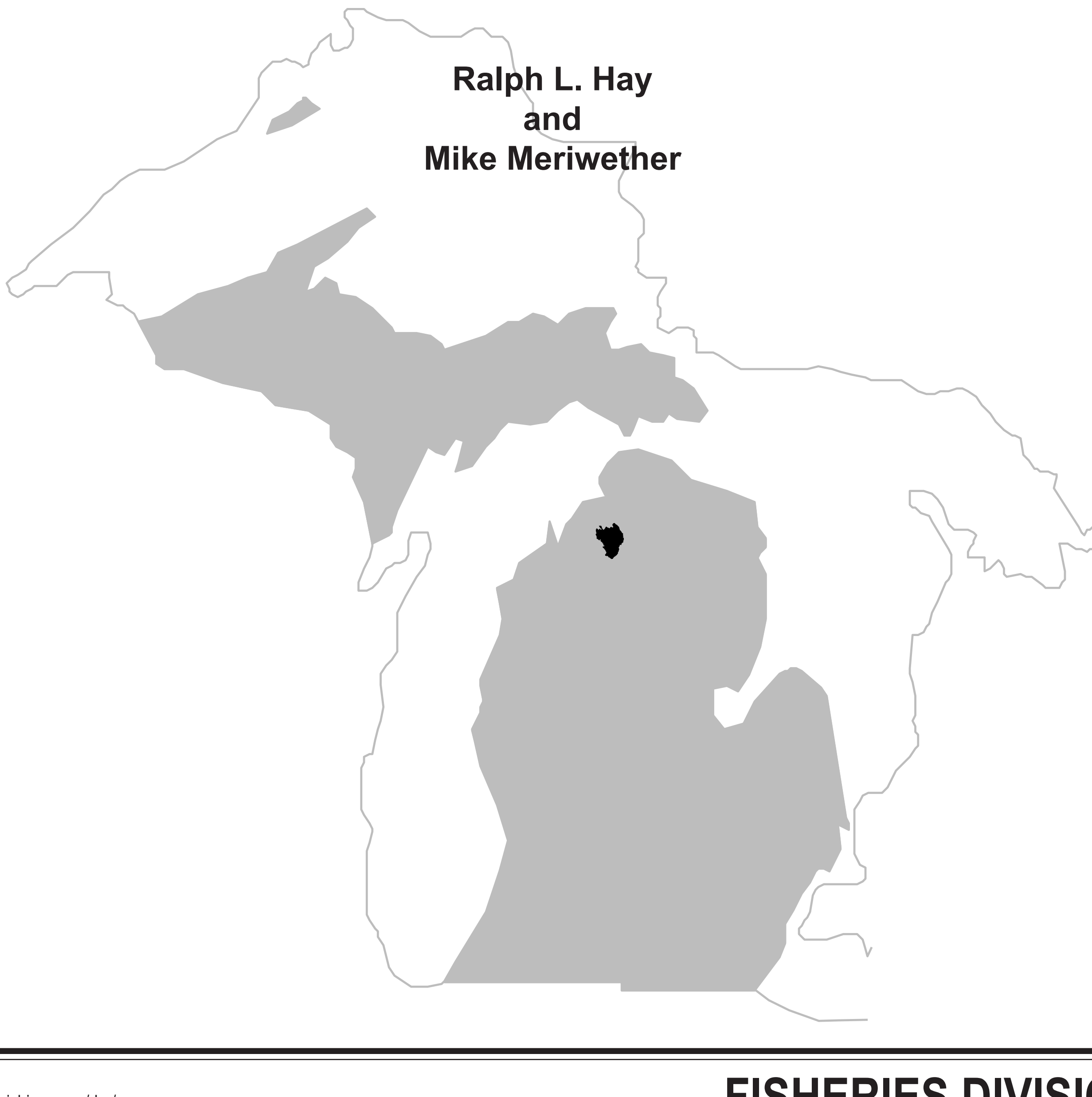
Michigan DNR

STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES

Number 28 March 2004

Jordan River Assessment

Ralph L. Hay
and
Mike Meriwether



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FISHERIES DIVISION
SPECIAL REPORT

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FISHERIES DIVISION

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Printed under authority of Michigan Department of Natural Resources
Total number of copies printed 410 — Total cost $1,914.14 — Cost per copy $4.67

Suggested Citation Format

Hay, R. L., and M. Meriwether. 2004. Jordan River Assessment. Michigan Department of Natural Resources, Fisheries Special Report 28, Ann Arbor.

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ACKNOWLEDGMENTS

The authors thank the staff of the Michigan Department of Natural Resources (MDNR), Michigan Department of Environmental Quality (MDEQ), United States Geological Survey (USGS), and Antrim Conservation District (ACD) that contributed information to the report. Special thanks to Thomas Rozich, Mark Tonello, Paul Seelbach, Liz Hay-Chmielewski of MDNR, Fisheries Division; Matthew Tonello, Frank Krist of MDNR, Land and Mineral Services Division; Greg Gatesy, MDNR, Forest Management Division; Bruce Walker, MDEQ, Surface Water Quality Division; Rick Westerhof, USFWS, Jordan River Federal Hatchery; Ellie Koon, USFWS, Sea Lamprey Control Unit; and Janet Pearson, ACD. We also appreciated the comments from the internal reviewers: Liz Hay-Chmielewski, David Borgeson Jr., Troy Zorn, Janice Fenske, and Thomas Rozich. Editorial comments from Paul Seelbach and Leon Hinz Jr. (the University of Michigan, School of Natural Resources and Environment) helped improve the content and discussion of key concepts in this assessment. A special thanks to Al Sutton for producing maps, figures, and to Ellen Grove for formatting and an eye for detail. Most of all we thank Liz Hay-Chmielewski for her diligence, patience, editing skills, organization, experience, and encouragement throughout the preparation of the assessment. Thanks to Thomas Rozich for completing the public comments section following the retirement of Ralph Hay November 2002.

EXECUTIVE SUMMARY

This assessment for the Jordan River watershed is one of a series being prepared by the Michigan Department of Natural Resources (MDNR), Fisheries Division for Michigan rivers. This report describes the Jordan River watershed and its biological communities.

River assessments are intended to provide a comprehensive reference for individuals who seek information about a river system. It pulls together known information about the watershed and demonstrates how the river is influenced by the physical landscape and its relationship to biological communities. Assessments are prepared to help identify problem areas and provide opportunities for solving these problems. It also identifies areas where information is needed to better understand, manage, and protect the river. Also, it is anticipated that this assessment will encourage citizens to become involved in the decision-making process that will benefit the river and its users.

This document consists of four principal sections: introduction, watershed assessment, management options, and public comments (with our responses). The watershed assessment is the nucleus of the document. The characteristics of the Jordan River watershed are described under twelve sections: geography, history, geology and hydrology, soils and land use patterns, channel morphology, dams and barriers, water quality, special jurisdictions, biological communities, fisheries management, recreational use, and citizen involvement.

The management options section identifies a variety of challenges and opportunities for protection, rehabilitation, or obtaining additional information to better understand the Jordan River. These management options are organized similar to the main sections in the river assessment. The management options listed are not necessarily recommended by MDNR, Fisheries Division, but are intended to provide a foundation for public discussion and aid in planning for the future of the Jordan River watershed.

The Jordan River is located in the northwest portion of Michigan's Lower Peninsula and drains an area of approximately 127 square miles in Antrim and Charlevoix counties. The mainstem of the Jordan River is 22.9 miles long, with a 485 foot drop in elevation between the source and the mouth at Lake Charlevoix. There are 29 named tributaries totaling approximately 90 miles. Major tributaries include Green River, Deer Creek, and Landslide Creek. The Jordan River watershed is primarily a riverine system since there are only three natural lakes (Deer, Mud, and Satterly) in the watershed. Nearly one-third (31%) of the watershed is state-owned land and the remainder is private.

For purpose of discussion, the Jordan River watershed is divided into three mainstem valley sections. Sections were identified based upon surficial geology, topography, and channel and valley characteristics. The upper Jordan River section flows across glacial outwash sand and gravel. It flows through predominately state-owned land its entire length from its origin downstream to Graves Crossing. Average gradient in this 12.9-mile section is 31.8 ft/mi. The riparian stream corridor consists of lowland swamp conifer forest. Upland hardwood forest dominates the steep rolling hills adjacent to the river valley. Water temperatures are cold and the stream channel is full of large woody structure. The lower Jordan River from Graves Crossing downstream to Lake Charlevoix flows across lacustrine sand and gravel. Average gradient in this 10-mile section is 7.5 ft/mi. The river lies within a wide valley and has a more defined stream channel. Lowland conifers border the stream and land ownership is a mixture of state and private. Agricultural lands are scattered along tributary streams. Deer Creek flows across a mixture of outwash sand and gravel, coarse glacial till, and lacustrine sand and gravel. It flows through private land and drains an extensive lowland swamp conifer forest. This 9.6-mile stream has an average gradient of 13.0 ft/mi. Agricultural lands dominate the upper reaches with a mixture of residential and light industrial land in the lower reaches.

Bands of Ottawa Indians are believed to have periodically inhabited the Jordan River watershed. Europeans settled the watershed around the mid-1800s, near the mouth of the Jordan River. Lumbering began in the late 1800s and continued into the 1920s. Pine were the first trees harvested for building material followed by the harvest of the vast stands of upland hardwoods. Hardwoods were used for lumber, wood alcohol, and charcoal in the manufacturing of pig iron.

The Jordan River is one of the most stable flowing streams in Michigan and has one of the highest baseflow yields in the state. It is one of only a few streams in the state that capture groundwater from adjacent watersheds. The hydrology of the watershed is strongly influenced by glacial deposits. The majority of the surficial geology deposits are glacial outwash sands, gravel, and coarse textured moraines. These glacial deposits contribute to the abundance of cold water and extremely stable flows. The Jordan River does not experience flood or drought conditions typical of many Michigan streams.

Approximately 61% of the watershed is classified as deciduous forestland and 27% as agricultural. Agricultural land uses include croplands (row crops and hay), pasture lands, and abandoned or fallow grasslands. Forestland uses include timber for building materials and paper products. Recreational uses are fishing, canoeing, hunting, camping, hiking, and general outdoor activities. There are 192 natural gas wells and one oil well in the watershed, the majority located on private land. There are 88 road-stream crossings identified. It is estimated that 30% of the crossings inhibit fish movement. The watershed is still rural, as there are no urban areas. The City of East Jordan lies at the mouth of the Jordan River outside the watershed boundary.

The average gradient of the Jordan River mainstem is 21.2 feet per mile, ranging from 32.3 feet per mile in the upper Jordan River to 3.3 feet per mile downstream from Webster Bridge. The gradient in the upper Jordan River does not appear high due to abundance of large woody structure creating numerous small diversions and mini-waterfalls, thus reducing the stream energy that could be used to incise the stream channel. The stream channel is shallow, wide, and in many places braided as it flows through glacial outwash sand and gravel. Excluding the extensive braiding of the stream channel, it averages about 94 feet wide. The stream returns to a single channel below Graves Crossing and averages about 60 feet wide. Deer Creek ranges from 12-15 feet in width above Patricia Lake.

Within the watershed there are only three dams registered with Michigan Department of Environmental Quality. One is located on the Green River and two are located on Deer Creek. The uppermost dam on Deer Creek is a lake-level control structure that maintains a legally established lake level for Deer Lake. The lowermost dam on Deer Creek is a retired hydroelectric dam that creates Patricia Lake. This dam blocks fish migrations including spawning sea lamprey, a serious pest in the Great Lakes. The dam on the Green River diverts water through a series of ponds that have been used for trout rearing. At the present time this facility is not commercially raising trout. Patricia Lake and Green River dams are detrimental to the overall health of the river because they impound high gradient fish spawning habitat, impair habitat for aquatic invertebrates, block fish movements, increase water temperatures, trap sediment, and fragment aquatic habitat. There are probably less than 20 small human-made dams and barriers on the smaller tributary streams.

There is one seasonally operated electric barrier on the mainstem of the Jordan River. This barrier was initially constructed to block adult migrating sea lamprey and is still operational each spring. It is also operated in fall to block salmon migrations in lieu of an abandoned mechanical barrier at the river mouth in the City of East Jordan.

Overall water quality is excellent in the Jordan River. There is very little development in the watershed. Geology of the watershed permits most precipitation to percolate through the extensive sand and gravel moraines. Most of the river water is from high-quality groundwater sources. Sand

and sediment from point and nonpoint sources have been a major concern. A great amount of effort has already been directed at controlling sediment input by Antrim and Charlevoix Conservation Districts, Friends of the Jordan River Watershed, Michigan Department of Environmental Quality, and Michigan Department of Natural Resources. Maintenance of stabilized banks, road stream crossings, and sand traps in the river are ongoing. Additionally, there are a few areas affected by excessive nutrients and these are being addressed through improvements in technology and best management practices.

Several governmental agencies have regulatory responsibilities that affect the river. The Michigan Departments of Natural Resources and Environmental Quality manage natural resources and state-owned lands, and enforce environmental regulations. The US Fish and Wildlife Service, US Department of Agriculture, Natural Resources Conservation Service, and US Environmental Protection Agency have responsibilities for specific Federal mandates. Counties and townships are involved in planning and zoning activities. Friends of the Jordan River Watershed, Inc. is the most active of the local, nonprofit organizations working within the watershed.

Fifty-one species of fish were native to the Jordan River watershed. Earliest written records that mention fish in the Jordan River are from the mid-1800s. Those records speak of the abundant grayling. Brook trout were first documented in the Jordan River in 1857. They were either native or recent migrants across Lake Michigan from Michigan's Upper Peninsula. The Jordan River now contains about 58 species of fish; eight of these are non-indigenous. One of the original species (Arctic grayling) is extirpated and four (finescale dace, common shiner, mimic shiner, and banded killifish) are of unknown status. No species of fish found in the watershed is listed as endangered, threatened, or of special concern by the Michigan Natural Features Inventory (MNFI).

Thirty-six species of amphibians and reptiles requiring water or wetlands for at least part of their life cycle have been identified as likely to be found in the Jordan River watershed. Three reptiles (wood turtle, Blanding's turtle, and eastern massasauga rattlesnake), but no amphibians are listed as special concern by MNFI.

One hundred sixty two species of birds are likely to be found in the Jordan River watershed. Fifty-six species have confirmed breeding status in the watershed. Seven species are listed as threatened and eight species are listed as special concern by MNFI.

Fifty-two species of mammals are listed as likely to be found in the Jordan River watershed. The woodland vole is listed as special concern by MNFI.

There have been 19 different vegetative cover-types inventoried on state land. Upland hardwood forests comprise 66% (including 12% aspen) and mixed swamp conifers 10%.

Three aquatic pest species are found in the Jordan River watershed. The sea lamprey (*Petromyzon marinus*) is the most serious pest. Also present are the microscopic protozoan *Myxobolus cerebralis*, a parasite that causes "whirling disease" in salmonid fishes, and purple loosestrife (*Lythrum salicaria*) a wetlands plant that displaces native plants.

