDRESS INFORMATIONAL AND EDUCATIONAL OPPORTUNITIES WITHIN THE EAST OSAGE RIVER BASIN.

Objective V.1: Inform other agencies, local government officials, land developers, landowners, and the general public of water quantity and quality conditions and problems in the watershed.

Problem/Opportunity: Sound watershed management depends on our ability to increase public awareness and educate the general public, landowners, city and county officials, and industrial and residential developers on the importance of improving water quality, and generate an interest in water quantity and quality problems and solutions.

Include the basin as a high priority for private landowner assistance within the West Central Region Private Land Plan.

Coordinate private landowner assistance with Agricultural Services, NRCS, FSA, The Nature Conservancy, USACE and MDNR to cultivate mutual interests and concerns for land and stewardship issues.

Incorporate information on Best Management Practices into MDC stream management workshops presented to local SWCDs, private industry, city and county governments and other agencies.

Attend public meetings regarding highway construction, development projects, 404 permits, and state or federal watershed projects to inform the public about local water quantity and quality and watershed issues and the importance of reporting all pollution incidents to the MDNR and MDC.

Write articles for local newspapers, Farm Bureau, University Extension, local SWCD, NRCS, and FSA newsletters, and conduct radio or TV programs concerning proper land use and local water quantity and quality problems and solutions.

Work with MDC Outreach & Education Consultants to incorporate information into teacher workshops concerning watershed and stream issues, particularly the need to promote advocacy of these resources and the importance of local citizen involvement to solve local problems by forming Stream Teams.

Seek opportunities to involve citizens and organizations in planning activities.

Publicize the acquisition, development and opening of new public access sites.

Promote the adoption of watershed streams by Stream Teams.

Promote the education of youth in the watershed by coordinating aquatic education opportunities for schools in the watershed with MDC Outreach & Education Consultants.

Write a Missouri Conservationist article on the Osage River.

Produce a video promoting the resources and public use opportunities, and stream ecology and preservation in the watershed.

Emphasize stream ecology, good stream stewardship and the MDC Streams for the Future program (using watershed models and the stream trailer where applicable) during presentations at adult and youth organizations, adult service clubs and sportsman's groups, Boy Scouts of America, Girl Scouts of America, Future Farmers of America, 4-H and Vo Ag youth groups, schools in the watershed, and fairs or other special events.

Promote stream ecology in MDNR (Ha Ha Tonka, Bennett Spring, LOZ state parks) and Wilmore Lodge brochures and at their visitor centers.

Promote the development of a River Learning Center to educate the public on river hydrology and the effects of current land use practices.

Promote the adoption of this plan by the Missouri Department of Natural Resources Non-point Pollution Program responsible for writing watershed plans for the state of Missouri.

Include questions on water quality, water quantity, habitat conditions, biotic community access and public awareness issues in telephone or mail surveys to the public residing in the watershed.

Incorporate these goals and objectives into the Regional Management Guidelines.

Enhance awareness among all resource and government agencies by providing copies of this inventory and assessment to MDNR offices at LOZ state parks; U.S. Army Corps of Engineers in Kansas City and the project office in Warsaw; the USFWS office in Columbia; SWCD, NRCS and FSA offices in Benton, Camden, Hickory, Laclede, Miller, Osage, Maries, Cole, Pulaski, and Morgan counties; MDC employees who work in the basin; Environmental Protection Agency, The Nature Conservancy, USGS, city and county officials, state and federal legislators, AmerenUE, and county libraries.

Provide copies of this plan to Stream Teams within the basin as requested.

Keep Stream Teams informed about water quality problems and other significant stream issues.

Include this inventory and assessment on the MDC watershed web page.

GOAL VI. MANAGE THE EAST OSAGE RIVER BASIN DATABASES TO PROVIDE ACCURATE AND UP-TO-DATE DATA, EASY ACCESSIBILITY, AND COMPATIBILITY WITH OTHER REGIONS, DIVISIONS, AND AGENCIES.

