ST. FRANCIS RIVER
WATERSHED
INVENTORY AND ASSESSMENT

PREPARED BY:
MARK BOONE
Fisheries Management Biologist
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For further information contact:
Fisheries Regional Supervisor
Southeast Regional Headquarters
2302 County Park Dr.
Cape Girardeau, MO 63701

Executive Summary

The St. Francis River originates in Iron County in Southeast Missouri and flows 225 miles to the Missouri/Arkansas border. In Missouri, the basin is equally divided (north and south) between the high-relief Ozark Plateau and the low-relief Mississippi Alluvial Plain. Wappapello Dam and Lake are located on the divide. For inventory and planning purposes, the basin is separated into two dissimilar subbasins: the upper subbasin above Wappapello Dam and the lower subbasin below Wappapello Dam.

The basin drains 1,839 square miles in Missouri. The headwater area is dominated by igneous rock in the Ozark uplift (St. Francois Mountains), followed in a downstream direction by sandstone and dolomites. The alluvial plain of the lower subbasin is topped with a layer of unconsolidated gravel, sand, silt, and clay and is bordered on the east by Crowleys Ridge. Drainage in the lower subbasin has been altered by a system of levees and drainage ditches. Most of the west bank of the lower St. Francis River is a levee, which prevents drainage into the river from the west.

The predominance of impervious rock in the upper basin limits infiltration and subsurface flows causing rapid runoff, flashy hydrographs, frequent flooding, and a poor aquifer that provides low, unstable base flows. Six dams are located in the upper subbasin which can affect flows and fish movement. These include Wappapello Dam and Lake (8,400 acres) and the dam at DiSalvo Lake on the mainstem and four dams located on mainstem tributaries. Flow in the lower subbasin is primarily regulated by water released through Wappapello Dam. However, extensive infiltration produces a good aquifer with abundant groundwater supplies.

Basin streams generally exhibit good water quality and most streams are classified as full use attainment. However, there have been some minor isolated problems with mining and smelting

activities and inadequate waste water treatment facilities in the upper subbasin. Two permitted water supply surface withdrawals exist in the upper subbasin. In the lower subbasin, headcutting, streambank erosion, and the resulting increased sediment load and deposition downstream adversely affect water quality. Irrigation is a major use of groundwater.

A statewide survey estimated 88,500 annual fishing trips in the St. Francis River basin, which ranked it 15th out of 38 basins surveyed. The basin was ranked 13th in total recreational worth in Missouri. In the lower subbasin, intense agriculture, poor land use, and channel modifications were cited as the primary problems that lowered recreational worth in the recreational value survey.

Historical land use in the upper subbasin includes mining, timber harvesting, annual burning, upland row cropping, and livestock grazing. Presently, land-use in the upper subbasin can be classified as 77 percent woodland, 10 percent grassland, 7 percent cropland, and 6 percent other uses. Wetland drainage, timber clearing, and flood control projects have converted the lower subbasin from an immense swampland forest to a vast agricultural area. Eighty eight percent of the lower subbasin is now used for crop land, followed by 7 percent woodland, and 3 percent grassland.

Public ownership in the basin totals more than 218,000 acres, with about 83 percent in the upper subbasin. The U. S. Forest Service is the largest landowner in the basin. The Missouri Department of Conservation owns 46,800 acres, which includes 28 Conservation Areas. Public lands provide 123 miles of stream frontages throughout the basin.

Streambank erosion is not a major problem in the upper subbasin, where riparian corridors are mostly forested and usually rated as good. Channel substrates are generally stable and diverse. Big Creek is the only upper subbasin stream with abundant gravel. Excessive streambank erosion and headcutting are serious problems in the channelized section of the lower subbasin mainstem and most of its tributaries. The quality of the riparian corridor varies considerably. The streambed is primarily composed of clay and sand, with very little diversity. Excessive sedimentation is occurring below the channelized sections.

There are 25 high-quality natural communities in the basin. Ten natural areas have been established in the basin to preserve, manage, and restore extant natural communities, ecological processes, and geological areas.

The basin exhibits good aquatic biodiversity. One hundred thirty fish species in 20 families have been collected. However, 23 fish species found in the basin are state-listed as species of conservation concern. Of these, one is considered extirpated from Missouri and six are listed as state endangered. No federally listed species exist in the basin.

Most streams support a diverse benthic invertebrate fauna. Forty eight mussel species have been identified, primarily from the mainstem. Eleven mussels are listed as species of conservation concern. One mussel species is state endangered, while no federally listed mussel species exist in the basin. Sixteen crayfish species have been collected, including the Big Creek and St.

Francis River crayfishes, which are endemic to the upper subbasin. An introduced crayfish may be a cause for concern. Six crayfish species are listed as species of conservation concern.

Angling is good for largemouth bass, spotted bass, smallmouth bass, shadow bass, a variety of sunfish, and channel catfish in the upper subbasin. Gigging for redhorse suckers is also good. Walleye have been stocked in the upper mainstem to restore the population. In the lower St. Francis River, fishing for spotted bass is good below Kennett, and fair throughout the remainder of the unchannelized portion of the lower river. Channel catfish, large buffalo fishes, gar, white bass, drum, and an occasional flathead catfish could be encountered anywhere on the river.

Four major goals for the basin are:

Goal I: Maintain or improve aquatic habitat conditions to meet the needs of native aquatic biota while accommodating society's demands for agricultural production and economic development.

Goal II: Maintain or improve water quality throughout the basin so that it is sufficient to support diverse aquatic biota.

Goal III: Maintain diversity of native aquatic organisms and improve the quality of fishing.

Goal IV: Improve the public's knowledge and appreciation of stream resources; recreational opportunities; and proper watershed, riparian corridor, and streambank management.

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LOCATION

The St. Francis River basin is located in southeast Missouri in Iron, St. Francois, Madison, Wayne, Washington, Ste. Genevieve, Bollinger, Stoddard, Butler, and Dunklin counties (Figure l). The river originates in northeast Iron County, on a divide that separates the Black, Big, and St. Francis river drainages, and flows 25 miles northeasterly around the St. Francois Mountains uplift. The river then turns south and flows 200 miles to the Missouri/Arkansas border, and then continues 207 miles through Arkansas and into the Mississippi River. The Floodway Ditches drain a portion of the St. Francis River basin. They contribute to the St. Francis River in the state of Arkansas and were not included in this document.

The St. Francis River flows through Wappapello Lake, which is situated near the center of Missouri's portion of the basin. Major tributaries to the river are Little St. Francis River and Big Creek above the Wappapello Dam, and Mingo Ditch and Dudley Main Ditch below the Wappapello Dam.

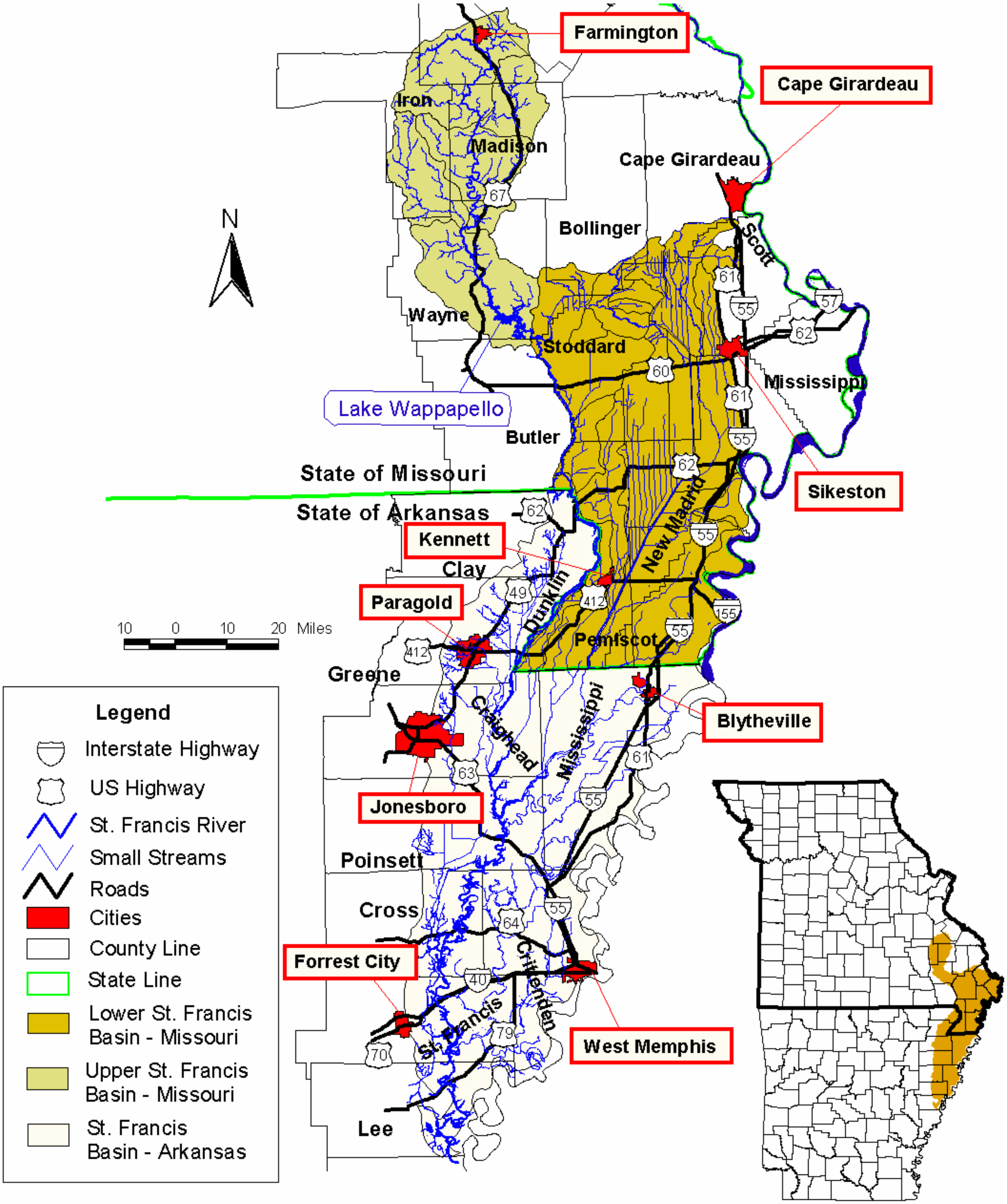

Figure lo. General location of the St. Francis Watershed in Missouri and Arkansas

GEOLOGY/GEOMORPHOLOGY

PHYSIOGRAPHIC REGION

In Missouri, the basin is equally divided (north and south) by the high-relief Ozark Plateau (to the north) and the low-relief Mississippi Alluvial Plain (to the south) (Figure nd). Wappapello Dam is located on the boundary of these natural divisions. Subdivisions of the Ozark Plateau include the St. Francois Mountains and the dissected Salem Plateau regions. Features in the Mississippi Alluvial Plain include low alluvial terraces and ridges which separate the flat plain into distinct subbasins that facilitates artificial drainage (Missouri Department of Natural Resources (MDNR) 1986a). Land elevations range from 1,740 ft National Geodetic Vertical Datum of 1929 (NGVD) in the headwaters to 234 ft NGVD at the Missouri/Arkansas border.

Radical differences in the geology of the upper and lower portions of the basin, and the influence of Wappapello Dam are responsible for the basin's divergent north-south distinctions related to hydrology, habitats, biota, land use, and water quality (Figure ge). Therefore, for the purpose of this report, the St. Francis Basin is separated into its two dissimilar subbasins: the upper subbasin above Wappapello Dam and the lower subbasin below Wappapello Dam.

GEOLOGY (UPPER SUBBASIN)

The headwater area is dominated by the Ozark uplift (St. Francois Mountains) which has exposed outcrops of Precambrian igneous rock (granite, rhyolite, felsite) on as much as 50 percent of the surface on some slopes (MDNR 1986a). The hard igneous rock has no overburden, and shut-ins, cascades, and waterfalls produce ancient rigid boundaries that control the course, gradient, and floodplain features of the first 80 miles of the river channel. Downstream, igneous rock is replaced by hard Cambrian dolomites and sandstone. Eventually, cherty Ordovician dolomite becomes the primary underlayment adjacent to the Wappapello Lake basin.

The absence of a deep cherty residuum in the igneous Ozark uplift and the formation of erosion resistant upland soils results in little gravel accumulation in the alluvial floodplain soils. Channel substrates contain a significant proportion of stable cobble, stone, and boulders, and streambank soils are more cohesive than in most Ozark streams because of lower densities of gravel. The Big Creek watershed is not strongly influenced by the St. Francois Mountains uplift. It is similar to the adjacent Black River basin, with its deep, cherty limestone residuum. The result is an abundance of gravel in Big Creek.

GEOLOGY (LOWER SUBBASIN)

The alluvial plain (Mississippi Embayment) downstream from the Wappapello Dam is topped with a 150-ft Quaternary layer of unconsolidated gravel, sand, silt, and clay (MDNR 1986a). Crowleys Ridge and other hills are underlain by Cretaceous and Tertiary rocks and covered with loess. The hills and natural terraces separate the alluvial plain into distinct basins.

SOIL TYPES (UPPER SUBBASIN)

Soils are transitional from the dominant Ozark Dome region above Wappapello Lake to the Ozark Border region adjacent to the lake (MDNR 1986a). Soils formed in the hard, igneous rock of the upland ridge tops lack an overburden of chert or loess and are typically described as extremely bouldery, cobbly, or stony with outcrops sometimes occupying 50 percent of the surface area (Natural Resource Conservation Service (NRCS) 1981, 1991, 1995a and 1995b). Fertility is low, reactions are acidic, runoff is rapid, and water capacity is low, which produces extremely droughty conditions most suitable for woodland and limited grass production. Soil series most frequently associated with the uplands are Irondale, Syenite, Delassus, and Clarksville.

The finer silt-loam soils formed on the slopes also contain a large proportion of stones and boulders, and a chert overburden appears on some foot slopes. A fragipan is usually present which can restrict root depth to less than three feet. Soil fertility is low, reactions are acidic, runoff is rapid, but water capacity is high and droughty conditions are limited to hot, dry summer periods. Some of the soils on the slopes can be tilled, but erosion hazards and low crop yields tend to limit agriculture activities to hay and pasture production. Soil series most frequently associated with the slopes are Auxvasse, Killarney, Courtois, Fourche, and Wilber.

The sand-silt-clay loams formed in floodplains are highly fertile, but fertility tends to decrease to moderate in a downstream direction. Soils range from neutral to only slightly acidic, runoff is moderate, and water capacity is high. Most of the floodplain soils can be tilled without a serious erosion threat, but hay and pasture products can often produce better yields than row crops. Soil series most frequently associated with the floodplains are Wakeland, Haymond, and Pope.

SOIL TYPES (LOWER SUBBASIN)

The soils in the lower subbasin are formed from deep alluvial deposits in the Mississippi Embayment region (MDNR 1986a). All of the silt-loam soils in the narrow subbasin (constricted by levees) share common characteristics of high fertility, strong acidity, poor drainage, moderate permeability, slow runoff, and high water capacity (NRCS 1979 and 1985). Outstanding row crop production can be obtained in the wet soils if the water table is lowered through artificial drainage (ditches) and lime is applied to neutralize the surface acidity. The soils also provide excellent growth potential for trees. The dominant soil series throughout the subbasin is Falaya. Some drier Dubbs silt-loam is present immediately below Wappapello Dam and an extremely wet Sharkey silty-clay is widespread near the Arkansas border.

WATERSHED AREA

The basin drains 1,839 square miles in Missouri (United States Department of Agriculture (USDA) 1981). This does not include the Little River by-pass system which enters the lower St. Francis River in Arkansas. About 71 percent of the drainage area (1,315 mi^2) is in the upper subbasin and 29 percent (524 mi^2) is in the lower subbasin (Table 1). Drainage in the upper subbasin is natural and is comprised of numerous small watersheds. Most of the drainage in the lower subbasin, however, is controlled by a system of levees and drainage ditches that restrict the entry of tributaries into the partially channelized mainstem. Most of the west bank is a major levee which forces runoff westward into the Black River basin. Consequently, the west bank has only a few tributaries, just below Wappapello Dam, and the east bank contains only a few controlled inlets.

STREAM MILEAGE, PERMANENCY, AND ORDER

The St. Francis River, from its headwaters to the Arkansas/Missouri border, is 225 miles long. A total of 4,032 tributary reaches occupying 4,102 miles of channel, in both subbasins, were identified, ordered, measured (by hand dividers) and classified as either intermittent or permanent as indicated on United States Geological Survey (USGS) 7.5 minute topographic maps. The names, mileage, and permanency of all 151 third order and larger streams were tabulated for each subbasin by order, watershed, and hierarchal river mile position in each watershed and is on file at the Missouri Department of Conservation's Southeast Regional Headquarters.

The upper subbasin is drier than most Ozark drainages on the Salem Plateau because of poor groundwater recharge associated with the predominance of impervious rock. Stream permanency is more typical of the prairie streams in north and west Missouri where 10 to 20 square miles of watershed are needed to maintain each mile of permanent stream (MDNR 1986a). Local exceptions to the ratio of basin area to length of permanent stream are the mainstems of Big Creek and the Little St. Francis River where the watersheds only need about three to four square miles to maintain each mile of flowing water.