The Jordan River and tributary streams are designated trout streams and are managed for trout and salmon. Brook and brown trout are abundant in the mainstem and in most tributaries. Potamodromous species, such as steelhead, coho salmon, and chinook salmon are also found in streams not blocked by barriers.

The Jordan River, from the headwaters downstream to Graves Crossing, has stable flows and cold water temperatures. The stream has an abundance of large woody structure and sand dominates the stream bottom. Brook, brown, and steelhead in addition to coho and chinook salmon are found in this section. Brook trout dominate from the headwaters downstream to the Jordan River National Fish Hatchery (JRNFH). Angling for brook trout is considered good with average size being small. Brown trout numbers increase from the JRNFH downstream to Graves Crossing.

The Jordan River from Graves Crossing downstream to Lake Charlevoix is a larger river. There is less woody structure in the stream and sand bedload is still common, although there are more gravel areas. Salmon and steelhead dominate this section of river. Most potamodromous angling occurs downstream from the electric barrier that blocks the upstream migration of fish from Lake Michigan. The electric barrier is operated in spring to block adult sea lamprey, but it also blocks most spring-run steelhead. In fall it is operated to block migrating chinook salmon, but also blocks some steelhead and coho salmon. There is a limited fall potamodromous fishery upstream from the electric barrier.

Deer Lake is the headwater of Deer Creek. The lake contains warmwater species of fish and provides good fishing for largemouth bass, yellow perch, rock bass, bluegill, and pumpkinseed. Deer Creek downstream to Patricia Lake has good gradient, with pool and riffle habitat. Water temperatures are cold and water quality is good. Angling is reported to be good for brown trout with an occasional brook trout. Development of public access on Deer Creek would enhance angling opportunities. Patricia Lake dam blocks potamodromous fish including sea lamprey. Passage of potamodromous fish over the dam would enhance natural reproduction of these species and provide additional angling opportunities. Removal of the dam would rehabilitate high gradient spawning gravel for fish. However, sea lamprey would have to be blocked from using Deer Creek for spawning or the creek would have to be chemically treated.

The Jordan River supports a wide variety of recreational activities. Many activities center on the river and river corridor and include fishing, canoeing, swimming, hunting, trapping, mushrooming, hiking, photography, and snowmobiling. There are three designated state watercraft launches on the mainstem of the Jordan River (Graves Crossing Forest Campground, Webster Bridge, and Rogers Road) and one on Deer Lake. There are two designated state Forest Campgrounds, one at Graves Crossing and the other at Pinney Bridge.

Management and preservation of the Jordan River receives strong public support from many different organizations. Some organizations work on specific issues such as fishing, hunting, and trapping. Friends of the Jordan River Watershed, Inc. work to educate and involve citizens regarding management and preservation of the entire watershed. It is important that local organizations and citizenry continue working to protect, manage, and rehabilitate the aquatic resources of the Jordan River because of public and private ownership, multiple user-groups, and limited governmental funding.

INTRODUCTION

This river assessment is one of a series of documents being prepared by Fisheries Division, Michigan Department of Natural Resources, for rivers in Michigan. We have approached this assessment from an ecosystem perspective, as we believe that fish communities and fisheries must be viewed as parts of a complex aquatic ecosystem. Our approach is consistent with the mission of the Michigan Department of Natural Resources, Fisheries Division, namely to "protect and enhance the public trust in populations and habitat of fishes and other forms of aquatic life, and promote optimum use of these resources for benefit of the people of Michigan".

As stated in the Fisheries Division Strategic Plan, our aim is to develop a better understanding of the structure and functions of various aquatic ecosystems, to appreciate their history, and to understand changes to systems. Using this knowledge we will identify opportunities that provide and protect sustainable fishery benefits while maintaining, and at times rehabilitating, system structures or processes.

Healthy aquatic ecosystems have communities that are resilient to disturbance, are stable through time, and provide many important environmental functions. As system structures and processes are altered in watersheds, overall complexity decreases. This results in a simplified ecosystem that is unable to adapt to additional change. All of Michigan's rivers have lost some complexity due to human alterations in the channel and on surrounding land; the amount varies. Therefore each assessment focuses on ecosystem maintenance and rehabilitation. Maintenance involves either slowing or preventing losses of ecosystem structures and processes. Rehabilitation is putting back some structures or processes.

River assessments are based on ten guiding principles of Fisheries Division. These are: 1) recognize the limits on productivity in the ecosystem; 2) preserve and rehabilitate fish habitat; 3) preserve native species; 4) recognize naturalized species; 5) enhance natural reproduction of native and desirable naturalized fishes; 6) prevent the unintentional introduction of exotic species; 7) protect and enhance threatened and endangered species; 8) acknowledge the role of stocked fish; 9) adopt the genetic stock concept, that is protecting the genetic variation of fish stocks; and 10) recognize that fisheries are an important cultural heritage.

River assessments provide an organized approach to identifying opportunities and solving problems. They provide a mechanism for public involvement in management decisions, allowing citizens to learn, participate, and help determine decisions. They also provide an organized reference for Fisheries Division personnel, other agencies, and citizens who need information about a particular aspect of the river system.

The nucleus of each assessment is a description of the river and its watershed using a standard list of topics. These include:

Geography - a brief description of the location of the river and its' watershed; a general overview of the river from its headwaters to its mouth. This section sets the scene.

History - a description of the river as seen by early settlers and a history of human uses and modifications of the river and watershed.

Geology and Hydrology - patterns of water flow, over and through a landscape. This is the key to the character of a river. River flows reflect watershed conditions and influence temperature regimes, habitat characteristics, and perturbation frequency.

Soils and Land Use Patterns - in combination with climate, soil and land use determine much of the hydrology and thus the channel form of a river. Changes in land use often drive change in river habitats.

Channel Morphology - the shape of a river channel: width, depth, sinuosity. River channels are often thought of as fixed, apart from changes made by people. However, river channels are dynamic, constantly changing as they are worked on by the unending, powerful flow of water. Diversity of channel form affects habitat available to fish and other aquatic life.

Dams and Barriers - affect almost all river ecosystem functions and processes, including flow patterns, water temperature, sediment transport, animal drift and migration, and recreational opportunities.

Special Jurisdictions - stewardship and regulatory responsibilities under which a river is managed.

Water Quality - includes temperature, and dissolved or suspended materials. Temperature and a variety of chemical constituents can affect aquatic life and river uses. Degraded water quality may be reflected in simplified biological communities, restrictions on river use, and reduced fishery productivity. Water quality problems may be due to point source discharges (permitted or illegal) or to nonpoint source runoff.

Biological Communities - species present historically and today, in and near the river; we focus on fishes, however associated mammals and birds, key invertebrate animals, threatened and endangered species, and pest species are described where possible. This topic is the foundation for the rest of the assessment. Maintenance of biodiversity is an important goal of natural resource management and essential to many fishery management goals. Species occurrence, extirpation, and distribution are also important clues to the character and location of habitat problems.

Fishery Management - goals are to provide diverse and sustainable game fish populations. Methods include management of fish habitat and fish populations.

Recreational Use - types and patterns of use. A healthy river system provides abundant opportunities for diverse recreational activities along its mainstem and tributaries.

Citizen Involvement - an important indication of public views of the river. Issues that citizens are involved in may indicate opportunities and problems that the Fisheries Division or other agencies should address.

Management Options follow and list alternative actions that will protect, rehabilitate, and enhance the integrity of the watershed. These options are intended to provide a foundation for discussion, setting priorities, and planning the future of the river system. Identified options are consistent with the mission statement of Fisheries Division.

Copies of the draft assessment were distributed for public review beginning September, 2002. A public meeting was held October 23, 2002 in East Jordan, Michigan. Written comments were received through November 15, 2002. Comments were either incorporated into this assessment or responded to in this section.

A fisheries management plan will be written after completion of this assessment. This plan will identify options chosen by Fisheries Division, based on our analysis and comments received, that the Division is able to address. In general, a Fisheries Division management plan will focus on a shorter time period, include options within the authority of Fisheries Division, and be adaptive over time.

Individuals who review this assessment and wish to comment should do so in writing to:

Michigan Department of Natural Resources
Fisheries Division
922 Emerson Road
Traverse City, Michigan 49686

RIVER ASSESSMENT

Geography

The Jordan River is located in the northwest Lower Peninsula of Michigan (Figure 1). This 22.9-mile river drains a watershed of approximately 127 square miles, contained within Antrim and Charlevoix counties. The river originates from several springs located in the northwest ¼ of the southeast ¼ of Section 21 of Warner Township, Antrim County, Michigan, at an elevation of 1066 feet above sea level. The river meanders southwesterly for about half its length until just before the confluence with the Green River. It then flows northwesterly into the South Arm of Lake Charlevoix in the city of East Jordan at an elevation of 581 feet (Figure 1). Lake Charlevoix drains into Lake Michigan at the City of Charlevoix.

The nearest large metropolitan area is Grand Rapids, Michigan, located 155 miles south of the Jordan River. Smaller nearby cities include: Traverse City, 44 miles southeast; Cadillac, 69 miles south; and Gaylord, which is 15 miles to the east.

There are 29 named tributaries totaling approximately 90 miles that flow into the Jordan River (Figure 2). An inventory of stream tributaries includes all streams identified from United States Geological Survey (USGS) topographic maps and cross referenced to the map book of Michigan Counties, Michigan Natural Resources Magazine. Most tributaries are less than three miles long, and have sufficient gradient to produce pools and riffles typical of Michigan trout streams. The largest are Green River, Landslide Creek, and Stevens Creek that flow north to the mainstem, and Deer Creek that enters the mainstem from the east. There are also approximately 15 unnamed permanent flowing tributaries.

Although draining a relatively small watershed, the Jordan River changes from its headwaters to Lake Charlevoix. It drops significantly in elevation (approximately 485 ft in 22.9 mi), flows across different landforms having distinct surficial geological characteristics, and changes in channel shape (Seelbach et al. 1997). Seelbach et al. (1997) identified 15 distinct valley segments for the Jordan River and major tributaries. Each valley segment is relatively homogenous in hydrology, limnology, channel morphology, and riparian characteristics; and breaks between segments usually occur at stream junctions, sharp changes in stream gradient, and boundaries of landforms. For this assessment and for ease of discussion by topic it was decided to combine several valley segments (identified by Seelbach et al. 1997) into “sections” of the watershed based upon landform elevation, surficial geology, and riparian characteristics. The three sections are: Upper Jordan River, Lower Jordan River, and Deer Creek (Figure 3).

Upper Jordan River

The Upper Jordan River flows through state-owned land its entire length. It flows across glacial till and outwash material (see **Geology and Hydrology and Channel Morphology**). Adjacent to the river is lowland swamp conifer forest eventually giving way to steep rolling upland forests. The headwaters consist of several springs located in a small, white cedar dominated wetland one mile west of Highway 131 and north of Jordan River Road (Figure 4). Streams originating from these small springs join together creating the mainstem, which then crosses Jordan River Road less than 200 yards from its origin. This upper segment is 12.9 miles long and begins building in size as it picks up water from Landslide and Stevens creeks and then the Green River. Six Tile, Section Thirteen, and Cascade creeks also contribute water. In addition to tributaries, the Upper Jordan River picks up considerable water from mainstem spring seeps. Water temperature in this section is cold and flows are very stable. The river has high gradient, but due to the large amount of instream woody structure, has braided channel morphology.

Lower Jordan River

The Lower Jordan River differs considerably from the upper section. Land within the lower catchment basin is a mixture of public and private ownership with some limited riparian residential development. Lowland swamp conifer forests still dominate the widening river corridor with the upland forests becoming more distant. Moderate amounts of agricultural activities occur in this lower section.

This section begins at the Graves Crossing timber bridge east of Highway 66 (Figure 4). The river turns northwesterly and returns to a single channel as it flows unconfined across a historical lake plain. This section flows for 9.6 miles and empties into the South Arm of Lake Charlevoix at the City of East Jordan. The river begins with swift current and then slows as it loses gradient. Flow stability remains very high.

Deer Creek

Deer Creek is privately owned its entire length. Agricultural activities dominate the upper end, with residential housing and light industrial development more prevalent on the lower end. Adjacent to Deer Creek is lowland swamp conifer forest quickly changing to rolling hardwood forest mixed with agricultural lands.

This section begins at the headwaters of Deer Creek at the Deer Lake outlet and flows 9.6 miles to the mainstem. The section flows through glacial outwash sand, gravel, and post-glacial alluvium. The stream receives groundwater inflows and has cold summer temperatures. It begins with a relatively low gradient as it flows through a large cedar and mixed hardwood swamp. Gradient increases in the lower half of the mainstem. A retired hydroelectric dam at Patricia Lake impounds Deer Creek. Below Patricia Lake impoundment, water flows remain stable and summer stream temperatures are elevated. Warner Creek is the largest tributary contributing flow to Deer Creek.

History

Native American activities within the river valley have not been well documented. Historians generally agree that the Ottawa tribe settled in the straits region of Lake Huron and Lake Michigan around the eighteenth century (Tanner 1986). Ottawa homelands overlapped with the larger Chippewa, Huron, and Potawatomi nations of the Great region (Dunbar 1965). Bands of Ottawa Indians would encamp from time to time near the mouth of the Jordan River. The Odawa Muhkwa (Ottawa Bear Clan) main village was built on the shore of what is now called South Arm of Lake Charlevoix (Minungus 1996). It was comprised of large rectangular structures topped with barrel-shaped roofs. Constructed of wood frames covered with birch or elm bark, each building was large enough to house as many as nine families. At times the Odawa village was home to three or four hundred people (Minungus 1996). The village was also dotted with temporary conical, bark covered tepees, which were moved as needed in the summer time to hunt, fish, or gather the resources of the land along the Zeebeh (Jordan River) (Minungus 1996). The importance of domesticated crops, especially corn, cannot be overstated. Within each village each person had an important role in producing food and assuring the well being of the group. When the Tchihmo-kahmon (long knife referring to European settlers) came and changed the area forever, the Odawa moved on. During the late 1800s some of the Odawa returned and purchased back land from the government (Minungus 1996).

Large scale logging of the river valley in the late 1800s changed the landscape of the region and had a major effect on the river. The valleys, including the stream corridor, were logged to the last tree of marketable size. The landscape of the river basin prior to the logging era consisted of mature forest of mostly deciduous trees, with sugar maple, basswood, white ash, aspen, and beech dominating the uplands. White cedar, white pine, hemlock, and associated lowland species dominated the river corridor. No documentation was found that the Jordan or Green Rivers were used to transport logs to market. There are several reasons that the Jordan River escaped the fate of so many other Michigan rivers. First, the Jordan River watershed was primarily northern hardwood forest and hardwoods were not harvested until the late 1800s and early 1900s, after the pine forests were exhausted. At this time railroads were well established, facilitating transportation of logs and hardwoods that were hard to float, being denser and less buoyant. Secondly, the Jordan River watershed does not have the qualities necessary to float logs. There is a true lack of rollways sites close to the river, with Deadman’s Hill the closest. Third, a tremendous number of check or splash dams would have had to be constructed, as the Jordan River has very stable flows, even today. No evidence of these dams has been found. Fourth and finally, the Jordan River above the confluence of the Green River has insufficient volume to effectively float logs.