Objective VI.1: Organize watershed databases to improve accessibility and compatibility.

Problem/Opportunity: Numerous databases were created and a large amount of data were compiled during the inventory for this plan. These databases must be readily accessible for general use and updating. They should also be compatible with those of other regions, divisions, and agencies to facilitate exchange of data.

Prepare documentation for all watershed databases.

Ensure that watershed databases are compatible with comparable statewide databases.

Incorporate these data into MoRAP and the Statewide Resource Assessment and Monitoring Plan.

Objective VI.2: Update watershed databases periodically to include the most current, accurate information.

Problem/Opportunity: Many of the watershed databases must be updated periodically to include the most recent data (e.g., 404 permits, fish collections). MoRAP is coordinating data preparation and maintenance of some databases throughout the state to increase compatibility and efficiency.

Develop a plan for updating watershed databases periodically.

Cooperate with MoRAP to improve database compatibility between agencies.

Incorporate all data collected by AmerenUE during the FERC relicensing process into the MoRAP database and appropriate items in MDC's Natural Heritage Database.

ANGLER GUIDE

Lake of the Ozarks (Central Region) Information: 573/346-2210

Fishing Prospects for Lake of the Ozarks

Largemouth Bass electrofishing surveys conducted during the spring of 2002 indicated good numbers of fish over the 15-inch size limit which should result in good to excellent fishing in 2003. Good numbers of sub-legal bass will provide plenty of catch-and-release action.The outlook for Spotted Kentucky bass over the 12-inch size limit is average. Crappie fishing should be excellent this spring as densities are the highest that they have been in over a decade. Many of these fish are of legal size (9 inches)and a fair number are over 11 inches.In addition, the large 2001 yearclass should reach legal size by the fall of 2003 providing excellent fishing into 2004. Catfishaction should be similar to the past few years. White bass fishing in 2003 should be good, as fairly high numbers of 6-8 inch fish were observed in the fall of 2002. Opportunities for catching Hybrid white bass are good in the Truman Dam tailwater and, during the summer and winter months, in spring-fed areas of the lake. **Walleye** are now well established in Lake of the Ozarks after 10 years consistent stocking. The fish stocked in 2001 enjoyed excellent survival. Most of these fish will reach a legal size of 15 inches by the spring of 2003. The lake also offers good fishing for a number of other species including **paddlefish**, **sunfish**, **gar**, and **carp**. Remember to use proper handling techniques when releasing sublegal (or legal) fish back to the water to ensure their survival.

Fishing Tips

Black bass Although bass can be caught year-round, the best times are spring and fall.Fish points, brush, and docks. The best producing lures are topwater baits (low light periods), plastic worms, crankbaits, and spinnerbaits. Winter is also an excellent time to fish for bass by slowly fishing jerkbaits off points.

Crappie The ability to locate good structure is the key to successful crappie fishing on Lake of the Ozarks . Good crappie fishing is often found during the spring spawning season. Late April through early May usually is best. Spawning begins when water temperature at the nest warms to the mid-50's, and usually peaks in the low to mid-60's. Most spawning occurs in coves or near their mouths, but you might find crappie along any bank with a gravel or woody structure. Crappie spawn at depths of 6-inch to over 20-foot depths, depending upon the water clarity. The clearer the water, the deeper they spawn. Spawning crappie can be caught with jigs (1/32 to 1/8 ounce), minnows, or small crank baits or spinners. Jigs are preferred by most anglers. Fish brushpiles and laydown timber where crappie concentrate.
During spring, you might find crappie grouped off the bank around brushy structure and suspended at about the same depth as other spawning fish.

Crappie are typically hard to catch in summer and early fall, but fishing improves during October and November. Throughout this period, crappie are in deeper water (from 15 to 30 feet) at the mouths of coves or along steeper banks and bluffs. They still like to concentrate around woody structure. Fish with jigs or minnow, moving often to find the fish. Some anglers have success trolling along steeper banks with small, deep-running crankbaits. By October, crappie head into shallower water again, changing location and depth frequently. In addition to the steeper banks, try fishing around points.

