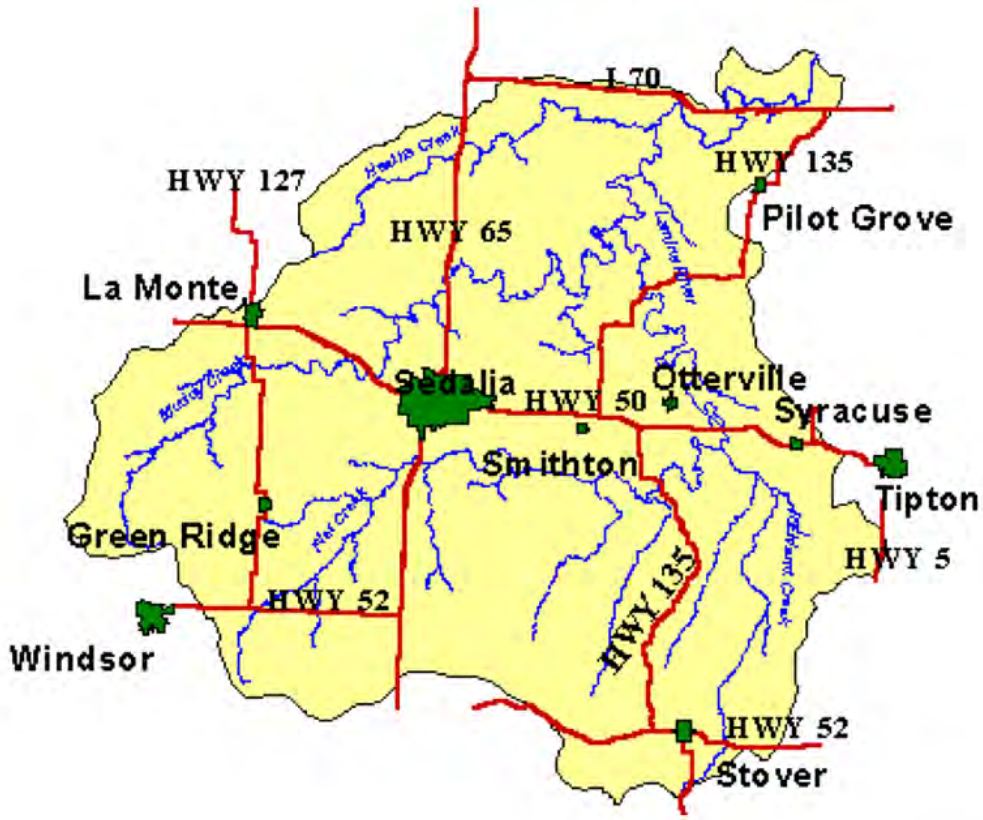

Lamine River

Watershed and Inventory Assessment

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Executive Summary

The Lamine River Basin is located in West Central Missouri in Benton, Johnson, Morgan, Moniteau, Saline and Cooper counties. The Lamine River originates at the confluence of Richland and Flat Creeks in northern Morgan County, and flows 50 miles northward through Cooper County to its confluence with the Blackwater River. The Lamine River above its confluence with Blackwater River is a sixth order stream with an area of 1080 square miles.

The Lamine River Basin is a rural watershed. The largest community in the watershed is Sedalia with a population of about 20,000. The area was settled by European immigrants shortly after the return of the Lewis and Clark expedition in 1804. Early descriptions of the basin indicate forests occurred along the stream valleys and steeper slopes leading to prairies on uplands. As the land was changed to agricultural use, sediment became a major pollutant affecting the river's ecosystem.

Approximately one half of the watershed is currently being row cropped while the remaining half is divided between forest and pasture. Livestock grazing occurs on approximately 83% of the forested lands in the basin. Nearly 90% of the upland forests are grazed.

Stream life and fishing are both threatened by occasional low dissolved oxygen. Major causes include nonpoint runoff from feedlots and pastures; isolated problems exist due to some point source discharges from the Sedalia vicinity into Muddy Creek. Whole-body recreation and boating on the Lamine River are usually safe but high levels of fecal coliform bacteria are sometimes found during high flows.

Several stream reaches in the Lamine River Basin have had chronic problems supporting fish populations. Low base flows during the summer contribute to these water quality problems. Point source and non-point sources have been documented to cause fish kills.

A major fish kill occurred in November 1989, when sewage effluent from a chicken layer operation polluted Long Branch and Muddy Creek, resulting in high ammonia levels which killed approximately 20,000 fish in 14 miles of Long Branch and Muddy Creeks.

Water quality in streams of the Lamine River Basin is not routinely monitored. One extensive study was done on Muddy Creek in 1997 and 1998 by the Missouri Department of Conservation. That study showed agricultural practices provided moderate levels of nutrients to Muddy Creek. However, the greatest source of excess nutrients was from subwatersheds in the vicinity of Sedalia. Levels of important nutrients increased dramatically and remained high for nearly 20 miles downstream.

The city of Sedalia withdraws water from Spring Fork Lake and has an auxiliary supply on Flat Creek (Pettis County S22, T45, R21). DNR records for 1998 showed six deep well users greater than 100,000 gal/day. The Tyson plant at Dresden had the largest well use at nearly 680 million gallons for the year. This was followed by Whiteman Airforce Base at 273 million gallons for the year.

Although several point source discharges exist in the Lamine River basin, most pollution problems have been associated with effluent from the Sedalia area. Raw sewage commonly enters Sewer Branch during periods of high runoff due to poor diversion of solid waste from the storm sewer system to the north sewage treatment plant. Another point source is the Tyson Plant at Dresden. The plant has been fined for warm water discharges into State waters. Excessive nutrients and warm water are reaching Muddy Creek via Little Muddy Creek subwatershed.

Most nonpoint source pollution in the basin is from soil erosion and animal waste runoff. Levels of dissolved oxygen can be very low during periods of low flow. Livestock waste in the basin is estimated by DNR personnel at over 2.6 million PE (human population equivalent).

The Lamine River Basin lies in two physiographic regions. Muddy Creek and Heath's Creek enter from the Osage Plains to the West while Richland Creek, Flat Creek and the mainstem Lamine River lie mainly in the Salem Plateau.

The Lamine River Basin is unglaciated and overlain by four to eight feet of loess derived soils. The soil

overlies dolomite in the upper part of the basin and limestone in the lower part of the basin. Baseflow is not well sustained during dry periods because most water movement in the basin is through the surface stream network and few notable springs exist.

The Lamine River Basin lies primarily in the Cherokee Prairies soil region. Highly erodible loess soils are well drained in most areas but poorly drained in other areas. Sheet and rill erosion from tilled land (9-13 tons/acre) is relatively high. Erosion from permanent pasture is much lower (2.5-5.0 tons/acre). Gully erosion is considered severe 200 - 500 tons/acre.

Major streams (fifth order and larger) in the Lamine River Basin have average gradients from 1.5 ft/mi to 19.1 ft/mi. Streams entering from the western portion of the watershed, including Heath's Creek, Muddy Creek and Flat Creek, have lower gradients than streams farther to the east. This shift in gradient reflects the transition from Prairie to Ozark border streams within the Lamine River Basin.

Average precipitation for the region is 38.5 inches. While most of the permanent flow in the Lamine River Basin is represented by the mainstem Lamine River, Flat Creek, Richland Creek, Muddy Creek and Heath's Creek, there are 64 third order or larger streams in the basin. Many of these streams have permanently flowing reaches during years of normal precipitation.

Approximately 92% of the mainstem Lamine River and Flat Creek are unaltered. Many small channelization projects are evident on topographic maps and some are associated with road building or agriculture. Levees are also limited in the Lamine River basin. Most levees in the basin are associated with channelization projects.

Streambank erosion was a problem in all streams sampled in the Lamine River basin. Most erosion problems were associated with barren or narrow corridors. Alterations of the channel were detrimental to bank stability in the reach. Streams with the most extensive bank erosion problems were near the lower end of the subbasin (Heath's Creek and Clear Creek). These streams possess little to no wooded corridor and most banks are denuded of vegetation. Middle Richland Creek and Haw Creek were among streams having the most stable banks.

In-stream fish cover in pools consisted mainly of snag habitat such as rootwads and logs. Woody cover was limited along heavily farmed reaches and some clearing of debris was evident, especially on the mainstem Lamine River. Boulders were present in some pools. Fish cover in pools of all streams generally was rated fair. Stream depths in pools were rated good to excellent at almost all habitat sampling sites. Increased depth associated with snags and boulders was documented at several sites. The mainstem Lamine River was not as deep as expected for a sixth order stream. Most sites possessed maximum depths of eight feet or less. Gravel and cobble were the predominant substrate forms in almost all streams regardless of their location in the basin. Little silt or other fine substrate was found and when it did occur, it was usually in a strip near the bank. One exception was the mainstem Lamine River which possessed a high proportion of silt at downstream sites.

Streams within the Lamine River Basin suffer from water quality problems associated with point and non-point pollution. Siltation in the main stem of the Lamine River and Heath and Muddy Creeks is excessive. Public awareness and education of city and county officials, industrial and residential developers and the general public are one of the best ways to reduce pollution from both point and non-point sources.

Compliance with existing laws as well as upgrades of sewage facilities will help reduce problems with point sources in the basin. Non-point sources can be improved by supporting watershed projects such as the USDA EQIP underway for Flat Creek.

The Lamine River Basin supports a diverse assemblage of fishes with 69 species re-collected by MDC personnel since 1940. Because over half of these species are from the "large" size group they are particularly desirable to anglers.

Due to the large and diverse number of sportfish present in the Lamine Basin management of target species is the highest priority. These target species in order of priority are: channel and flathead catfishes, largemouth and spotted bass, and crappie. Management of nektonic species will be limited to sampling

for species community information to document changes over time that measure improvements in stream water quality or habitat that result from strategies outlined in previous sections. Periodic fish tissue sampling will occur to monitor contaminant levels in selected fish species.