The apparently liberal USGS topographic map designation of 688 miles of permanent streams does not agree well with the 281 miles of stream above Wappapello Dam that are classified as permanent under the Missouri Water Quality Standards Code of State Regulations (MDNR 1981). The Code of State Regulations permanent mileage estimate is probably a more accurate assessment because it is based on a thorough survey of field observations (Funk 1968). Most of the disagreement between the topographic map measurements and the Code of State Regulations mileage estimate probably occurs in the second and third order channels of the upper subbasin where the aquifer is known to be poor and base flows are unstable. A similar disagreement between permanent mileage estimates was noted in the adjacent Headwaters Diversion basin (Missouri Department of Conservation (MDC) 1994).

Flow in the mainstem of the lower St. Francis River is primarily regulated by water released by Wappapello Dam. However, the permanency of tributary streams in the lower subbasin is similar to the wet Ozark region where only four to eight miles of watershed are needed to maintain each mile of permanent stream. A high water table and large amounts of surface water compensate for the low relief that is usually associated with high watershed to length of permanent stream ratios (MDNR 1986a).

The USGS topographic map designation of 234 miles of permanent stream in the lower subbasin agrees well with the 204 miles of permanent stream classified by the Code of State Regulations (MDNR 1981). The closer agreement in the lower subbasin is probably due to the lower percentage of second and third order channels designated as permanent on topographic maps.

CHANNEL GRADIENT

Gradient information was calculated from USGS 7.5 minute topographic maps (20-ft contours in the upper subbasin and 5- or 10-ft contours in the lower subbasin) and tabulated by subbasin, watershed, stream, and order (Table 2). Gradient plots were prepared for the mainstem and 38 fourth order and larger tributaries. All gradient information is on file at the MDC's Southeast Regional Headquarters.

The St. Francis River flows swiftly out of the steep uplift of the St. Francois Mountains and meanders through the moderately-sloped Salem Plateau before spilling out onto the flat Mississippi Alluvial Plain after exiting Wappapello Dam. The steep gradients in the upper subbasin are influenced by the uplift which has exposed massive outcrops of erosion-resistant granites that provide hard points, vertical controls, and rigid channel boundaries. The result is an undulating mainstem gradient that provides much habitat diversity. This includes some spectacular and often dangerous whitewater rapids that are rated Class III, IV, and V, depending on river stage (Hawksley 1989). The west side of the subbasin is much steeper than the east side. West side tributaries such as Big Creek and Stouts Creek are two to four times steeper, run straighter courses, and contain harder substrates than typical east side tributaries such as Wolf Creek and the Little St. Francis River (Table 2).

On the alluvial lowlands of the lower subbasin, the partially channelized mainstem gradient drops at a fairly consistent rate of one ft/mile for 100 miles through the Bootheel region of Missouri. Prior to channelization and levee construction, which greatly reduced the length of the channel, the gradient was considerably less than 0.5 ft/mile. Tributary streams that drain low alluvial terraces are typically low gradient, engineered channels, such as Mingo Ditch (Table 2). Some headwaters fall steeply off the west slope of Crowley's Ridge.

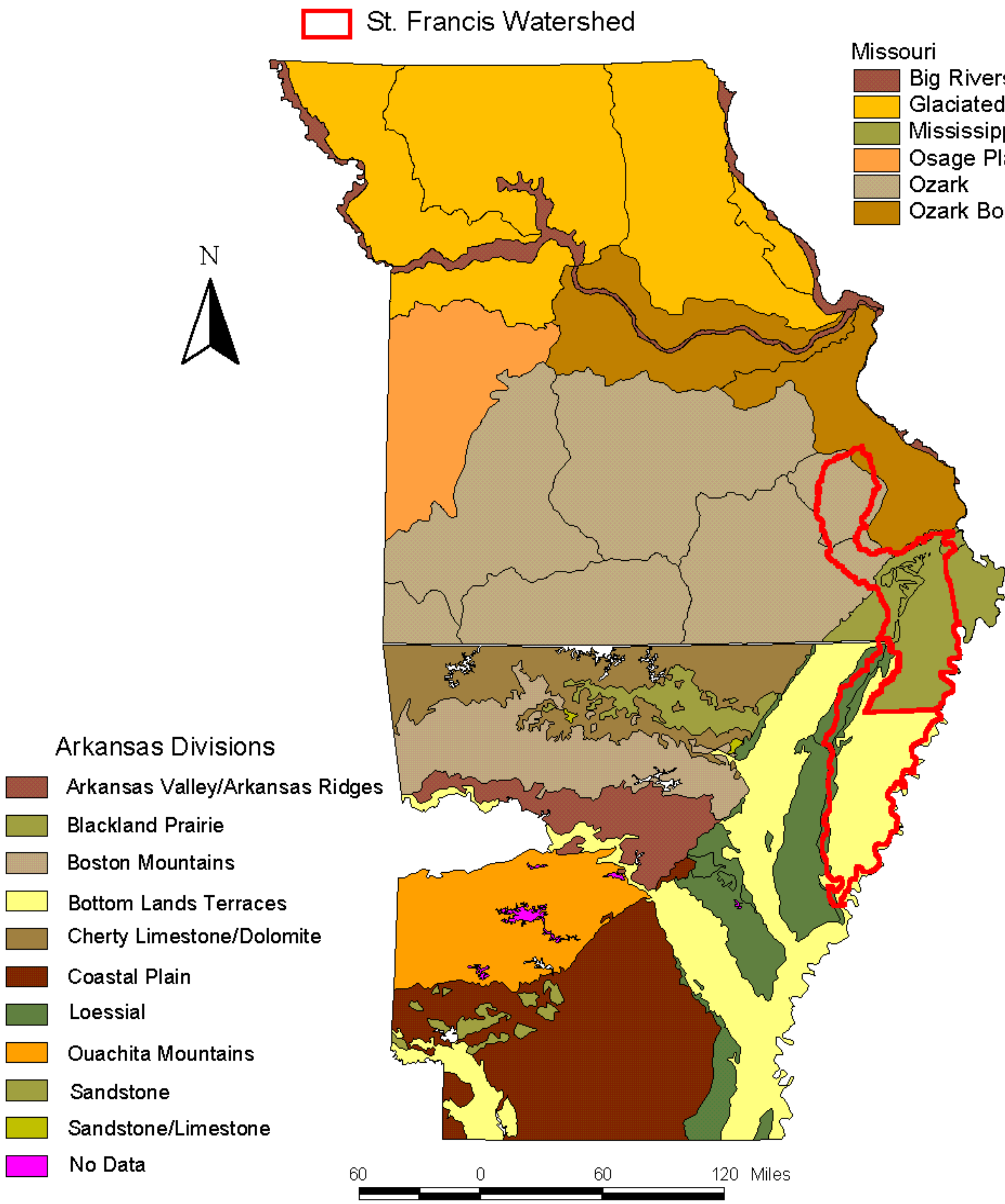

Figure nd. Natural divisions in the St. Francis watershed, in Missouri and Arkansas

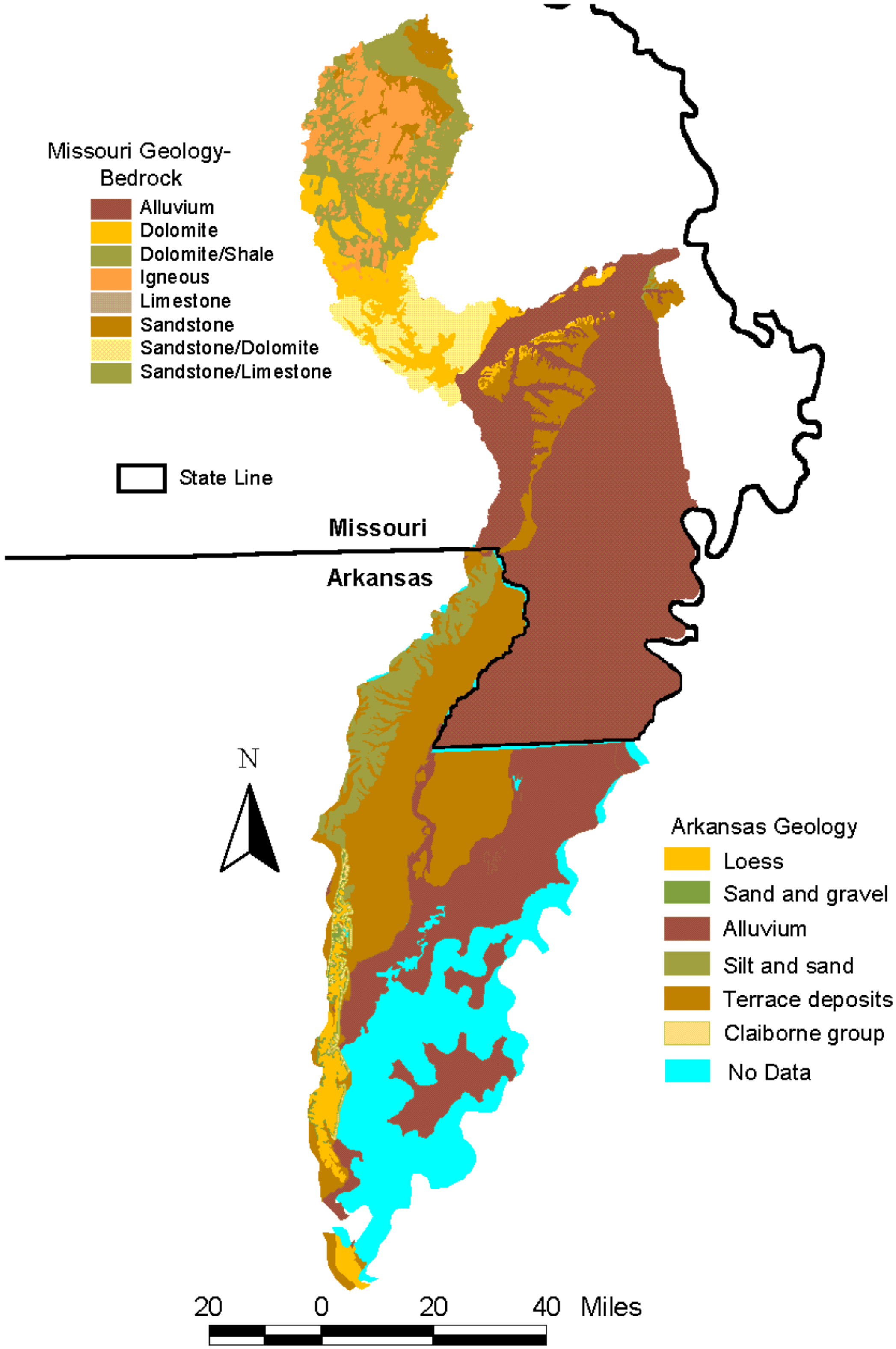

Figure ge. Geological divisions in the St. Francis Watershed in Missouri and Arkansas

Table 1. Drainage area of major watersheds in the St. Francis River basin, Missouri (modified from: USDA 1981)

Watershed	Max. Order	Area (mi^2)	% of Subbasin
Indian Creek	4	25.5	1.9
Wolf Creek	5	65.9	5.0
Doe Run Creek	4	30.8	2.3
Wachita Creek	4	31.0	2.4
Stouts Creek	5	77.8	5.9
Little St. Francis River	5	139.2	10.6
Cedar Bottom Creek	4	16.9	1.3
Marble Creek	4	49.5	3.8
Twelvemile Creek	4	64.0	4.9
Cedar Creek	4	23.8	1.8
Big Creek	5	197.0	15.0
Clark Creek	4	54.6	4.1
Hubble Creek	4	19.0	1.5
Big Lake Creek	4	30.6	2.3
Otter Creek	4	74.2	5.6
Lost Creek	4	68.1	5.2
Asher Creek	4	23.7	1.8
Wappapello Lake	6	13.9	1.1
All Smaller Tributaries	≤3	309.6	23.5
Upper Subbasin Totals		1315.1	100.0
Mingo Ditch	5	140.9	26.9
Dudley Main Ditch	5	155.8	29.7
Un-named Ditch	5	49.0	9.3
Varney River Ditch	4	44.0	8.4
All Smaller Tributaries	≤3	134.5	25.7
Lower Subbasin Totals		524.2	100.0
St. Francis Basin Totals		1839.3	

Table 2. Channel gradients of primary streams in the St. Francis River basin.

	Average Gradient (ft/mi)					
Stream	**6º**	**5º**	**4º**	**3º**	**2º**	**1º**
Upper St. Francis River	4.7	8.0	18.1	11.6	43.0	225.0
Big Creek		11.2	29.4	45.4	75.4	160.2
Stouts Creek		21.5	28.8	53.6	70.1	166.7
Little St. Francis River		7.6	8.9	35.1	62.1	133.1
Wolf Creek		4.1	5.0	14.7	23.1	55.6
Lower St. Francis River	1.1	---	---	---	---	---
Mingo Ditch		1.3	4.5	32.1	51.4	84.0
Lick Creek/Dudley Main Ditch		2.6	6.2	8.1	22.2	66.7
Un-Named Ditch		2.7	3.4	16.6	58.8	212.5

LAND USE

HISTORICAL LAND USE (UPPER SUBBASIN)

Jacobson and Primm (1994) gave a detailed account of the historical land use of the Ozark Plateau, which is outlined in this section. The headwaters of the St. Francis River basin have undergone the same type of land disturbances that are typical of the Ozark Plateau. Suppression of wildfire was followed by mining, highly selective upland logging, annual burning to support open range for grazing, transient attempts at upland row cropping, a second intensive timber cutting concentrated on the slopes, and most recently, increased grazing intensity.

Prior to the 1800s, the subbasin was in the historic pine range -- a wildfire-maintained upland savannah dominated by shortleaf pine with a prairie grass understory. The steep valley walls grew lush forests of oak, hickory, and pine, while the valley bottoms produced dense stands of bottomland hardwoods.

Early prospectors mined mineral deposits (lead, zinc, silver, iron) on the slopes of the St. Francois Mountains. During the early settlement period (1800-1880) settlers raised crops in the valleys and grazed livestock on the forested hillsides and the natural grass of the uplands. Small logging operations selectively cut old growth timber in the uplands and a network of roads was developed. Land disturbances caused by early settlement had minimal effect on runoff and erosion.

During the timber boom (1880-1920), large-scale timber operations began. Many settlers moved to the region for jobs. Log drives down streams could be large and logs were not tied into rafts. In 1909, Missouri began regulating log drives because they were dangerous and damaged stream banks. By 1920, most of the marketable shortleaf pine and hardwoods had been cut and the larger mills ceased operation.

Many of the unemployed loggers and lumber mill workers settled on the cut-over land vacated by the departing timber companies. Indiscriminate logging took more, the remnant forest was burned each year to increase grass production, livestock over-grazed the newly converted range land, and bottomland agriculture (row crops and livestock) expanded.

Agriculture peaked from 1940 to 1950, then decreased. Passage of an open range law, fewer range fires, acquisition of public lands, improved soil conservation practices, and reforestation of marginal pasture and row crop acreage all contributed to improved watersheds.

HISTORICAL LAND USE (LOWER SUBBASIN)

The entire Bootheel region of Missouri (which includes the lower subbasin of the St. Francis River) has undergone a total landscape transformation from an immense swampland forest, with intermingled streams, lakes, swamps, bayous, and sloughs, to a vast agricultural area.

This conversion to agriculture required more than 200 years and three extensive land disturbances: drainage, clearing, and flood control. Major drainage and flood control projects were aided by direct and indirect government involvement in planning and construction. This included levees, Wappapello Lake and other storage reservoirs, Headwater Diversion Channel, floodways, cutoffs, ditches, pump stations, and mainstem channelization. Clearing was dependent on successful drainage and flood control programs. Reclamation clearing was accomplished by private enterprise (logging followed by agriculture) on drained lands, with government encouragement through land grants, land promotions, price supports, liberal allotments, and special subsidies. Land reclamation was, at first, a slow and difficult process. In 1912, just four percent of the Bootheel forests had been cut (MDC 1989). By 1989, however, only 10 percent of the forests remained and 96 percent of the wetland acres had been drained (USCOE 1991). The development of modern machinery greatly accelerated land reclamation, especially between 1950 and 1970.

RECENT LAND USE (UPPER SUBBASIN)

This subbasin is 77 percent woodland, 10 percent grassland, 7 percent cropland, and 6 percent other land uses, which includes industrial, urban, and water developments (MDNR 1984)(Figure lu). Small cropland tracts are most often restricted to the wider mainstem floodplains in St. Francois County, while grasslands (hay fields and pasture) tend to be associated with bottoms and cleared ridge-tops in Iron, Madison, and Wayne counties. Land use patterns have apparently stabilized.

The woodlands are usually large upland tracts of oak-hickory forest dominated by a black-scarlet oak association (45%) and a secondary white oak association (31%). Succession is toward conversion to a more desirable white oak forest type. The tracts are considered moderately (56%) to poorly (26%) stocked with proportional stand size-classes of 49 percent sawtimber, 33 percent poletimber and 18 percent seedlings and saplings (Leatherberry 1990). Most of the woodlands (71%) are privately owned; 19 percent are under state or federal stewardship. Livestock grazing in woodlands can present some ecological and hydrologic concerns relating to canopy closure, understory development, leaf litter accumulation, and soil compaction.