Winter can be one of the best times for crappie fishing, if you're willing to brave the elements. Small jigs or minnows fished slowly around structure in deep water along steep banks or bluffs is usually the best method. Crappie hits can be light during winter so watch for line movement.

Lake of the Ozarks regulations for crappie are 9-inch minimum length limit and 15 daily.

White bass and **Hybrid striped bass** In April and May, white bass migrate up several tributaries to spawn. Notable spawning runs take place in the Osage, Glaize, and Niangua Arms of Lake of the Ozarks . Although hybrid striped bass may be caught along with white bass during this time, they do not spawn. The population of hybrid striped bass in Lake of the Ozarks is being maintained through stockings by the Conservation Department.

During the remainder of the year, these fish are found in main lake areas near some kind of underwater structures (e.g., underwater humps, sharp points) or near drop-offs just outside flats and humps. White bass and hybrid striped bass may be caught by vertically jigging , casting or trolling spoons, jigs, and crankbaits. Something to keep in mind is that the bulk of the diet of white and hybrid striped bass is gizzard shad so your baits should imitate shad (white, silver or silver and black are good colors). Mid to late summer is also the time when white bass may surface to feed on schools of gizzard shad. Schools of feeding bass are located by surface activity which usually occurs early in the morning or late in the evening. Casting small surface or shallow running crankbaits, jigs, or spinners into a feeding school of white bass can give incredible results. Catching fish on every cast or two fish per cast if jigs are tied in tandem is not uncommon. This type of feeding activity is somewhat unpredictable. Fall white bass fishing typically involves fishing windy main lake points with deep diving crankbaits, jigs, or spinners. This activity usually starts in September and continues into November.

Good areas to locate hybrid striped bass include both the Truman and Bagnell Dam tailwaters and spring fed areas of the lake.

Lake of the Ozarks regulations for white bass and hybrid striped bass are 15 daily in the aggregate, no more than 4 daily can be larger than 18 inches.

Walleye Walleye are typically caught on steep rocky points on crankbaits, jigs, and minnows.In March and April, walleye make a spawning migration up into the Osage and Niangua Arms of Lake of the Ozarks . Although some natural reproduction may occur, the population of walleye in Lake of the Ozarks is being maintained through stockings by the Conservation Department.

Blue, channel and flathead catfish The best months are usually May through September. Some of the more popular methods for catching catfish include:

- Drifting with pole and line in the evenings over flats and shallow areas with shad.
- Setting trotlines next to the old river channel where the water depth changes abruptly from deep to shallow.
- Drifting jugs over the flats and shallow areas near the main channel and off points.
- Fishing rip rap areas along the dam and bridge abutments in June when catfish are spawning.

Trolling crankbaits over gradually sloping points also works well at this time.

· Popular baits for channel catfish are shad, cut shad, and prepared baits; for blue catfish they are shad, cut shad, and live baits; and live baits (sunfish less than 5" or goldfish) are best for flathead catfish. Truman Lake regulations for channel and blue catfish are 10 daily in the aggregate and 5 daily for flathead catfish. Truman Lake typically has good catfish fishing.

Paddlefish The paddlefish snagging season is March 15 through April 30.The best areas include the upper Osage Arm above the 70 mile mark and the Niangua Arm from the Hwy 54 Bridge down to the Mouth. The population of paddlefish in Lake of the Ozarks is being maintained through stockings by the Conservation Department.

GLOSSARY

Alluvial soil Soil deposits resulting directly or indirectly from the sediment transport of streams, deposited in river beds, flood plains, and lakes.

Aquifer An underground layer of porous, water-bearing rock, gravel, or sand.

Benthic Bottom-dwelling; describes organisms which reside in or on any substrate.

Benthic macroinvertebrate Bottom-dwelling (benthic) animals without backbones (invertebrate) that are visible with the naked eye (macro).