Public use of streams has not been determined in the basin even though this is the second largest free flowing river system in the state. Public access to streams is limited. Only five access areas exist on Lamine River. To date, public awareness efforts publicizing recreational opportunities in the basin have not been conducted.

The large number of miles of quality float streams, a diverse sportfish fauna, and the proximity to Sedalia and surrounding communities provides a good potential for increasing public use by increasing public access. Increasing the awareness of Lamine River Basin recreational opportunities would increase use and awareness of the resources value.

Location

The Lamine River Basin, which is actually a subbasin of the Blackwater-Lamine River Basin, is located in West Central Missouri in Benton, Johnson, Morgan, Moniteau, Saline and Cooper counties. The Lamine River originates at the confluence of Richland and Flat Creeks in northern Morgan County (Fig. 1), and flows 50 miles northward through Cooper and Johnson Counties to its confluence with the Blackwater River. Major tributaries of the Lamine River above the Blackwater are Heath's Creek, Muddy Creek, Flat Creek and Richland Creek. Several smaller streams exist in the subbasin as well (Fig. 1).

Figure 1. Location of the Lamine River Watershed.

Geology

Physiographic Region

The Lamine River Basin lies in two physiographic regions. Muddy Creek and Heath's Creek enter from the Osage Plains to the West while Richland Creek, Flat Creek and the mainstem Lamine River lie mainly in the Salem Plateau (MDNR 1986).

Geology

The Lamine River Basin is unglaciated and overlain by four to eight feet of derived soils. The soil overlies dolomite in the upper part of the basin and limestone in the lower part of the basin. Little water moves into the subsurface of the basin, probably due to a clayey residuum that overlies the limestone or dolomite bedrock and the presence of shale. Baseflow is not well sustained during dry periods because most water movement in the basin is through the surface stream network and few notable springs exist (MDNR 1984).

Soil Types

The Lamine River Basin lies primarily in the Cherokee Prairies soil region (MDNR 1986). Highly erodible loess soils are well drained in most areas but poorly drained in other areas. Sheet and rill erosion from tilled land (9-13 tons/acre) is relatively high considering an acceptable level of 2-5 tons/acre (Anderson 1980). Erosion from permanent pasture is much lower (2.5-5.0 tons/acre) as expected. Gully erosion is considered severe (200 - 500 tons/acre) in the region of the subbasin based on a statewide comparison (Anderson 1980).

Watershed Characteristics

The Lamine River above its confluence with Blackwater River is a sixth order stream with an area of 1080 square miles (USDA/SCS 1981; Table 1). One other sixth order stream, Flat Creek, flows northeastward forming the Lamine River at its confluence with Richland Creek. Flat Creek has the largest watershed (400 square miles) in the Lamine River Basin. Three fifth order streams, Muddy Creek, Heath’s Creek, and Richland Creek, and several fourth order streams are present in the Lamine River Basin (Table 1).

Stream ordering is a classification technique that is an indication of the relative size of a stream. This is useful but with it alone, we are not able to determine how the subject stream relates to the remainder of the stream system. For example, there are thirty-three third order streams in the Lamine River Basin but their watershed sizes vary greatly. Some are comprised of as few as four 1st order streams but watersheds of 10 - 20 1st order streams are common. One is comprised of forty 1st order streams. Likewise, the order designation does not indicate where the subject stream lies relative to the entire basin. This information is important because, within any given basin, downstream locations typically have greater species diversity and habitat complexity (Sheldon 1968 and Horwitz 1978). Thus, a tributary of the lower Lamine River should be expected to have a different species assemblage than a tributary of the same order in the upper reaches of the watershed. Knowing the relative location of a stream within the basin, a concept referred to as "spatial scale", is valuable information for stream fisheries management.

Channel Gradient

Gradient information was obtained from MDC Research Section gradient computer file and/or calculated from USGS 7.5' topographic maps. Gradient plots of fourth order and larger streams were prepared (Appendix 1). Major streams (fifth order and larger) in the Lamine River Basin range in average gradient from 1.5 ft/mi (mainstem Lamine River) to 19.1 ft/mi (Little Richland Creek). Streams entering from the

western portion of the watershed, including Heath's Creek, Muddy Creek and Flat Creek, have lower gradients than streams farther to the east (Richland Creek and Haw Creek). This shift in gradient reflects the transition from Prairie to Ozark border streams within the Lamine River Basin.

Figure 2. Geology of the Lamine River Watershed.

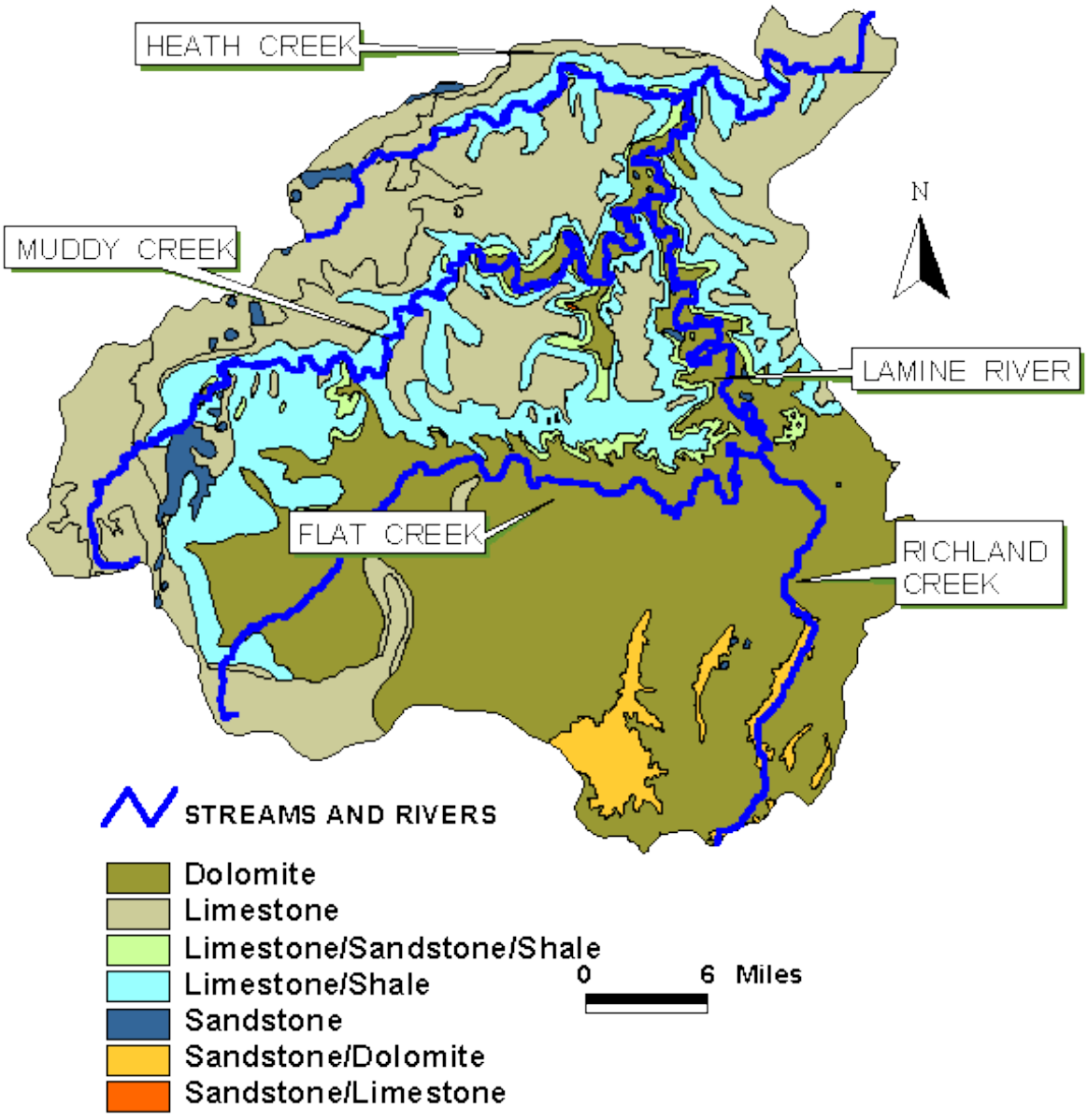
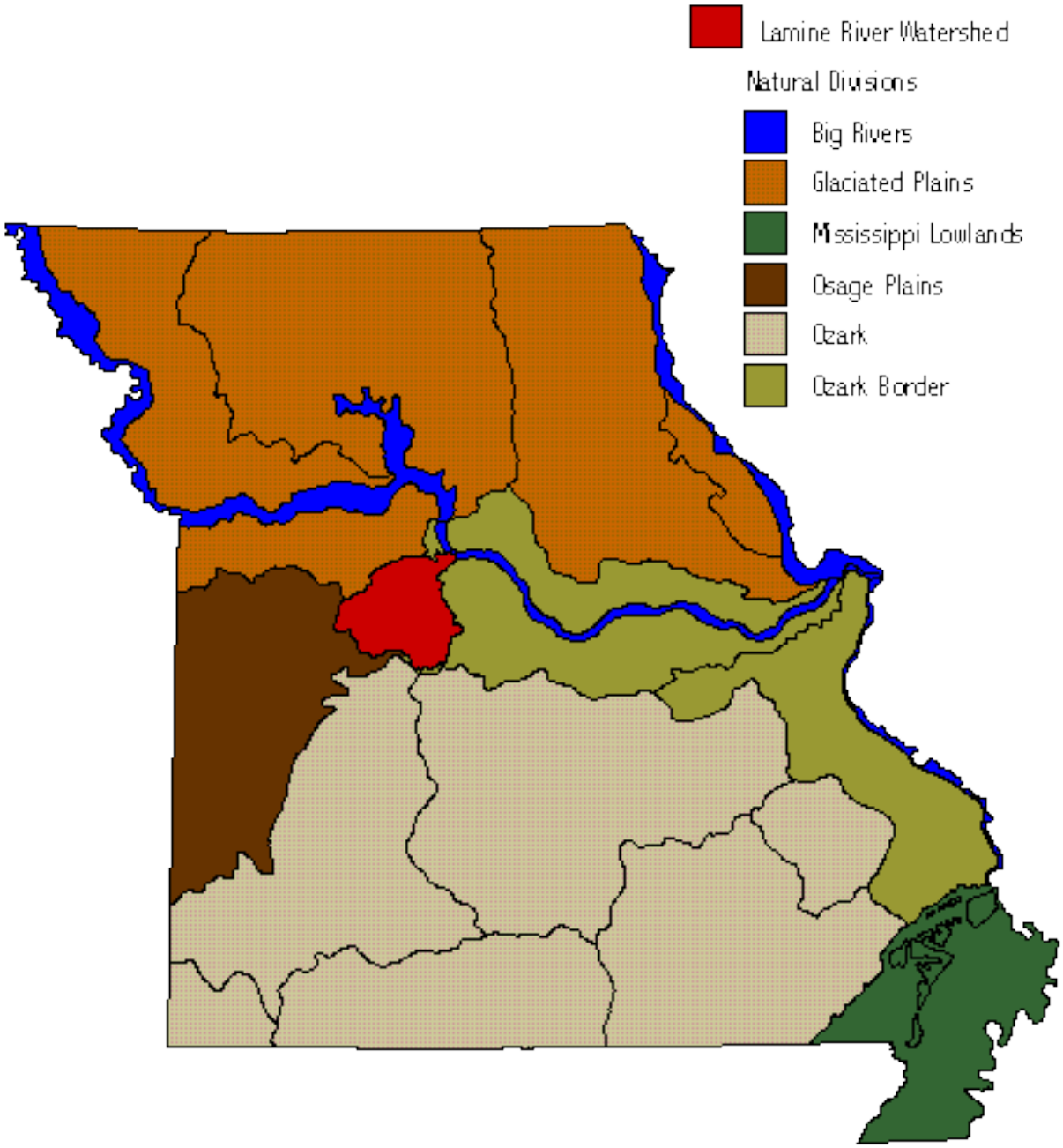