A local mining industry (iron, lead, zinc, quarried red granite) and various small urban centers provide important components of the basin's economy. Small farms are common throughout the basin, but most farm operators supplement their incomes with off-farm employment.

The subbasin is mostly rural and sparsely populated (MDNR 1986). The communities of Farmington, Fredericktown, and Ironton and the area surrounding Wappapello Lake are experiencing the greatest population growth. Uncontrolled sediment and stormwater runoff at construction sites can pose localized problems. There are no industrial developments, associated with the small urban centers, that pose serious threats to local streams.

RECENT LAND USE (LOWER SUBBASIN)

Land use patterns (clearing and reclamation) stabilized after the most recent flood control (major levees) and drainage (mainstem channelization) projects were completed during the early 1970s. Presently, the subbasin is 90 percent cropland and pasture (predominately row crop) and only 10 percent forest (MDNR 1984) (Figure lu**)**. Agriculture is the most important industry in the subbasin as indicated by the high percentage of cropland. No significant change in land use is expected in the future. Woodland conversion to cropland is dependent on additional drainage, which is now seldom economically feasible because the woodlands are widely scattered and newly enacted legislation.

The remnant woodlands are old growth oak-gum-cypress forest types that occupy low, moist soil sites. Wooded tracts are considered poorly stocked with proportional stand size-classes of 92 percent sawtimber, 7 percent poletimber, and only one percent seedlings or saplings (Hansen 1991). Most of the woodlands are now under state or federal stewardship; 28 percent of the woodland resource remains in private ownership.

The larger, wide-based levees throughout the subbasin are often used to produce hay crops. Sometimes the smaller, steeper-sloped levees are fenced and used as seasonal pasture for livestock (Norman 1973).

The subbasin has a sparse population concentrated in the small communities of Bloomfield, Puxico, Cardwell, Puxico, Arbyrd, Dudley, Qulin, and western Dexter (MDNR 1986a). Some of these communities are located on the vulnerable inside portion of the setback St. Francis River Levee, but are protected from flooding by secondary levee systems. There are no industrial developments associated with these small, suburban communities that pose serious threats to local streams and drainage ditches.

SOIL CONSERVATION PROJECTS

The upper subbasin contains three completed small watershed Special Area Land Treatment projects (SALT) and one completed large watershed EARTH project.

> VILLAGE CREEK SALT (Project Number S-159), a 3,845-acre treatment area in the Little St. Francis River watershed in northeast Madison County, was conducted from 1994-1999 by the Madison County Soil and Water Conservation District (SWCD). The project addressed sheet and gully erosion on woodlands, pasture, and streambanks through livestock fencing, rotational grazing, re-seeding, and pond construction. Landowner participation was considered light. Accomplishments included treating 1,442 acres of grassland (over-seeded and fertilized), fencing 124 woodland acres to exclude livestock, building five ponds to stop gully erosion, and developing four springs (Selma Mascaro, Madison County SWCD, Personal Communication).
>
> PEACHTREE FORK SALT (Project Number S-136), a 3,241-acre treatment area in the Clark Creek watershed in northwest Wayne County, was conducted from 1993 to 1998

with variable funding from the Wayne County SWCD. The project addressed sheet and gully erosion, primarily on woodlands and pasture, and some cropland acreage through livestock fencing, rotational grazing, re-seeding, cropland rotation, and dry-hole pond construction. Incentives included special rental rates for a seed drill and 75 percent cost sharing for seed, fencing, and pond construction. Landowner interest was low; only 391 acres were adequately treated and most of this was on woodlands (Tom Johnson, Wayne County NRCS, Personal Communication).

FLATWOODS SALT (Project Number S-020), a 2,908-acre treatment area in the Rock Creek watershed in east Iron County, was started in 1988 and terminated in 1991 after a total expenditure of $35,000 by the Iron County SWCD. The project emphasized woodland stewardship and sheet and gully erosion on pastures through proper planning of timber harvest, re-seeding, and pond construction. The project resulted in a number of completed farm plans, about 1,075 acres of pasture re-seeded with warm and cool season grasses, one gully control structure installed, and a spring-fed watering tank for livestock. Livestock fencing was not an approved practice. Thirty-four out of 75 eligible landowners took advantage of the free use of a seed drill, but did not often apply for cost-share seed benefits (Edward Templeton, Iron County NRCS, Personal Communication).

CRANE POND CREEK EARTH (Project Number E-023), an 11,164-acre treatment area in east Iron County, was conducted from 1994 to 1999 by the Iron County SWCD. The goal of the EARTH project was to treat at least 75 percent of the 9,489 acres needing treatment. The area was divided into cropland, pasture, woodland, gullies, and other land classes. A total of 70% or 6,567 acres were treated using cost share funds (Kenny Wooten, Iron County NRCS, Personal Communication).

The lower subbasin has no planned, ongoing, or completed SALT or EARTH watershed projects. Also, no soil conservation projects authorized by the Watershed Protection and Flood Prevention Act (PL-566 projects) have been planned or completed in either subbasin.

PUBLIC AREAS

Public ownership in the basin totals more than 218,600 acres, with about 83 percent of the public lands located in the upper subbasin and 17 percent in the lower subbasin. The Mark Twain National Forest (U.S. Forest Service) is the largest public landowner in the upper subbasin with 90,200 acres of scattered upland forest tracts, which contain little permanent water. The MDC owns about 46,800 acres, which includes 28 Conservation Areas that are managed as upland and bottomland forests, waterfowl hunting areas, or stream accesses (Tables 1 and 2). The USCOE project lands around Wappapello Lake total 44,300 acres, and are managed primarily for timber and upland wildlife resources. The USFWS operates the 22,000-acre Mingo National Wildlife Refuge in the lower subbasin as a waterfowl refuge. The MDNR provides multiple recreation opportunities on 15,011 acres in four state parks (Elephant Rocks, St. Joe, Sam A. Baker, Wappapello) in the upper subbasin.

CORPS OF ENGINEERS 404 JURISDICTION

The St. Francis River basin lies within two USCOE jurisdictions, the St. Louis and Memphis Districts. The St. Louis District is responsible for the upper subbasin, including Wappapello Lake and the operation of Wappapello Dam for the purpose of downstream flood control. The Memphis District is responsible for the waters in the lower subbasin, below Wappapello Dam, but does provide input on water released through the dam. All applications or inquiries regarding 404 permits need to be directed to the appropriate district office:

> St. Louis District USCOE, Regulatory Office, 1222 Spruce Street, St. Louis, MO 63103-2833. Telephone: 314/331-8579
>
> Memphis District USCOE, Regulatory Branch, 167 N. Main Street, Room B-202, Memphis, TN 38103-1894. Telephone: 901/544-3471.

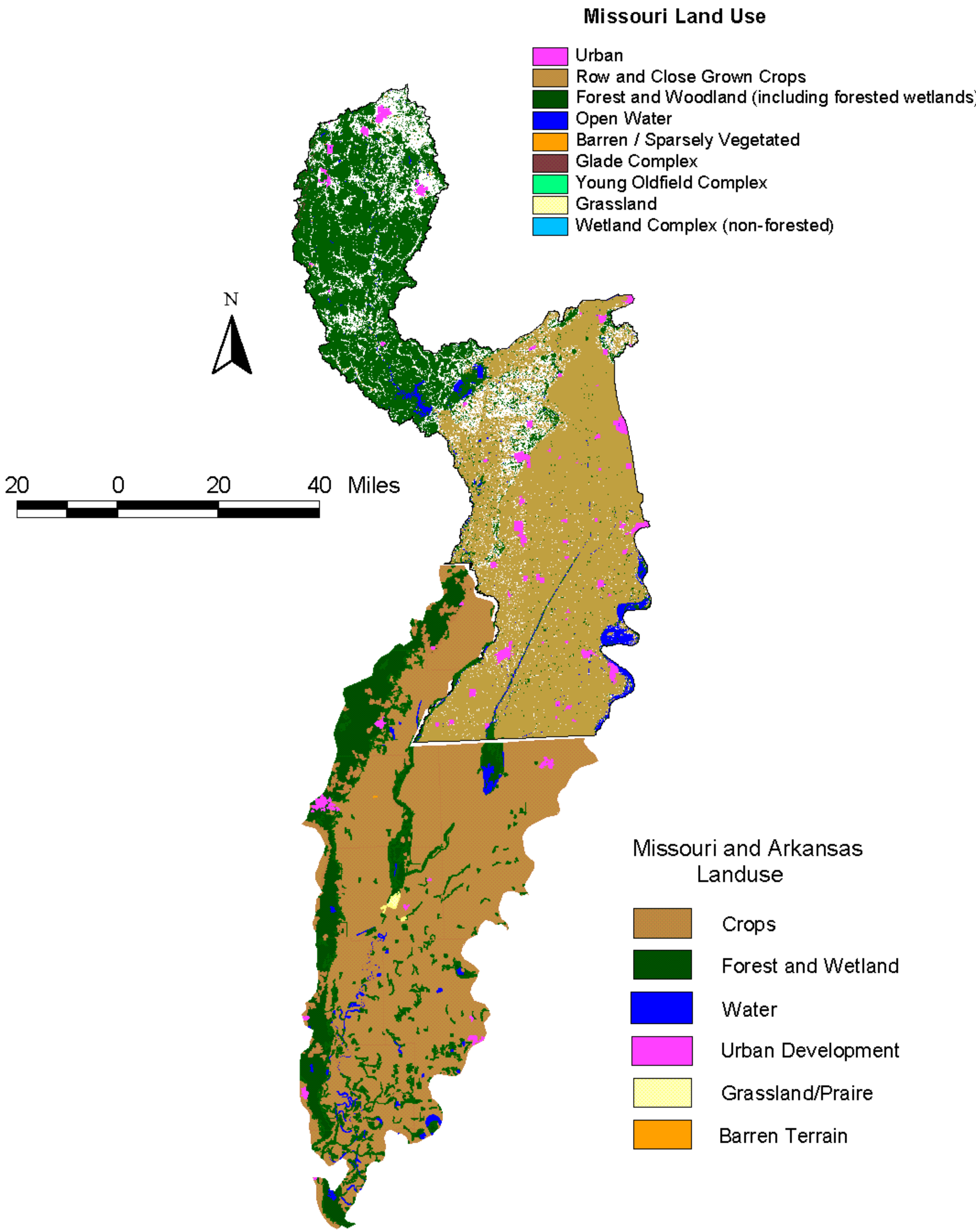

Figure lu. Recent land use in the St. Francis Watershed in Missouri and Arkansas.

Table 1. Public areas owned by MDC in the upper St. Francis River basin.

Public Area	Acres	County
Bismarck Lake Conservation Area (CA)	1188	St. Francois
Buck Mountain CA	194	St. Francois
Buford Mountain CA	3743	Iron
Coldwater Access	78	Wayne
Coldwater CA	7372	Wayne and Bollinger
Flatwoods CA	909	Wayne
Funk Memorial CA	180	Iron
Graves Mountain CA	3678	Wayne and Iron
Gruner Ford Access	4	St. Francois
Ketcherside Mountain CA	3356	Iron
Knob Lick Tower Site	5	St. Francois
Millstream Gardens CA	684	Madison
Riverside CA	2528	Iron, Reynolds, and Wayne
Roselle Access	22	Madison
Silva CA	236	Wayne
Syenite Access	29	St. Francois
Thompson Ford Access	84	Madison
University Forest CA	7149	Wayne and Butler
Yokum School CA	160	Wayne

Table 2. Public areas owned by MDC in the lower St. Francis River basin.

Public Area	Acres	County
Ben Cash Memorial Conservation Area (CA)	1309	Dunklin
Chalk Bluff Trail Access	82	Dunklin
Duck Creek CA	6234	Stoddard and Bollinger
Fisk Access	4	Butler
Frisbee Cutoff Access	92	Dunklin
Holly Ridge CA	991	Stoddard
Oak Ridge CA	243	Stoddard
Otter Slough CA	4863	Stoddard and Butler
Wilhelmina CA	1399	Dunklin and Butler

HYDROLOGY

PRECIPITATION

Average annual precipitation in the upper subbasin (Farmington, Missouri weather station) is 40.5 inches, with 18.5 inches of annual runoff (NRCS 1981). The average annual precipitation in the lower subbasin (Kennett, Missouri, weather station) is 49.5 inches, with 22.0 inches of annual runoff (NRCS 1979). The nine inches of additional rainfall in the lower subbasin occurs during the cooler months. Average spring air temperature is about 5°F warmer and the growing season is 35 days longer in the lower subbasin.

GAGING STATIONS

The USGS is responsible for recording flows in the upper subbasin and the United States Army Corps of Engineers (USCOE), Memphis District, records mainstem flows in the lower subbasin. The USGS currently operates four mainstem gages, two tributary gages, a lake-stage recorder at the dam, and another mainstem gage immediately below the dam (Table 1). The USCOE operates eight stage recorders on the mainstem of the river below the dam (Table 1). There are no USCOE gaging stations on tributaries in the lower subbasin.

USGS gage information is recorded and published by water year (October 1 through September 30), and includes long-term averages (period of record) and summary statistics that include low flow information. USCOE gage information, available by request, is recorded by calendar year and does not include long-term averages and summary statistics related to low flows because of the regulated flow exiting Wappapello Dam.

STREAMFLOW CHARACTERISTICS (UPPER SUBBASIN)

Streamflow characteristics are listed in Table 2. Peak discharges usually occur in November and December, and again during April. February stream flows generally equal the mean annual discharge at each gage site. Discharge typically recedes sharply during June, and base flows are reached by early July and continue through October.

Periods of peak discharge do not correspond with periods of greatest precipitation. Early winter peak discharges, with about 3.3 inches of monthly precipitation, are slightly higher than spring discharges, with about 4.6 inches of monthly precipitation. The highest floods and maximum recorded discharges, at all gage sites, have occurred during the winter months. Winter watershed conditions are probably responsible for increased runoff during winter storm events. Less evapotranspiration (cool air temperatures), less ground cover (annual plants), a naked forest canopy (raindrop interception), saturated soils (some snow), or frozen soils are all factors that can contribute to increased winter runoff.

The predominance of impervious rock in the upper basin limits infiltration, fracturing, and subsurface flows, causing rapid runoff which produces flashy hydrographs and frequent flooding.

The result is a poor aquifer that provides low, unstable base flows with few springs. High gradient, fourth and fifth order tributaries on the west slope of the mainstem (Stouts Creek, Marble Creek) and lower gradient, fifth order tributaries on the east slope (Little St. Francis River, Wolf Creek) can become intermittent during periods of drought.

Groundwater supply, storage, and movement steadily improve in a downstream direction as the shallow igneous bedrock in the headwaters is eventually replaced by deeper water-soluble dolomites near Wappapello Lake. Higher and less variable mainstem base flows are evident at downstream gage sites. However, even at the Patterson gage, which is only five miles above Wappapello Lake, low-flow stability is considerably less than the neighboring Black River and Castor River basins. Wappapello Lake rests on a much younger, water-soluble Gasconade dolomite that allows considerable groundwater movement (MDNR 1986a). Some small tributary streams that now drain directly into the lake (*e.g*. Otter Creek, Happy Hollow Creek) are losing streams that emerge as springs on the lake bottom (*e.g*. Blue Springs).

Exceptions to the subbasin's seasonal low flow are Big Creek (fifth order) and its major tributary, Crane Pond Creek (fourth order). The geology of the Big Creek watershed is not greatly influenced by the St. Francois Mountains uplift, but, instead, is more closely related to the deep, cherty limestone residuum of the upper Black River basin. The unconsolidated alluvium throughout the watershed provides subsurface storage and allows rapid groundwater movement that sustains and stabilizes base flows.

It appears that the magnitude of floods is more related to average hydraulic gradient than watershed area. For example, the Little St. Francis River has the second largest area, but the lowest gradient. Several smaller streams had similar, or greater magnitude floods. Cedar Bottom and Wachita creeks have small watershed areas, but steeper gradients and had flood magnitudes similar to larger streams.

STREAMFLOW CHARACTERISTICS (LOWER SUBBASIN)

Flow in the lower St. Francis River is primarily regulated by water released through Wappapello Dam. However, extensive infiltration produces a good aquifer with abundant groundwater supplies, high base flows, and a water table high enough to maintain standing water in large drainage ditches during prolonged dry periods. The high water table can also cause major agriculture problems.

Flood flows (typically exceeding 25,000 cubic feet per second (cfs)) in the upper river are stored in Wappapello Lake and released at rates which reduce flooding the lower subbasin. The USCOE Water Control Release Schedule for Wappapello Dam is dictated by reservoir stage, time of year (expected precipitation), and downstream agricultural activities (MDC 1995). The maximum possible release through the dam is 10,000 cfs, which is authorized only if reservoir storage capacity is threatened. The normal maximum discharge is 7,000 cfs during January and February, which can cause some limited agricultural flooding downstream if Mingo Ditch and Dudley Main Ditch have significant discharges. During most of the agricultural year (April through November), the preferred maximum discharge through the dam will produce a controlled maximum flow of 3,800 cfs at the Fisk, Missouri and St. Francis, Arkansas gage stations. The minimum authorized low flow discharge through Wappapello Dam is 40 cfs. However, recent low flow measurements have determined that the minimum discharge going through the dam is actually 60 cfs (USCOE Personal Communications).