Biota The animal and plant life of a region.

Biocriteria monitoring The use of organisms to assess or monitor environmental conditions.

Channelization The mechanical alteration of a stream which includes straightening or dredging of the existing channel, or creating a new channel to which the stream is diverted.

Concentrated animal feeding operation (CAFO) Large livestock (ie.cattle, chickens, turkeys, or hogs) production facilities that are considered a point source pollution, larger operations are regulated by the MDNR. Most CAFOs confine animals in large enclosed buildings, or feedlots and store liquid waste in closed lagoons or pits, or store dry manure in sheds. In many cases manure, both wet and dry, is broadcast overland.

Confining rock layer A geologic layer through which water cannot easily move.

Chert Hard sedimentary rock composed of microcrystalline quartz, usually light in color, common in the Springfield Plateau in gravel deposits. Resistance to chemical decay enables it to survive rough treatment from streams and other erosive forces.

Cubic feet per second (cfs) A measure of the amount of water (cubic feet) traveling past a known point for a given amount of time (one second), used to determine discharge.

Discharge Volume of water flowing in a given stream at a given place and within a given period of time, usually expressed as cubic feet per second.

Disjunct Separated or disjoined populations of organisms. Populations are said to be disjunct when they are geographically isolated from their main range.

Dissolved oxygen The concentration of oxygen dissolved in water, expressed in milligrams per liter or as percent.

Dolomite A magnesium rich, carbonate, sedimentary rock consisting mainly (more than 50% by weight) of the mineral dolomite ($CaMg(CO_3)_2$).

Endangered In danger of becoming extinct.

Endemic Found only in, or limited to, a particular geographic region or locality.

Environmental Protection Agency (EPA) A Federal organization, housed under the Executive branch, charged with protecting human health and safeguarding the natural environment — air, water, and land — upon which life depends.

Epilimnion The upper layer of water in a lake that is characterized by a temperature gradient of less than 1º Celcius per meter of depth.

Eutrophication The nutrient (nitrogen and phosphorus) enrichment of an aquatic ecosystem that promotes biological productivity.

Extirpated Exterminated on a local basis, political or geographic portion of the range.

Faunal The animals of a specified region or time.

Fecal coliform A type of bacterium occurring in the guts of mammals. The degree of its presence in a lake or stream is used as an index of contamination from human or livestock waste.

Flow duration curve A graphic representation of the number of times given quantities of flow are equaled or exceeded during a certain period of record.

Fragipans A natural subsurface soil horizon seemingly cemented when dry, but when moist showing moderate to weak brittleness, usually low in organic matter, and very slow to permeate water.

Gage stations The site on a stream or lake where hydrologic data is collected.

Gradient plots A graph representing the gradient of a specified reach of stream. Elevation is represented on the Y-axis and length of channel is represented on the X- axis.

Hydropeaking Rapid and frequent fluctuations in flow resulting from power generation by a hydroelectric dam's need to meet peak electrical demands.

Hydrologic unit (HUC) A subdivision of watersheds, generally 40,000-50,000 acres or less, created by the USGS. Hydrologic units do not represent true subwatersheds.

Hypolimnion The region of a body of water that extends from the thermocline to the bottom and is essentially removed from major surface influences during periods of thermal stratification.

Incised Deep, well defined channel with narrow width to depth ration, and limited or no lateral movement. Often newly formed, and as a result of rapid down-cutting in the substrate

Intermittent stream One that has intervals of flow interspersed with intervals of no flow. A stream that ceases to flow for a time.

Karst topography An area of limestone formations marked by sinkholes, caves, springs, and underground streams.

Loess Loamy soils deposited by wind, often quite erodible.

Low flow The lowest discharge recorded over a specified period of time.

Missouri Department of Conservation (MDC) Missouri agency charged with: protecting and managing the fish, forest, and wildlife resources of the state; serving the public and facilitating their participation in resource management activities; and providing opportunity for all citizens to use, enjoy, and learn about fish, forest, and wildlife resources.