In 1840, Amos Williams is thought to have been one of the first Europeans to have settled in the river valley and is credited with naming the river “Jordan” after the holy land cited in the Bible (Munroe 1869). Settlement of the river valley began at its mouth in 1869, with the establishment of a lumber camp owned by the Redlington Lumber Company (Galmore 1949). In 1873, Solomon G. Isman settled on 80 acres near the south arm of Pine Lake (now Lake Charlevoix) and established the ”South Arm” post office in 1874 (Galmore 1949). Active homesteading of the area began in 1874.

In 1879, Mr. J.C. Glenn moved his hardwood sawmill from Leland to East Jordan. He was joined by William P. Porter and together they formed the East Jordan Lumber Company. The company controlled most of the hardwood acreage in Jordan Township, plus other acreage in Echo and Chestonia townships. The Antrim Iron Company controlled additional acreage in Antrim, Kalkaska, and Otsego counties. Their operations included manufacturing of charcoal, wood alcohol, pig iron, and hardwood lumber (W. Kirkpatrick, Antrim Conservation District forester, retired, personal communication). The coming of the Glenn and Porter sawmill was the beginning of the lumber industry in the region. Land granted to Davis Ward of Pontiac resulted in the Detroit to Charlevoix Railroad. Mr. Ward quickly added the Fredric to East Jordan spur as, “Insurance for his timber” (Hoover et al. 1996). Logging operations intensified throughout the late 1800s and continued through the mid-1920s. Because of their large land holdings, the Antrim Iron Company was able to operate into June of 1944.

The lumber industry employed hundreds of men that worked during winter. Many men arranged with their employers to buy forty acres of cleared land (usually the sawmill owner was also the landowner). These men homesteaded and converted forest to agricultural land. The 1920 census lists Antrim County with a total of 1,750 farms (W. Kirkpatrick, Antrim Conservation District forester, retired, personal communication). These small family farms were primarily subsistence farms.

Prior to the climax of lumbering era in the late 1800s, the Jordan River was quite an attraction for people throughout the nation. The abundant grayling were the target of many anglers traveling to the area. Later, steamers from Chicago would bring sightseers into the Charlevoix area and boats would take many up the Jordan River as far as Webster’s Road, where they would eat lunch before heading back down river. A swing bridge at East Jordan facilitated boat travel up the river (D. Borgeson, MDNR, Fisheries Division, personal communication).

Forest fires were a natural aftermath on the thousands of acres of land bearing the remains of freshly cut trees. The Department of Conservation advocated the use of fires as they helped eliminate wood debris from the land in preparation for productive agricultural crops (W. Kirkpatrick, Antrim Conservation District forester, retired, personal communication). It was not until 1922 that the Michigan Department of Conservation (now the Michigan Department of Natural Resources) adopted a fire prevention policy. However, even with this policy, many fires burned uncontained throughout the Jordan River Valley (W. Kirkpatrick, Antrim Conservation District forester, retired, personal communication).

Agricultural activities were relatively short lived within the river valley. Sandy, nutrient poor soils and a short growing season discouraged many farmers. After World War I, as industrialization and auto production began to take off in southern Michigan, jobs and opportunities developed there. Gradually, under-employed loggers and farmers abandoned their lands for greater fortunes within the developing urban areas of southern Michigan. It is estimated that 650 farmers left Antrim County within the 18-year period 1920–1938 (W. Kirkpatrick, Antrim Conservation District forester, retired, personal communication). Similar exits from farms were experienced in other Northern Michigan counties. Over the course of a few years, many of the abandoned acres reverted back to the State of Michigan because of non-payment of property taxes (W. Kirkpatrick, Antrim Conservation District forester, retired, personal communication). Much of the upper Jordan River remains in state ownership.

Land uses in the past 100 years have affected the Jordan River watershed. Logging, fire, road and railroad construction, and agricultural activities altered both stream hydrology and sediment loading. Removal of land vegetation increased stream yield by reducing evapotranspiration losses (Berry 1992). Fragile sandy soils, destabilized by these activities quickly eroded to the river. Excessive sand bedload degrades fish habitat and negatively effects trout survival and growth of all life stages (Hansen 1971; Alexander and Hansen 1982).

Individual efforts to increase public awareness of problems in the watershed, and to remedy these, began as early as 1961. In 1966, the “Save the Jordan” steering committee drafted bylaws for an inter-municipality committee, under the provisions of Michigan’s Act 200 of the public Acts of 1957. The “Save the Jordan” steering committee served as a precursor to the Jordan River Watershed Commission. On January 15, 1967, the Jordan River Watershed Commission became one of the first groups in the State of Michigan to be formed for the purpose of maintaining and preserving a river. Eleven sub-state governmental units entered into agreement under the authority of P.A. 200 of 1957. The Jordan River Watershed Commission set the pattern for the future stewardship of the river. Through the Jordan River Watershed Commission, the Jordan became the first Michigan river to be designated under the State Natural Rivers Act (P.A. 231 of 1970). It was designated a Wild and Scenic River by MDNR, Natural Resource Commission in 1972 (see **Special Jurisdictions**).

Geology and Hydrology

Melting glaciers formed the Jordan River watershed. During the Wisconsonian stage of glaciation in the Pleistocene Epoch, 10,000 to 75,000 years ago, most of Michigan and Indiana were covered with ice (Farrand and Eschman 1974). The retreat of glaciers left Michigan with a geologically youthful and complex landscape. The Jordan River watershed is thought to have been formed during the re-advancement of the Cay ice front 13,000 years ago (Farrand and Eschman 1974). This ice front culminated in a well-developed terminal moraine system known as the Port Huron morainic system (Farrand and Eschman 1974). The subsequent glacial retreat strongly influenced soil types, topography, and hydrology of the river. The resulting landforms (hills and valleys) along with proximity to Lake Michigan influence the amount and frequency of precipitation. The path that water takes (by surface runoff or through groundwater flow) to the stream channel affects the volume and stability of flow, channel morphology, temperature, water quality, and subsequently biological communities (Wiley and Seelbach 1997).

Geology and Physiography

Land features created by melting and movement of glaciers characterize the surface geology of the northern part of the Lower Peninsula of Michigan (Farrand and Eschman 1974). Surface topography and soils of the Jordan River valley are end moraines, outwash sand channels, and coarse tills with gentle to steep slopes and drainage draws created during the last continental glacial period, the Wisconsonian (Farrand and Eschman 1974). Coarse textured moraines are unsorted mixtures of sandy loams, outwash sand and gravel, clay lenses, and cobble and boulders. The Jordan River watershed drains extensive deposits of outwash sand and gravel (Figure 5; Farrand and Bell 1982). Glacial outwash is deposited by rapidly melting waters from the glaciers at end moraines. This material is fine to coarse sand alternating with layers of small gravel to large cobble. This water carried a mixture of sand, gravel, and cobble; this material was deposited as water velocity decreased, dropping cobble first and carrying sand farthest from the edge of the glacier. Lacustrine sand and gravel, along with some fine organic material are present only in the lower reaches of the Jordan River valley (Anonymous 1978).

These glacial deposits have strong influences on land use, soils, and river behavior. The finer textured end moraine and lucustrine deposits areas are associated with sandy loam and loam type soils typically used for agricultural. Forest lands occur on the coarser textured till and outwash sand and gravel within the watershed (see **Soils and Land Use Patterns**).

Geologic features of the Jordan River are relatively consistent throughout the river sections (see **Geography**). Nearly 90% of the watershed is glacial outwash sand and gravel, and coarse textured till (MDNR, Spatial Information Resource Center, unpublished data). Lacustrine sand and gravel deposits make up the remainder of the watershed. With surficial geologic material dominated by outwash sand and glacial till, the Jordan River experiences higher groundwater yield rates and lower runoff rates than areas in Michigan dominated by clay or silt lake-bed materials (Bent 1971; Richards 1990; Wiley and Seelbach 1997). The vast quantities of highly permeable, deep sandy glacial deposits in the watershed allow for high rates of water infiltration. The relatively high elevations (400 ft at Deadman’s Hill) provide the necessary groundwater slope (and hydrostatic pressure) resulting in large volumes of groundwater flow into the river system. The Jordan River has the second highest mean groundwater loading (2.23 meters per day) of the 35 major watersheds in the Lower Peninsula of Michigan (Wiley and Gough 1995). Relative contributions of groundwater to a stream determine flow stability and water temperature.

Groundwater flows into the Jordan River also benefit from being located at a lower altitude than adjacent inland river basins. This river captures additional groundwater from these adjacent basins, creating exceptionally high base flows (Hendrickson and Doonan 1972).

Climate

The Jordan River’s northern latitude, exposure to the effects of Lake Michigan, and higher topography control the climate in the watershed (Eichenlaub 1990; Albert et al. 1986). Lake Michigan tends to moderate extremes in air temperatures. Spring and summer are cooler and fall and winter are warmer than inland areas at the same latitude. Reducing the risk of late spring freezes combined with extended mild fall temperatures extends the growing season (Albert et al. 1986). The prevailing westerly winds off Lake Michigan pick up moisture and as they rise over the steep topography release substantial quantities of rain and snow.

Mean annual air temperature in the Jordan River watershed is 44°F (Gooding 1995). In winter, the average air temperature is 22.6°F and the average daily minimum temperature is 14.7°F (Anonymous 1978). During the summer, average July air temperature is 68°F (Gooding 1995).

Mean annual total precipitation in the watershed is 35.67 inches (National Weather Service, Gaylord, MI). Of the total precipitation, 18.8 inches, or 53%, usually falls during April through September, which includes the growing season for most crops. The heaviest one day rainfall recorded was 5.6 inches at East Jordan on August 17, 1995. There are about 27 thunderstorms each year and most occur in June and July (Anonymous 1978).

Average seasonal snowfall is 89.9 inches. The greatest snow event at any one time during the period of record (1929-1996) was 37 inches. On average, 120 days have at least one inch of snow on the ground. Ground accumulation varies greatly from year to year. Snow accumulation is related to air temperature and precipitation (Anonymous 1978).

Annual Water Flow

The United States Geological Survey (USGS) has maintained a flow gauging station (number 04127800) on the Jordan River at Webster Bridge (about 4.5 miles upstream from East Jordan) since 1967. The catchment area upstream of this gauging station is 67.9 square miles or 53 percent of the watershed. Records from this gauging station indicate that the mean discharge rate of the Jordan River for the past 32 years is 188.7 cubic feet per second (cfs).

Precipitation falling on a watershed can take four routes. Part of the water can travel overland in the form of surface runoff; part travels quickly beneath the surface to the stream; part can be held in the soil and used by plant roots and lost through evaporation and transpiration; and part seeps down to the water table and moves slowly towards the stream channel (Hendrickson and Doonan 1972; Wiley and Seelbach 1997).

The amount and frequency of precipitation, and how that precipitation reaches the river, influences stream flow patterns. The Jordan River watershed is dominated by permeable soils contributing to extremely stable annual flows of the river. Stable flows are characterized by having lower peak flows and higher base flows, because precipitation is delivered slowly to the stream through the ground. High flows are typical in March and April compared with relatively stable flow the rest of the year (Figure 6). High discharge in early spring is a function of snowmelt and precipitation flowing rapidly across saturated soils.

Seasonal Flow

Seasonal streamflow stability is the variation in discharge over time. The magnitude and frequency of high flows determine channel morphology and are related to water quality, temperature, and biological diversity (Poff and Ward 1989). Poff and Ward (1989) found that hydrologic factors (such as flow stability) are significant environmental variables affecting fish species composition. Streams with stable flows had more species classed as specialized feeders, i.e., feeding on benthic invertebrates, other fish, and surface insects. Stable flow species were also less tolerant of silt and turbid water. Stable stream flows are crucial for trout populations, influencing growth, survival, abundance, and reproductive success (Hendrickson and Doonan 1972; Coon 1987; Seelbach 1987, 1993).

Stability of flow provides an index of many characteristics of streams, including source of flow, channel characteristics, temperature, and land cover in the watershed. Since the climatic patterns are the same throughout the watershed, differences in flow stability can be attributed to surficial geology, land cover, or human influences on land use (Wesley and Duffy 1999).

One method for analyzing flow stability is to compare the mean of the monthly mean flows for the months with the highest and lowest flows for a period of record. The lower the value, the more stable the flow. A value of 1.0 would indicate a perfectly stable flow where there is no variation between mean high and low flows. The Jordan River has a ratio of 1.3, indicating a very stable flow whereas the North Branch of the Kawkawlin River has a value of 36.2 (Figure 7). Most rivers with ratios less than 2.0 are streams where the catchment is dominated by highly permeable soils, such as sand and gravel. These are typically streams with self sustaining trout populations (P. Seelbach, MDNR, Fisheries Division, personal communication).

Flow stability can also be examined with flow duration curves using percent exceedence data from USGS gauging stations. An exceedence flow is the discharge that can be equaled or exceeded for a given percentage of time. For example, the 10% exceedence value is the discharge that can be expected to be equaled or exceeded 10% of the time within a given water year (October-September). A 10% or less exceedence value represents high flows, for example, during snowmelt or extraordinary storm (such as rain) events. The 50% exceedence value represents median discharge, as half of the time it is higher, and half of the time flow is less than this value. The 90% exceedence value is the discharge that can be expected to be equaled or exceeded 90% of the time. The 90% exceedence value is often referred to as base flow and indicates contributions of groundwater regardless of recent precipitation.

When comparing streams of different catchment size it is necessary to standardize values. One such method is to divide each exceedence flow value by its median exceedence value. The resulting standardized discharge represents the magnitude of discharge relative to its median value. For exceedence flows greater than the 50% flow the smaller the number, the more stable the stream flow. Example: if the value of 10% exceedence flow (flood conditions) divided by 50% median flow is 2, then the flood is twice the median flow.

The Jordan River has a standardized discharge at 10% exceedence of 1.2, meaning that floods are only 1.2 times the median discharge (Figure 8). The Jordan River doesn’t experience severe flooding like other rivers. By contrast, the North Branch of the Kawkawlin River has a standardized discharge at 10% exceedence of 31. This is typical of rivers in clayey or compacted soils where surface runoff contributes most of the flow. The flatter the standardized high flow exceedence curves the more stable the discharge.

The ratio of high base flows (90% exceedence flows) to the median base flow also indicates flow stability. The higher the ratio of 90% exceedence flow to 50% median flow the more stable the stream. The Jordan River has a standardized low flow discharge of 0.9, indicating high contributions of groundwater relative to overland flow (Figure 9). The North Branch of the Kawkawlin River has a ratio close to zero, indicating almost no baseflow relative to overland flow, and subsequently experiences seasonally unstable flows.

Base Flow

Base flow is that portion of precipitation that has passed into and through the soil to become groundwater and eventually discharged to the stream channel. Groundwater is slow to reach the channel and slow to decline after reaching a peak (Hendrickson and Doonan 1972). It is base flow water that keeps rivers flowing during prolonged periods of drought, typically in late summer.