Peak flows at the Fisk gage station, 23 river miles below the dam, seldom exceed the channel capacity of 8,090 cfs. At the St. Francis gage station, 54 river miles below the dam, peak winter flows average 14,700 cfs, frequently exceeding the channel capacity of 6,300 cfs. Overbank flows in this channelized reach of river, however, are contained within an extensive levee system. There is not enough watershed area between the dam and the Fisk gage to provide significant runoff. However, major storm events can produce additional runoff that causes some overbank flows near the St. Francis gage.

Every five years the dam is completely closed for safety inspection that requires a complete de-watering of the spillway, which usually takes 8 to 12 hours to complete. However, the USCOE pumps water from Wappapello Lake into the river to maintain base flows.

An instantaneous record of channel depth (gage height) can be accessed through a 24-hour microwave telephone service at the Fisk and St. Francis gage stations. During stable flows, mean daily discharge can be inferred from gage height and mean daily velocity can be inferred from discharge.

DAM AND HYDROPOWER INFLUENCES

Wappapello Dam was completed in 1941 and has a drainage area of 1,310 mi^2. Project parameters are listed in Table 3. Generating capacity is a 175 kw turbine that only provides power to the dam facilities. Increasing hydropower capacity is not economically feasible. The dam impedes the upstream movement of fishes.

A mainstem dam at DiSalvo Lake (at Bismarck Conservation Area), is 30 ft high and blocks all upstream movement of fishes. The concrete dam was built in 1944 by the Hanna Mining Company, and is in the fourth order section of the mainstem at RM 423.2. The lake is 210 acres and floods 1.8 miles of St. Francis River channel.

There are four concrete dams located on mainstem tributaries in the upper subbasin that can block the upstream movement of fishes. Fredericktown Lake (municipal) is on the Little St. Francis River (5°) at RM 17.4; Killarney Lake (private) is on Stouts Creek (5°) at RM 4.8; Crane Lake (U. S. Forest Service, USFS) is on Crane Pond Creek (4°) at RM 13.2; and, Iron Mountain Lake (municipal) is on Indian Creek (4°) at RM 4.1. The impoundments are approximately 100 acres each and have extremely high watershed:lake area ratios. The dams have been in place for at least 40 years, and all have some draw-down capabilities. Killarney Lake was completely drained down to the old river channel in 1994 for dam repairs. A considerable amount of gravel was dredged from the basin during the draw-down.

In the lower subbasin, no dams or water control structures exist on the mainstem of the St. Francis River, in Missouri. Mingo Ditch, the largest tributary to the lower river, has a low-head water control structure (United States Fish and Wildlife Service (USFWS) Mingo National Wildlife Refuge (NWR) spillway) that can impede or encourage the upstream movement of fishes, depending on spillway operation. High velocity currents through the spillway during spring runoff or planned draw-downs attract many species of fish that eventually migrate through the spillway and upstream into the 3,000-acre swamp/wetland/ditch system on the refuge. When the spillway is not releasing excess refuge water, the discharge in Mingo Ditch (5°) is reduced to intermittent flow for at least three miles below the control gates (RM 16.2).

Table 1. Gaging Stations in the St. Francis River basin, Missouri.

Site	Stream	Agency	Gage Number	Location
ACTIVE GAGES				
Roselle	Upper St. Francis River	USGS	07034000	Hwy. 72
Mill Creek	Upper St. Francis River	USGS	07035800	Hwy. E
Saco	Upper St. Francis River	USGS	07036100	Hwy. C
Patterson	Upper St. Francis River	USGS	07037500	Hwy. 34
Wappapello Lake	Upper St. Francis River	USGS	07039000	Wappapello Dam
Iron Bridge	Lower St. Francis River	USGS	07039500	Co. Rd.
Fisk	Lower St. Francis River	USCOE	07040000	Hwy. 60
Dekyns	Lower St. Francis River	USCOE		Hwy. 53
St. Francis	Lower St. Francis River	USCOE	07040100	Hwy. 62
Brown Ferry	Lower St. Francis River	USCOE		Hwy. C
Holly Island	Lower St. Francis River	USCOE		Hwy. 84/90
Hargrove	Lower St. Francis River	USCOE		Railroad Trestle
Hopkins	Lower St. Francis River	USCOE		Hwy. 25
Lake City	Lower St. Francis River	USCOE		Hwy. 18
Des Arc	Big Creek	USGS		Hwy. 143
Fredericktown	Little St. Francis River	USGS		Hwy. 72
INACTIVE GAGES				
Ironton	Brewers Creek	USGS		
Fredericktown	Barnes Creek	USGS		
Piedmont	Clark Creek	USGS		

Table 2. Streamflow data for the St. Francis River Basin (USFR= upper St. Francis River, BGCK=Big Creek, LTSF= Little St. Francis River, CLCK=Clark Creek) (MDNR, 1995)

Gage Location	Stream	Max. c.f.s.	Min. c.f.s.	50% Exceeds	90% Exceeds	7-Day Q2	7-Day Q10
Roselle	USFR	43000	0.8	82	6	1.2	0.1
Mill Creek	USFR	24200	1.7	181	15		
Saco	USFR	65800	5.1	264	29		
Patterson	USFR	155000	8.0	335	52	32	15
Des Arc	BGCK	16000	5.1	55	16	9.0	4.8
Fredericktown	LTSF	11200	0.6	36	2.6	0.4	0
Patterson	CLCK	15500				2.8	1.4

Table 3. Wappapello Lake project parameters.

Specification	Conservation Pool	Recreation Pool	Flood Pool
Elevation (NGVD)	354.74	359.74	394.74
Surface Area (Acres)	5,200	8,400	23,200
Storage Capacity (Acre-Feet)	30,900	85,100	613,200
Average Depth (Feet)		6.5	
Maximum Depth (Feet)	42	47	82
Shoreline (Miles)		180	
Flooded Mainstem (Miles)	26	28	35
Runoff Capacity (Inches)			8.8

WATER QUALITY AND USE

BENEFICIAL USE ATTAINMENT

Missouri Department of Natural Resources (MDNR) evaluates water quality to insure that state waters can support designated uses including, but not limited to, fishing, swimming, public water supply, and agriculture (MDNR 1986b). Most of the basin, including the entire St. Francis River and Wappapello Lake are classified as full use attainment (MDNR 1986b). Parts of Wolf, Goose, Saline, Shays, Village, Mill, and Big creeks are listed as partial use attainment, meaning that there are some water quality problems (MDNR 1986b). Village and Mill creeks contain one-mile sections where uses are not met and serious water problems exist. Eroding lead mine tailings caused several habitat degradation (MDNR 1986b).

The mainstem of the St. Francis River, Big Creek, Little St. Francis River, and Wappapello Lake are classified for whole-body contact recreation (MDNR 1986a). The Little St. Francis River, above Saline Creek, (Fredericktown City Lake) is a designated drinking water supply (MDNR 1986a and Vandike 1995). Shepherd Mountain Lake, on an un-named tributary to Stouts Creek, is a designated drinking water supply for the communities of Ironton and Arcadia (MDNR 1986a and Vandike 1995).

In the lower subbasin, the lower St. Francis River is also classified for whole-body contact recreation (MDNR 1986a). Water quality is generally suitable for aquatic biota; however, the diversity and densities of biota have suffered because of habitat degradation due to channelization, sedimentation, turbidity, and occasional low dissolved oxygen concentrations (MDNR 1984). No surface water source is classified as a public drinking water supply.

WATER USE

Two permitted water supply surface withdrawls exist in the upper subbasin. Fredericktown removes water (425,000 gallons per day) from Fredericktown City Lake and Ironton and Arcadia remove 290,000 gallons per day from Shepherd Mountain Lake.

Irrigation is a major use of groundwater in the Bootheel. More than 500,000,000 gallons were used for irrigation in 1984 in each of Stoddard and Dunklin counties (MDNR 1986a). Most of this water probably comes from shallow wells. MDNR (1986a) indicates that no irrigation occurs in the upper subbasin.

The entire basin provides some significant recreational opportunities. A 1977 statewide stream angling survey estimated 88,500 annual fishing trips, which ranked the basin 15th in angling pressure out of 38 basins surveyed (Hanson 1980). In 1981, a statewide recreational value survey ranked the basin 13th (out of 38) in total recreational worth (Bachant et. al., 1982). Intense agriculture, poor land use, and channel modifications were cited as the primary problems that lowered recreational worth in the recreational value survey. These types of problems are inherent to the lower subbasin and are not typically associated with the upper subbasin. In fact, much of the upper river is included on the Interior Department's Nationwide Rivers Inventory, and a 17-mile segment is classified and managed as a heavily used "scenic waterway" in the Mark Twain National Forest (MTNF) Land and Resource Plan (Forest Plan).

Whitewater canoeing and kayaking are popular activities between Highways 72 and D on the mainstem in Madison County. The majority of activity occurs during the spring. Several sections are rated as class V rapids when the water levels are high.

WATER QUALITY

Good water quality is generally shared throughout both subbasins and Wappapello Lake. No wide-spread chronic or persistent problems that affect aquatic communities are evident. Wappapello Lake is slightly eutrophic; low dissolved oxygen concentrations normally develop in the hypolimnion during summer stratification. During the summer, high water temperatures can occur in the lower river throughout a 20-mile reach between the mouth of Mingo Ditch and the Wilhelmina Cutoff. This occurs because the channelized reach is wide and shallow with poor riparian vegetation that limits shading.

Some detailed water quality information is collected at select USGS surface-water gage stations or at special water-quality monitoring sites. The water quality data can include sediment, chemical, or microbiological parameters. Gage records are available through annual USGS Water Resource Data water-year reports, or the USGS computerized data retrieval system, WATSTOR. The St. Francis River basin has two active and three inactive water-quality gage sites:

> Active gage No. 07037300; Big Creek at Sam A. Baker State Park; 1992 to present; microbiological and chemical (including heavy metals, chlorinated hydrocarbons, organophosphates); low frequency, continuing record.
>
> Active gage No. 07036100; St. Francis River at Saco; 1988 to present; mean daily suspended sediments; continuous record.
>
> Inactive gage No. 07036940; Big Creek at Chloride; 1969 to 1975 and 1983 to 1990; chemical (including heavy metals); low frequency, continuing record.
>
> Inactive gage No. 07036100; St. Francis River at Saco; 1983 to 1989; microbiological and chemical (including heavy metals); low frequency, continuing record.
>
> Inactive gage No. 07040100; St. Francis River at St. Francis, Arkansas; 1969 to 1975; chemical; low frequency, continuing record.

Another source of detailed water quality information is the USCOE limnological data currently being monitored at two sites in Wappapello Lake, two sites on the St. Francis River above the lake, and one site below the dam. The data includes sediment, chemical (including heavy metals, chlorinated hydrocarbons, organophosphates), and microbiological parameters, collected since

1983 at six-week intervals, March through November. The water quality data base is accessible through the Environmental Quality Section, St. Louis District, USCOE.

Section 303(d) of the Federal Clean Water Act requires states to list waters not expected to meet established state water quality standards (MDNR 1998). The Farmington West waste water treatment plant degrades approximately 1.5 miles of the upper St. Francis River. In this section, both biological oxygen demand (BOD) and ammonia standards are not met. Big Otter Creek, a tributary to Big Creek, has been affected by releases of heavy metals by the Doe Run Lead Smelter. Village Creek receives excessive sediment from Mine La Motte. Sawdust pile leachate and an unknown source decrease the pH at two locations on Trace Creek near Saco.

NONPOINT SOURCE POLLUTION (UPPER SUBBASIN)

The basin has some of the lowest erosion potential in the state, which results in particularly low sediment yields, bed loads, and turbidities. The annual erosion rate for all land types in the upper basin totals only 2.9 tons/acre. Sheet erosion on tilled land is the most serious threat, at a moderate 13-18 tons/acre. Gully erosion and sheet erosion on permanent pasture and non-grazed forest is considered slight. Sediment yield to streams, typically low in the Ozark region, is extremely low at only 0.6 tons/acre/year (Anderson 1980).

NONPOINT SOURCE POLLUTION (LOWER SUBBASIN)

Nonpoint sources are much more likely to impact water quality than point sources in the lower subbasin. The primary sources are nutrient and pesticide loading from agricultural runoff (90% of the subbasin is cropland and pasture). Nutrients entering the mainstem cause few water quality problems because of buffering and dilution. Enrichment in many of the smaller tributary ditches, however, can cause extreme turbidities, excessive growth of aquatic plants, and low dissolved oxygen concentrations, which can cause localized fish kills during summer low flow periods (MDNR 1984). Pesticide residues are present in surface and shallow groundwater supplies throughout the subbasin. Two percent of 124 wells in the alluvial aquifer exceeded drinking water standards for pesticides (atrazine, alachlor, or metolachlor) and Nitrate-N levels were exceeded in 17 percent of the wells (MDNR 1984).

The rates of soil erosion in the lower subbasin are similar to the low rates in the upper subbasin, even through most of the watersheds have been cleared for intensive row crop production. The Natural Resource Conservation Service estimated sheet erosion at 2.5 to five tons/acre/year and gully erosion at 0 to 0.16 tons/acre/year which are both considered slight to moderate (MDNR 1984). Nearly flat topography contributes to low sheet erosion. However, despite low stream gradients ($\approx$1 ft/mi), headcutting and rill and gully erosion are substantial problems upstream from the channelized sections. An extensive depositional area of sand and silt is located on a reach of the mainstem channel immediately downstream from the Wilhelmina Cutoff at RM 259.2. In this area, the river changes from a channelized reach (26 miles were cut off) to a natural meandering channel. The gradient decreases at this point, which causes the deposition. Another depositional area is downstream of the Highway 84/90 bridge, west of Kennett, Missouri.

POINT SOURCE POLLUTION (UPPER SUBBASIN)

From about 1720 until 1947, lead, copper, nickel and cobalt ores were mined from several locations near Fredericktown (MDNR 1984). This mining activity has periodically affected water quality by contaminating localized surface water, groundwater, channel substrates, and vegetation with heavy metals and other harmful mine, mill, or smelter byproducts (MDNR 1986a). The primary pollutants, which can often exceed State Water Quality Standards, are lead, zinc, iron, nickel, copper, cobalt, cadmium, chromium, airborne sulfur dioxide, and acid water. Village Creek, Mill Creek, and Toler Branch suffered from sedimentation from mine tailings. Goose and Saline creeks contained elevated levels of cobalt and nickel from artesian flow from the Madison Mine.

The Annapolis Lead Mine on Big Creek, the Pilot Knob Pellet Company on Brewers Creek, the Iron Mountain Mine on Indian Creek, and the Catherine Lead Mine on Logtown Branch all have tailing ponds or chat piles. Although safely contained at the present time, they have the potential to release toxic trace-elements into receiving streams.

Another threat of heavy metal trace-element contamination is the ASARCO lead smelter near Glover, Missouri. Smelter runoff entering nearby Big Creek once violated zinc and cadmium standards (MDNR 1984), and smelter smoke stack emissions, containing high concentrations of sulfur dioxide, can have negative impacts on downwind plant and animal communities. In the late 1980s, a water treatment facility was constructed that was successful in meeting state standards for zinc and cadmium (MDNR 1984). However, a health advisory was issued in 1999 by the Missouri Department of Health for Big Creek near Glover. Centrarchids were the only fish analyzed and found to be contaminated with lead. Subsequently, additional samples of centrarchids and catostomids were tested for contaminants. Although they did not exceed the action level of 300 ppb for lead, the advisory was continued in 2000 because of the previous results.

In June 1992, a breached tailings barrier at International Specialty Products spilled 1,500 cubic yards of non-toxic powdered rhyolite rock into Big Creek near Annapolis, Missouri. The spill deposited fine sediments, two feet deep, for a distance of one mile and temporarily caused extreme turbidities for 15 miles. No fish were killed, but macroinvertebrate communities did not fully recover until most of the sediment had been flushed out of the system by early 1994.

Municipal waste discharges, throughout this sparsely populated subbasin, are mostly small, adequately designed, and pose few serious threats to the water quality of receiving streams. Eight National Pollution Discharge Elimination System (NPDES) permitted wastewater discharges are located in the upper subbasin (Table 1). Upgraded facilities and improved operation and maintenance of the municipal sewage systems have reduced the frequency of untreated effluent releases, which most often resulted in only minor aesthetic impacts on six miles of permanent streams (MDNR 1984). Filamentous algal blooms often occur during the summer in the mainstem below Farmington, which indicates nutrient enrichment and the potential for periods of low dissolved oxygen. The planned upgrade in the Farmington Treatment Plant should alleviate this problem.

Point sources for non-municipal discharges are limited to 74 NPDES permits (unpublished data from MDNR 2001). The lagoons (associated with subdivisions, camp grounds, schools, hospitals) have no record of causing pollution problems, and are generally situated on first order dry-channel tributaries.

POINT SOURCE POLLUTION (LOWER SUBBASIN)

Most point source discharges are restricted to a few watersheds in the northern portion of the subbasin. Eight NPDES permitted wastewater discharges are located in the lower subbasin (Table 2). In the southern reaches, mainstem levees constrict the width of the floodplain and increase flood stages, which greatly limits suitable space for municipal or industrial development. The total volume of municipal waste discharge is linked to the sewage lagoons in the small northern communities of Dexter, Bloomfield, and Dudley, which eventually drain into the Dudley Main Ditch tributary network. The lagoons in the northern community of Puxico drain into the Mingo Ditch network through Turkey Creek. Cardwell is the only southern community in the subbasin, and its three-cell system drains into Kinnemore Slough, which eventually enters the St. Francis River in the state of Arkansas. Lagoon effluent has never severely impacted water quality in any of the receiving streams, primarily because rapid soil infiltration and groundwater dilution rates limit effluent duration. The MDNR (1984), however, has suggested that the Puxico and Bloomfield facilities be eventually upgraded to three-cell systems.