Missouri Department of Natural Resources (MDNR) Missouri agency charged with preserving and protecting the state's natural, cultural, and energy resources and inspiring their enjoyment and responsible use for present and future generations.

Mean monthly flow Arithmetic mean of the individual daily mean discharge of a stream for the given month.

Mean sea level (MSL) A measure of the surface of the Earth, usually represented in feet above mean sea level. MSL for conservation pool at Pomme de Terre Lake is 839 ft. MSL and Truman Lake conservation pool is 706 ft. MSL.

Necktonic Organisms that live in the open water areas (mid and upper) of waterbodies and streams.

Non-point source Source of pollution in which wastes are not released at a specific, identifiable point, but from numerous points that are spread out and difficult to identify and control, as compared to point sources.

National Pollution Discharge Elimination System (NPDES) Permits required under The Federal Clean Water Act authorizing point source discharges into waters of the United States in an effort to protect public health and the nation's waters.

Nutrification Increased inputs, viewed as a pollutant, such as phosphorous or nitrogen, that fuel abnormally high organic growth in aquatic systems.

Optimal flow Flow regime designed to maximize fishery potential.

Perennial streams Streams fed continuously by a shallow water table an flowing year-round.

pH Numeric value that describes the intensity of the acid or basic (alkaline) conditions of a solution. The pH scale is from 0 to 14, with the neutral point at 7.0. Values lower than 7 indicate the presence of acids and greater than 7.0 the presence of alkalis (bases).

Point source Source of pollution that involves discharge of wastes from an identifiable point, such as a smokestack or sewage treatment plant.

Recurrence interval The inverse probability that a certain flow will occur. It represents a mean time interval based on the distribution of flows over a period of record. A 2-year recurrence interval means that the flow event is expected, on average, once every two years.

Residuum Unconsolidated and partially weathered mineral materials accumulated by disintegration of consolidated rock in place.

Riparian Pertaining to, situated, or dwelling on the margin of a river or other body of water.

Riparian corridor The parcel of land that includes the channel and an adjoining strip of the floodplain, generally considered to be 100 feet on each side of the channel.

7-day Q^{10} Lowest 7-day flow that occurs an average of every ten years.

7-day Q^{2} Lowest 7-day flow that occurs an average of every two years.

Solum The upper and most weathered portion of the soil profile.

Special Area Land Treatment project (SALT) Small, state funded watershed programs overseen by MDNR and administered by local Soil and Water Conservation Districts. Salt projects are implemented in an attempt to slow or stop soil erosion.

Stream Habitat Annotation Device (SHAD) Qualitative method of describing stream corridor and instream habitat using a set of selected parameters and descriptors.

Stream gradient The change of a stream in vertical elevation per unit of horizontal distance.

Stream order A hierarchial ordering of streams based on the degree of branching. A first order stream is an unbranched or unforked stream. Two first order streams flow together to make a second order stream; two second order streams combine to make a third order stream. Stream order is often determined from 7.5 minute topographic maps.

Substrate The mineral and/or organic material forming the bottom of a waterway or waterbody.

Thermocline The plane or surface of maximum rate of decrease of temperature with respect to depth in a waterbody.

Threatened A species likely to become endangered within the foreseeable future if certain conditions continue to deteriorate.

United States Army Corps of Engineers (USCOE) and now (USACE) Federal agency under control of the Army, responsible for certain regulation of water courses, some dams, wetlands, and flood control projects.

United States Geological Survey (USGS) Federal agency charged with providing reliable information to: describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect the quality of life.

Watershed The total land area that water runs over or under when draining to a stream, river, pond, or lake.

Waste water treatment facility (WWTF) Facilities that store and process municipal sewage, before release. These facilities are under the regulation of the Missouri Department of Natural Resources.

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LIST OF FIGURES

LIST OF TABLES

LOCATION

LANDUSE

HYDROLOGY

WATER QUALITY

BIOTIC