Hydrographs of flow during late summer months can indicate the relative contribution of base flow to the stream. When comparing catchments of different sizes it is necessary to standardize discharge. One such method is to calculate yield; yield is defined as discharge divided by catchment area. The Jordan River has a very large baseflow yield of about 2.5 cfs/mi^2 (Figure 10), the East Branch of the Pine River near Tustin has a yield less than 0.5 cfs/mi^2, and the North Branch of the Kawkawlin River has a yield near zero. Differences in baseflow yield are largely due to geology, topography, and soils (Hendrickson and Doonan 1972).

The relative proportion of precipitation reaching the stream can be determined by comparing discharge (expressed as inches of rain in the catchment) to the annual precipitation. The smaller the ratio, the greater the loss of water to the stream. For many rivers less than 50% of the precipitation reaches the stream (Figure 11). The Jordan River is an exception in that the ratio of 1.2 indicates that the discharge is greater than what can be accounted for in precipitation falling within the catchment. It appears that the Jordan River catchment captures groundwater from more elevated inland watersheds to the southeast, most likely the Manistee and Au Sable Rivers (Hendrickson and Doonan 1972).

There are no permanent gauging stations on any tributary streams. However, the United States Fish and Wildlife Service (USFWS) has taken some flow measurements as part of their sea lamprey treatment program. In August of 1997, stream flow measurements were: 24.2 cfs for the Green River at Pinney Bridge Road, 29.4 cfs for Deer Creek at Highway M-32, and 22.5 cfs for Landslide Creek at Pinney Bridge Road (E. Koon, USFWS, personal communication). Baseflow yields in the Green River and Landslide Creek appear much greater than Deer Creek. Stream discharge is similar for the three streams despite the smaller catchment areas of the Green River and Landslide Creek. Reason for the higher yields in the Green River and Landslide Creek are due to the streams receiving high groundwater inflows from the coarse-textured end moraines to the south.

Daily Stream Flows

Daily flow stability is another very important factor in determining the health of a stream and the aquatic community it supports. In natural streams, daily fluctuations of flow are usually gradual. Large daily fluctuations can increase erosion of unstable stream banks, decrease stream cover for aquatic organisms, and strand organisms with receding waters. These fluctuations also can affect species diversity and production (Gislason 1985).

Hydrographs (graphs of daily discharge over time) are used to summarize daily flow data and flow stability. The shape of a hydrograph indicates how precipitation and snowmelt travels to a stream channel and how fast it moves through a stream system. Assuming climate is relatively constant for many years, then changes in the shape of the hydrograph may be the result of human alterations to the landscape. Changes to the landscape could be: 1) rendering extensive areas impervious to water infiltration, 2) construction of storm water drains, and 3) construction of hydroelectric dams or flow control structures (Wesley and Duffy 1999).

Peak daily flow curves in the Jordan River are very symmetrical, i.e., a rapid increase in flow is followed by an equally rapid decrease in flow (Figure 12). These flow curves are similar regardless of season. Rain, snowmelt, or combinations of both create symmetrical flow curves. Symmetrical flow curves are typical of watersheds with clayey soils and in the spring when soils are frozen or saturated with water (Wesley and Duffy 1999). However, there is very little clay in the Jordan River watershed and relatively small amounts of ground frost due to the porous sandy soils (Hendrickson and Doonan 1972). The steeper slopes and lower permeability of the moraines in the Jordan River valley result in lower rates of infiltration and groundwater discharge, and higher rates of surface runoff as compared to flat outwash sands and gravel (Hendrickson and Doonan 1972). Surface erosion on the hills is minimized due to the plant roots holding the soil particles together. The precipitation as rain or snowmelt is allowed to infiltrate the soil and move quickly down slope as shallow groundwater through the permeable glacial till and accelerated towards the stream by gravity due to the steep slopes.

There are three artificial impoundments in the Jordan River watershed (see **Dams and Barriers**). The Jordan River does not experience large daily water fluctuations due to releases from these dams. The dam on the Green River is used to impound water for fish rearing by diverting upstream water through excavated ponds. The lake-level control structure at the Deer Lake outlet maintains a minimum summer elevation in the lake. The Patricia Lake Dam has a fixed crest overflow with no means for altering discharge.

Soils and Land Use Patterns

Soils

The general distribution of soil textures in the watershed has been mapped (Figure 13). For specific soil associations and distributions, review the soil survey maps found in the Soil Survey of Antrim County (Anonymous 1978). In this assessment, soils have been lumped into three groups based on the composition of sand, loam, or clay as described below (Anonymous 1978):

Group	Soil type
A	Tawas- Ensley- Roscommon: Very poorly drained and poorly drained, nearly level, mucky, loamy, and sandy soils in depressions on plains.
B	Emmet-Montcalm: Well drained and moderately well drained, gently sloping to very steep, loamy and sandy soils on knolls, ridges, and hills.
C	Kalkaska- Montcalm: Somewhat excessively drained and well drained, nearly level to very steep, sandy soils on hills, ridges and knolls.

Upper Jordan River

The Upper Jordan River consists of glacial till and outwash material. The stream corridor is primarily composed of poorly drained soils from Group A. Upland soils are well-drained soils on steep slopes and categorized as Group C.

Lower Jordan River

The Lower Jordan River consists of glacial till then changes to lucustrine deposits below Graves Crossing. Soils along the stream corridor remain as Group A soils. Upland soils are predominately Groups B and C soils.

Deer Creek

Soils in the Deer Creek segment are mainly characterized by Group B soils but Group A soils still dominate the stream corridor. Soils remain underlain with glacial till and outwash material.

Land Use/Cover

Original land cover type in the watershed was predominately upland hardwoods (84%) and cedar swamp (13%) (Figure 14). After the logging era in the late 1800s and early 1900s, some of the forestland was converted to agriculture (see **History**). Today, deciduous forests cover about 61% of the watershed (Gooding 1995). The deciduous tree species found in the Jordan River watershed typically occur in relatively moist climates and on well drained soils relatively high in organic matter that are associated with coarse textured end moraine ridges, drumlins on ground moraines, and undifferentiated end moraine-ground moraine complexes (Burger and Kotar 1999). Of the major watersheds in the Lower Peninsula the Jordan River has the highest percentage of deciduous forests (Gooding 1995). Although the original cedar and lowland conifers were logged, the second growth still remains along the Jordan River mainstem and Warner Creek.

Forestland uses include the production of aspen, pine, and hardwood sawlogs for building construction. Forest management practices can affect river hydrology. Cutting practices and the type of vegetation being managed (such as conifer forest, hardwood forest, or grassland), affects evapotranspiration by forests, and strongly influences total and seasonal yield of water to the river (Urie 1966a; Urie 1966b; Urie 1977). Other recreational uses on forest land include wildlife hunting and viewing opportunities, fishing, camping, hiking, and scenic viewing (see **Recreational Use**).

Approximately 31% of the watershed is State of Michigan ownership (MDNR, Spatial Information Resource Center, unpublished data). Most of the public land is located in the upper section of the Jordan River mainstem, frequently referred to as the “Jordan River Valley” (Figure 15).

In contrast to the ownership of the watershed as a whole, 80 percent of the river frontage on the Jordan River mainstem is in public ownership (see **Special Jurisdictions**). This large percentage of public land, in conjunction with the Natural Rivers designation for private land, has helped protect the river by limiting activities within a 400 foot management zone (Anonymous 1974a). Public land (25,791 acres) within the watershed was obtained through the MDNR forest development fund, wildlife funds (sportsman contributions), and as tax reverted lands. Management techniques employed on public lands include select thinning in hardwood forests, shelter-wood cuts, and clear-cutting of aspen for regeneration of even-aged stands to benefit wildlife habitat (Anonymous 1993a; Anonymous 1994a; Anonymous 1994b).

Agriculture accounts for about 27% of the land use in the Jordan River watershed (Gooding 1995). Agricultural land uses include croplands (row crops, hay, and specialty crops), pasture, and abandoned or fallow grasslands. Agricultural activities are limited in most of the watershed due to dry and nutrient poor sand and gravelly soils. Most agricultural ownership occurs on gently rolling hills with a mixture of loamy and sandy soils.

Wet soil types make up 28% of the land area in the Jordan River watershed (Gooding 1995). These include loamy and organic soils that retain moisture and are conducive to agriculture. Lowland conifers and hardwoods occupy a portion of the wet soils along the rivers. As with any river, wetlands are critical for floodwater control, groundwater recharge and discharge, water quality, sediment filtering, nutrient removal, shoreline stabilization, fish and wildlife habitat, and recreation. Although regulated by the state and federal statute, wetland environments continue to be threatened by draining and filling practices. Private wetlands along rivers are often the last to be developed since many upland river sites have already been developed.

Urban development in the Jordan River watershed is less than 1% (Gooding 1995). The City of East Jordan, with a population of 2,052 residents, is adjacent to the watershed at the mouth of the Jordan River. Urban sprawl is not yet evident in this community. However, significant growth of residential and retirement homes has occurred in other larger cities nearby (Gaylord, Charlevoix, and Traverse City) and it is only a matter of time before growth spills over to the smaller communities. People are moving to rural environments for a more tranquil lifestyle. With increased development comes an increase in impervious surfaces (roofs, parking lots, and roads) that could change the hydrology of the

Jordan River (Leopold 1968; see Geology and Hydrology). Deer Creek is the most likely portion of the watershed to be affected by this development since most of the land is private.

Oil and gas development within the watershed is extensive but has been restricted to some degree. Currently there are 192 Antrim gas wells, 1 Niagara oil well, and 21 brine disposal wells within the watershed (Figure 16) (MDNR, Spatial Information Resource Center, unpublished data). Nearly 88% of the wells are located on the private land that comprises 69% of the watershed (MDNR, Spatial Information Resource Center, unpublished data). Less than 12% of the wells are located on State of Michigan land because 98% of the state land is classified as non-development or non-leasable (MDNR, Spatial Information Resource Center, unpublished data).

Upper Jordan River

Forestland dominates most of the Upper Jordan River. Lowland coniferous trees dominate the river corridor that is very poorly drained, nearly level, mucky, loamy, and sandy soils. Hardwoods dominate the uplands that are excessive to well drained, steep, sandy soils on hills, ridges, and knolls. There are some private parcels with residential homes, mostly located on tributary streams.

Lower Jordan River

There are lowland coniferous forestlands along the mainstem of the Jordan River. Agricultural pasture land is common along Highway M-66 in the moderately well drained loamy and sandy soils. Some small abandoned farm fields occur east of the Jordan River mainstem in the excessively drained sandy soils. Residential homes are more common in this lower section of the Jordan River.

Deer Creek

Lowland coniferous forestlands occur along the river corridor in soils similar to the Jordan River mainstem. Agricultural land is common in the upper sections of Deer Creek in the moderately well drained loamy and sandy loam soils. Residential homes are more numerous in the lower sections of Deer Creek.

Bridges and Other Crossings

There are 88 bridge or culvert crossings identified within the watershed (Table 1; Anonymous 2001a). There are an unknown number of private roads, driveways, and temporary trails crossing small tributary streams. In addition, oil and gas development, residential construction, and road construction associated with land development continue to increase the number of crossings within the watershed. Poorly constructed roads with steep slopes, lack of water diversion, and shoulders not stabilized are thought to be contributing sediment problems within the watershed (Anonymous 2001a). Pinney Bridge, Jordan River, and the Cascade roads have some drainage problems.

The majority of road stream crossings that exist within the watershed are located on tributary systems. Only five bridge crossings and five culvert crossings exist on the mainstem of the Jordan River. Pinney Bridge (a foot bridge), which crosses the Jordan mainstem at the junction of Pinney Bridge and Cascade roads was replaced by MDNR, Forest Management Division in 2001. Culvert crossings are far more common within the watershed than bridges. Although more economical to build, poorly placed culverts are considered a significant factor in sediment delivery to the river system. Poorly sized culverts tend to disrupt drainage patterns and also contribute sediment to a system. A road and stream-crossing inventory conducted in 2001 identified erosion and drainage issues as well as recommending best management practices (Anonymous 2001a).

There are three submerged pipeline crossings documented within the mainstem Jordan River. In the lower section there are two wastewater flow lines and a natural gas transmission line near Chestonia Bridge. There are probably fewer than a dozen buried electrical or phone lines crossing the river. Submerged crossings and those for utilities are not considered to have had a significant effect on the Jordan River system.

Channel Morphology

Channel building (erosion and deposition) is driven by the relationship between stream power and the available sediment load. Erosion occurs where stream power exceeds sediment load. Deposition occurs where sediment load exceeds stream power. The stream in attempting to achieve equilibrium between power and sediment load makes adjustments in channel form. The adjustments are made through changes in stream gradient (meandering increases stream length and reduces gradient). During the adjustment both erosion and deposition occur along a channel.

Channel gradient

Stream gradient (usually measured as feet of vertical drop per lineal river mile) and water discharge together influence channel form, streambed composition, and fish distributions because they combine to generate stream power, that is the primary force to erode and transport sediment (Hynes 1970; Knighton 1984). In glaciated areas, high gradient streams are usually found traversing end moraines. If the glacial deposits are coarse textured gravel and sand, and occur in hilly terrain, then these streams usually receive large quantities of groundwater (Wiley and Seelbach 1997). In these areas, stream gradient is also related to water temperature, flow stability, substrate composition, and distribution of coldwater fishes (Zorn et al. 2002)

The average gradient of the mainstem of the Jordan River is 21.2 ft/mi, with a range from 3.3 to 32.3 ft/mi (Figure 17). The variability in gradient affects channel shape and habitat that in turn influences the kinds of fish and other aquatic life that will inhabit the stream. Typical channel characteristics by gradient class are shown below (G. Whelan, MDNR, Fisheries Division, unpublished data). For these channel characteristics, hydraulic diversity refers to the variety of water velocities and depths found in the river. The best habitat offers a good variety of stream velocity and depth to support life histories of various aquatic species. Fish and other aquatic life are typically most diverse and productive in those parts of a river with gradient between 10 and 69.9 ft/mi (G. Whelan, MDNR, Fisheries Division, personal communication; Trautman 1942).