Point sources for non-municipal discharges are limited to 62 NPDES permits (unpublished data from MDNR 2001). No complaints have been reported for these facilities.

Intensive poultry operations have increased in recent years. At present, 18 intensive poultry farms, all operating in Stoddard County, have the potential to cause water quality problems without proper waste control.

Table 1. NPDES permitted wastewater discharges in the upper St. Francis River subbasin (unpublished data from MDNR 2001).

Facility Name	Receiving Stream	Location T-R-S	County
Annapolis STP	Big Creek	T31 R3E S22	Iron
Acradia E Lagoon	Tributary to Stouts Creek	T33 R4E S5	Iron
Arcadia W WWTF	Stouts Creek	T33 R4E S5	Iron
Farmington E WWTP	Kennedy Branch/ Wolf Creek	T36 R6E S32	St. Francois
Farmington W WWTF	Tributary to St. Francis River	T35 R5E S11	St. Francois
Fredericktown WWTF	Saline Creek	T33 R7E S8	Madison
Greenville WWTF	Tributary to St. Francis River	T28 R5E S1	Wayne
Ironton WWTF	Stouts Creek	T34 R4E S32	Iron

Table 2 NPDES permitted wastewater discharges in the lower St. Francis River subbasin (unpublished data from MDNR 2001).

Facility Name	Receiving Stream	Location T-R-S	County
Arbyrd WWTF	Tributary to Honey Cypress Ditch	T16 R8E S5	Dunklin
Bloomfield Lagoon	Lick Creek	T26 R10E S14	Stoddard
Cardwell WWTF	Tributary to Kennemore Slough	T16 R7E S2	Dunklin
Dexter W Lagoon	Dudley Main Ditch	T25 R10E S20	Stoddard
Dudley WWTF	Lick Creek Ditch	T25 R9E S28	Stoddard
Puxico WWTF	Turkey Creek	T27 R8E S35	Stoddard
Stoddard Co. PWSD #1	Dudley Main Ditch	T25 R10E S29	Stoddard
Stoddard Co. PWSD #5	Tributary to Lick Creek Ditch	T26 R10E S12	Stoddard

HABITAT CONDITIONS

CHANNEL ALTERATIONS

No channel alterations have occurred in the upper subbasin. However, extensive alterations have occurred in the lower subbasin (USCOE 1991). Under provisions of the 1849 Swamp Lands Act, swamp lands were donated to the states with the requirement that the proceeds from land sales be used to construct levees and drainage ditches. The preparation of a comprehensive flood plan was begun by local citizens through the St. Francis Valley Drainage Association, which was organized in 1904. A comprehensive flood plan was adopted in 1911, and eventually became the St. Francis Basin Project. However, by 1911 the local citizens had already begun construction of levees along the river from Wappapello, Missouri to St. Francis, Arkansas. A levee was completed on the west bank in 1922, by local interests, from near where Wappapello Dam now exists to the Missouri-Arkansas state line. A levee was also completed along the east bank in 1923. These levees provided inadequate flood protection. Congress enacted the Flood Control Act of 15 June 1936, which authorized levees, channel diversions, and channel enlargements to control flooding. Furthermore, the Chief of Engineers could, and did, modify the plan to include a detention reservoir, eventually known as Wappapello Lake. The federal government subsequently reconstructed the levees and constructed Wappapello Dam in 1941. Above Crowleys Ridge the levees are fairly close to the river bank. But, from Crowleys Ridge to the state line, the flow is confined by a leveed floodway, which varies from 0.75 to 2.5 miles wide.

Channelization of the river from the lower end of Wilhelmina Cutoff to the mouth of Mingo Ditch began in 1966 and took approximately nine years to complete. The lower river was channelized from RM 259.2 to RM 278.1 and now ranges from 120 to 200 feet wide. The mainstem was designed to contain 7,000 cfs plus tributary flow.

Between the confluence of Mingo Ditch and Highway 62, 28.3 miles of stream was lost to channelization. This amounts to a 51 percent loss of stream and an increase in gradient from 0.63 ft/mi to 1.27 ft/mi. The creation of the Wilhelmina Cutoff reduced the length of that reach of river from 18.65 miles to 6.6 miles, a 65 percent loss. The gradient increased in this reach from 0.54 ft/mi to 1.52 ft/mi. Moderate to severe habitat destruction has occurred and will continue to occur throughout the subbasin upstream of the channelization. Headcutting in the mainstem, tributaries, and lateral ditches has caused lower stream bed elevations, wider and shallower stream channels, and steeper banks, which are experiencing severe sloughing and erosion in many locations. Increased deposition downstream is causing abundant unconsolidated sediments, decreased depths, and accelerated bank erosion. Most of the lower subbasin tributaries have also been channelized--with similar consequences.

High water temperatures, particularly in the smaller lateral ditches, can occasionally cause stress and mortality of fish and invertebrates during summer low-flow periods. Increased water temperature is influenced by channelization and ditch maintenance which increases channel widths, reduces water depths, and removes riparian shade.

The main channel from 0.5 miles upstream from Highway 84 to 6.5 miles downstream has almost completely filled in with sediment, logs, and other debris. This log jam has been accumulating additional trees, logs, and sediment for many years and has diverted the majority of the flow east and west adjacent to the levees. The USCOE is developing a plan to deal with the log jams.

STREAM HABITAT ASSESSMENT

The MDC Stream Habitat Assessment Device (SHAD), version II, was used to describe the quality of streambank, corridor, and channel habitat conditions in the basin. SHAD uses objective measurements and subjective ratings to rank particular habitat parameters into categories that allow inter- and intra-basin evaluation and comparison. Sixty-six and thirty SHADs were conducted in the upper and lower subbasins, respectively.

All fourth order streams and larger were assessed, plus a few third order streams. The selection and distribution of SHAD sites were dictated by stream order, gradient, and access, and location of representative sites within that stream reach. The length of individual SHAD sites was adjusted (usually extended to include more pool/riffle sequences) to enhance the accuracy if an obvious anomaly was measured. Channel conditions such as pool/riffle ratio, cover density, average width, and maximum average depth were calculated for each site.

SHAD evaluations suggest that most of the surveyed habitats in the upper subbasin are generally in good condition. The problems that occur are usually minor, scattered, and most often associated with streambank instability.

In lower subbasin streams, channelized sections are in very poor condition due to headcutting and sloughing streambanks. Depositional reaches (*e.g.* below Wilhelmina Cutoff and below Highway 84/90) are also suffering poor habitat conditions. The remaining areas of the lower subbasin are in good condition, with only minor problems. Specific discussion on habitat conditions will be separated by subbasin.

Upper Subbasin

Streambank Conditions: Analysis of the SHAD summaries suggest that streambank erosion is not excessive (Table 1). At least 82 percent of the streambanks that were surveyed were not experiencing any accelerated erosion and very little severe erosion was identified. Streambank protection quality was quite variable (Table 1). The St. Francis River and Stouts Creek were mostly good while Big Creek and Little St. Francis River were rated good to fair. Only Wolf Creek and a few smaller mainstem tributaries had a poor protection rating. Bottomland hardwoods were the dominant vegetation, followed by shrubs (understory vegetation), and annual vegetation. Some large granite rocks and outcroppings provide additional streambank protection.

Corridor Conditions: The quality of the forested portion of the riparian corridors is rated as good (dense stand of trees and understory) throughout most of the subbasin (Table 2). Only the Little St. Francis River and Wolf Creek basins contained corridors rated as poor. The mainstem and western tributaries (Big and Stouts creeks) tended to have wider forested riparian corridors, while the eastern tributaries (Little St. Francis River and Wolf Creek) have much narrower corridors.

Channel Conditions: Channel substrates are generally stable and quite diverse, primarily composed of gravel and cobble, followed by sand, boulders, and rock outcroppings. Big Creek contains a greater percentage of gravel while the Little St. Francis River probably contains more sand than other subbasin streams. The pool/riffle ratio in the mainstem is as high as 22:1 and averages 4.5:1. Smaller basin streams have much smaller ratios, usually below 5:1. Average maximum pool depths in the mainstem generally ranged from 4 to 7.5 feet deep. Abundant woody cover (e.g. logs, rootwads, fallen trees) provides excellent fish habitat. The average amount of woody cover in the mainstem, Big Creek, Little St. Francis River, and Stouts Creek was 53, 60, 33, and 24 woody structures per mile, respectively.

Lower subbasin

Streambank Conditions: SHAD summaries suggest that streambank erosion is not excessive (Table 3). The greatest amount of erosion is occurring in the channelized sections of the mainstem and tributaries. Headcutting has lowered the stream bed elevations, and has also begun to cause gully erosion in the smaller tributaries. Sloughing of bank soils and rill erosion have also caused problems. Extended periods of high discharge from Wappapello Dam after storm events probably increases the erosion potential. Very little streambank erosion is occurring in the leveed floodway below Highway 84, west of Kennett, because flow is distributed over a wider area, thus reducing the erosive power of the flow.

Only about half of the streambanks were rated as having good quality vegetation to protect against streambank erosion (Table 3). The channelized sections of the mainstem and tributaries probably account for the majority of poor streambank vegetation because the banks are often too steep to allow the growth of woody vegetation. It is possible that the soil composition (mostly clay), low gradient (1 ft/mi), and the engineered design of the channel assist with streambank protection and stabilization. Vegetative bank protection improves in the leveed floodway.

Corridor Conditions: The quality of the forested portion of the riparian corridor is rated as 84 percent good and 16 percent fair along the mainstem (Table 4). The majority (86%) of Mingo Ditch is also rated as good, but 14 percent is rated as poor. The corridor quality along Varney River and Dudley Main ditches are mostly poor (75% and 87%), with only small areas of good quality corridor vegetation. The average width of the forested corridor is also much less for Varney River and Dudley Main ditches than for the mainstem or Mingo Ditch. The width of the wooded corridors is dependent on the extent of agricultural activity.

Channel Conditions: Throughout the subbasin, the stream bed is primarily composed of clay and sand, with very little diversity. Excessive sedimentation is occurring below the channelized sections between the lower end of the Wilhelmina Cutoff and Highway 62, and below Highway 84. The abundance of woody cover varied considerably, with a greater amount of cover in the unchannelized sections. The mainstem contained an average of 69 logs, trees, or rootwads per mile. Even Varney River Ditch and Mingo Ditch averaged 47 and 51 woody structures per mile, respectively. No woody cover was located in Dudley Main Ditch.

IMPROVEMENT PROJECTS

Since 1990, improvement projects have been installed on four streams in the basin for the purposes of streambank stabilization, streambank revegetation, corridor revegetation, elimination of headcutting, or creation of instream fish habitat. Three of the projects are located on public lands owned by either MDC or DNR and one MDC Landowner Cooperative Project (LCP) has been installed on private land.

SAM A. BAKER STATE PARK Cedar Tree Revetment Project: Big Creek at RM 1.75 ; fifth order; 313-foot-long eroding streambank; single row tree revetment installed in October 1990; additional trees added in subsequent years; willow stakes planted March 1991 to 1993. The revetment eventually stabilized the eroding streambank toe. Natural revegetation and willow staking have been successful in establishing vegetation on the site.

VIRGINIA MELLOR LCP Cedar Tree Revetment Project: Twelvemile Creek at RM 13.7; third order; 300-foot-long eroding streambank; single row tree revetment installed October 1994; additional cedars added June 1996; willow stakes and tree seedlings planted February and March 1995; additional willow stakes added spring 1996 and 1997. A major flood during the spring of 1999 removed most of the cedar trees in the revetment and because of recurring problems, the revetment may not be repaired.

BEAVER LAKE OUTLET DITCH (Otter Slough C.A.) Headcutting Control Project: A large grade control structure was constructed at the mouth of the ditch in 1994. A pipe was placed along the entire length (352 ft) of the outlet Ditch between Beaver Lake and Dudley Main Ditch (Ditch #12) to carry the flow. The project has successfully halted the headcutting.

BRADYVILLE DITCH (Otter Slough C.A.) Headcutting Control Project: In 1999, four grade control structures were constructed in the lower 460 feet of Bradyville Ditch, a tributary to Dudley Main Ditch. The lower 110 feet of the ditch was lined with riprap over the entire channel. The banks were re-sloped to a 3:1 grade. The project has been successful in stopping the headcutting.

UNIQUE HABITATS

MDC's Natural Heritage Database lists 25 high-quality natural communities in the St. Francis River basin (Table 5). Nelson (1987) describes in detail the different community types. Flatwoods have an impermeable or slowly permeable subsoil hard-pan layer over poorly drained level land. Mesic bottomland forests contain mixed bottomland hardwoods on level to gently sloping natural levees or higher elevations of floodplains, with soils that are moderately well drained. Oxbows are sections of former stream meanders that have become isolated from the main channel. Swamps and shrub swamps are depressions, oxbow ponds, or backwater sloughs, with poorly drained soils, that are inundated for extended periods of time. Wet bottomland forests contain bottomland hardwoods or cypress trees found on level stream corridors associated with poorly drained soils that are wet for significant periods. Wet-mesic bottomland forests are also composed of bottomland hardwoods or cypress trees which are located on level to gently sloping stream corridors on somewhat poorly drained soils that are seasonally or intermittently wet for significant periods.

Ten natural areas exist in the basin (Table 6) (MDC 1996). Natural areas were established to preserve, manage, and restore extant natural communities, ecological processes, and geological areas.

Table 1. Streambank protection and erosion ratings in the upper St. Francis River subbasin as determined by SHAD surveys.

	Streambank Protection Rating (%)			Streambank Erosion Rating (%)		
Stream	**Good**	**Fair**	**Poor**	**None**	**Moderate**	**Severe**
St. Francis River	89	11	0	93	6	1
Big Creek	66	34	0	93	4	3
Little St. Francis River	58	33	9	89	5	6
Stouts Creek	100	0	0	98	2	0
Wolf Creek	32	44	24	97	3	0
Other Tributaries	52	37	10	82	17	1

Table 2. Riparian corridor information in the upper St. Francis River subbasin as determined by SHAD surveys.

	Corridor Quality (%)			
Stream	**Good**	**Fair**	**Poor**	**Average Width (Ft.) Forested Corridor**
St. Francis River	89	11	0	85
Big Creek	84	16	0	90
Little St. Francis River	70	21	9	60
Stouts Creek	83	17	0	74
Wolf Creek	54	42	4	36
Other Tributaries	75	25	0	84

Table 3. Streambank protection and erosion ratings in the lower St. Francis River subbasin as determined by SHAD surveys.

	Streambank Protection Rating (%)			Streambank Erosion Rating (%)		
Stream	**Good**	**Fair**	**Poor**	**None**	**Moderate**	**Severe**
St. Francis River	54	46	0	92	8	1
Varney River Ditch	24	37	38	100	0	0
Dudley Main Ditch	34	25	41	84	16	0
Mingo Ditch	73	13	14	100	0	0

Table 4. Riparian corridor information in the lower St. Francis River subbasin as determined by SHAD surveys.

	Corridor Quality (%)			
Stream	**Good**	**Fair**	**Poor**	**Average Width (Ft.) Forested Corridor**
St. Francis River	84	16	0	70
Varney River Ditch	25	0	75	15
Dudley Main Ditch	13	0	87	13
Mingo Ditch	86	0	14	68

Table 5. High-quality natural communities in the St. Francis River basin.

Community Name	Area Name*	Size (Acres)	Ownership *
Flatwoods	Cypress Lateral Ditch	10	Private
Flatwoods	Cypress Lateral Ditch	10	Private
Flatwoods	Cypress Lateral Ditch	75	Private
Flatwoods	Otter Slough CA	20	MDC
Mesic Bottomland Forest	Peppermint Creek	40	USCOE
Mesic Bottomland Forest	Mud Creek NA	157	USFS
Mesic Bottomland Forest	Willow-Oak RNA	40	USFWS
Oxbows and Sloughs	Otter Slough NA	5	MDC
Shrub Swamp	Otter Slough NA	10	MDC
Shrub Swamp	Mingo NWR	520	USFWS
Shrub Swamp	Ben Cash Memorial CA	10	MDC
Swamp	Bradyville NA	4	MDC
Swamp	Indian Hill Island	40	Private
Swamp	Otter Slough NA	275	MDC
Swamp	Otter Slough NA	5	MDC
Swamp	Ben Cash Memorial CA	83	MDC
Wet Bottomland Forest	Ben Cash Memorial CA	107	MDC
Wet Bottomland Forest	Mingo NWR	180	USFWS
Wet Bottomland Forest	Elm-Ash-Maple RNA	72	USFWS
Wet-Mesic Bottomland Forest	Bradyville NA	135	MDC
Wet-Mesic Bottomland Forest	Mingo NWR	60	Private
Wet-Mesic Bottomland Forest	Cherrybark RNA	60	USFWS
Wet-Mesic Bottomland Forest	Ben Cash Memorial CA	63	MDC
Wet-Mesic Bottomland Forest	Mingo NWR	---	USFWS
Wet-Mesic Bottomland Forest	Mud Creek NA	157	USFS

* NA= natural area, CA=conservation area, NWR=national wildlife refuge, RNA=research natural area; USFS=U.S. Forest Service, USCOE=U.S. Army Corps of Engineers, MDC=Missouri Department of Conservation, USFWS=U.S. Fish and Wildlife Service

Table 6. Natural areas located in the St. Francis River basin.