Figure 3. Location of the Lamine River Watershed within Missouri's Natural Divisions.



Land Use

Historic and Recent Land Use

The Lamine River Basin was settled by white immigrants shortly after the return of the Lewis and Clark expedition in 1804 (USDA-SCS 1977). Early descriptions of the basin indicate forests occurred along the stream valleys and steeper slopes leading to prairies on uplands. During the 1800's, common forest flora included hickory, oak, walnut, gum and bottom land hardwoods. As settlement continued, clearing of forests for cropland progressed. By the 1900's, tree cutting increased for fuel and building material and the land was drained as agricultural production expanded. As the land was changed to agricultural use, sediment became a major pollutant affecting the river's ecosystem (USDA-SCS 1977). Analysis of historic aerial photos of the Lamine River in the region of the Lamine River Wildlife Area show dismal land practices within that portion of the basin in the late 1930's (Steve Gough, MDC, Personal Communication). Extensive overgrazing and gully formation on agricultural land are evident. Aerial photos taken in the 1950's and 1960's reveal abandoned pasture and cropland which was severely eroded. Much of the same land was cleared again in the 1970's for agricultural use.

The Lamine River Basin is a rural watershed containing a below average population density compared to that of the state as a whole. (USDA-SCS 1977). The largest community in the watershed is Sedalia with a population of about 20,000. Runoff from the Sedalia area is into the Flat Creek and Muddy Creek subbasins.

Land use in the Lamine River Basin was determined from LANDSAT Thematic Mapper Data (Brown 1989). Approximately one half of the watershed is currently being rowcropped while the remaining half is divided between forest and pasture. Land use in the smaller watersheds within the basin reflects the transition from Prairie to Ozark streams. Land use is mostly cropland in the Prairie Region, while Ozark watersheds are predominantly forested (Table 2). Pasture represents 15-20 percent of land use in almost all of the basin watersheds (Table 2).

Forest land in the Lamine River Basin is typically slopes forested with large contiguous blocks of upland oaks (USDA-SCS 1977). About 14% of the forest grows on bottom lands. Livestock grazing occurs on approximately 83% of the forested lands in the basin. Nearly 90% of the upland forests are grazed.

Most of the forest land in the basin is in poor hydrologic condition due to excessive grazing.

No major channelization projects have been completed in the Lamine River basin (MDNR 1986), but as in most agricultural watersheds in Missouri, small stream sections have been straightened by landowners in an attempt to slow erosion on their property. According to SCS personnel (Pettis, Cooper and Morgan Counties), drainage ditches and diversions are limited in the basin as are levees, especially on the mainstem Lamine River. Most drainage modifications were implemented to divert water from upland fields around bottom land fields which have drainage problems.

Soil Conservation Projects

From the mid 1980s through the 1990s a number of watershed practices were conducted by NRCS and the Pettis County SWCD in subwatersheds within Lamine River watershed. Springfork Creek SALT was the first. The project was initiated in 1986 and completed in 1991 for the watersheds of Cheese Creek and Springfork Creek in Pettis and Benton Counties. Cheese Creek flows to Springfork Lake which is the primary water supply for Sedalia. The purpose of the five-year project was to reduce levels of nitrogen, phosphorous, and sediment reaching Springfork Lake. This was among the first AgNPS SALT projects conducted in the state. The project allowed small parcels of land to be identified and prioritized for treatment based on impacts to water quality.

Other projects followed primarily to reduce sediment loads reaching streams. Beaver Dam Creek SALT (1990-1995), Long Grove Branch SALT (1990-1995), and Shaver Creek EARTH (1994-1999) projects

all helped reduce sediment in the Lamine River watershed.

One project is active, the Flat Creek Environmental Quality Incentive Program (EQIP) project. EQIP uses federal funds to provide cost-shares to willing land owners wishing to improve and protect water quality. Cost share is provided for stack houses, lagoon and other aspects of proper nutrient management. Other agencies are participating including the Missouri Department of Conservation, which is providing cost share for alternate water systems to cattle producers in return for cattle exclusion from streams and riparian areas. MDC also provides technical and cost-share assistance to landowners in Flat Creek watershed.

Public Areas

There are ten public areas owned or managed by MDC and one Missouri Department of Natural Resources (MDNR). Lamine Conservation Area is the largest public area in the basin with 5748 acres of land and 16 miles of stream frontage (Table 3). Manito Lake Wildlife Area is the second largest public area in the basin with 851 acres including a 77-acre lake. Manito Lake is located at the headwaters of the Little Richland Creek. The third largest public area in the basin is J. N. Turkey-Kearn Memorial Wildlife Area which contains approximately 2 miles of frontage along Muddy Creek. Kahrs-Boger Park is the only remaining public area in the basin where frontage of third order or larger streams exists. About one-half mile of Lake Creek, a tributary of Flat Creek, crosses the southeast portion of Kahrs-Boger Park.

Five public stream access sites, with boat ramps, exist on the mainstem Lamine River (Figure 2). The only other public access site (excluding stream frontage on public areas) in the Lamine River Basin is Pinhook Access on Muddy Creek in Pettis County, but it does not have a boat ramp at this time. No state or national forests, national wildlife refuges or MDC natural history areas exist in the Basin.

Corps of Engineers 404 Jurisdiction

The entire Lamine River Basin is under jurisdiction of the Kansas City District of the U.S. Army Corps of Engineers. Applications for 404 permits should be directed to the Kansas City office — Address: Regulatory Functions, 700 Federal Bldg., Kansas City, MO 64106.

Figure 4. Landuse of the Lamine River Watershed.