Gradient class	Fish habitat	Channel characteristics
0.0 – 2.9 ft/mi	low	mostly run habitat with low hydraulic diversity
3.0 – 4.9 ft/mi	fair	some riffles with modest hydraulic diversity
5.0 – 9.9 ft/mi	good	riffle-pool sequences with good hydraulic diversity
10.0 – 69.9 ft/mi	excellent	established, regular riffle-pool sequences with excellent hydraulic diversity
70.0 – 149.9 ft/mi	fair	chute and pool habitats with only fair hydraulic diversity
> 150 ft/mi	poor	falls and rapids with poor hydraulic diversity

Based upon gradient nearly 12.9 miles (56%) of the Jordan River mainstem can be classified as having excellent fish habitat due to an average gradient of 31.8 ft/mi. The remaining 10.0 miles (44%) have good habitat, with a gradient that averages 7.5 ft/mi. River valley sections are described as follows:

Upper Jordan River

The upper section has the highest gradient with a 410 feet of drop over 12.9 miles (mean of 31.8 ft/mi). The abundance of instream large woody structure and the presence of active and historical beaver ponds have impeded stream flows in this section, giving the on-site impression that there is not much gradient. What exists in the stream channel is a multitude of small drops in elevation over and around the woody structure. Stream power varies considerably within the channel based upon abundance and location of obstructions. In essence the channel contains numerous small locations where erosion, transport, or deposition are occurring. Sand deposition is more noticeable in the upper sections because the stream lacks sufficient power to readily transport sand due to its small size and stable flows. In the lower end of this section, the large water inflow from Landslide Creek and Green River increases discharge and stream power. This increased stream power is now able to transport sand more easily and form a more distinct channel. This results in the classic run–riffle and riffle-pool habitats becoming more pronounced in the lower end just above Graves Crossing.

Lower Jordan River

Good gradient constitutes 100 percent of this 10.0-mile section. The section drops an average of 7.5 ft/mi. Run-riffle and riffle-pool habitats are characteristic of this river section. The level of Lake Michigan can influence the lowermost mile of river. As Lake Michigan and Lake Charlevoix elevations increase, the velocity of the lower river decreases and this section is sometimes referred to as a “drowned river mouth”.

Deer Creek

Deer Creek is 9.6 miles long with an average gradient of 13.0 ft/mi. The upper section from Deer Lake downstream to Fuller Road has an average gradient of 7.1 ft/mi. This section has good fish habitat, with some riffle-pool sequences. The lower section from Fuller Road downstream to its confluence with the Jordan River has an average gradient of 19.8 ft/mi. It is in this section of high gradient area that the Patricia Lake dam was constructed and reduced surface water gradient in the impoundment to near zero. Above the influence of the impoundment the river has regular riffle-pool sequences.

Channel Cross Section

Channel morphology is determined by streambed and bank material, channel structures, and stream power (discharge x gradient). In stable-flow streams there can be a variety of channel forms and cross sections. In streams that flow through sand valleys the channel cross-sections tend to be wide, with shallow pools and runs. Stream channels can be wide and shallow if there are obstructions (large in-stream woody structure) in the channel that forces the flow into erodible stream bank material. In extreme cases where the channel contains numerous obstructions (woody material) there may develop multiple channels, giving the stream a braided appearance. In areas where there are stable, more resistant banks the channels may be narrower and deeper. Undersized culverts and narrow bridges may intensify erosion downstream of a structure as the increased energy (from narrowing the channel) dissipates downstream through erosion of the bottom and banks, creating deep, wide pools typically found below these structures. Detailed measurements of channel cross section can be used to identify where significant channel changes may have occurred. Unfortunately detailed historical and present channel cross sections for the Jordan River are lacking.

Upper Jordan River

This segment meanders mostly unconfined through a valley of glacial outwash sand. It has an average depth of only 16 inches with a range of 2 – 36 inches. At its beginning, the river meanders though a series of old beaver floodings with stream width from 2.5 to 65 feet. Further downstream the river flows in multiple channels due to lateral erosion of the unconsolidated stream bank material caused by the deflection of water into the banks by the abundance of instream woody material. The stream appears to be braided because of the observed multiple channels. The average stream width including all of the individual channels and islands is 94 feet (Antrim Conservation District, Stream Measurements of the Jordan River, 1999, unpublished data). The river splits into two distinct channels between Pinney Bridge and the confluence with the Green River. The abundance of large woody structure produces diverse habitat by creating a mosaic of hydraulic conditions. The channel is mostly shallow with a sand bottom; however there exist numerous small areas of swift water with gravel bottom, and also areas of deeper, slow water with overhead cover. These areas provide important spawning, feeding, resting, and nursery habitats for fish.

Lower Jordan River

This section meanders unconfined over lacustrine sand and gravel. The river returns to a single channel averaging 60 feet wide with a range from 34 to 130 feet. Stream depth ranges from 16 to 50 inches. Large woody structure is common in the stream but is primarily restricted to the shoreline. Speculation is that most of the mid-channel woody material was removed by recreational canoeists. Substrate is mostly gravel and sand.

Deer Creek

Deer Creek begins as outflow from Deer Lake, first flowing through glacial outwash sand and gravel, then through coarse textured glacial till, and finally across lacustrine sand and gravel to the confluence with the Jordan River. Gradient increases as it flows across the more resistant glacial till. Stream width ranges from 12 to 15 feet from Deer Lake downstream to Patricia Lake impoundment. There is an abundance of large woody structure from downed trees. Bottom substrate is mostly sand and gravel.

Dams and Barriers

Dams

There are three human-made dams in the Jordan River system registered with the Michigan Department of Environmental Quality (MDEQ) (Figure 18). One dam is located on Green River and two on Deer Creek. The dam on the Green River does not require inspection by MDEQ since it impounds less than five acres of water. Additionally, there are an unknown number (probably less than 20) small private dams and excavated ponds connected to tributary streams.

Dams have many detrimental effects on aquatic animals that depend on rivers. They impede seasonal movements of fish to refuge and spawning habitats (Schlosser 1991). Dams deny potamodromous fish access to spawning habitats. They also block resident fish from seeking suitable areas for feeding, resting, and optimal temperature. Clapp (1988), Clapp et al. (1990), Regal (1992), and Hudson (1993) found that brown trout seasonally travel long distances to feed, spawn, and to seek thermal refuge. Dams fragment river systems and transform high quality river habitat into lentic habitat.

The lentic environment created by dams may become suitable habitat for species that negatively affect organisms in the riverine environment. For example, northern pike inhabiting an impoundment on a coldwater stream may increase mortality rate on salmonids via predation. In larger impoundments, boats may bring undesirable exotic organisms (such as zebra mussels, Eurasian milfoil, etc.) into the watershed.

The increased length of shoreline in impoundments allows for additional development that increases the risk for introduction of pollutants. Development on impoundments tends to be closer to the water than on rivers because there is less risk of property loss to erosion. This can contribute to nonpoint sources of pollution, such as nutrients from lawn fertilization.

Impoundments that spill warm surface waters over the dam typically increase downstream surface temperatures. During hot summer months this can be critical to some aquatic animals. This warmer water may eliminate certain aquatic organisms, including fish (Ward 1984).

Many dams were built on high gradient areas to provide the greatest hydraulic height for the least cost. These riffle-pool areas were probably some of the best habitats in the river, but are no longer available to potamodromous and resident species requiring these habitats for spawning and feeding. Natural stream channels are constantly striving to be in equilibrium with the amount of water and sediment entering versus that amount which leaves the system. Dams interrupt this natural process. Aggradation of the streambed occurs upstream as sediments are deposited in the slow moving water in the reservoir. These sediment deposits make the river wider and shallower; eliminating undercut banks and filling deep pools. Conversely, sediment free water leaving the reservoir has additional energy. The stream becomes “hungry or starved” for sediment, resulting in excessive stream channel scour and bank erosion. This loss of diverse habitat affects fish and other aquatic organisms at different life stages.

Dams that regulate legally established lake-levels can eliminate the naturally occurring, slow changes in water levels that happen between seasons and years. Abrupt installation or removal of water controlling boards can produce flooding or drought conditions. The mere presence of a dam necessitates routine maintenance and alterations to flow that could produce catastrophic results.

Dams also interfere with navigation on rivers. Canoeing down the stream requires portages around dams.

Dams are sometimes built to maintain minimum lake-levels. These lakes usually have lake-levels established and recorded by local court orders. Naturally-fluctuating lake levels are held constant to comply with the court order. In response, streams downstream of the dam may become nearly dry during summer months as water is retained in the lake to provide recreation. Sometimes the stream may experience flood conditions when excess water is spilled at the dam to lower lake-levels, especially during fall, so as to prevent ice damage to riparian properties.

There are only three human-made dams registered with MDEQ (Table 2). Each dam is described in its respective valley section below.

Upper Jordan River

The Green River Trout Farm (Webber) Dam was built in 1950. The impounded water is diverted through a private trout rearing facility. It is not regulated by MDEQ under Part 315 of the Michigan Natural Resources and Environmental Quality Protection Act (1994 PA 451) because it impounds less than one acre and has a head of less than six feet (P. Wessel, MDEQ, personal communication). The dam is rated Hazard Type 3 since it has a low head and failure would not cause severe property damage. The impoundment is currently filled with sand. There are no provisions for fish passage on this small private dam. The last known status report on file with MDEQ is 1960.

Lower Jordan River

There are no dams on the mainstem of the Jordan River. There is a small, unregistered human-made dam (less than 5-foot head) on Gook's Creek near Mt. Bliss Road (Figure 18).

Deer Creek

Construction of the present Deer Lake water control structure began in fall 1973 and was completed on June 5, 1974 (D. Stolt, Charlevoix County Drain Commissioner, personal communication). The structure is owned by the Deer Lake Property Owners Association and is regulated by MDEQ under Part 307 of the Michigan Natural Resources and Environmental Quality Protection Act (1994 PA 451). The structure consists of steel sheet piling with wooden stop logs in the center spillway to control the lake level. The structure maintains a summer elevation of 709 feet above sea level that was established by Charlevoix County Circuit Court on October 28, 1965. Delegating authority for the structure is with the Charlevoix County Drain Commissioner. At a 2-foot head, the lake is 490 acres. However, on May 1, 2001 the measured head was only 4 inches. It was last inspected in 1997 and is rated Hazard Type 3. Failure of the dam and a subsequent increase in stream flow may not cause significant property damage, but would affect the stream channel and habitat for aquatic organisms. There are no provisions for fish passage on this low head dam.

The oldest of the three registered dams is Patricia Lake Dam, located about 0.5 miles upstream from Deer Creek's confluence with the Jordan River. It was originally built in 1891 as a gristmill. In 1903 it was converted to an electric plant and after several owners, Consumers Power Company abandoned the facility on September 9, 1950 (Grand Rapids Press, October 17, 1950). The original height of the dam was 32 feet with a head of 28 feet. When Consumers Power Company abandoned the facility, they lowered the dam height to 23 feet and lowered the head to the present 13 feet. It has a surface draw near the center of the dam and now impounds about 65 acres of water. The dam is regulated by MDEQ under Part 315 of the Michigan Natural Resources and Environmental Quality Protection Act (1994 PA 451). The dam was last inspected in 1995 and is considered safe by MDEQ. It is rated Hazard Type 2 (dam failure would cause severe property damage). There are no provisions for fish passage and the current owner is East Jordan Plastics, which uses Patricia Lake for non-contact cooling in a manufacturing process. The non-contact cooling discharge is located within 150 feet of the dam outlet and discharge water temperature is 61°F year around (J. Kraft, MDEQ, Surface Water Quality Division, personnel communication).

Barriers

Currently there is only one seasonal barrier on the Jordan River (Figure 18). The electric barrier located on the mainstem, about two miles upstream from Lake Charlevoix, was constructed in 1988 by MDNR, Fisheries Division to block spawning sea lamprey, migrating upstream from Lake Michigan. The electric weir is operated annually from March 1 to July 15, the peak spawning period for sea lamprey. During operation of the weir, upstream migration of potamodromous and other resident fishes are blocked. Steelhead migrations begin in early March and continue into April. Only the earliest migrating individuals are able to get past the weir. In any particular year the upstream fishery will be good if fish run early as a result of mild winters. In the 1960s, there was a very good potamodromous run of brown trout in the Jordan River during summer months. This fishery began to decline in the 1970s and by late 1980s it had disappeared. Efforts to reestablish this potamodromous run of brown trout may be inhibited by the operation of the electric weir in June and early July. Fish moving downstream (potamodromous adults and smolts) can pass safely through the electrical field. MDNR, Fisheries Division operated the weir until 1997, at which time the United States Fish and Wildlife Service (USFWS) assumed responsibility.

Fall operation of the electric weir began in 1999 to block chinook salmon in order to reduce potential effects on the resident trout fishery. Electric settings are the same as in spring (to stop adult sea lamprey) and are adequate to stop adult fish. The weir is operational from September 1 through November 1, peak spawning time for chinook salmon. Coho salmon and steelhead migrations begin during this time but usually peak in November. The electric barrier blocks upstream migrations of other fish during this period. MDNR, Fisheries Division operates the electric weir in the fall. The fall operation replaced the mechanical blocking weir located at the mouth of the Jordan River in the City of East Jordan. The metal grates and the structure (that remains) were deemed a safety hazard, and are not currently used to block fish.

Culverts have the tendency to become “perched” over time creating barriers to fish passage. It is estimated that about 30 percent of the crossings within the watershed pose fish passage problems (Anonymous 2001a).

O’Brien’s Pond, located near the headwaters of Warner Creek (a tributary to Deer Creek), no longer exists as originally built. It was constructed in the 1960s on state land to create about 90 acres of waterfowl habitat. The low-head earthen dam failed in the mid-1970s and was not rebuilt. Remnants of the dam still impound about one foot of water creating an impoundment of about 30 acres. Beavers occasionally plug the open section (about 15 feet wide), creating an impoundment up to the original size.

Beavers are native to the Jordan River watershed and presence of their dams on streams is a natural occurrence. Unlike human-made dams, they are usually short lived, lasting 5 to 15 years (Alexander et al. 1995). Beaver dams may be located on the mainstem and tributaries depending on beaver population and source of building materials (aspen trees). Information on beaver populations and number of dams in the watershed is lacking. Beaver trapping is allowed in the watershed, but information on harvest is lacking. Beaver dams can inhibit movement of fish. The impoundments can accumulate substantial amounts of sediment and increase the wetted surface of the stream channel several hundred-fold (Naiman et al. 1986). However, their affect on stream water temperature in the Jordan River system may be minimal due to large volumes of groundwater inflow (see **Geology and Hydrology**).

Water Quality

Overview

Water quality in the Jordan River watershed is considered excellent, primarily due to lack of development in the watershed (see **Soils and Land Use Patterns**). The geology permits most precipitation to percolate through the extensive sand and gravel moraines into the ground (see **Geology and Hydrology**). Groundwater comprises about 90% of the discharge in the Jordan River (Hendrickson and Doonan 1972). Management efforts are therefore directed more to protection and preservation of the existing water quality standards.

Water quality is evaluated in terms of designated uses of water for: agriculture and industry, public drinking, recreational body contact, navigation, and ability to support aquatic life and wildlife. Regulatory agencies monitor the water to ensure compliance with established standards for various designated uses listed in Rule 100 of Water Quality Standards (Part 4) of Administrative Rules, promulgated pursuant to Part 31 of the Michigan Natural Resources and Environmental Protection Act (1994 PA 451). MDEQ, Surface Water Quality Division (SWQD) is the lead agency for protection of water quality in Michigan.

All streams within the watershed are trout streams designated by the Director of the MDNR (Table 3) under the authority of section 48701(m) of the Michigan Natural Resources and Environmental Protection Act (1994 PA 451). There are many criteria used to classify trout streams and warmwater streams, the two most important being water temperature and dissolved oxygen. MDEQ has developed standards for trout streams that require a minimum of 7 ppm of oxygen and water temperatures that shall not exceed 68°F (Rule 64 and 75 of Part 31 of 1994 PA 451).