Natural Area	County	Size (Acres)	Ownership*
Beech Springs	Stoddard	35	MDC
Bradyville	Stoddard	139	MDC
Buck Mountain	St. Francois	120	MDC
Cash Swamp	Dunklin	310	MDC
Holly Ridge	Stoddard	84	MDC
Mud Creek	Butler	1038	USFS
Mudlick Mountain	Wayne	1370	MDNR
Otter Slough	Stoddard	20	MDC
Royal Gorge	Iron	80	MDC
St. Francis River	Madison	1.2 stream miles	MDC

* USFS= U.S. Forest Service, MDC=Missouri Department of Conservation, MDNR=Missouri Department of Natural Resources

BIOTIC COMMUNITY

FISH COMMUNITY DATA

The fishes of the St. Francis River basin have been sampled extensively with seines since the 1930s and electrofishing equipment since the 1980s. Seining data are available from 56 sites in the upper subbasin and 33 sites in the lower subbasin. Electrofishing data has been collected from 13 sites in the upper subbasin and nine sites in the lower subbasin.

Seine samples provide the qualitative and quantitative indicators that can best define fish communities. Electrofishing samples, using boat-mounted equipment, mostly emphasized the collection of species which could have some angling value. No attempt was made to collect nektonic or benthic fish species by electrofishing.

A total of 130 species representing 20 families have been collected by all methods from the St. Francis basin. The families and number of species are: Cyprinidae (38 species), Percidae (25 species), Catostomidae (16 species), Centrarchidae (15 species), Ictaluridae (11 species), Fundulidae (4 species), Lepisosteidae (3 species), Clupeidae (3 species), Petromyzontidae (2 species), Esocidae (2 species), Hiodontidae (2 species), and Moronidae, Elassomatidae, Cottidae, Poeciliidae, Atherinidae, Aphridoderidae, Amiidae, Anguillidae, and Sciaenidae (one species each).

Further discussions of the fish communities will be separated by subbasin because the upper subbasin is within the Ozark Faunal Region and the lower subbasin is within the Lowland Faunal Region, which includes the Crowley's Ridge creeks (Pflieger 1997).

Upper Subbasin

A total of 106 fish species representing 16 families have been collected by seining in the subbasin (Table 1). The central stoneroller and longear sunfish were the most widely distributed species, occurring at 86 and 82 percent of the sample sites, respectively (Table 1). Thirteen other species were encountered from at least 50 percent of the sites: largescale stoneroller, striped shiner, bigeye shiner, bluntnose minnow, creek chubsucker, northern hogsucker, northern studfish, blackspotted topminnow, green sunfish, bluegill, rainbow darter, striped fantail darter, and orangethroat darter.

A total of 31 species that were found in the subbasin prior to 1971 have not been collected since then (Table 2). However, this is probably because the sites where those species were found have been sampled very little or not at all since 1976.

In addition, 14 species typically found in the lower subbasin (longnose gar, shortnose gar, blacktail shiner, common carp, Mississippi silvery minnow, ribbon shiner, weed shiner, suckermouth minnow, smallmouth buffalo, bigmouth buffalo, orangespotted sunfish, western sand darter, crystal darter, and drum) have not been collected since the construction of

Wappapello Lake. The construction of Wappapello Lake probably eliminated the most suitable habitat for these species in the upper subbasin (Pflieger 1997). Eight species (common carp, silver redhorse, shorthead redhorse, channel catfish, chain pickerel, white bass, walleye, and drum) have been sampled by electrofishing since 1976, but not by seining (Table 3).

Since 1978, 32 species in 12 families have been collected with boat electrofishing (Table 3). Longear sunfish, gizzard shad, and golden redhorse were the most abundant species. Overall, largemouth bass and spotted bass were more abundant than smallmouth bass, which were found mainly in the shut-ins and riffles. The exception is Big Creek, where smallmouth bass dominate the black bass community.

Lower Subbasin

Ninety-two fish species from 18 families have been collected by seining in the subbasin (Table 1). Bluegill, blackspotted topminnow, mosquitofish, gizzard shad, and largemouth bass were the most widely distributed species, occurring at 73-85 percent of the sample sites (Table 1). Eight other species have been collected from at least 50 percent of the sample sites (*i.e.* blacktail shiner, pirate perch, brook silverside, warmouth, orangespotted sunfish, longear sunfish, spotted bass, and bluntnose darter).

Twenty species previously collected from the subbasin have not been collected by seining since 1976 (Table 2). However, this is probably because the sites where those species were found have been sampled very little or not al all since 1976. The construction of Wappapello Lake probably eliminated the most suitable habitat for some of these species in the lower subbasin. Twelve species (bowfin, American eel, skipjack herring, river carpsucker, lake chubsucker, smallmouth buffalo, bigmouth buffalo, black buffalo, golden redhorse, brown bullhead, and flathead catfish) have been collected by electrofishing since 1967, but were not collected by seining.

Forty one species in 14 families have been collected with boat electrofishing (Table 3). In the unchannelized reaches, bluegill, longear sunfish, gizzard shad, and smallmouth buffalo were the most common species. In the channelized section, the most abundant species were gizzard shad, common carp, smallmouth buffalo, and freshwater drum. Spotted bass were more abundant than largemouth bass. Grass carp and goldeye were collected by electrofishing, but not by seining, adding to the species list.

CREEL DATA

A state-wide angler survey (Weithman 1991) was conducted from 1983 to 1988 and is the only source of creel information for the basin (Table 4). Accurate estimates of total angler pressure, catch, and harvest cannot be made where the number of anglers interviewed is low. However raw survey data which partitions angler species preference, effort, success, and satisfaction can provide some data that describe angler utilization of the fishery resource. A total of 845 St. Francis River anglers were surveyed. Black bass and no species preference (anything) were the most common preferences, followed by sunfish and catfish. Catch and harvest rates were quite variable and led by suckers, frogs, sunfishes, drum, anything, and black bass. Sunfish and black bass were the predominant species caught. The fishing quality rating ranged from 4 to 7 (10=Best) for most species, which is considered moderately good.

FISH STOCKING

A walleye restoration project began in 1996. Fingerlings (1-2") were released in May of each year from 1996-1999. A total of 196,098 walleye fingerlings were stocked between Highways 72 and 34. Adult walleye from the lower Black River were used as broodstock. A no-harvest regulation was implemented to protect the newly-stocked fish. On waters of Wappapello Lake and its tributaries, including the St. Francis River and its tributaries above Wappapello Dam, all walleye and sauger must be returned to the water unharmed immediately after being caught.

COMMERCIAL HARVEST

Commercial fishing is allowed in the part of the St. Francis River which forms a boundary between the states of Arkansas and Missouri. Regulations of the state where the fisher or musseler is licensed shall apply in the St. Francis River. Commercial fishing pressure is thought to be light.

FISH SPECIES OF CONSERVATION CONCERN

Since the settlement of Missouri, many species have declined to levels of concern and some have disappeared entirely (MDC 2000). Twenty-three fish species found in the St. Francis River basin are of particular concern due to population declines or apparent vulnerability from a statewide perspective. Each species is ranked from S1 (worst) to S5 according to their relative endangerment. The status of each of these species in the basin is discussed below.

<u>Mooneye (State Rank–S3)</u>: Only two lower subbasin sites contained collections of mooneye. Pflieger (1997) noted that it has never been common in Missouri and may be declining.

<u>Cypress Minnow (State Rank–S1)</u>: The only recent records of this species were from collections made 1979 and 1984 near the Ben Cash Conservation Area in the lower subbasin. Cypress minnows were relatively common more than 50 years ago (Pflieger 1997).

<u>Mississippi Silvery Minnow (State Rank–S3S4)</u>: According to Pflieger (1997), this minnow is common in the lower St. Francis River, but has been extirpated above Wappapello Dam. This species has been collected as recently as 1994.

<u>Pallid Shiner (Extirpated)</u>: Once common in the Lowlands, this species has declined, and is probably extirpated from Missouri (Pflieger 1997). Increased siltation associated with altered land use practices is the suspected cause of its decline.

Ironcolor Shiner (State Rank–S1): Distribution of this species is limited to the central part of the Southeastern Lowlands where it typically occurs as isolated, highly localized populations, but sometimes is quite abundant (Pflieger 1997). Many populations of ironcolor shiners no longer exist and their continued existence in Missouri is doubtful (Pflieger 1997).

Taillight Shiner (State Rank–S1): Pflieger (1997) describes this minnow as one of the rarest Missouri minnows and may soon be extirpated in the state. It has only been collected from two lower subbasin sites and was last collected in 1941.

Ozark Shiner (State Rank–S2): This species currently exists in the St. Francis basin only in Marble Creek in the upper subbasin (Pflieger 1997). The most recent collection was made in 1992.

Pugnose Minnow (State Rank–S4): Primarily a Lowland species in Missouri, this minnow may have increased in numbers in recent decades (Pflieger 1997). They seem to be widely distributed in the lower subbasin.

Eastern Slim Minnow (State Rank–S2S3): Reservoir construction is the suspected cause of the extirpation of this species from the St. Francis River basin (Pflieger 1997). It has been collected from three upper subbasin sites, but not since 1937.

Highfin Carpsucker (State Rank–S2): This species was collected from two sites above Wappapello Lake prior to 1957 and the site immediately below the dam in 1989. This carpsucker is rare in Missouri and may be more uncommon now than in the past (Pflieger 1997).

Blue Sucker (State Rank–S3): This species is fairly common in the lower subbasin.

Lake Chubsucker (State Rank–S2): Lake chubsuckers have been collected in several tributaries to the lower St. Francis River. They are also fairly common in pool #1 on Duck Creek Conservation Area (DCCA). This sucker is restricted to the Lowland Faunal Region and is becoming increasingly rare and localized in occurrence and could become extirpated from Missouri if trends continue (Pflieger 1997).

Brown Bullhead (State Rank–S3): According to Pflieger (1997), the only confirmed self-sustaining populations in Missouri occur in pool #1 on DCCA and in Mingo National Wildlife Refuge (MNWR) in the lower subbasin. Brown bullheads are collected by electrofishing each year from Pool#1 on DCCA.

Mountain Madtom (State Rank–S1S2): This species is rare in Missouri and was collected only once from the St. Francis basin in 1997 in the upper subbasin.

Starhead Topminnow (State Rank–S2): DCCA and MNWR support the only known substantial population in Missouri. It seems to have disappeared from the remainder of its former locations (Pflieger 1997).

Flier (State Rank–S3): This species has been collected from ditches in DCCA, MNWR, and from the Wilhelmina Cutoff. Fliers occur almost exclusively in the Lowlands and are naturally uncommon and sporadic in distribution (Pflieger 1997).

Bantam Sunfish (State Rank–S2): DCCA and MNWR support the only populations of this species in Missouri (Pflieger 1997).

Western Sand Darter (State Rank–S2S3): This species has been collected from five sites in the lower subbasin, as recently as 1995. It has also been collected from one site in the upper subbasin. Pflieger (1997) noted that it is common in the Lowland ditches, but not abundant anywhere in Missouri, and may be declining in numbers.

Scaly Sand Darter (State Rank–S3): This species has been collected from both subbasins, most recently from the lower subbasin in 1995 and the upper subbasin in 1992. The scaly sand darter is primarily a Lowland species and has apparently declined in recent decades (Pflieger 1997).

Crystal Darter (State Rank–S1): Although never common, this darter was found in drainages of the Lowlands, including the St. Francis River (Pflieger 1997). This species has been collected from five sites in the lower subbasin and two sites in the upper subbasin, but not since 1964. Pflieger (1997) adds that the species is probably gone from the St. Francis basin and its presence in other basins is in doubt.

Harlequin Darter (State Rank–S2): This Lowland species is one of the rarest darters in Missouri. It was collected from five locations in the lower St. Francis River and from the Wilhelmina Cutoff when these sites were last sampled in 1979.

Longnose Darter (State Rank–S1): Pflieger (1997) believes this species still exists in the upper St. Francis River, but is rare. It was collected from only two sites from the upper river in--1957 and 1970.

River Darter (State Rank–S3): Although most abundant in the Mississippi River, this darter is common in large ditches and streams in the Lowlands (Pflieger 1997). It has been collected from six sites in the lower subbasin.

FEDERAL AND STATE LISTED SPECIES

No federally listed fish species exist in the basin. However, four species (blue sucker, Ozark shiner, crystal darter, and longnose darter) have been collected from the basin that were formerly included on the federal list as C2–Candidate for listing. MDC lists one fish species as extirpated, the pallid shiner. Six species (cypress minnow, taillight shiner, mountain madtom, crystal darter, harlequin darter, and longnose darter) are listed as state Endangered. See the 'Fish Species of Conservation Concern' section for a brief status of these species in the basin.

No federally listed mussel species have been found in the basin. However, six species have been collected that were formerly included on the federal list as C2. These species include the elktoe, western fanshell, snuffbox, Ouachita kidneyshell, rabbitsfoot, and little purple. The western fanshell is considered endangered by MDC (MDC 2000). No state or federally listed crayfish have been collected from the basin.

INVERTEBRATE COMMUNITY

Benthic invertebrates are important to aquatic ecosystems because they are prey for many species of fish, mammals, and other invertebrates. They are also indicators of good water quality because many species cannot tolerate poor conditions. Therefore, the number of invertebrate taxa may indicate the quality of the water within a particular stream. Table 5 lists the number of taxa collected in several basin streams. Most of these streams support a diverse invertebrate fauna, indicating good water quality and habitat. It is unknown why Brewer Creek and Scroggin Branch support fewer invertebrate taxa.

Freshwater mussels are common in the basin according to Bates and Dennis (1983), Oesch (1984), Buchanan (1996), and Roberts et al. (1997). Forty-eight mussel species have been identified from the basin (Table 6). The majority have been found in the mainstem, but many tributaries support mussels. According to Buchanan (1996) no naiades were collected from Big, Twelvemile, or Otter creeks.

Mussels are also excellent environmental indicators. Many mussel species are declining nationwide. Therefore, the presence of a diverse mussel community may indicate stable conditions, low siltation, and good water quality and habitat. Eleven mussel species are listed in the Missouri Species of Conservation Concern Checklist (MDC 2000). These include the elktoe, flat floater, rock pocketbook, western fanshell, snuffbox, black sandshell, southern hickorynut, bankclimber, Ouachita kidneyshell, rabbitsfoot, and little purple (Table 6). These are of particular concern due to population declines or apparent vulnerability from a statewide perspective (MDC 2000). Each species is ranked from S1 (most endangered) to S5 according to their relative endangerment.

Sixteen crayfish species have been collected, including the Big Creek and St. Francis River crayfishes, which are endemic to the upper subbasin (Table 7) (Pflieger 1996). The woodland crayfish (*Orconectes hylas*) is an introduced species and may be a cause for concern. The St. Francis River crayfish was once abundant in Stouts Creek, but has been replaced by the woodland crayfish above Lake Killarney. The woodland crayfish has also been found in Big Creek. The belted crayfish may also be an introduced species. It is endemic to the Big and Meramec River drainages, but three specimens were collected from the St. Francis River in 1987. Six crayfish species (vernal, Cajun dwarf, Shufeldt's dwarf, shrimp, St. Francis River, Big Creek crayfishes) are listed in the Missouri Species of Conservation Concern Checklist (MDC 2000). They are of particular concern due to population declines or apparent vulnerability from a statewide perspective. Each species is ranked from S1 to S5 according to their relative endangerment.

Table 1. Percent of sites in each subbasin where a species was collected (Data from seine samples).

Family/Species	Common Name	Percent	
		Upper Subbasin	Lower Subbasin
PETROMYZONTIDAE	**LAMPREYS**		
Ichthyomyson castaneus	Chestnut lamprey	2	
Lampetra aepyptera	Least brook lamprey	5	
LEPISOSTEIDAE	**GARS**		
Lepisosteus oculatus	Spotted gar		18
L. osseus	Longnose gar	7	27
L. platostomus	Shortnose gar	2	27
AMIIDAE	**BOWFINS**		
Amia calva	Bowfin		12
HIODONTIDAE	**MOONEYES**		
Hiodon tergisus	Mooneye		6
ANGUILLIDAE	**FRESHWATER EELS**		
Anguilla rostrata	American eel		6
CLUPEIDAE	**HERRINGS**		
Alosa chrysochloris	Skipjack herring		3
Dorosoma cepedianum	Gizzard shad	11	73
D. petenense	Threadfin shad		3

Table 1. continued.