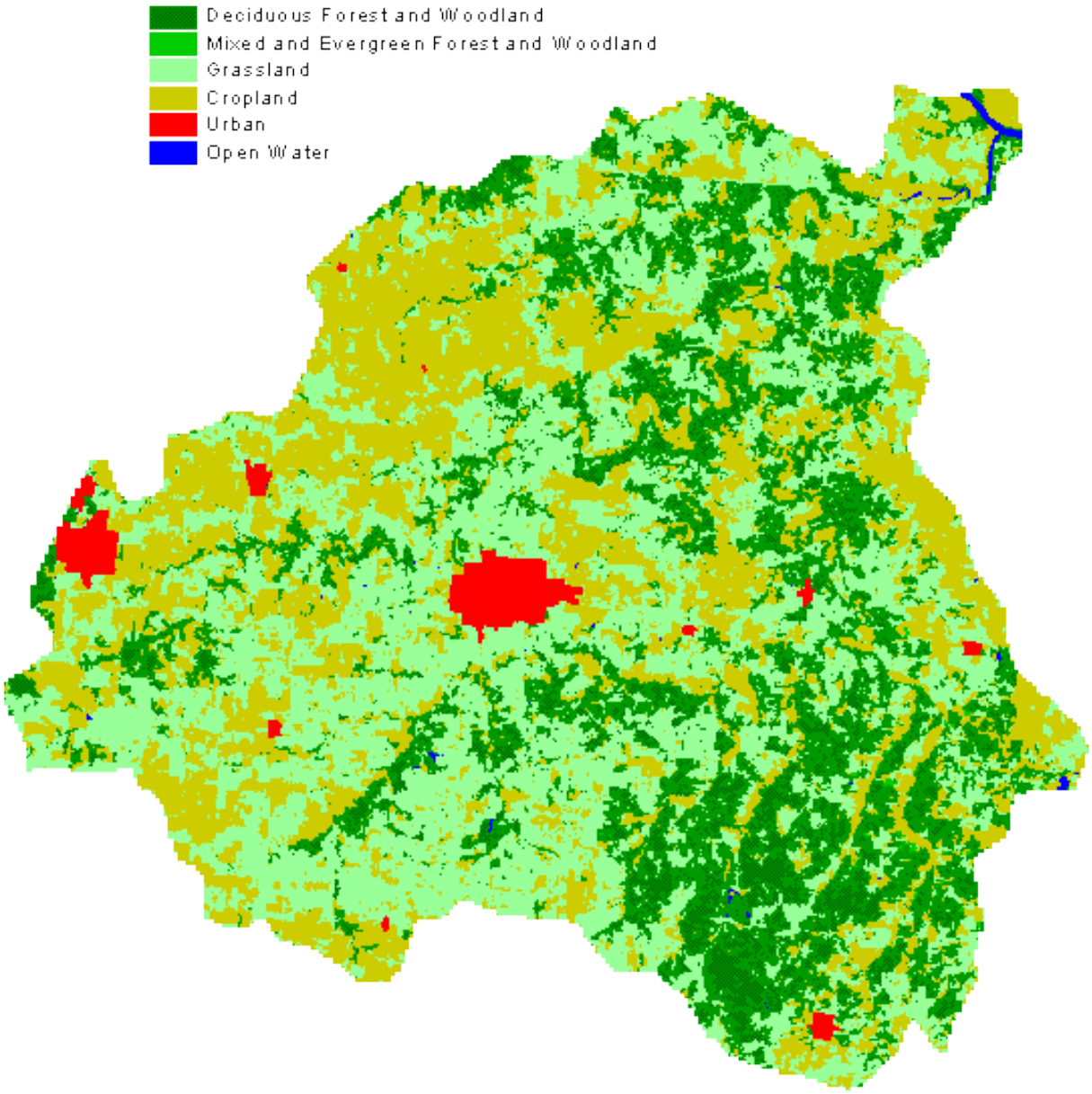


Table 2. Land use in the Lamine River Watershed.

Watershed	Area (mi^2)	Forest	Cropland	Pasture	Other
Lamine River above confluence with Blackwater River	1080	33%	46%	18%	3%
Flat Creek	400	24%	55%	19%	2%
Muddy Creek	295	25%	54%	17%	4%
Heath's Creek	107	30%	54%	16%	0%
Richland Creek	137	52%	32%	15%	1%
Haw Creek	72	52%	37%	11%	0%
Gabriel Creek	48	56%	26%	18%	0%

Table 3. Public areas owned or managed by MDC and one Missouri Department of Natural Resources (MDNR).

Area	Acres	Frontage (mi)	Major Stream
Lamine River W.A. (MDC)	5,748	16	Lamine River Flat Creek Richland Creek Otter Creek Harlan Creek
Manito Lake W.A. (MDC)	851	—	—
J.N. Turkey Kearn Memorial W.A. (MDC)	1,674	4	Crooked Creek Muddy Creek
W.R. Kearn Memorial W.A. (MDC)	120	—	—
Mora W.A. (MDC)	601	—	—
Bothwell State Park (UNK)	247	—	—
Drover's Prairie (MO Prairie Foundation)	80	—	—
Kahrs-Boger Park (MDC)	108	0.4	Lake Creek
Grandfather Prairie (MDC)	78	—	—
Paint Brush Prairie (MDC)	314	—	—
Friendly Prairie (MO Prairie Foundation)	40	—	—
Pin Hook Access	4	—	—
Roberts Bluff Access	7	—	—
Harriman Hill Access	37	—	—
De Bourgmont Access	3	—	—
Sedalia CSC	12.4	—	—
Swinging Bridge Access	25	—	—

Hydrology

Precipitation

Average precipitation for the region encompassing the Lamine River basin is 38.5 inches (Waite et al. 1988). The greatest amount of precipitation falls in May and June (MDNR 1986). Average annual runoff for the region is 10 inches.

USGS Gaging Stations

Currently there is one U.S. Geological Survey (USGS) gaging stations operating in the Lamine River Basin. A stage recorder is located on the Lamine River at State Highway A bridge near Otterville and its period of record is from 1987 to the present. Subsequent to a major fish kill in 1989, a crest station was installed on Muddy Creek at the Highway H bridge north of Georgetown.

Permanent/Intermittent Streams

While most of the permanent flow in the Lamine River Basin is represented by the mainstem Lamine River, Flat Creek, Richland Creek, Muddy Creek and Heath's Creek, there are 64 third order or larger streams in the basin. Many of these streams have permanently flowing reaches during years of normal precipitation. Due to the complexity of the watershed, stream intermittency is best illustrated by USGS 7.5-minute topographic maps. A listing of 7.5-minute quad maps covering the mainstem and longest reach of each stream of fourth or larger order is provided (Table 4) to expedite access to information about flow as well as other stream characteristics.

Hydrologic Characteristics

No major dam or hydropower projects exist in the Lamine River basin at this time. Approximately 20 lakes over two acres in surface area exist in the basin (MDNR 1984). Spring Fork Lake, a water supply reservoir for Sedalia, has a surface area of 178 acres and is the largest lake in the basin. Manito Lake, 77 acres, is the only other large lake in the basin. Manito Lake is located 4.5 miles south of Tipton at the Manito Lake Conservation Area and was built for recreation.

Table 4. USGS 7.5-minute quadrangle maps covering mainstem and longest arm of fourth order and above streams in the Lamine River Basin. Maps are listed in order from mouth of stream to headwaters.

Stream	Maps
Lamine River (confluence with Blackwater river to confluence of Richland and Flat Creeks)	Pilot Grove North, Nelson, Clifton City, Pilot Grove South, Otterville East
Brush Creek	Pilot Grove North, Pilot Grove South
Heath's Creek	Nelson, Longwood, Houstonia, Hughesville
Marlin Creek	Nelson, Clifton City
Clear Creek	Nelson, Clifton City, Pilot Grove South
Muddy Creek	Clifton City, Beaman, Hughesville, Sedalia West, Green Ridge North, Burtville, Windsor
Shaver Creek	Clifton City, Otterville West, Sedalia East
Sewer Branch	Beaman, Sedalia East
Little Muddy Creek	Hughesville, La Monte
Coon Creek	Sedalia West
Otter Creek	Otterville East, Tipton
Richland Creek	Otterville East, Florence, Stover
Gabriel Creek	Otterville East, Florence, Pyromont
Little Richmond Creek	Otterville East, Florence, Fortuna
Messer Creek	Otterville East, Tipton
Middle Richland Creek	Florence, Stover
Flat Creek	Otterville East, Otterville West, Sedalia East, Sedalia West, Ionia, Green Ridge South, Lincoln
Haw Creek	Otterville West, Pyromont, Crockerville
Lake Creek	Otterville West, Pyromont, Bahner, Cole Camp
Walnut Creek	Sedalia East, Bahner
Spring Fork	Sedalia East, Bahner

Water Quality

Beneficial Use Attainment

Stream life and fishing are both threatened by occasional low dissolved oxygen (MDNR 1984). Point sources are the predominant cause of excessive nutrients leading to nutrification of Muddy Creek. Seasonal peaks occur in agricultural subwatersheds, but high levels of phosphorous, ammonia, nitrate and nitrites reach the system from Sedalia's sewage treatment plants and agriculture dependent industry. This is reflected within the aquatic invertebrate community as well. A specific beetle, family Staphylinidae, is commonly associated with cattle manure and was collected in good numbers on Flat Creek during summer months in 1988, 1989 and 1990. Whole-body recreation and boating on the Lamine River is usually safe but high levels of fecal coliform bacteria are sometimes found during high flows.

Chemical Quality of Stream Flow, Contaminants and Fish Kills

A review of MDC records revealed that several stream reaches in the Lamine River Basin have had chronic problems supporting fish populations. Low base flows during the summer contribute to these water quality problems. Most of these reaches are associated with point sources including Sedalia's sewage treatment plants and agriculture related industry. During the 1960's, effluent from Sedalia's south sewage treatment plant caused chronic fish kills in tributaries leading to Flat Creek as well as in the mainstem of Flat Creek. In 1967, fish were killed in 20 miles of Flat Creek due to high ammonia and/or low dissolved oxygen resulting from sewage effluent from the south plant. In 1971, 4000 fish were killed in the same reach of Flat Creek. Throughout the 1970's the problem continued until a new south sewage treatment plant was completed in 1985. Although fish kills in Flat Creek near Sedalia are no longer common, tributaries leading to Muddy Creek are chronically affected by raw sewage during storm runoff. Throughout the 1980's, poor separation of raw sewage from storm runoff has resulted in degraded conditions in Sewer Branch (Pearl River) which empties into Muddy Creek north of Sedalia. The reach of Sewer Branch above U.S. Highway 65 is frequently black from raw sewage effluent and is usually not habitable to fish. The city of Sedalia plans to improve the system to divert the sewage from the storm runoff but it will take several years to complete.

Repairs at Sedalia's central sewage treatment plant which releases effluent into Muddy Creek via Brushy Creek resulted in a fish kill in September 1990. Due to cool weather and rains, an accurate count of dead fish was difficult to obtain. Poorly treated sewage polluted the stream from September 1990 to March 1991 and did not met Missouri Water Quality Standards for ammonia or BOD during this time.

A major fish kill occurred in November 1989, when sewage effluent from a chicken layer operation polluted Long Branch and Muddy Creek, resulting in high ammonia levels which killed approximately 20,000 fish. Approximately 14 miles of Long Branch and Muddy Creeks were affected beginning just upstream from the Johnson/Pettis County line. A project is currently underway to determine the extent of recolonization by fish and invertebrates in the reach which was almost devoid of life following the fish kill. The project is being conducted by MDC Fisheries regional personnel.

Drift and egg deposition from adult insects such as chironomid midges, dipterans, mayflies and stoneflies began to contribute to recovery by 22 weeks after the manure spill. The presence of a highly imbalanced invertebrate community at sites A, B, C and D indicates that the invertebrates had not yet recovered 50 weeks after the manure spill. Invertebrate sampling was not conducted after week 50.

Many fish and invertebrate species in Muddy Creek are fairly tolerant to organic enrichment. Steady improvement in fish abundance within all trophic groups by week 33 after the manure spill shows that recovery was well underway by then. However, fluctuations in abundance of fish species and individual fish continued to be relatively greater at polluted sites compared to the reference site at week 241.