Point Source Pollution

Point source pollutants enter a receiving water at a distinct point, i.e., a pipe or ditch. These point sources are governed by the Federal Clean Water Act (PA 1972). The National Pollution Discharge Elimination System (NPDES) permits regulate the sources. NPDES permits are issued by MDEQ, Surface Water Quality Division.

Currently there are two NPDES permits in the Jordan River watershed. East Jordan Plastics, Inc. was issued a NPDES permit for discharge of non-contact cooling water into Patricia Lake, on Deer Creek. The well-water discharge flows average 32,000 gallons per day and water temperature is 61°F all year. Discharge is 24 hours per day and 280 days per year. The discharged water (less than 0.5% of the stream flow) temperature should not affect aquatic organisms in Deer Creek. The Jordan River National Fish Hatchery (JRNFH) was issued a permit to discharge a maximum of 12,200,000 gallons per day of fish rearing water to the upper Jordan River at Six Tile Creek. The permit for the JRNFH was modified in July 2000, reducing the total allowable phosphorus discharge from 2,800 to 2,000 pounds per year. Phosphorus discharges to the Jordan River via Six Tile Creek can increase algae growth (Szluha 1974).

There are no NPDES permits for The Green River Trout Farm. The Clean Water Act dealing with NPDES permit requirements exempt coldwater fish rearing operations if they produce less than 20,000 pounds of fish per year and feed less than 5,000 pounds of food during a month (D. Dell, MDEQ, Surface Water Quality Division, personal communication).

Nonpoint Source Pollution

Nonpoint source pollution is viewed as the major cause of pollution affecting waters in the United States today (Dysart 1985, as cited in Dodge 1998). Nonpoint source pollutants do not originate at a specific point. They enter surface water through atmospheric deposition or water transport, including groundwater. Nonpoint source pollutants include sand, sediments, nutrients, bacteria, or chemicals. Sources are usually surface runoff from agricultural fields, roads, construction sites, lawns, groundwater contamination, or accidental chemical spills.

Excessive sand bedload has deleterious effects on the health of a stream. The sand covers fish spawning gravel, destroys aquatic invertebrates used as food by fish, eliminates fish cover, aggrades the stream channel, and alters stream width and depth (Alexander and Hansen 1983). The result of these effects is a reduction in fish numbers. Nutrients can lead to excessive and unwanted plant growths. Bacteria can cause human health problems. Chemicals may pose direct health hazards or result in mortalities to fish and other aquatic organisms.

Nonpoint source pollution is probably the greatest threat to the Jordan River watershed due to its rural setting. Intense development of oil and gas wells in the watershed has created concern for protection of the river. The potential exists for drilling accidents, spills of oil and oil byproducts, and accidents from transportation of the products. Leaks or spills from well-pipe casings could contaminate groundwater and have serious long-term consequences. Buried pipelines could leak or rupture, contaminating groundwater. Pipeline right-of-ways through wetlands, and across or buried beneath streams are a source of sediment pollution during construction and subsequent use by unauthorized motorized vehicles. Transport roads and stream crossings are also a source of sediment pollution. There are few utility line crossings in the watershed and consequently these are not believed to be major contributors to sedimentation (see **Soils and Land Use Patterns**, *Bridges and Other Crossings*).

Logging operations can also contribute sediment pollution through improper road construction, location, and maintenance. Minimal logging currently occurs in the Jordan River valley and probably doesn't contribute much sedimentation.

Improperly constructed bridges and culverts may also contribute sediment pollution. There are numerous culverts in the watershed that are undersized and improperly placed that contribute to erosion of sediment (see **Soils and Land Use Patterns**, *Bridges and Other Crossings*).

Eroding soils that enter a stream from road surfaces, ditches, and disturbed areas adjacent to roads can affect aquatic habitats (Eaglin and Hubert 1993). Pinney Bridge Road is a gravel road that parallels the Jordan River for about two miles. In many places the road is within a few feet of the river. Numerous small culverts transport water from spring seeps on one side of the road to the stream. Sand was noted entering the river at many locations along this stretch of river from bank erosion, culvert crossings, and road runoff. Many sites have been stabilized with rock riprap during the last 10 years through efforts of the Friends of the Jordan River Watershed, Inc. (FJRWI), Antrim Conservation District (ACD), and other local organizations. Additionally, cedar posts were installed along the road (to prevent sediment from entering the river from the road), culverts extended, and vegetation planted to stabilize eroding banks. Some sites are in need of repair and new sites are being identified. There is still concern that sand is entering the river from surface runoff and road-grading operations.

Agriculture can be a major source of sedimentation and nutrient loading to streams and lakes. Cattle grazing along stream channels tramples vegetation and contributes to sand and soil erosion. Overgrazing on uplands can contribute to soil erosion during heavy rains. Stockpiling of animal wastes too close to streams can add excessive nutrients. Improper tilling of fields can also be a source of soil and sediment pollution. Several major sites associated with agriculture were identified as contributing sediment pollution; these were corrected about 10 years ago (J. Person, ACD, personal communication). An inventory just completed of lands that potentially contribute sediment, nutrients, or both to the streams has been completed by the Charlevoix Conservation District (CCD) and local volunteers as part of the Lake Charlevoix Watershed project (K. Martin, Charlevoix Conservation District, personal communication). There were thirteen sites found within the Jordan River watershed and priorities are being developed to address the most severe (Anonymous 2000a).

Construction activities in lakes, streams, and wetlands can be a source of sediment pollution and can destroy habitat needed by aquatic organisms. MDEQ, Land and Water Management Division regulates construction activities in lakes, streams, and wetlands under Part 301 and 303 of the Michigan Natural Resources and Environmental Protection Act (1994 PA 451). Erosion of soils from earth moving activities is a major threat to rivers, lakes, and wetlands. This has not been identified as a major contributor of sediment in this watershed to date. This type of activity is regulated by local units of government under Part 91 of the Natural Resources and Environmental Quality Protection Act (1994 PA 451).

Road construction, culvert and bridge replacements, and river access points have for many years contributed sediment to the Jordan River. Friends of the Jordan River Watershed, Inc., local units of government, conservation groups, and volunteers have spent several hundred thousand dollars and thousands of hours of labor correcting these problems during the last 20 years. A few road crossings, access sites, and portions of roads still contribute sediment, but are currently being addressed by these same organizations.

Dissolved Oxygen, Temperature, and Nutrients

Dissolved oxygen and water temperatures are two of the most critical factors affecting aquatic communities (Hynes 1970). Standards for dissolved oxygen are established depending on the water type (Great Lakes or inland stream) and designated use (warmwater or coldwater fishery). Standards for trout streams (Jordan River and tributary streams) require a minimum of 7 ppm dissolved oxygen (Rule 64 or Water Quality Standards) in order to support survival and development of salmonid eggs and fry.

Fish are found across a fairly wide range of water temperature. Physiologically, fish communities can be characterized as either coldwater or warmwater types. Coldwater species (salmonids and cottids) thrive in waters where the maximum daily mean summer temperature is usually less than 71°F (Gowing and Alexander 1980; Lyons et al. 1996). Warmwater fish communities usually predominate in water temperatures warmer than 71°F. The USGS gauging station on the Jordan River (#04127800) has monitored monthly maximum river temperatures from 1967 through 1983 (Table 4). At no time during the warmest months did the maximum river temperature exceed the standard (68°F) established by MDEQ to protect coldwater species of fish (Rule 75 of Water Quality Standards).

Nutrients are necessary for plant growth, and with increased levels of nutrients there is usually an increase in plant growth. Plants produce oxygen (through photosynthesis) during daylight and use oxygen (through respiration) during night. Increased amounts of plant growth can cause extreme daily fluctuations in oxygen concentrations. Low oxygen levels may induce stress and mortality on aquatic organisms.

Minimal data have been collected on nutrient levels in the Jordan River watershed, probably because of the existing high quality water. Some water chemistry data has been collected by MDEQ near the Jordan River National Fish Hatchery and at various locations on Deer Creek and its tributaries (Table 5).

In general, nutrient levels (phosphorus and nitrogen) in the watershed appear low. In the Jordan River (below the hatchery), Hog Creek (Karthase Road), and Warner Creek (Barber Road) a few samples have exceeded the range of values typical of trout streams in the northwest Lower Peninsula of Michigan (Table 5). The most likely reason for elevated levels in Hog and Warner creeks was from agricultural runoff (animal manure) and in the Jordan River from the JRNFH discharge of wastewater. Phosphorus and nitrogen levels immediately below the JRNFH were elevated over upstream levels. Szluha (1974) found that despite increased periphyton growth immediately below the hatchery (from increased phosphorus loading), oxygen levels were not affected significantly. Within a mile of the hatchery, the stream assimilated most nutrients and was near background levels. Phosphorus loading to the river from hatchery effluent has decreased since late 1970s (Anonymous 1988a). Actions credited for this reduction have been more efficient use of fish food, improved raceway cleaning, and addition of an effluent settling basin in 1972. The settling basin on the hatchery property is pumped and cleaned out 3-5 times a year and the sludge disposed of on land away from surface water. The JRNFH is currently exploring methods for further reductions in phosphorus discharge (R. Westerhof, US Fish and Wildlife Service, JRNFH, personal communication).

Sites of Environmental Contamination

MDEQ, Environmental Response Division, has identified three sites of environmental contamination in the Jordan River watershed as of 2000. These three registered sites are located in the lower segment of the Jordan River: W & K Salvage yard on Bartholomew Road, East Jordan Tool and Die on Rogers Bridge Road, and East Jordan Coop Bulk Plant on Highway M-32. These sites are registered and regulated under Part 201 of the Natural Resources and Environmental Protection Act (1994 PA 451). The act identifies the contamination, responsible parties, risk assessment, evaluation, and possible cleanup at the site. W & K Salvage and East Jordan Tool and Die were listed only because of their type of business. W & K Salvage handles lead (batteries), zinc, copper, and chromium. East Jordan Tool and Die uses hydraulic oils in cutting metal. There have been no soil samples or monitoring wells and both are considered a low priority, as groundwater contamination is not likely (E. Pelc, MDEQ, personal communication). East Jordan Coop Bulk Plant was listed in 1991 when petroleum products were discovered in groundwater near the facility. Remedial action has occurred, consisting of soil vapor extraction to remove the petroleum products. Monitoring wells beyond the property have not found any existing contamination. It is expected that the site will be deleted from the registry in a couple of years with no effect on Deer Creek or Jordan River (E. Pelc, MDEQ, personal communication). MDEQ, Environmental Response Division is responsible for continued monitoring and evaluation of these sites.

Fish Contaminants

Fish are a good source of protein, low in saturated fats and many anglers enjoy eating them. However, fish can accumulate contaminants in their body tissues and sometimes concentrations can be elevated to levels that pose health risks to humans. As a result, health advisories are developed to alert people about certain health risks from eating these fish.

Fish have been collected since 1980 and analyzed for contaminants as part of Michigan’s Fish Contaminant Monitoring Program (FCMP). The FCMP is coordinated by MDEQ, Surface Water Quality Division. MDNR, Fisheries Division, Michigan Department of Community Health (MDCH), Michigan Department of Agriculture (MDA), US Environmental Protection Agency (USEPA), and US Geological Survey (USGS) assist in collecting and analyzing fish samples. FCMP has four goals (Anonymous 1999):

(1) Support the development of the Michigan Department of Community Health’s (MDCH) Michigan Fish Advisory to issue general and specific advisories against eating certain sport fish from Michigan’s waters.

(2) Support the regulation of commercial fisheries sales in Michigan’s waters through Michigan Department of Agriculture (MDA) sampling.

(3) Identify spatial differences and temporal trends in the quality of Michigan’s waters.

(4) Evaluate whether existing pollution prevention, regulatory, and remedial programs are effectively reducing chemical contamination in the aquatic environment.

The Michigan Fish Advisory 2000 does not list any specific waters in the Jordan River watershed as having fish consumption advisories. However, since potamodromous fish migrate into portions of the Jordan River watershed, the advisory pertaining to Lake Michigan for those species should be followed.

Mercury consumption advisories have been issued statewide for fish-eating fishes common to inland lakes in the state (Anonymous 2000a). Mercury is highly toxic to aquatic organisms and is very persistent in the environment. The methyl form of mercury is most common in fish (O'Neal 1997). Long-term ingestion of mercury contaminated fish can produce neurological symptoms such as numbness in the extremities, tremors, spasms, and difficulty in walking. Mercury levels in Michigan fish are usually higher in inland lakes than in streams or the Great Lakes (Wood et al. 1995).

Mercury can enter surface waters from point-source discharges, nonpoint source runoff, or atmospheric deposition. Mercury deposition in the Jordan River watershed would most likely occur due to atmospheric deposition due to the wilderness character of the area. Electric utility coal combustion accounted for about 41% of air emissions of mercury in Michigan (Anonymous 1996).

River Classification by Fisheries Division

In 1967, MDNR, Fisheries Division classified the state's streams according to their fish populations and ability to provide recreational fishing (Anonymous 1967). The classification is based on stream temperature and habitat quality. Classifications were: 1) top-quality trout streams capable of supporting self-sustaining populations of salmonids; 2) second-quality trout streams that contain significant salmonid populations maintained by stocking; 3) top-quality warmwater streams that contain self-sustaining warmwater species; and 4) second-quality warmwater streams that have limited sport fish populations due to pollution, competition, inadequate reproduction, or lack of suitable habitat.

All streams in the Jordan River watershed were classified as trout streams using this classification (Figure 19). At least 75% of the total stream mileage in the watershed was classified as top quality.

Special Jurisdictions

Jurisdiction over rivers, lakes, wetlands, and riparian zones lies in state and federal statutes, and with local units of government in the form of zoning ordinances. MDEQ administers most of the state (Table 6) and some Federal statutes (Table 7) that protect aquatic resources.

Navigability

Public rights on Michigan waters is a complex issue. The Law Enforcement Division, MDNR (Anonymous 1993b) provides a comprehensive discussion of the issues dealing with navigability and public waters in Michigan. A navigable inland stream is 1) any stream declared navigable by the Michigan Supreme Court; (2) any stream included within the navigable waters of the United States by the United States Army Engineers for administration of the laws enacted by Congress for the protection and preservation of the navigable waters of the United States; (3) any stream which floated logs during the lumbering days, or a stream of sufficient capacity for the floating of logs in the condition which it generally appears by nature, notwithstanding there may be times when it becomes too dry or shallow for that purpose; (4) any stream having an average flow of approximately 41 cfs, and average width of 30 ft, and average depth of about one ft, capacity of "floatage" during spring seasonal periods of high water, used for fishing by the public for an extended period of time, and stocked with fish by the state; (5) any stream which has been or is susceptible to navigation by boats for purposes of commerce or travel; (6) all streams meandered by the General Land Office Survey in the mid 1800s (Anonymous 1993b).