CYPRINIDAE	**MINNOWS**		
Campostoma pullum	Central stoneroller	86	
C. oligolepis	Largescale stoneroller	66	
Cyprinella galactura	Whitetail shiner	18	
C. venusta	Blacktail shiner	20	61
C. whipplei	Steelcolor shiner	39	15
Cyprinus carpio	Common carp	9	21
Erimystax harryi	Ozark chub	16	
Hybognathus hayi	Cypress minnow		24
H. nuchalis	Miss. silvery minnow	16	21
Luxilus chrysocephalus	Striped shiner	63	6
L. zonatus	Bleeding shiner	43	
Lythrurus umbratilis	E. Redfin shiner	27	30
cyanocephalus	Ribbon shiner	4	36
L. fumeus	Hornyhead chub	25	
Nocomis biguttatus	Golden shiner	13	42
Notemigonus crysoleucas	Bigeye chub	32	
Notropis amblops	Pallid shiner		12
N. amnis	Emerald shiner	11	30
N. atherinoides	Bigeye shiner	59	
N. boops	Silverjaw minnow	5	
N. buccatus	Ironcolor shiner		12
N. chalybaeus	Wedgespot shiner	21	
N. greenei	Taillight shiner		6
N. maculatus	Ozark minnow	30	
N. nubilus	Ozark shiner	7	
N. ozarcanus	Rosyface shiner	34	
N. rubellus	Telescope shiner	36	
N. telescopus	Weed shiner	2	30
N. texanus	N. E. mimic shiner	4	24
N. v. volucellus	Pugnose minnow	4	45
Opsopoeodus emiliae	Suckermouth minnow	2	6
Phenacobius mirabilis	S. redbelly dace	14	
Phoxinus erythrogaster	Bluntnose minnow	63	39
Pimephales notatus	Fathead minnow	2	
P. promelas	E. slim minnow	5	
P. tenellus parviceps	Bullhead minnow	5	48
P. vigilax	Creek chub	36	9
Semotilus atromaculatus			

Table 1. continued.

CATOSTOMIDAE	**SUCKERS**		
Carpiodes carpio	River carpsucker	2	3
C. cyprinus	Quillback	4	
C. velifer	Highfin carpsucker	4	
Cycleptus elongatus	Blue sucker		6
Erimyzon oblongus	Creek chubsucker	52	9
E. sucetta	Lake chubsucker		15
Hypentelium nigricans	Northern hogsucker	57	
Ictiobus bubalus	Smallmouth buffalo	2	9
I. cyprinellus	Bigmouth buffalo	5	9
I. niger	Black buffalo		3
Minytrema melanops	Spotted sucker	7	27
Moxostoma anisurum	Silver redhorse	5	
M. carinatum	River redhorse	5	
M. duquesnei	Black redhouse	34	
M. erythrurum	Golden redhorse	32	9
M. macrolepidotum	Shorthead redhorse	4	12
ICTALURIDAE	**CATFISHES**		
Ameiurus melas	Black bullhead	14	24
A. natalis	Yellow bullhead	27	21
A. nebulosus	Brown bullhead		6
Ictalurus punctatus	Channel catfish	7	39
Noturus albater	Ozark madtom	13	
N. eleutherus	Mountain madtom	2	
N. exilis	Slender madtom	5	
N. gyrinus	Tadpole madtom	2	30
N. miurus	Brindled madtom	7	21
N. nocturnus	Freckled madtom	2	15
Pylodictis olivaris	Flathead catfish	4	18
ESOCIDAE	**PIKES**		
Esox americanus	Grass pickerel	20	21
E. niger	Chain pickerel	4	18
APHREDODERIDAE	**PIRATE PERCHES**		
Aphredoderus sayanus	Pirate perch	5	55
FUNDULIDAE	**KILLFISHES**		
Fundulus catenatus	Northern studfish	55	
F. notatus	Blackstripe topminnow	7	27
F. dispar	Starhead topminnow		27
F. olivaceus	Blackspotted topminnow	70	79
POECILLIIDAE	**LIVE BEARERS**		
Gambusia affinis	Mosquitofish	13	76

Table 1. continued.

ATHERINIDAE	**SILVERSIDES**		
Labidesthes sicculus	Brook silversides	39	58
COTTIDAE	**SCULPINS**		
Cottus carolinae	Banded sculpin	20	
MORONIDAE	**TEMPERATE BASSES**		
Morone chrysops	White bass	2	15
ELASSOMATIDAE	**PYGMY SUNFISHES**		
Elassoma zonatum	Banded pygmy sunfish		27
CENTRARCHIDAE	**SUNFISHES**		
Ambloplites ariommus	Shadow bass	34	12
Centrarchus macropterus	Flier		18
Lepomis cyanellus	Green sunfish	71	36
L. gulosus	Warmouth	13	52
L. humilis	Orangespotted sunfish	9	61
L. macrochirus	Bluegill	57	85
L. megalotis	Longear sunfish	82	67
L. microlophus	Redear sunfish	5	3
L. miniatus	Redspotted sunfish	11	27
L. symmetricus	Bantam sunfish		12
Micropterus dolomieu	Smallmouth bass	46	3
M. punctulatus	Spotted bass	43	52
M. salmoides	Largemouth bass	34	73
Pomoxis annularis	White crappie	7	45
P. nigromaculatus	Black crappie	11	39

Table 1. continued.

PERCIDAE	**PERCHES**		
Ammocrypta clara	Western sand darter	2	18
A. vivax	Scaly sand darter	14	15
Crystallaria asprella	Crystal darter	4	18
Etheostoma asprigene	Mud darter		18
E. blennioides	Greenside darter	41	
E. caeruleum	Rainbow darter	70	
E. chlorosomum	Bluntnose darter	2	58
E. flabellare lineolatum	Striped fantail darter	50	3
E. gracile	Slough darter		36
E. histrio	Harlequin darter		21
E. nigrum	Johnny darter	4	3
E. proeliare	Cypress darter	4	30
E. s. spectabile	N.E. Orangethroat darter	50	6
E. stigmaeum	Speckled darter	11	18
E. zonale	Banded darter	25	3
Percina c. caprodes	Ohio logperch	25	9
P. evides	Gilt darter	16	3
P. maculata	Blackside darter	7	30
P. nasuta	Longnose darter	4	
P. phoxocephala	Slenderhead darter	2	
P. sciera	Dusky darter	7	36
P. shumardi	River darter		15
P. vigil	Saddleback darter	4	9
Stizostedion canadense	Sauger	2	
S. vitreum	Walleye	4	
SCIAENIDAE	**DRUMS**		
Aplodinotus grunniens	Freshwater drum	4	18

Table 2. Fish species collected by seining in three time periods (A= 1930-1941, B=1947-1971 and C=1976-1996).

Family/Species	Common Name	Upper Subbasin			Lower Subbasin		
		A	B	C	A	B	C
PETROMYZONTIDAE	**LAMPREYS**						
Ichthyomyson castaneus	Chestnut lamprey		X				
Lampetra aepyptera	Least brook lamprey		X	X			
LEPISOSTEIDAE	**GARS**						
Lepisosteus oculatus	Spotted gar					X	X
L. osseus	Longnose gar	X	X		X	X	X
L. platostomus	Shortnose gar	X			X	X	X
AMIIDAE	**BOWFINS**						
Amia calva	Bowfin					X	
HIODONTIDAE	**MOONEYES**						
Hiodon tergisus	Mooneye					X	
ANGUILLIDAE	**FRESHWATER EELS**						
Anguilla rostrata	American eel					X	
CLUPEIDAE	**HERRINGS**						
Alosa chrysochloris	Skipjack herring				X		
Dorosoma cepedianum	Gizzard shad	X	X	X	X	X	X
D. petenense	Threadfin shad						X

Table 2. continued.

CYPRINIDAE	**MINNOWS**						
Campostoma pullum	Central stoneroller	X	X	X			
C. oligolepis	Largescale stoneroller	X	X	X			
Cyprinella galactura	Whitetail shiner	X	X	X			
C. venusta	Blacktail shiner	X	X		X	X	X
C. whipplei	Steelcolor shiner	X	X	X	X	X	
Cyprinus carpio	Common carp	X	X		X	X	X
Erimystax harryi	Ozark chub	X	X	X			
Hybognathus hayi	Cypress minnow				X		X
H. nuchalis	Miss. silvery minnow	X	X		X	X	X
Luxilus chrysocephalus	Striped shiner	X	X	X			X
L. zonatus	Bleeding shiner	X	X	X			
Lythrurus umbratilis cyanocephalus	E. Redfin shiner	X	X	X	X	X	X
L. fumeus	Ribbon shiner	X	X		X	X	X
Nocomis biguttatus	Hornyhead chub	X	X	X			
Notemigonus crysoleucas	Golden shiner	X		X	X	X	X
Notropis amblops	Bigeye chub	X	X	X			
N. amnis	Pallid shiner				X	X	
N. atherinoides	Emerald shiner	X	X	X		X	X
N. boops	Bigeye shiner	X	X	X			
N. buccatus	Silverjaw minnow	X		X			
N. chalybaeus	Ironcolor shiner					X	X
N. greenei	Wedgespot shiner	X	X	X			
N. maculatus	Taillight shiner				X		
N. nubilus	Ozark minnow	X	X	X			
N. ozarcanus	Ozark shiner	X	X	X			
N. rubellus	Rosyface shiner	X	X	X			
N. telescopus	Telescope shiner	X	X	X			
N. texanus	Weed shiner		X			X	X
N. v. volucellus	N. E. mimic shiner			X	X		X
Opsopoeodus emiliae	Pugnose minnow	X		X	X	X	X
Phenacobius mirabilis	Suckermouth minnow	X				X	X
Phoxinus erythrogaster	S. redbelly dace	X	X	X			
Pimephales notatus	Bluntnose minnow	X	X	X	X	X	X
P. promelas	Fathead minnow		X				
P. tenellus parviceps	E. slim minnow	X					
P. vigilax	Bullhead minnow	X		X	X	X	X
Semotilus atromaculatus	Creek chub	X	X	X		X	X

Table 2. continued.

CATOSTOMIDAE	**SUCKERS**						
Carpiodes carpio	River carpsucker		X			X	
C. cyprinus	Quillback		X	X			
C. velifer	Highfin carpsucker	X	X				
Cycleptus elongatus	Blue sucker					X	X
Erimyzon oblongus	Creek chubsucker	X	X	X		X	X
E. sucetta	Lake chubsucker				X	X	
Hypentelium nigricans	Northern hogsucker	X	X	X			
Ictiobus bubalus	Smallmouth buffalo		X			X	
I. cyprinellus	Bigmouth buffalo	X	X		X	X	
I. niger	Black buffalo					X	
Minytrema melanops	Spotted sucker		X	X	X	X	X
Moxostoma anisurum	Silver redhorse	X	X				
M. carinatum	River redhorse	X	X				
M. duquesnei	Black redhouse	X	X	X			
M. erythrurum	Golden redhorse	X	X	X	X	X	
M. macrolepidotum	Shorthead redhorse	X	X		X	X	X
ICTALURIDAE	**CATFISHES**						
Ameiurus melas	Black bullhead	X	X	X	X	X	X
A. natalis	Yellow bullhead	X	X	X	X	X	X
A. nebulosus	Brown bullhead					X	
Ictalurus punctatus	Channel catfish	X	X		X	X	X
Noturus albater	Ozark madtom		X	X			
N. eleutherus	Mountain madtom			X			
N. exilis	Slender madtom		X				
N. gyrinus	Tadpole madtom			X	X	X	X
N. miurus	Brindled madtom	X	X	X	X	X	X
N. nocturnus	Freckled madtom	X				X	X
Pylodictis olivaris	Flathead catfish		X	X	X	X	
ESOCIDAE	**PIKES**						
Esox americanus	Grass pickerel	X	X	X	X	X	X
E. niger	Chain pickerel	X			X	X	X
APHREDODERIDAE	**PIRATE PERCHES**						
Aphredoderus sayanus	Pirate perch	X	X	X	X	X	X
FUNDULIDAE	**KILLFISHES**						
Fundulus catenatus	Northern studfish	X	X	X			
F. notatus	Blackstripe topminnow		X	X	X	X	X
F. dispar	Starhead topminnow				X	X	X
F. olivaceus	Blackspotted topminnow	X	X	X	X	X	X
POECILLIIDAE	**LIVE BEARERS**						
Gambusia affinis	Mosquitofish	X		X	X	X	X

Table 2. continued.

ATHERINIDAE	**SILVERSIDES**						
Labidesthes sicculus	Brook silversides	X	X	X	X	X	X
COTTIDAE	**SCULPINS**						
Cottus carolinae	Banded sculpin	X	X	X			
MORONIDAE	**TEMPERATE BASSES**						
Morone chrysops	White bass		X			X	X
ELASSOMATIDAE	**PYGMY SUNFISHES**						
Elassoma zonatum	Banded pygmy sunfish					X	X
CENTRARCHIDAE	**SUNFISHES**						
Ambloplites ariommus	Shadow bass	X	X	X	X	X	X
Centrarchus macropterus	Flier				X	X	X
Lepomis cyanellus	Green sunfish	X	X	X	X	X	X
L. gulosus	Warmouth	X	X	X	X	X	X
L. humilis	Orangespotted sunfish	X			X	X	X
L. macrochirus	Bluegill	X	X	X	X	X	X
L. megalotis	Longear sunfish	X	X	X	X	X	X
L. microlophus	Redear sunfish		X	X			X
L. miniatus	Redspotted sunfish	X	X	X	X	X	X
L. symmetricus	Bantam sunfish					X	X
Micropterus dolomieu	Smallmouth bass	X	X	X		X	
M. punctulatus	Spotted bass	X	X	X	X	X	X
M. salmoides	Largemouth bass	X	X	X	X	X	X
Pomoxis annularis	White crappie	X	X	X	X	X	X
P. nigromaculatus	Black crappie	X	X	X	X	X	X

Table 2. continued.

PERCIDAE	**PERCHES**						
Ammocrypta clara	Western sand darter		X		X		X
A. vivax	Scaly sand darter	X	X	X	X	X	X
Crystallaria asprella	Crystal darter	X	X		X	X	
Etheostoma asprigene	Mud darter				X	X	X
E. blennioides	Greenside darter	X	X	X			
E. caeruleum	Rainbow darter	X	X	X			
E. chlorosomum	Bluntnose darter			X	X	X	X
E. flabellare lineolatum	Striped fantail darter	X	X	X			X
E. gracile	Slough darter				X	X	X
E. histrio	Harlequin darter				X	X	X
E. nigrum	Johnny darter	X		X			X
E. proeliare	Cypress darter			X	X	X	X
E. s. spectabile	N.E. Orangethroat darter	X	X	X		X	X
E. stigmaeum	Speckled darter	X	X	X	X	X	X
E. zonale	Banded darter	X	X	X		X	
Percina c. caprodes	Ohio logperch	X	X	X	X		X
P. evides	Gilt darter	X	X	X	X		
P. maculata	Blackside darter	X	X	X	X	X	X
P. nasuta	Longnose darter		X				
P. phoxocephala	Slenderhead darter		X				
P. sciera	Dusky darter	X	X	X	X	X	X
P. shumardi	River darter				X	X	X
P. vigil	Saddleback darter		X	X	X	X	
Stizostedion canadense	Sauger		X				
S. vitreum	Walleye		X				
SCIAENIDAE	**DRUMS**						
Aplodinotus grunniens	Freshwater drum		X		X	X	X

Table 3. Percent of the total number of fish collected by boat electrofishing in the St. Francis River basin (UNCH=unchannelized reach, CHAN=channelized reach).

Family/Species	Common Name	Upper Subbasin	Lower Subbasin	
			UNCH	CHAN
LEPISOSTEIDAE	**GARS**			
Lepisosteus oculatus	Spotted gar		3	2
L. osseus	Longnose gar	<1	1	3
L. platostomus	Shortnose gar		5	9
AMIIDAE	**BOWFINS**			
Amia calva	Bowfin		<1	<1
HIODONTIDAE	**MOONEYES**			
Hiodon alosoides	Goldeye		<1	
ANGUILLIDAE	**FRESHWATER EELS**			
Anguilla rostrata	American eel		<1	<1
CLUPEIDAE	**HERRINGS**			
Alosa chrysochloris	Skipjack herring		<1	<1
Dorosoma cepedianum	Gizzard shad	14	11	17
CYPRINIDAE	**MINNOWS**			
Ctenopharyngodon idella	Grass carp		<1	
Cyprinus carpio	Common carp	<1	6	16
CATOSTOMIDAE	**SUCKERS**			
Carpiodes carpio	River carpsucker		1	4
C. cyprinus	Quillback		<1	1
C. velifer	Highfin carpsucker			<1
Cycleptus elongatus	Blue sucker		<1	2
Hypentelium nigricans	Northern hogsucker	5		
Ictiobus bubalus	Smallmouth buffalo		10	12
I. cyprinellus	Bigmouth buffalo		3	2
I. niger	Black buffalo		1	<1
Minytrema melanops	Spotted sucker	3	<1	
Moxostoma carinatum	River redhorse	<1	<1	3
M. duquesnei	Black redhouse	1	<1	
M. erythrurum	Golden redhorse	12	<1	
M. macrolepidotum	Shorthead redhorse	<1	1	1

Table 3. continued.