Greater fish trophic group instability observed at polluted sites compared to the reference site indicates

that fish populations had not fully recovered within 241 weeks of the initial pollution event. The relative scarcities of sunfish > 7 inches and black bass > 12 inches at the polluted sites compared to what was observed during the fish kill provides further evidence that these species had not totally recovered 241 weeks after the fish kill. The low numbers of larger sunfish and bass that are available to anglers have greatly diminished the attractiveness of Muddy Creek for angling, since these sizes are more readily sought by anglers.

Water quality in streams of the Lamine River Basin is not routinely monitored. Dissolved oxygen, temperature and ammonia levels have been measured in association with fish kill investigations. As indicated above, typical water quality problems include low dissolved oxygen and/or high ammonia levels resulting from non-point and point-source pollution. Historic water quality data exists from a previous USGS gage station on the mainstem Lamine River near its confluence with the Blackwater River. Data for the period from 1979 to 1986 are available from MDC Streams South personnel or the USGS. The Missouri Department of Health's advisory pertaining to fatty fishes outside of the Ozarks is applicable to fish caught anywhere in the Lamine River watershed. The advisory says you should eat no more than one pound per week of fatty fishes such as catfish, carp, buffalo, drum, suckers or paddlefish from anywhere in Missouri outside the Ozark region.

Water Use

Currently there are two public surface water withdrawals from the Lamine River Basin. The city of Sedalia withdraws water from Spring Fork Lake and has an auxiliary supply on Flat Creek (Pettis County S22, T45, R21). MDNR's current record of water users does not list any major water withdrawals (greater than 100,000 gallons/day) from the basin for irrigation or industry as of 1987. More current data is being compiled at this time (Jeanette Barnett, MDNR, Personal Communication).

Point Source Pollution

Almost all of Pettis County lies within the Lamine River watershed. From 1990 to 1994, twenty-four water quality investigations were performed in Pettis County. Three of these resulted in fish kills. Agriculture manure was identified as the cause of 5 of the 16 known causes. From 1995 thru July of 1999, twenty-eight water quality investigations were performed in Lamine River watershed. Six resulted in Fish Kills. Agriculture manure was identified in 15 of 23 known causes.

Although several point source discharges exist in the Lamine River basin (MDNR 1984), most pollution problems have been associated with effluent from the Sedalia area. Raw sewage commonly enters Sewer Branch during periods of high runoff due to poor diversion of solid waste from the storm sewer system to the north sewage treatment plant. This combined sewage outfall is located near the Grand Avenue crossing on Pearl River. Raw sewage has been observed in the river, which is unclassified for any beneficial use by MDNR, for at least one mile downstream from the outfall. Other than problems associated with the combined sewage outfall on Pearl River, point-source pollution is limited in the Lamine River basin.

Nonpoint Source Pollution

In 1997 there were an estimated 88,675 dairy and beef cattle in watershed. There were 67,830 hogs and pigs in watershed. The number of poultry occurring at any one time includes 5.7 million broiler chickens, ½ million breeders, 336,000 pullets, and 1.1 million turkeys.

In 1992 there was an estimated 1.5 million people equivalents (PE) of livestock in the Lamine River watershed. An estimate made in 1999 shows 2.6 million PE. The difference is almost entirely explained by the addition of 1.2 million PE added by chickens since 1992.

There are two small abandoned coal mined areas on upper Muddy Creek in Johnson County which may cause occasional minor problems with low pH, high sulfate and high iron levels in the receiving streams.

To report incidents of pollution, contact the Department of Natural Resources.

Habitat Conditions

Channel Alterations

No large-scale channelization projects have been conducted in the Lamine River Basin. Approximately 92% of the mainstem Lamine River and Flat Creek are listed by MDNR (1986) as unaltered. Many small channelization projects are evident on topographic maps and some are associated with road building. Personal interviews of landowners by MDC Fisheries Regional personnel have revealed other small (less than .5 mile) channelization projects along reaches where meanders were encroaching on farmland or pasture. Soil survey personnel (NRCS) related that other alterations such as levees are also limited in the Lamine River basin. Most levees in the basin are associated with channelization projects. Stream Habitat Assessment Device (SHAD) surveys also revealed little channel alteration in the basin. A combination of on-site inspection and review of topographic maps and/or aerial photos is necessary to determine channelization impacts within a stream reach.

Gravel removal from streams is also evident in the Lamine River Basin. Active and inactive gravel operations have been observed by fisheries management personnel during SHAD surveys and stream contact work. Like channelization, gravel operations are not easy to document on generalized maps but should be documented along critical reaches identified for stream management projects.

Unique Habitat

Two unique habitats exist in the Lamine River Basin. Elk Lick Spring is a small spring on Heath's Creek in Saline County near Marshall. The spring has an average discharge of 32,000 gallons per day (Vineyard and Feder 1982). A series of riffles on the mainstem Lamine River also are important as possible walleye spawning sites. Fisheries management personnel have captured walleye in riffles along the reach of the Lamine River extending between Heath's Creek and Muddy Creek. Riffle areas farther upstream also may provide walleye spawning habitat, although the species has not been collected at those sites.

Because the Lamine River is a tributary of the Missouri River, it provides important backwater habitat that may be critical to fish production and diversity in the big river. Brown (1989) found densities of larval fish of several big river taxa to be higher in tributaries, including the Lamine River, than in the Missouri River. White bass, blue suckers and freshwater drum larvae were found almost exclusively in the Lamine River, the largest tributary sampled. A combination of deep water and gravelly substrate is unique in larger tributaries such as the Lamine and Gasconade Rivers and this type of habitat may enhance production and diversity of fishes in the Missouri River.

Stream Habitat Assessment

Streambank erosion was a problem in all streams sampled in the Lamine River basin. Several streams exhibited increased erosion at downstream sites. There was no clear pattern of stream erosion between Prairie streams, such as Muddy Creek, and Ozark border streams, like Richland Creek. Based on habitat samples, both stream types have erosion problems associated with narrow corridors. One advantage Ozark border streams have is increased topographic relief, which is associated with stable, bluff-protected banks. Some bluff protection is also present in Prairie streams such as Muddy and Flat creeks. Streams with the most extensive bank erosion problems were near the lower end of the subbasin (Heath's Creek and Clear Creek). These streams possess little to no wooded corridor and most banks are denuded of vegetation. Middle Richland Creek and Haw Creek were among streams having the most stable banks.

Streambank erosion with massive failings and poor bank protection were evident in areas of stream alterations such as channelization, dredging, and bridges. A sampling reach along Otter Creek is a good example of erosion problems associated with channel alterations. In summary, most erosion problems were associated with barren or narrow corridors, regardless of their physiographic differences. Secondly,

any alterations of the channel were detrimental to bank stability in the reach.

Land use bordering narrow corridors is primarily row crop and pasture regardless of the stream being sampled. Any location of modest relief along the stream was generally being farmed. Floodplain scour was evident at several sites, usually associated with a narrow corridor which was unable to reduce floodwater velocities before they entered a field. Cattle grazing was evident at some sampling sites and if present in the corridor, the area possessed a park-like appearance with mature trees and virtually no undergrowth.

Instream fish cover in pools consisted mainly of snag habitat such as rootwads and logs. Woody cover was limited along heavily farmed reaches and some clearing of debris was evident, especially on the mainstem Lamine River. Boulders were present in some pools. Fish cover in pools of all streams generally was rated fair. Instream cover in Muddy Creek was rated highest in the Lamine River Basin while cover in the Richland Creek system was rated low. The mainstem Lamine River also received a low rating for instream cover. Riffle areas offered cobble and boulders as well as water willow as primary cover types. Muddy Creek was rated high in riffle habitat quality while most other streams were rated fair to good in riffle habitat quality. Some reaches of riffle habitat possessed good substrate diversity (bedrock, cobble, boulder and gravel) important to fish and invertebrates. Undercut banks including overhanging bedrock shelves were present at some sites and appeared to be providing quality fish habitat.

Stream depths in pools were rated good to excellent at almost all habitat sampling sites. Increased depth associated with snags and boulders was documented at several sites. Uniform depths were associated with sampling sites located on altered sections of streams such as one on Otter Creek. The mainstem Lamine River was not as deep as expected for a sixth order stream. Most sites possessed maximum depths of eight feet or less.

Gravel and cobble were the predominant substrate forms in almost all streams regardless of their location in the basin. Little silt or other fine substrate was found and when it did occur, it was usually in a strip near the bank. One exception was the mainstem Lamine River which possessed a high proportion of silt at downstream sites. Prairie streams such as Heath's Creek and Muddy Creek possessed higher proportions of silt than other streams in the basin. Streambeds were unstable and uniform along areas associated with man's activities such as channelization or dredging (e.g. Otter Creek, Lake Creek).

No water quality problems were evident at stream habitat sampling sites. Water was usually clear with limited algae during the sampling period. As expected, Ozark border streams had higher water clarity than Prairie streams. One study found Muddy Creek to have turbidities seven times higher than those of Richland Creek (USDA-SCS 1977).

Channel alterations consisted of channel straightening, dredging, levees and problems due to slab bridges. Channel alterations that were observed are documented in individual stream summaries. Channel alterations were not evident at most stream habitat sampling sites. Total length of altered channel, as indicated from topographic maps, for each stream is provided. This information may only represent a small proportion of actual channelization that has occurred in each stream.

Biotic Communities

Fish Community Data

Fish collections by MDC research and management personnel (West Central Region) are summarized. Collections are divided into three groups (large, nektonic and benthic fish) based on their ecological affinity (Pflieger 1989). Relative abundance of fish in each group is provided for each of five subbasins including Heath's Creek, Muddy Creek, Flat Creek, Richland Creek and the mainstem Lamine River. Most collections were made by seining except in areas where water was too deep. All nektonic and benthic fish were collected by seining unless otherwise indicated on summary sheets. Large fish were collected by electrofishing, seining, or a combination of the two methods. Data on the summary sheets (Appendix 4) is not highly quantitative in nature; it is meant to provide a basic idea of the community structure in each of the subbasins.