In Michigan, navigable waters have been divided into two classes, strictly navigable and floatable. Strictly navigable waters are those capable of use for valuable boat or vessel navigation. Floatable waters are those, suitable in their natural condition, for the floating of logs. Public rights are attached to waters included in either class. The right to public use of navigable streams includes the right of trespass upon the submerged soil, but does not extend to uplands of riparian owners (Anonymous 1993b).

No streams in the Jordan River watershed have been declared legally navigable by the Michigan Supreme Court, United States Army Corp. of Engineers, or through Legislative enactment. Likewise, Judicial courts have not declared any streams as non-navigable. The mainstem of the Jordan River is most likely navigable, especially from Graves Crossing downstream, as commercial fishing guides floated this section of river in the late 1800s (Anonymous 1884). Commercial canoe liveries presently use this section of river.

County Drain Commissioners

The Drain Code (1956 PA 40) gives county drain commissioners the authority to establish designated drains to aid in flood control and water management. The Charlevoix County Drain Commissioner is responsible for maintaining the legally established lake level of Deer Lake. As of 2000, there were no designated drains in the Jordan River watershed (M. Stone, Antrim County Planner and D. Stolt, former Charlevoix County Drain Commissioner, personal communications).

State Natural and Scenic River Designation

In 1972, the Jordan River was designated the first wild-scenic river in the State of Michigan under authority of Section 13 of PA 231, 1970. Designated portions are all tributaries and the mainstem from its source in section 22, T31N, R5W in Antrim County downstream to Roger’s Bridge in section 35, T32N, R7W in Charlevoix County and all lands lying within 400 feet of the river’s edge (Figure 20). Authority to designate natural rivers is now in Part 305 of the Michigan Natural Resources and Environmental Protection Act (1994 PA 451).

The purpose of the designation is: “(a) to promote public health, safety and general welfare, to prevent economic and ecological damages due to unwise development patterns within the natural river district and to preserve the values of the natural river district for the benefit of present and future generations. (b) To protect the free flowing conditions, fish and wildlife resources, water quality, scenic and aesthetic qualities, and historical and recreational values of the Jordan river and adjoining land. (c) To prevent flood damages due to interference with natural flood plain characteristics by excluding developments that are vulnerable to flood damages. (d) To provide for residential and other permitted development that will complement the natural characteristics of the natural river system.” (Anonymous 1974a). The MDNR, Fisheries Division administers the Natural Rivers program.

Blue Ribbon Trout Stream Designation

Michigan has several thousand miles of designated trout streams. About 868 miles of the state’s designated trout streams are classified as “Blue Ribbon Trout Streams” by MDNR, Fisheries Division. Blue Ribbon Trout Streams support excellent populations of wild resident trout, produce diverse insect populations with good fly hatches, possess physical characteristics suitable for fly casting, are shallow for wading, have a reputation for providing a quality fishing experience, and have good water quality. Nine miles of the Jordan River mainstem, from the confluence with the Green River downstream to the Charlevoix County line, are classified as Blue Ribbon Trout Stream (Figure 20).

Special Local Watercraft Controls

Local Townships under authority of Part 801 (Marine Safety) of the Michigan Natural Resources and Environmental Protection Act (1994 PA 451) may petition the MDNR, Law Enforcement Division, to regulate watercraft for public safety. In June 1971, an Administrative Rule (R281.715.1) was adopted to prohibit use of motorboats in the Jordan River from the Charlevoix-Antrim County line downstream to M-32 Bridge in the City of East Jordan. At present, large boats are excluded from the river at M-32 Bridge due to metal beams associated with a former salmon blocking weir. The metal beams should be removed for safety reasons since it's not being used to block salmon.

Special Recreational Regulations

The Director of the Department of Natural Resources under the authority of Part 504 of the Michigan Natural Resources and Environmental Protection Act (1994 PA 451) may issue special orders. Order 4.8 of Land Use Orders of the Director states "A person shall not do any of the following on state-owned lands lying within an area bounded on the west by highway M-66, on the north by highway M-32, on the east by highway US-131, and on the south by Alba highway in an area known as the Jordan valley, Antrim and Charlevoix counties:

(1) Operate a wheeled motorized vehicle except for otherwise lawful operation upon a designated trail, designated route, or designated area.

(2) Camp in other than a designated camping site.

(3) Launch a canoe from state forest land into the Jordan river upstream of Graves Crossing in section 32, T31N R6W, Antrim county, to the origin of the Jordan river.

(4) Operate a snowmobile:
   (a) Off established one- and two-track forest trail roads (cross country).
   (b) On established one- and two-track forest trail roads unless snow covered.
   (c) On a pathway (non-motorized) marked and developed for cross country skiing, hiking, or snowshoeing.

(5) Operate a bicycle on the Jordan river pathway."

These rules are necessary to insure use consistent with the management goals established for the Jordan River valley as outlined in the Jordan Valley Management Plan (Anonymous 1975). MDNR, Forest Management Division is the lead agency in administrating this rule.

Jordan Valley Management Plan

In 1975, MDNR, Forest Management Division led efforts to develop a management plan (with public input) for the Jordan River valley (Anonymous 1975). The valley roughly corresponds to land along the mainstem of the Jordan River from the headwaters downstream to Rogers Road Bridge and tributary streams. Most is State of Michigan land (Figure 15). The purpose for the plan was to develop a logical direction in the planning for, and control of recreation, along with use and protection of the natural resources within the Jordan River valley. The principle idea was that the Jordan River valley be developed primarily as a natural area. Recreational activities would be of a quiet character. Other uses such as timber management and vehicular traffic would be permitted where compatible with the primary use. Off-road-vehicles would not be allowed on state forest land within the valley.

The management plan listed five goals:

(1) Maintain high water quality in the mainstem of the Jordan River and tributary streams.

(2) Manage use in order to maintain and enhance the environmental integrity of the Jordan River valley, with special emphasis on quiet recreation.

(3) Manage the vegetation to help protect water quality.

(4) Manage and maintain fish and wildlife for the benefit of humans.

(5) Acquire through purchase or exchange, private land within the designated Jordan River valley boundary.

MDNR, Forest Management Division is the lead agency in administering the plan.

Oil and Gas Regulations

Oil and gas reserves exist beneath lands of the Jordan River watershed. MDEQ, Geological Survey Division (GSD) and MDNR, Forest Management Division (FMD) regulate drilling on and leasing of state lands. There is joint cooperation between MDEQ and MDNR as outlined in a Memorandum of Understanding (Anonymous 1997).

Drilling and production of oil and gas is authorized under Part 615 (Supervisor of Wells) of the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451. MDEQ, GSD is the lead agency for regulation of drilling and production activity. The majority of wells in the watershed are located on private property (see **Soils and Land Use Patterns**, *Land Use*) since most state land is classified as non-leasable or non-developmental.

Leasing of state land is administered by MDNR under authority of Part 5 (General Powers and Duties) of the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451. MDNR shall identify lands for leasing and shall recommend to the Natural Resources Commission (NRC) its classifications for leasing as development, non-development, or non-leasable. There are approximately 25,791 acres of state land within the Jordan River watershed. Less than 2 percent of this land is classified as development (with restrictions), 18 percent as non-development, and 80 percent as non-leasable (M. Tonello, MDNR, Land and Mineral Services Division, personal communication). The non-leasable classification is given to lands that are unique or environmentally sensitive where the greatest emphasis is on protection of surface resources (Anonymous 1995). Mineral rights are not leased nor sold under non-leasable classification. This classification does not protect minerals from being extracted by other owners, resulting in lost revenue to the State of Michigan. MDNR, Forest Management Division is the lead agency in classification of state lands for mineral leasing.

State Land Reserve

The Friends of the Jordan River Watershed, Inc. (FJRWI) recently nominated portions of state land within the watershed for designation as a State Land Reserve. Article X, Section 5 of the State Constitution provided the State Legislature authority to designate State Land Reserves by two-thirds vote of the Legislature. In 1998 the Legislature passed Act 114 that establishes Natural Resources Commission (NRC) authority to accept, review, and provide recommendations to the Legislature regarding creation of State Land Reserves. The statute (by amending NREPA, 1994 PA 451) establishes specific conditions that must be met for lands to be included as a State Land Reserve.

A tract of land is eligible for NRC consideration for designation as a State Land Reserve if it includes at least 640 contiguous acres and contains one or more of the following (Part 502a of NREPA, 1994 PA 451):

(1) Critical dune as regulated under Part 353

(2) High-risk area (Part 323)

(3) Wetland (Part 303)

(4) Endangered species protection (Part 365)

(5) A wilderness or natural area (Part 351)

(6) A natural river (Part 305)

(7) Any other significant surface or subsurface natural feature or area of environmental sensitivity

Land within a State Land Reserve shall not be removed from the reserve, sold, leased, or otherwise disposed of except by an act of the Legislature. MDNR shall attempt to purchase, trade, or otherwise acquire any holdings within the contiguous area of the State Land Reserve that will improve ownership patterns, including any severed mineral rights. Any owner of an inholding in the State Land Reserve who offers that land for sale or lease shall first offer the land to the state and shall give the state first right of refusal, provided the land transfer is subject to the State Transfer Tax. Exemptions to the State Transfer Tax are transfers or sale of land to specific family members, thus they are not subject to the state having first right of refusal. It was also an opinion that such designation did not require Legislative approval to permit camping, issue surface use permits, easements, and other contracts so long as it was in the public interest and did not negatively affect the natural resource (B. Schmidt, Assistant Attorney General, personal communication).

The NRC established minimum criteria and procedures for review of State Land Reserves (memorandum to the NRC, dated 11/09/2000). FJRWI are updating the original nomination and expect to resubmit the package to the State Natural Resources Commission (J. Richter, President of FJRWI, personal communication). To date there are no State Land Reserve designations (L. Boyd, Land and Mineral Services Division, personal communication).

Natural Area Designation - Proposed

Part 351 (Wilderness and Natural Areas) of the Natural Resources and Environmental Protection Act (PA 451,1994) sets the general guidelines under which MDNR is to identify, dedicate, and administer Wilderness, Wild, and Natural Areas. The Jordan River watershed and in particular, the river valley contain unique geological, ecological, recreational, and scenic qualities (see **Geology and Hydrology, Soils and Land Use Patterns, Biological Communities and Recreational Use**). Forest Management Division has proposed a portion of the river valley for a Natural Area (approximately 2,000 acres) and Old Growth Forest Designation (approximately 3,000 acres). MDNR divisions are currently working on details for these special designations. Forest Management Division is the lead agency in developing guidelines for possible inclusion in the program. Land use activities would be more restrictive in Natural Areas than in Old Growth Areas (G. Gatesy, MDNR, personal communication).

Biological Communities

Original fish communities

Descriptions of fish communities in the Jordan River system prior to European settlement are lacking. The earliest written records that mention fish in the Jordan River are from the mid 1800s. Those records speak of the abundant Arctic grayling (Norman 1887). Other species were probably in the streams with this species but did not receive the attention of early writers. Suckers, northern pike, shiners, and whitefish were mentioned as being associated with grayling in Michigan streams (Hallock 1873; Mather 1874 and 1875; Oatka 1888). Potamodromous species including lake sturgeon, whitefishes, suckers, and lake trout most likely inhabited at least the lower portions of the Jordan River and Deer Creek.

Brook trout were first documented in the Jordan River in 1857 (Norman 1887). They were either native or recent migrants across Lake Michigan from Michigan's Upper Peninsula (Vincent 1962). The first documented stocking of brook trout in the Lower Peninsula of Michigan was in the south branch of the Tobacco River (Clare County) in spring 1870 (Mershon 1923). The first recorded stocking of brook trout in the northern part of the Lower Peninsula wasn't until 1882 when streams were stocked in Cheboygan and Charlevoix counties (Anonymous 1883). By the late 1800s, brook trout were observed in several rivers south of the Jordan River. The Jordan River changed from a predominately Arctic grayling stream (mid 1850s) to one dominated by brook trout (late 1880s) in just 30 years (Anonymous 1884; Norman 1887; Whitaker 1887). Replacement of the Arctic grayling by brook trout was probably the result of interspecific competition (Vincent 1962). Humans, through stocking, hastened the natural migration of brook trout southward to suitable streams (Vincent 1962).

The first scientific collection of fish from the Jordan River was in 1926. In the earliest surveys, biologists found brook trout, brown trout, rainbow trout, slimy sculpin, white sucker, blacknose dace, bluntnose minnow, creek chub, and finescale dace. Many of the same species found in the 1920s collections are still present. Status of the finescale dace is unknown since it has not been collected since 1926. The banded killifish, common shiner, and mimic shiner were last collected in 1950. Changes in the aquatic environment have occurred since then that has affected fish distribution and abundance. Fifty-one species of fish are native to the Jordan River watershed (Table 8).

Factors Affecting Fish Communities

Settlement in the watershed beginning in the mid 1800s to the present has had an effect (for example dams blocking migrations) on fish communities. The influence from nonpoint source pollution (sediment from logging and agriculture), point source pollution (nutrient discharges), dams (blocking fish migrations), land use (sediment from road-stream crossings), and introduction and invasion of exotic species (fish stockings and sea lamprey) are covered in more detail in other sections. However, a brief summary of these effects will help in understanding present fish communities.

Settlers to the area cleared the land of vast hardwood and pine stands. Loggers, prior to log drives, removed large natural dams of woody structure to facilitate transport of logs. Log drives damaged stream banks and scoured the stream channel. Vast areas of cutover slash frequently burned resulting in barren soils. These soils were easily eroded, and tons of sand and sediment poured into the streams. These sediments covered spawning, feeding, and resting areas for fish. Fish food organisms, and probably fish, were killed by drastic and excessive sedimentation. Recent excavations (several feet deep) of sand traps have uncovered logs with ownership marks from the lumbering era, suggesting that large amounts of sand entered the river following the logging era or that channels were badly incised and now the channels are re-built.

To facilitate the transport of lumber by boat to Lake Michigan it was necessary to cut a channel (through a series of pools and rapids) between Lake Charlevoix and Round Lake in 1869 (Anonymous 1884). The level of Lake Charlevoix dropped several feet in elevation to that of Lake Michigan. This sudden drop in elevation of Lake Charlevoix increased the slope of the lower Jordan River. The increase in slope resulted in the river having more power to transport the sand sediment. River travelers in the early 1880s noted that the lowermost section of river had sand and that the current was slow enough that boats could be poled upstream a couple of miles (Anonymous 1884). Today, natural fluctuations in Lake Michigan (and Lake Charlevoix) of several feet can similarly affect the transport of sediment in the lower mile of the Jordan River. As Lake Michigan and Charlevoix levels rise, slope of the lower river decreases and so does the power of the stream to transport sand. Within the confined channel the stream becomes deeper, velocity decreases, and sand deposition occurs.

As the land was cleared of trees, hydropower power was needed to run the sawmills. Dams fragment a river system; they block spawning migrations for potamodromous fish. Fish are no longer able to migrate seasonally for feeding, spawning, or other refuge. Some of the best spawning (high-gradient, gravel areas) reaches of a river system are where dams are built. Dams also affect fish communities by fluctuating water flows that scour and erode downstream channels, eliminating the transport of large woody structure, and increasing water temperatures downstream. Patricia Lake Dam (formerly used for hydroelectric power) still remains on Deer Creek. Hydroelectric dams were probably not constructed on the mainstem of the Jordan River because of the wide valley. The small discharges of the tributary streams were unsuitable for the construction of hydropower dams.