ICTALURIDAE	**CATFISHES**			
Ameiurus melas	Black bullhead	<1		
A. natalis	Yellow bullhead	1		
Ictalurus punctatus	Channel catfish	2	1	5
Pylodictis olivaris	Flathead catfish	<1	1	2
ESOCIDAE	**PIKES**			
Esox americanus	Grass pickerel	<1	<1	
E. niger	Chain pickerel	<1	<1	
APHREDODERIDAE	**PIRATE PERCHES**			
Aphredoderus sayanus	Pirate perch		<1	<1
COTTIDAE	**SCULPINS**			
Cottus carolinae	Banded sculpin	<1		
MORONIDAE	**TEMPERATE BASSES**			
Morone chrysops	White bass	<1	<1	1
CENTRARCHIDAE	**SUNFISHES**			
Ambloplites ariommus	Shadow bass	4		
Lepomis cyanellus	Green sunfish	3	<1	1
L. gulosus	Warmouth	<1	1	
L. humilis	Orangespotted sunfish		<1	
L. macrochirus	Bluegill	4	21	1
L. megalotis	Longear sunfish	32	14	2
L. microlophus	Redear sunfish	1	1	
L. miniatus	Redspotted sunfish	<1	<1	
Micropterus dolomieu	Smallmouth bass	4		
M. punctulatus	Spotted bass	6	9	5
M. salmoides	Largemouth bass	6	5	1
Pomoxis annularis	White crappie	1	3	1
P. nigromaculatus	Black crappie	<1	1	<1
PERCIDAE	**PERCHES**			
Percina c. caprodes	Ohio logperch	1	<1	
Stizostedion canadense	Sauger			<1
S. vitreum	Walleye	<1		
SCIAENIDAE	**DRUMS**			
Aplodinotus grunniens	Freshwater drum	<1	2	12

Table 4. Summary of select creel parameters reported in the Missouri State-Wide Angler Survey (1983-1988) for the St. Francis River. Because of limited angler contacts (845 anglers surveyed during the 6-year period), data for all years were combined.

Species Preference	No. of Anglers	% of Anglers	% of Hours Fished	Catch Rate	Harvest Rate	Fishing Quality Rating (10=Best)	% of Total Catch
Anything	245	29	23	0.9	0.3	4.1	-
Black Bass	250	30	36	0.6	0.2	4.4	24
Sunfishes	156	19	12	1.2	0.7	5.6	59
Catfishes	149	18	23	0.1	0.1	4.7	8
Suckers	19	2	4	2.9	2.9	7.1	3
Walleye	4	1	<1	0.1	0.1	5.7	<1
Carp	4	1	1	0.3	0.3	5.0	1
Buffalo	4	1	1	0	0	5.0	<1
Shadow Bass	3	<1	<1	0.5	0.5	7.0	4
Drum	2	<1	<1	0.9	0.9	10.0	1
Frogs	9	1	1	2.2	2.2	7.4	1
Total	845	102	Wtd. Avg.	0.7	0.4	4.8	101

Table 5. Benthic invertebrate distribution in select streams in the St. Francis River basin. (Source = MDC database)

Number of Taxa Collected

Taxonomic Group	STF	BGC	LSTF	BRC	KNC	SBR	CCK	SAC
Platyhelminthes	1	1	1	1	1	0	2	1
Nematoda	1	1	1	0	1	0	1	1
Nematomorpha	1	1	1	0	1	0	0	1
Annelida	3	3	3	2	3	0	2	2
Crustacea	9	6	4	4	5	0	6	8
Plecoptera	17	39	14	13	11	0	29	19
Ephemeroptera	31	41	26	7	17	2	23	19
Odonata	7	15	11	3	10	5	6	9
Hemiptera	7	14	7	0	6	0	6	10
Megaloptera	2	4	3	2	2	1	2	3
Neuroptera	0	0	1	0	0	0	0	0
Trichoptera	17	46	20	9	19	5	32	32
Lepidoptera	1	1	2	0	1	0	2	0
Coleoptera	20	57	23	13	13	5	20	25
Diptera	17	24	29	8	17	7	15	32
Hymenoptera	0	0	0	0	0	0	0	0
Arachnoidea	1	1	1	0	1	0	1	1
Mollusca (excluding mussels)	11	9	8	3	6	0	4	5
Total	146	263	155	65	114	25	151	168

STF-St. Francis River
BGC-Big Creek
LSTF-Little St. Francis River
BRC-Brewer Creek
KNC-Knob Creek
SBR-Scroggin Branch
CAC-Carver Creek
SAC-Saline Creek

Table 6. Freshwater mussels of the St. Francis River basin.

Species	Common Name
Alasmidonta marginata	Elktoe
A. viridis	Slippershell
Amblema plicata	Threeridge
Cyclonaias tuberculata	Purple pimpleback
Elliptio dilatata	Spike
Fusconaia flava (=undata)	Wabash pig toe
Megalonaias nervosa	Washboard
Obovaria jacksoniana	Southern Hickorynut
Pleurobema coccineum	Round pigtoe
Plectomerus dombeyana	Bankclimber
Ptychobranchus occidentalis	Quachita kidney-shell
Quadrula c. cylindrica	Rabbitsfoot
Q. metanevra	Monkeyface
Q. pustulosa	Pimpleback
Q. quadrula	Mapleleaf
Tritogonia verrucosa	Pistolgrip
Unionerus tetralasmus	Pondhorn
Anodonta grandis corpulenta	Stout floater
A. g. grandis	Giant floater
A. imbecillis	Paper pondshell
A. suborbiculata	Flat floater
Arcidens confragosus	Rock pocketbook
Lasmigona complanata	White heelsplitter
L. costata	Fluted-shell

Strophitus undulatus	Squawfoot
Actinonaias ligamentina	Mucket
Cyprogenia aberti	Western fanshell
Epioblasma triquetra	Snuffbox
Lampsilis brevicula	Ozark broken-ray
L. orbiculata	Pink mucket
L. ovata (=cardium)	Pocketbook
L. siliquoidea	Fatmucket
L. teres anodontoides	Yellow sandshell
L. t. teres	Slough sandshell
Leptodea fragilis	Fragile papershell
Ligumia recta	Black sandshell
L. subrostrata	Pondmussel
Obliquaria reflexa	Threehorn wartyback
Potamilus alatus	Pink heelsplitter
P. ohioensis	Pink papershell
P. purpurata	Purple shell
Toxolasma lividus glans	Little purple
T. parvus	Lilliput
Truncilla donaciformis	Fawnsfoot
T. truncata	Deertoe
Venustaconcha ellipsiformis	Ellipse
Villosa iris	Rainbow
V. lienosa	Little spectaclecase

Table 7. Crayfishes of the St. Francis River basin.

Species	Common Name
Procambarus clarkii	Red swamp crayfish
P. acutus	White River crayfish
P. viaeveridus	Vernal crayfish
Cambarellus puer	Cajun dwarf crayfish
C. shufeldtii	Shufeldt's dwarf crayfish
Cambarus diogenes	Devil crayfish
C. hubbsi	Hubb's crayfish
Orconectes lancifer	Shrimp crayfish
O. palmeri	Gray-speckled crayfish
O. harrisoni	Belted crayfish
O. luteus	Golden crayfish
O. virilis	Northern crayfish
O. punctimanus	Spothanded crayfish
O. quadruncus	St. Francis River crayfish
O. peruncus	Big Creek crayfish
O. hylas	Woodland crayfish

MANAGEMENT PROBLEMS AND OPPORTUNITIES

GOAL I: Maintain or improve aquatic habitat conditions to meet the needs of native aquatic biota while accommodating society's demands for agricultural production and economic development.

Status: Aquatic habitats, riparian areas, and the watershed are mostly in good condition in the upper subbasin. However, land management can be improved on public and private land. Through coordination and cooperation with other agencies, best management practices can be employed. The channelized sections of the lower subbasin have been drastically altered and need rehabilitation. Headcutting, erosion, and sediment deposition are serious problems. The U.S. Army Corps of Engineers (USCOE) has regulatory control over these channels. Improvements in the subbasin are possible through improved coordination with and assistance to the USCOE.

Objective 1. Maintain, expand, and restore riparian corridors; enhance watershed management; improve in-stream habitat; and reduce streambank erosion throughout the basin.

Strategies

* Provide technical assistance and recommendations about streams to all landowners, public agencies, and private contractors that request it.

* Ensure that all Missouri Department of Conservation (MDC) conservation areas are examples of good watershed, riparian corridor, and stream management by including appropriate recommendations and prescriptions in area plans.

* Encourage and assist other government agencies to use proper watershed, riparian corridor, and stream management on their lands.

* Improve landowner stream stewardship by promoting and implementing MDC's incentive programs.

* Work with the Natural Resource Conservation Service (NRCS), Farm Service Agency (FSA), and Soil and Water Conservation Districts (SWCD) to provide and promote incentive programs that will improve watershed, riparian corridor, and stream stewardship (*e.g.* fencing, corridor tree planting, livestock watering systems, pond construction).

* Promote and participate in SALT and EARTH projects so that appropriate practices are available to landowners to improve watershed, riparian corridor, and stream stewardship.

* Review Section 404 and other permit applications, comment on anticipated adverse impacts, and recommend measures to protect watershed and aquatic environments.

* Periodically monitor habitat conditions; methods may include, but are not limited to SHAD surveys, GIS technology, aerial photography, or helicopter reconnaissance.

* Encourage Missouri Department of Natural Resources (MDNR) to implement best reclamation techniques for mine tailing dams and ponds, and chat piles.

Objective 2. Reduce stream channel instability, sedimentation, and blockages in the lower subbasin.

Strategies

* Encourage drainage districts and landowners to leave vegetated strips, preferably trees, along ditches and streams.

* Encourage the USCOE to evaluate the headcutting that is occurring in the mainstem, tributaries, and lateral ditches and the resulting downstream sedimentation.

* Encourage the USCOE to formulate and implement a plan that would eliminate further headcutting and excessive sedimentation. The plan should also include actions to restore in-stream and streambank habitats.

* Provide recommendations to the USCOE concerning the project to remove the channel blockage/logjam in the mainstem below Highway 84, west of Kennett.

GOAL II. Maintain or improve water quality throughout the basin so that it is sufficient to support diverse aquatic biota.

Status: Water quality is generally good throughout the basin. However, mines, tailing ponds, chat piles, and inadequate waste water treatment facilities (*e.g.* Farmington's) can cause poor water quality. Lead smelting will continue to be a concern for Big Creek. High water temperatures in the channelized sections of the lower subbasin can pose problems for aquatic organisms.

Objective 1. Ensure that basin streams meet state water quality standards.

Strategies

* Review NPDES, Section 404, and other permit applications; assist with the enforcement of existing water quality laws; and recommend measures to protect aquatic communities.

* Encourage Missouri Department of Natural Resources (MDNR) to implement best reclamation techniques for mines, tailing dams and ponds, and chat piles.

* Support the upgrade of the Farmington waste water treatment facility.

* Oppose the establishment of landfills in areas that may contaminate basin streams.

* Cooperate with other state and federal agencies to investigate pollution events and fish kills.

* Work with the Missouri Department of Health and MDNR to reduce contaminant levels in fish by collecting fish for contaminant analysis, advising the fishing public about contaminants, and identifying sources of contamination.

* Encourage and assist the MDNR to monitor construction sites to ensure that best management practices are used to limit erosion and sediment input into streams.

* Encourage and assist other government agencies to use proper watershed, riparian corridor, and stream management practices on their lands.

* Improve landowner stream stewardship by promoting and implementing MDC's incentive programs.

* Work with the Natural Resource Conservation Service, Farm Service Agency, and Soil and Water Conservation Districts to provide and promote incentive programs that will improve watershed, riparian corridor, and stream stewardship (e.g. fencing, corridor tree planting, livestock watering systems, pond construction).

* Promote and participate in SALT and EARTH projects so that appropriate practices are available to landowners to improve watershed, riparian corridor, and stream stewardship.

* Educate livestock producers by providing them with technical information about management practices (*e.g.* alternative watering systems, management intensive grazing) to keep livestock waste from entering streams..

Objective 2. Encourage the public to become advocates for high-quality water.

Strategies

* Encourage formation of additional STREAM TEAMs and STREAM TEAM associations within the basin.

* Encourage STREAM TEAMs to participate in the Volunteer Water Quality Monitoring Program and to report pollution, other water quality problems, and illegal trash dumping to the proper authorities.

* Encourage and assist STREAM TEAMs in removing trash from all major basin streams.

* Media contacts, presentations, special events, and literature distribution will be used to reach people throughout the basin to enhance their awareness of water quality problems and viable solutions.

* Serve in an advisory role to STREAM TEAMs and other citizen organizations and local governments on water resource issues.

GOAL III. Maintain diversity of native aquatic organisms and improve the quality of fishing.

Status: The basin supports a diverse aquatic biota, including 130 fish species, 48 mussel species, and 16 crayfish species. Most streams support a diverse benthic invertebrate fauna.

Objective 1. Monitor, assess, and protect aquatic populations and communities.

Strategies

* Encourage STREAM TEAMs to participate in the Volunteer Water Quality Monitoring Program to monitor aquatic invertebrates.

* Assist the MDC malacologist with basin naiad surveys and help maintain or improve a diverse and healthy naiad community.

* Encourage and support Protection Division personnel with the protection of mussels from illegal harvest.

* Maintain proper habitat conditions (*e.g.* improved water quality, reduced siltation) through improved watershed, riparian corridor, and streambank management.

Objective 2. Provide diverse, high-quality angling opportunities.

Strategies

* Evaluate the status of the sport fish community by conducting periodic electrofishing surveys.

* Propose and implement regulations, as needed, that might improve the quality of fishing for a variety of species (e.g. smallmouth bass, spotted bass, shadow bass, walleye, channel catfish).

* Identify critical habitat areas for sportfish species and maintain or enhance these areas as needed.

* Continue efforts to establish a self-sustaining walleye population in the upper St. Francis River.

* Determine angler preferences through creel or angler opinion (mail-in or phone) surveys.

Objective 3. Improve access to basin streams.

Strategies

* Acquire and develop public access and frontage sites for boating, canoeing, kayaking, and bank fishing at strategic points.

* Improve bank fishing and other aquatic wildlife-based recreational opportunities on public lands.

GOAL IV. Improve the public's knowledge and appreciation of stream resources; recreational opportunities; and proper watershed, riparian corridor, and streambank management.

Status: Public education will continue through a variety of avenues. Stream management workshops for landowners, classes for teachers, seminars at Sports Shows and other events, and contacts with the news media will provide a variety of means to educate the public.

Objective 1. Educate the public on the value of healthy stream ecosystems and encourage advocacy on behalf of basin streams.

Strategies

* Assist with the University of Missouri's project, Sustaining Natural Resources on Private Lands in the Central Hardwood Region. This project will be conducted in the St. Francis River and Black River basins in Missouri.

* Conduct aquatic education programs in cooperation with MDC Outreach and Education Division and local area schools.

* Encourage basin STREAM TEAMs to promote the value and opportunities associated with basin streams.

* Encourage formation of additional STREAM TEAMs and STREAM TEAM associations within the basin.

* Provide technical assistance and recommendations about streams to all landowners, public agencies, and private contractors that request it.

* Cooperate with other agencies (e.g. NRCS, MDNR, SWCD) to promote participation in watershed and stream incentive programs and SALT or EARTH programs.

* Work with MDC's Outreach and Education Division staff to conduct stream management workshops for school teachers.

* Work with MDC's Private Land Services (PLS) staff to promote good stream stewardship through workshops and one-on-one contacts with landowners.

* Work with PLS staff to present workshops and programs to local government officials about stream dynamics and the importance of good watershed management and healthy riparian corridors.

Objective 2. Educate the public about aquatic-related recreational opportunities in the basin.

Strategies

* Promote angling opportunities through MDC's Fishing Prospects, media, presentations, and special events.

* Increase awareness of the angling opportunities for non-game fishes (e.g. buffalo, gar, carp, drum).

* Promote aquatic-related activities (e.g. angling, snorkeling, canoeing, kayaking, site-seeing) through the media, presentations, and special events.

ANGLER GUIDE

In the upper St. Francis River, anglers can expect good fishing for all three species of black bass. Spotted bass and largemouth bass are more common in the riffle/pool habitats and smallmouth bass are more common in the shut-ins from Hwy. 72 to Silvermines (Hwy. D). Black bass greater than12 inches are common with some greater than 15 inches. Shadow bass (goggle-eye) angling is fair, with most fish between five and seven inches, plus some greater than eight inches. Anglers have good success catching channel catfish. Most channel catfish are 12 to 24 inches long. Gigging for redhorse suckers is good from Grunner Ford Access (Hwy. H) in St. Francois Co. to Wappapello Lake. Small walleye were stocked throughout the river, from 1996 to 1999, to restore the population. To protect these fish, harvest of walleye and sauger is not permitted in Wappapello Lake, the St. Francis River above the lake, or their tributaries. All walleye must be returned to the water unharmed immediately.

In the lower St. Francis River, fishing for spotted bass and largemouth bass is fair in the unchannelized portion of the river between Wappapello Dam and Kennett (Hwy. 84). Few fish are greater than12 inches. Spotted bass are more common from Kennett (Hwy. 84) to the Arkansas state line, with good numbers of fish up to 15 inches long. There are many six- to eight-inch bluegill for several miles below Wappapello Dam. Fair numbers of bluegill are present throughout the remainder of the unchannelized portion of the river. Trotlines and limblines produce some nice stringers of channel catfish. Most of the channel catfish are less than 22 inches long. Large buffalo and gar and an occasional flathead catfish, white bass, or drum could be encountered anywhere on the river.

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 1^o 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 hierarchical 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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