A total of 69 fish species have been collected in the Lamine River Basin by MDC personnel (Table 6). Of that total, 33 species were categorized in the "large" group which includes centrarchids, catostomids, ictalurids and other large forms. The green sunfish *(Lepomis cyanellus)* was the most abundant fish in this group and was present at all five Lamine River subbasins. Another wide-ranging species, the largemouth bass *(Micropterus salmoides)* was the second most abundant species. Surprisingly, the longear sunfish *(Lepomis megalotis)* an Ozark-lowland species (Pflieger 1971) was the third most abundant fish in the subbasin, largely due to high densities in Richland and Flat creeks which are more Ozarkian systems than Heath's and Muddy creeks. The black bullhead *(Ictalurus melas),* golden redhorse *(Moxostoma erythrurum),* bluegill *(Lepomis macrochirus),* and common carp *(Cyprinus carpio)* follow as the most common species in the drainage. All of the above species were present in all five of the subbasins (Lamine River, Heath's Creek, Muddy Creek, Richland Creek and Flat Creek). With the exception of the longear sunfish and golden redhorse, all are wide ranging species (Pflieger 1971).

A transition from Prairie to Ozark border streams is somewhat evident in the large fish group. Green sunfish were more predominant in Muddy and Heath's creeks than in Richland and Flat creeks where longear sunfish and redhorse species (black or golden) were more or equally predominant. In the mainstem Lamine River, the gizzard shad *(Dorosoma cepedianum)* was the most abundant large fish followed by a large river species, the freshwater drum *(Aplodinotus grunniens).* These species are probably more abundant in the mainstem Lamine due to its size and direct link to the Missouri River.

Largemouth bass are common in all subbasins and very abundant in Muddy Creek. Spotted bass *(Micropterus punctulatus)* were not abundant in any of the streams except the Lamine River where they represented 8% of the large fish collection. Crappie *(Pomoxis spp.)* were not abundant in any of the collections although local fishermen have commented on good crappie fishing in some of the streams including the mainstem Lamine River. Bluegill, longear sunfish, and orangespotted sunfishes *(Lepomis humilis)* were widely distributed in the basin and relatively abundant. The channel catfish *(Ictalurus punctatus)* was not predominant in any of the research collections although they represented 36% of the catch in more recent samples of Muddy Creek. The flathead catfish *(Pylodictis olivaris)* was also rarely captured. Walleye *(Stizostedion vitreum)* were captured in very small numbers in the mainstem Lamine River and Flat Creek. A few white bass *(Morone chrysops)* were also collected from Flat Creek.

The greatest number of large fish species (28) existed in Flat Creek which probably provides a larger diversity of habitats than any other stream in the basin, due to its size and Ozark border location in the basin. The mainstem Lamine River possessed the second largest number of species (25). Muddy Creek and Heath's Creek, both Prairie streams contained the smallest number of large species.

Additional sampling in 1989 in the Heath's Creek, Muddy Creek, and Flat Creek subbasins did not reveal major changes in species composition but a few additional species were collected. Spotted bass were a new addition to the Muddy and Heath's creeks species list in 1989. The addition of spotted bass to these collections may reflect expansion from the mainstem Lamine River and Flat Creek where it was

previously collected. In Muddy Creek, channel and flathead catfish as well as freshwater drum were added to the species list. In Flat Creek, the black crappie *(Pomoxis nigromaculatus)* was collected for the first time in 1989.

A few large fish species were collected in research samples prior to 1960 that have not been collected since. For instance, the highfin carpsucker *(Carpiodes velifer),* an Ozark species was collected in Flat Creek in 1940. No other specimens have been collected in the Lamine River Basin since that time.

Several nektonic species shared predominance in the Lamine River basin. Two prairie species, the Common shiner *(Notropis cornutus)* and red shiner *(Notropis lutrensis);* one Ozark-Prairie species, the central stoneroller *(Campostoma anomalum);* and two wide ranging species, the bluntnose minnow *(Pimephales notatus)* and redfin shiner *(Notropis umbratilis)* were equally abundant in the basin. The nektonic fish assemblage differed from prairie to Ozark border streams within the basin. Wide ranging and Prairie species such as the redfin shiner, bluntnose minnow, and red shiner were predominant in Heath's Creek and Muddy Creek while species including the central stoneroller and southern redbelly dace predominated in Richland Creek samples. The common shiner, a Prairie species, was also abundant in Richland Creek.

Flat Creek which is a transitional stream between the Prairie and Ozark region possessed a diverse assemblage of nektonic fish including a high abundance of rosyface shiners *(Notropis rubellus),* red shiners, redfin shiners, bluntnose minnows, and brook silversides *(Labidethes sicculus).* The northern studfish *(Fundulus catenatus)* and plains topminnow *(Fundulus sciadicus),* both Ozark species, were present in Flat and Richland Creek collections but absent in collections from the Prairie streams (Heath's Creek and Muddy Creek). The predominant nektonic species in the mainstem Lamine River was the ghost shiner *(Notropis buchanani),* a Prairie species, which was present at two of the three collection sites. The red shiner and bluntnose minnow were also abundant in the mainstem Lamine River.

One species of special interest is the Topeka shiner *(Notropis Topeka).* One specimen was found in Clear Creek in 1992, and three specimens were found in Greer Spring in 1995. Populations of this species seems to be declining possibly due to siltation in the agricultural watersheds where it remains (Pfleiger 1997).

Additional fish collections in 1989 did not reveal major shifts in nektonic fish assemblages. A collection from Haw Creek in the Flat Creek Subbasin yielded a large number of central stonerollers which were not abundant in research samples. This may have been due to the location of the sampling site on Haw Creek which is a more Ozarkian stream than other tributaries in the Flat Creek Subbasin.

A few members of the nektonic group were present in earlier research samples and never collected in later years. The plains minnow *(Hybognathus placitus),* a big river species, was collected in the mainstem Lamine River in 1940. The western silvery minnow *(Hybognathus argyritis),* also a big river species was collected in Muddy Creek in 1940.

The orangethroat darter *(Etheostoma spectabile)* was by far the most abundant benthic species in the Lamine River Basin. The species represented 45-75% of the collection in all five of the subbasins. Other benthic fish common to most subbasins were the suckermouth minnow *(Phenacobius mirabilis)* and fantail darter *(Etheostoma flabellare).* In the mainstem Lamine River the slenderhead darter *(Percina phoxocephala),* an Ozark-Prairie species, was the second most common benthic fish. The suckermouth minnow and gravel chub *(Hybopsis x-punctata)* were also common in the mainstem Lamine River. In the Prairie streams, Heath's Creek and Muddy Creek, the orangethroat darter represented about 50% of the catch and the other 50% mainly consisted of johnny darters *(Etheostoma nigrum);* logperch *(Percina caprodes);* and suckermouth minnows. Flat Creek possessed the greatest number of species of benthic fishes (11) including the least darter *(E. microperca),* an Ozark species, and the blackside darter *(E. maculata),* a Prairie species. Richland Creek collections contained only five benthic fish species and 80% of the specimens were orangethroat darters.

A unique species collected in the past was the freckled madtom *(Noturus nocturnus)* of which one

specimen was collected in the mainstem Lamine River in 1940. The freckled madtom is a lowland species which is not abundant at any locations in Missouri (Pflieger 1975). Additional collections did not reveal major changes in the fish community or benthic species as compared to earlier research collections.

Overall, a shift in the fish assemblage from Prairie to Ozark-border streams is evident in the Lamine River Basin. Flat Creek represents the transition between the two regions and contains a very diverse fish community. Major changes in the fish community of the Lamine River basin over the last 20 years are difficult to detect due to the lack of recent collections. Several key species exist in the basin that may serve as indicators of increased water quality as new stream and watershed projects progress. Examples are the Topeka shiner, rosyface shiner, least darter, northern studfish and plains topminnow. The blacknose shiner is also of special interest due to its endangered status in the state. The Lamine River provides fishing opportunities for largemouth and spotted bass, white bass, catfish, sunfishes and crappie. Specialized sampling techniques should provide a better representation of the sport fish community. Another sport fish, walleye, may have been more abundant in the mainstem Lamine River during the early part of this century. This supposition is based on accounts related by older anglers in the area. As fish sampling continues, walleye spawning habitat may be better identified enabling fisheries managers to increase the abundance of this species to the basin.

Ichthyoplankton Collection

Larval fish taxa collected in the Lamine River by Brown (1989) are shown in (Table 7). The list includes two additions, the paddlefish *(Polyodon spathula)* and blue sucker *(Cycleptus enlongatus*), to those previously reported by MDC.

Aquatic Invertebrates

Twenty-seven species of mussels have been collected in the Lamine River Basin since 1965 (Oesch 1984; Table 8). Based on the general range of crayfish in Missouri (Pflieger 1996), a list of species expected in the Lamine River basin is provided (Table 9).

Threatened and Endangered Species

The blacknose shiner *(Notropis heterolepis),* a state listed endangered species in Missouri, has been collected as recently as 1962 in South Flat Creek. No threatened or endangered crayfishes or mussels are listed for consideration in the basin (Missouri Natural Heritage database 1999).

The Topeka shiner was placed on the Federal Endangered species list in January 1999. Only small, remnant and fragmented populations have been recently documented in smaller subwatersheds within Lamine River watershed.

Introductions

Bighead Carp are native to eastern China and were introduced to Arkansas in 1973. They are easily identified by the location of eyes below the midline of the fish. They have reached 40 to 50 pounds in as little as 5 years. Evidence of natural reproduction in Missouri waters occurred in 1989 when they were seined from Carrol County stream. Bighead Carp are found most commonly in the big rivers and the lower portions of their large tributaries. They obtain food by passing water over gill rakers. Zooplankton is the primary diet, but phytoplankton are also consumed. Food habits of this fish may conflict with native fish species such as paddlefish, bigmouth buffalo and young of other native species.

Grass Carp are native to Eastern Asia and released into open water of Arkansas shortly after 1963. They were first documented in Missouri in 1971 in the Mississippi River. They have become numerous in the large rivers, and the 1992 commercial harvest was nearly 40,000 pounds. They are stocked in many farm ponds to control aquatic vegetation problems. They sometimes escape to smaller streams where they are sometimes found. Young grass carp feed on small crustaceans and other invertebrates. At about 8 inches

long, they shift to a diet consisting of much aquatic vegetation and some animal matter. Harmful effects on native fish populations was feared, but effects have not yet been documented.

River Otters *(Lutra canadensis)* were reintroduced to Lamine River in 1983. The population has done well. Since 1996, trappers have helped manage otter populations in Lamine River and other areas throughout the state.

Other Management/Research Efforts

An invertebrate and fish recolonization study was initiated following a major fish kill on Muddy Creek in November 1989 (see Fish Kill section). The study will determine the chronology of natural repopulation of fish and invertebrate species, provide basic water quality information and stream habitat information along the impacted reach.

Four University of Missouri (UMC) studies are currently being conducted in the Lamine River basin. A study to provide baseline information on species composition and relative abundance and biomass of macroinvertebrates in Richland and Flat creeks as well as the mainstem Lamine River is completed. Major habitats sampled were riffle, snag, water willow *(Justicia americana)* and pool. Riffle and snag habitats in all streams had the greatest biomass which were dominated by filter feeding Trichoptera. While these two habitats contributed the greatest biomass per unit area, they comprised less than four percent of the total area. Results indicate that any efforts to increase total area available in either of these habitat types (such as artificial riffles or tree revetments) will result in positive increases of invertebrate densities and biomass in these streams.

A second study is being conducted to monitor fish communities in headwater creeks of agricultural watersheds throughout Missouri including Cheese, Flat, Henry and Spring Fork creeks in the Lamine River Basin. The study is designed to compare fish communities in watersheds that have received special land treatment (SALT) to those that have not. In addition to fish sampling, data related to stream health such as invertebrate abundance and diversity, frequency of flow, substrate composition, oxygen concentrations, temperature, nutrient and suspended solid concentrations and habitat variables also are being collected. Objectives are to determine whether these variables respond to the farmland management program and to relate differences in stream characteristics to differences in fish community structure among the streams.

A third study recently initiated by UMC personnel involves fish and habitat sampling on Haw and Gabriel creeks. Objectives of the study are as follows:

1) to develop useful models, and test and refine existing models, relating habitat characteristics to fish community structure and to density and biomass of smallmouth bass and other centrarchids;
2) to determine microhabitat preferences of several stream fish which would be used in developing habitat suitability curves for habitat evaluations or instream flow evaluations specific to Ozark border streams; and
3) to evaluate the applicability of currently used biological indices of fish communities as measures of stream integrity to Ozark border streams.

For further information or copies of annual reports on the three UMC studies listed above, contact Dr. Charlie Rabeni, 112 Stephens Hall, UMC, Columbia, Missouri 65211.

One other project involves the lower two miles of the Lamine River near its confluence with the Missouri River. The project objective is to determine relative and seasonal abundance, growth rates and condition of juvenile catfish in various habitats of the Missouri River including the lower portions of tributaries. Sampling was conducted on the Lamine River from July 1988 to November 1989 with small mesh hoop nets.

Table 6. Total fish species collected in the Lamine River Basin by MDC personnel.

Large Fish	
Shortnose Gar	*Lepisosteus platostomus*
Longnose Gar	*L. osseus*
American Eel	*Anguilla rostrata*
Gizzard Shad	*Dorosoma cepedianum*
Goldeneye	*Hiodon alosoides*
Common Carp	*Cyprinus carpio*
River Carpsucker	*Carpiodes carpio*
Highfin Carpsucker	*C. velifer *1940*
Quillback	*C. cyprinus*
White Sucker	*Catostomus commersoni*
Northern Hog Sucker	*Hypentelium nigricans*
Smallmouth Buffalo	*Ictiobus bubalus*
Bigmouth Buffalo	*I. cyprinellus*
Black Buffalo	*I. niger*
Black Redhorse	*Moxostoma duquesnei*
Golden Redhorse	*M. erythrurum*
Shorthead Redhorse	*M. Macrolepidotum*
Black Bullhead	*Ictalurus melas*
Yellow Bullhead	*I. natalis*
Channel Catfish	*I. punctatus*
Flathead Catfish	*Pylodictis olivaris*
White Bass	*Morone chrysops*
Green Sunfish	*Lepomis cyanellus*
Orangespotted Sunfish	*L. Humilis*
Bluegill	*L. Macrochirus*
Longear sunfish	*L. megalotis*
Smallmouth Bass	*Micropterus dolomieui*
Spotted Bass	*M. punctulatus*

Large Fish	
Largemouth Bass	*M. Salmoides*
White Crappie	*Pomoxis annularis*
Black Crappie	*P. Nigromaculatus*
Walleye	*Stizostedion vitreum*
Freshwater Drum	*Aplodinotus grunniens*

Benthic Fish	
Gravel Chub	*Hybopsis x-punctata*
Suckermouth Minnow	*Phenacobius mirabilis*
Stonecat	*Noturus flavus*
Tadpole Madtom	*N. gyrinus*
Freckled Madtom	*N. nocturnus *1940*
Fantail Darter	*Etheostoma flabellare*
Least Darter	*E. Microperca*
Johnny Darter	*E. Nigrum*
Orangethroat Darter	*E. Spectabile*
Logperch	*Percina caprodes*
Blackside Darter	*P. maculata*
Slenderhead Darter	*P. phoxocephala*

Nextonic Fish	
Central Stoneroller	*Campostoma anomalum*
Western Silvery Minnow	*Hybognathus argyritis *1940*
Plains Minnow	*H. Placitus *1930*
Horneyhead Chub	*Nocomis biguttatus*
Golden Shiner	*Notemigonus crysoleucas*
Emerald Shiner	*Notropis atherinoides*
Ghost Shiner	*N. buchanani*
Common Shiner	*N. cornutus*
Bigmouth Shiner	*N. dorsalis*
Blacknose Shiner	*N. heterolepis*
Red Shiner	*N. lutrensis*
Rosyface Shiner	*N. rubellus*
Sand Shiner	*N. stramineus*
Topeka Shiner	*N. Topeka*
Redfin Shiner	*N. umbratilis*
Bluntnose Minnow	*Pimephales notatus*
Flathead Minnow	*P. promelas*
Southern Redbelly Dace	*Phoxinus erythrogaster*
Creek Chub	*Semotilus atromaculatus*
Trout Perch	*Percopsis omiscomaycus*
Northern Studfish	*Fundulus catenatus*
Plains Topminnow	*F. Sciadicus*
Mosquitofish	*Gambusia affinis*
Brook Silverside	*Labidesthes sicculus*

Table 7. Larval fish taxa collected in the Lamine River.

Taxa	1987	1988
Polydodon spathula	X	X
Lepisosteus spp.	X	
Dorosoma cepedianum	X	X
Hiodon alosoides	X	X
Cyprinid spp.	X	X
Cyprinus carpio	X	X
Carpiodes spp.	X	X
Catostomus commersoni		
Cycleptus elongatus	X	X
Ictiobus spp.	X	X
Ictalurus punctatus	X	X
Pylodictis olivaris	X	
Gambusia affinis	X	
Morone chrysops	X	X
Lepomis spp.	X	X
Pomoxis spp.	X	X
Percina spp.	X	X
Aplodinotus grunniens	X	X

Table 8 Twenty-seven species of mussels have been collected in the Lamine River Basin since 1965.

Common Name	Taxa
Paper Floater	*Anodonta imbecilis*
Giant Floater	*A. grandis*
Squaw Foot	*Strophitus undulatus*
White Heel Split	*Lasmigona complanata*
Pistol-Grip	*Tritogonia verrucosa*
Maple Leaf	*Quadrula quadrula*
Pimple-Back	*Q. pustulosa*
Three-Ridge	*Amblema plicata*
Wabash Pig-Toe	*Fusconaia flava*
Round Pig-Toe	*Pleurobema sintoxia*
Lady Finger	*Elliptio dilatata*
Pound Horn	*Uniomerus tetralasmus*
Three-Horned Warty-Back	*Obliquaria revlexa*
Ellipse	*Venustaconcha ellipsiformis*
Deer-Toe	*Truncilla truncata*
Fragile Paper Shell	*Leptodea fragilis*
Pink Heel-Splitter	*Potamilus alatus*
Pink Paper Shell	*P. ohioensis*
Pond Mussel	*Ligumia subrostrata*
Slough Sand Shell	*Lampsilis teres*
Fat Mucket	*L. radiata*
Pocketbook	*L. Ventricosa*

Table 9. List of Crayfish expected to occur in the Lamine River Basin based on distribution maps in Pflieger (1987).

Common Name	Taxa
Papershell Crayfish	*Orconectes immunis*
Northern Crayfish	*O. Virilis*
Prairie Crayfish	*Procambarus gracilis*
Devil Crayfish	*Cambarus diogenes*

Management Problems and Opportunities

The Missouri Department of Conservation (MDC) is charged with the '...control, management, restoration, conservation and regulation of the bird, fish, game, forestry and all wildlife resources of the state...' As stated in MDC's recent Regional Management Guideline documents, 'The Conservation vision is to have healthy, sustainable plant and animal communities throughout the state of Missouri for future generations to use and enjoy, and that fish, forest, and wildlife resources are in appreciably better condition tomorrow than they are today.' In order to achieve this vision, efforts to better manage streams and their watersheds will be a continuing priority in the Lamine River watershed.

This section includes strategic guidelines to provide MDC Fisheries Division staff working in the watershed with management direction to address the issues detailed in earlier sections. These issues include point and non-point source pollution, increasing urbanization, loss of riparian vegetation, the effects of large confined animal operations, increasing demands for recreation, and threats to aquatic life within the watershed. The guidelines will be used to address future stream management, public awareness, and public access issues and needs. Efforts specifically related to the management of impounded waters are addressed in detail elsewhere and are not included here.

Goal I: Maintain or improve water quality in the Lamine River watershed so all streams are capable of supporting native aquatic communities.

Objective I.1: Streams within the watershed will meet state standards for water quality.

Guidelines:

- Collect fish for contaminant analysis for the Department of Health and cooperate in advising the fishing public on the impacts of contaminant levels in fish.
- Review NPDES, Section 404, and other permits and recommend measures to protect aquatic communities.
- Determine the effects of long-term point and non-point pollution on the biota of Muddy Creek.
- Train and involve Stream Teams in water quality monitoring and advocacy in the Lamine River Basin.

Objective I.2: Increase awareness of local government officials and industrial and residential developers of water quality conditions and problems in the Lamine River basin.

Guidelines:

- Determine the extent of public and local institutional knowledge of point and non-point pollution problems.
- Inform the public about water quality problems in the basin and promote citizen involvement in reporting and preventing pollution.
- Present workshops to local government agencies and developers on water quality problems in the basin and their role in solving them.

Goal II: Improve aquatic habitat conditions in the Lamine River basin to meet the needs of native aquatic species while accommodating society's demands for water and agricultural production.

Objective II.1: Maintain, expand and restore vegetated riparian corridors to meet the cost share guidelines; improve in-stream habitat (pools with woody debris, boulders and/or aquatic vegetation) and stabilize streambanks on all third order and larger streams.

Guidelines:

- Cooperate with landowners to install streambank, riparian and in-stream cover improvement projects on private lands using technical assistance and incentives.
- Inventory and monitor stream and riparian corridors and recommend habitat maintenance and enhancement projects on the Lamine River and Turkey Kearn conservation areas and any new areas acquired with stream frontage in the Lamine River basin.
- Cooperate with county Soil and Water Conservation District (SWCD) boards to incorporate stream improvement practices in their cost share programs.
- Review all 404, in-stream dredging, bridge construction or other development projects for impacts to streams in the Lamine River Basin to maintain, improve or protect aquatic habitats.

Objective II.2: Increase landowner awareness of local stream resources and good watershed and stream management practices.

Guidelines:

- Work with MDC's Outreach and Education Division staff to develop stream management related materials for private landowners.
- Establish and maintain stream management demonstration sites.
- Promote good stream stewardship through landowner workshops and stream demonstration site tours.
- Ensure that all MDC areas are examples of good stream and watershed management.
- Provide technical recommendations to all landowners that request assistance.
- Improve landowner stewardship of streams by promoting and implementing cost share programs, including MDC's watershed-based programs, that include streambank stabilization, alternative watering practices, and establishment and maintenance of quality riparian corridors.

Objective II.3: Identify and protect unique Lamine River Basin aquatic habitats from development or degradation.

- Coordinate fish population sampling on the main stem Lamine River with universities, MDC-Fisheries Research and Regional Fisheries personnel to further define and delineate unique and critical habitats.
- Protect Elk Lick Spring and spawning riffles used by walleye and Missouri River fishes through acquisition, landowner easements or cooperative projects.

Goal III: Maintain diverse and abundant populations of native aquatic species while accommodating angler demands for quality fishing.

Objective III.1: Evaluate and maintain sportfish populations and maintain sufficient quality and condition of these populations to satisfy the angling public.

Guidelines:

- Develop standardized sampling procedures for target species and implement a monitoring program to obtain trend data on fish populations which will be used to determine population objectives for management purposes.
- Identify critical spawning and nursery areas for walleye, white bass and other Missouri River fishes and acquire, maintain or enhance these areas as needed to improve the habitat.
- Using regulations, stocking, habitat improvement, and other methods, implement population improvement programs for target species once population objectives have been determined for these species.

Objective III.2: Maintain populations of native non-game fishes, including the Topeka and blacknose shiners, and aquatic invertebrates at or above present levels throughout the watershed.

Guidelines:

- Develop standard sampling techniques for assessing fish communities, including the use of indicator species, and implement a monitoring program to track trends in species diversity and abundance.
- Use regulations, stocking, habitat improvement and other techniques to implement programs to protect or enhance fish species diversity and abundance.

Goal IV: Improve the public's appreciation for stream resources and increase recreational use of streams in the Lamine River watershed.

Objective IV.1: Develop and maintain access sites, bank fishing areas, and trails in sufficient numbers to accommodate anticipated increases in public use.

Guidelines:

- Conduct a recreational use survey within the basin in conjunction with a creel survey to determine existing levels of use and satisfaction with recreational opportunities in the basin.
- Acquire public access and/or frontage on Flat, Muddy, Heath, Haw and Lake creeks and the main stem of Lamine River.
- Improve bank fishing and other aquatic wildlife-based recreational opportunities on MDC lands in the basin through implementation of recommended strategies in area plans.
- Develop a nature trail and a short tour guide of stream improvement projects on the Lamine River Conservation Area.

Objective IV.2: Increase public awareness of stream recreational opportunities, local stream resources, and good watershed and stream management practices.

Guidelines:

- Work with MDC's Outreach and Education Division staff to use streams in aquatic education programs.
- Identify and develop stream locations appropriate for educational field trips near participating schools.
- Maintain a stream emphasis at public events such as the State Fair, area boat shows, etc.
- Include the Lamine River in future revisions of *Ozark Waterways, Floating in North* Missouri and other float-oriented publications.
- Include the Lamine River Basin in the publication *Missouri Watershed Survey of Recreational Value and Associated Problems.*
- Assist in the development of articles, videos, etc. that highlight Lamine River watershed recreational opportunities.
- Prepare an annual fishing prospectus for selected streams.
- Promote the formation of Stream Teams and Stream Team associations within the watershed.
- Distribute information through Stream Teams and related organizations.

Angler Guide

Flat and Richland creeks don't have much in common until they meet in Morgan County to form a prominent Missouri River tributary - the Lamine River. From its beginning just south of Highway 50 to its confluence with the Missouri, 59 river miles north, the Lamine meanders through rolling central Missouri farmland. The Lamine's waters are home to favorite fish species, and its rich bottom land produces bumper crops of corn, soybeans and milo. The uplands are pastures and oak/hickory forests.

Boaters have access to Lamine River at any of 5 ramps. Small boats can be launched in the Lamine from the parking area south of Highway 50 bridge. There is a concrete boat ramp at Route A bridge, just east of Otterville. Boats also can be launched at the east end of the steel bridge on Wildlife Road which runs from Route BB to Route A (in Otterville, where BB turns west, go due north and keep bearing right).

Catfish are probably the most sought-after species from the Lamine. Pole and line anglers favor minnows, worms and chicken liver for bait, while most set lines are baited with live sunfish. Anglers using minnows and worms will draw more from the Lamine and its tributaries than catfish, however. Drum, crappie, bass and sunfish will be regular customers, too.

For those willing to get their feet wet, wading Richland Creek can produce enjoyable green sunfish and bass fishing. There is a 12-inch length limit on bass in streams. Bass season in the Lamine River and its tributaries runs from the Saturday of Memorial Day weekend to the last day of February.

Throughout most of the year, the Lamine is floatable from its beginning. However, riffles will have to be negotiated by foot during the dry summer months from the juncture of Flat and Richland Creeks to Roberts Bluff Access.

River travelers have a good chance of catching a glimpse of an otter along the Lamine. During the Missouri Department of Conservation's 10-year otter reintroduction project, 20 river otters were released near — you guessed it — Otterville. Those otters have done well and dispersed all along the stream, even branching out into tributaries like Muddy Creek and the Blackwater River.

River access is limited downstream from Lamine CA. An exception is the 25-acre MDC Swinging Bridge site. Currently, anglers have bank access south of the old swinging bridge on MDC land. The old bridge is closed, so approach from the south on Swinging Bridge Drive north of Clifton City. Remember, landowner permission is needed when public access is lacking.

The lower Lamine has three MDC accesses: Roberts Bluff, south of I-70 at the Blackwater exit, take the south outer road east to Buffalo Prairie Road; Harriman Hill north of I-70, again from the Blackwater exit, north, then east on Route M; and de Bourgmont at Highway 41 west of Boonville.

Harriman Hill is one of MDC's oldest accesses. Primitive campsites are provided on a first-come, first-served basis. Harriman Hill provides boaters easy access to the Blackwater River, about 500 yards downstream. Approximately six miles up the Blackwater is Blackwater Bridge MDC Access, on Route K just north of the community of Blackwater.

Both Harriman Hill and de Bourgmont can put snaggers into the action during the March 15 through April 30 paddlefish season. If a wider expanse of water is your goal, it's only three miles from de Bourgmont to the Lamine's junction with the Missouri.

The Lamine River provides ample diversity, from wade fishing on the upper reaches to experiencing a Missouri River backwater tributary, not to mention all that lies between.

Other public land near the Lamine River includes Manito Lake CA and Katy Trail State Park. Manito Lake CA is east on Highway 50 to Tipton then south on Highway 5 about four miles. The lake itself is 77 acres of angling pleasure, with a disabled-accessible fishing jetty. The area's remaining 800 acres provide plenty of upland opportunities.

Katy Trail State Park is a linear park managed by the Missouri Department of Natural Resources, Division of State Parks. Katy trail is only 30 feet wide but it's over 200 miles long and will go from

Sedalia to St. Charles. It's a favorite for bicyclists, hikers and runners. The portion of Katy Trail spanning the Lamine River runs from Sedalia to Jefferson City. Katy Trail access closest to the Lamine is at Clifton City on Highway 135 in western Cooper County.

Glossary

Alluvial soil: Soil deposits resulting directly or indirectly from the sediment transport of streams, deposited in riverbeds, 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 (i.e. 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} Celsius 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.

Nektonic: 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 and 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 un-forked 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.

Wastewater 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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