The riparian corridors along the mainstem of the Jordan River and Deer Creek are still vegetated with large trees. However, some lands along tributaries to Deer Creek and the lower Jordan River were cleared for agriculture (MDNR, Spatial Information Resource Center, unpublished data). Large trees were removed along sections of these streams. Streamside vegetation has many beneficial effects: providing shade and reducing water temperatures, increasing inflow of terrestrial food, decreasing sediment delivery, increasing cover, and increasing bank stability needed for fish cover. Large trees that die and fall into the steam provide cover for fish and serve as a substrate for fish food organisms (invertebrates). Poor agriculture practices contribute to soil erosion. Improperly tilled soils, overgrazing of land by animals and uncontrolled animal access to streams can destroy stream banks, vegetation, and contribute sediment to the stream. Recently, thirteen sites in the Lower Jordan River and Deer Creek valley sections have been identified that may be contributing pollution to streams (K. Martin, Charlevoix Conservation District, personal communication).

Residential development in the watershed is primarily restricted to the Lower Jordan River and Deer Creek. Residential development along streams also affects fish communities. Clearing land for buildings and roads can affect biological communities. Structures render soils impervious thus transporting surface water quickly to the stream and altering stream flow. Surface water transports nutrients and contaminants easily and quickly to streams. Water filtering through the ground contributes to more stable flows, and cooler and cleaner water. Clearing of streamside vegetation contributes to bank erosion, sediment loading, solar heating, and elimination of a source of woody structure to the stream. The State Natural Rivers designation has helped minimize the effect of these activities on most of the Jordan River mainstem and tributaries (see **Special Jurisdictions**). However, Deer Creek and its tributary streams lack this special zoning.

Introduction of non-indigenous fish species (Table 9) can affect fish communities through predation or competition for food or spawning habitat. Of the eight non-indigenous fish species found in the Jordan River watershed, only the sea lamprey and alewife entered the Great Lakes and the Jordan River as invaders from the Atlantic Ocean (Anonymous 1974b). The other six species were intentionally stocked in the Great Lakes watershed to enhance fish community structure and provide sport-fishing opportunities. Chinook salmon, brown trout, and steelhead have been stocked in the Jordan River watershed by MDNR, Fisheries Division.

Steelhead were introduced into Michigan (from California) in 1876 (Anonymous 1974b). The initial stocking was in the Au Sable River but as soon as 1880 they were stocked into the Boyne River (Anonymous 1974b). It is likely that in a few years rainbow trout found their way into the Jordan River either through migration (from the nearby Boyne River stocking) or from direct stocking. Statewide, stocking numbers and locations increased annually so that in 1914 nearly 5 million rainbow trout were stocked. Stockings probably hastened what would have occurred naturally through straying behavior but over a longer period of time. Steelhead today inhabit all Great Lake tributary streams with cold, clean water and suitable habitat for spawning.

Brown trout were introduced into Michigan (from Germany) in 1884 (Anonymous 1974b). Initial stocking was in the Pere Marquette River. However, in 1889 brown trout were stocked in an inlet to Deer Lake, Charlevoix County (Anonymous 1974b). Once established in Deer Creek they probably spread quickly to the Jordan River mainstem and tributaries. They were stocked in waters suitable for rainbow and brook trout.

Present Fish Communities

The Jordan River now contains 58 species of fish (Table 8), based on surveys by MDNR, Fisheries Division; MDEQ, Surface Water Quality Division; and USFWS, Lamprey Management Unit. Some species are found throughout the watershed and others in localized areas (Appendix 1). One original native species is now extirpated (Arctic grayling) and four (finescale dace, mimic shiner, common shiner, and banded killifish) are of unknown status. Comprehensive fish inventories have not been conducted in the Jordan River system since 1960. Recent fisheries inventories (population estimates) have focused primarily on salmon and trout in the mainstem of the Jordan River (Figure 21). The absence of chinook salmon from fish collections is because most have smolted (in May and June) and emigrated from the river by the time surveys are conducted in late summer or early fall. Information on other species collected during these recent surveys is lacking. Inventories of fish communities are done primarily by electrofishing. Chinook salmon, coho salmon, brown trout, rainbow trout, and brook trout spawn successfully in the watershed (Carl 1982; MDNR, Fisheries Division, unpublished data). There are no species of fish listed as endangered, threatened, or of special concern by the Michigan Natural Features Inventory (MNFI). Following is a description of fish communities by valley sections.

Upper Jordan River

This 12.9-mile section of the Jordan River is subdivided into two areas due to differences in habitat and fish communities. Potamodromous species are infrequently found in the upper reach because of natural and human-made obstructions.

Headwaters downstream to JRNFH

MDNR surveys found an abundance of naturally produced brook trout from the headwaters downstream to the 4th road crossing (Table 10). Reproduction of brown trout, coho salmon, and steelhead occurs but to a lesser degree. Average standing stocks (lbs/ac) of salmonids at these four uppermost stations equals the average for 14 northern Michigan trout streams (Table 11). Standing stocks averaged 76 lbs/ac with a range from 49 to 121 lbs/ac. Sculpins and suckers are often found at the same locations as brook trout. Brook trout spawn in gravel beds in the shallows of headwater streams (Scott and Crossman 1973). Areas with strong spring water flow are favored, a condition found in many places in the Jordan River and tributary streams. Large beaver dams and "perched" or undersized road culverts may inhibit migration of potamodromous fish to the upper section.

JRNFH downstream to Graves Crossing
Naturally produced steelhead, coho salmon, and brown trout dominate the river from the Old Bridge station downstream to Graves Crossing (Table 10). Brook trout are present but in lesser numbers. Standing stocks (lbs/ac) of salmonids at these four stations average 87 lbs/ac with a range from 36 to 139 lbs/ac (Table 11). The Old Bridge station had 139 lbs/ac, second highest of the 14 northern Michigan streams sampled (Gowing and Alexander 1980). This section is more readily accessible by potamodromous species and larger resident brown trout. There are no road culverts to impede fish migration.

Lower Jordan River

This 10.0-mile section of the Jordan River has less gradient than the upper river as it flows through lake plain sands. It is subdivided into two subsections based upon change in gradient and fish habitat.

Graves Crossing downstream to Webster Bridge
This 5.4-mile section of river has a gradient that averages 11.1 ft/mi. Salmon, steelhead, and larger brown trout dominate this section of the Jordan River. Standing stocks of trout and salmon at two index stations averaged 17.9 lbs/ac (Table 10). They rank below the average for the 14 northern Michigan trout streams studied by Gowing and Alexander (1980). This low estimate may be, in part, due to the large size of the river and low gear efficiency. Brook trout are occasionally caught.

Webster Bridge downstream to Lake Charlevoix
This 4.6-mile section of river has low gradient (3.3 ft/mi). No fisheries inventory exists, in part due to its relatively large size and difficulty in sampling with traditional electrofishing gear. About 10,000 yearling-size winter strain steelhead are stocked annually. Seasonal migrations of potamodromous fish (primarily chinook salmon, coho salmon, and steelhead) provide much of the recreational fishery. Trophy size brown trout are caught along with an occasional large brook trout. Carp, bass, pike, alewife, and an occasional walleye are caught in the lower two miles of the river (angler reports).

Deer Creek

Deer Lake
Deer Lake is the headwater for Deer Creek. Deer Lake is a 490-acre natural lake with a water-control structure at the outlet to maintain a summertime level. The lake contains a warmwater fish community. Predominant species include bluegill, rock bass, yellow perch, pumpkinseed, largemouth bass, and bullheads (MDNR, Fisheries Division, unpublished data). Also present, but in lesser numbers, were smallmouth bass, northern pike, black crappie, and white suckers. The lake shoreline is developed with houses. It is presumed that the lake has no excessive aquatic vegetation problems, as there are no records on file to indicate chemical treatments to control aquatic vegetation (MDNR, Fisheries Division files). The low-head structure at the outlet blocks upstream migrations of most warmwater species.

Deer Lake outlet downstream to Fuller Road
The upper 5.1-mile section of Deer Creek from Deer Lake downstream to Fuller Road has gradient of about 7.1 ft/mi. Fish inventory data in the mainstem of Deer Creek and tributary streams is sparse due to lack of collections by MDNR. However in 1990, MDNR, Surface Water Quality Division collected

fish as part of a water quality study. Brown trout, brook trout, bluntnose minnow, blacknose dace, brook stickleback, creek chub, mottled sculpin, rock bass, and common white sucker were collected from Deer, Warner, Collins, and Eaton creeks (Anonymous 1992). Potamodromous species are absent from this river section because of Patricia Lake Dam.

Fuller Road downstream to Jordan River

This 4.5-mile section of Deer Creek from Fuller Road downstream to the Jordan River has high gradient (19.8 ft./mi). Patricia Lake Dam was constructed in this area because of the high gradient. The impoundment has a mixture of trout and coolwater species (based upon angler reports). Anglers also report catching some trophy size brown trout below the dam in addition to warmwater species (smallmouth bass, pike, and panfish), and potamodromous trout and salmon. The presence of bass, pike, and panfish suggest the impoundment warms the downstream water of Deer Creek. Comprehensive fish inventory data is lacking for this section of river, including Patricia Lake.

Aquatic Invertebrates

Invertebrates are important food items for other animals including fish, mammals, birds, reptiles, and amphibians. Their abundance and diversity are good indicators of stream quality (Anonymous 1991a). Because of the generally excellent water quality in the Jordan River watershed there have been very few collections of aquatic invertebrates. MDEQ, SWQD, Great Lakes Environmental and Assessment Section (GLEAS) have collected most data. GLEAS personnel use Procedure #51 (Anonymous 1991a) to collect biological data and assess ecological status on wadeable streams. Data from these few studies and reports were compiled here by valley sections (Table 12). The United States Fish and Wildlife Service (USFWS) periodically treats the Jordan River for control of sea lamprey with TFM (3-trifluoromethyl-4-nitrophenol). This chemical can negatively affect aquatic communities (see **Pest Species, aquatic pests-present in the watershed**). Michigan Natural Features Inventory (Anonymous 2000b) lists a snail, the spike-lip crater (*Mesodon sayanus*) as special concern in the state. This snail has been documented in the Jordan River watershed. Although it is not afforded legal protection under Part 365 (Endangered Species Protection) of the Michigan Natural Resources and Environmental Protection Act (1994 PA 451) it is of special concern due to dwindling numbers. If populations continue to decline it may be recommended for threatened or endangered status, and thereby given legal protection under the Act. Listed below is a brief discussion of aquatic invertebrate abundance and diversity by valley section.

Upper Jordan River

MDEQ periodically monitors water quality of the Jordan River near the JRNFH. Studies conducted from late 1960s through 1990s consistently indicated a high diversity of invertebrates, especially intolerant taxa (Anonymous 1969; Anonymous 1988a; Anonymous 1994c; Anonymous 1994d). This indicates a history of very good water quality. Effluent discharges from the JRNFH appear to have had minimal effects on invertebrate communities in the river. Intolerant taxa of mayfly, caddisfly, and stonefly were found above and below the hatchery.

Lower Jordan River

Studies of invertebrates appear to be lacking for the mainstem from Graves Crossing downstream to Lake Charlevoix. One study was conducted by MDEQ, SWQD on Suttons Creek, a tributary to the mainstem. Construction of a small private dam had a deleterious effect on the benthic invertebrates below the dam (Anonymous 1973). The benthic fauna changed from mayfly, caddisfly, and stonefly to one dominated by worms and flies. Subsequent evaluation of conditions in Suttons Creek has not been completed.

Deer Creek

MDEQ, SWQD, GLEAS conducted a biological survey of Deer Creek and major tributaries as part of their nonpoint source surveillance program in 1990. Procedure #51 was used to determine any effects land management practices may have on the study streams. Deer Creek mainstem, Collins Creek, and Eaton Creek were judged to be moderately impaired based on the aquatic invertebrates present (Anonymous 1992). Warner Creek was judged to be only slightly impaired based on aquatic invertebrate communities. Physical habitat measurements (such as bottom substrate, embeddedness, deposition, and streamside cover) for Eaton Creek indicated slight impairment and that was suggested to be related to livestock access to the stream (Anonymous 1992).

Amphibians and Reptiles

Amphibians and reptiles are an integral component of the Jordan River watershed. Many of these animals rely on the aquatic environment for habitat, reproduction, and food (Harding 1997). They are consumers of animals and plant material. They are also an important food source for other species including fish, mammals, and birds.

Thirty-six species of amphibians and reptiles requiring water or wetlands for at least part of their life cycle have been identified as likely to be found in the Jordan River watershed (Table 13; Harding and Holman 1990; Harding and Holman 1992; Holman et al. 1989). The extensive wetlands adjacent to the river in this large river valley are undoubtedly important to many of these animals. Of the reptiles likely to be found in the Jordan River watershed, three (wood turtle, Blanding's turtle, and eastern massasauga rattlesnake) are listed as special concern by MNFI (Anonymous 2000b). If numbers continue to decline they may be recommended for inclusion on the state-threatened and endangered list, thus affording legal protection to their habitat. Information on exact distribution and abundance within the watershed is sparse for many species. A comprehensive inventory of these important animals is recommended.

Birds

Birds are an integral component of a watershed. They are consumers of plant seeds, and of animals including insects. Many people enjoy recreational viewing of birds. Some species also provide recreation and food for hunters.

Birds use various aquatic habitats in the Jordan River watershed for breeding, feeding, and resting. Some of these birds are year-round residents while others are transients at different times of the year. The downy woodpecker, hairy woodpecker, and pileated woodpecker are year-round residents that require forests, woodlots, and river corridors. Herons, mergansers, cormorants, osprey, and eagles consume considerable quantities of fish during their lives (Peterson 1965; Alexander 1976). Hawks and owls feed on birds, small mammals, reptiles, fish, and large insects (Peterson 1980). Many diving and dabbling ducks traveling the Mississippi Flyway use the Jordan River watershed for resting and feeding during their migrations (Bellrose 1980).

One hundred sixty two species of birds are likely to be found in the Jordan River watershed (Table 14; Brewer et al. 1991; Peterson 1980). Fifty-six species have confirmed breeding status in the watershed. Seven species are listed as threatened and eight species are listed as special concern by MNFI (Anonymous 2000b). The bald eagle is also listed as a federally threatened species under the Federal Endangered Species Act of 1973. Information on distribution and abundance of these birds in the Jordan River watershed is limited. A comprehensive inventory of birds listed as threatened and of special concern in the watershed is recommended.

Mammals

River corridors and wetlands are important habitats for mammals. They use these areas for feeding, breeding, travel, and as places of refuge. Whitetail deer, ruffed grouse, squirrels, and raccoons require upland forests and use the river corridor as a source of water. River otter, muskrat, and mink are also found. Many small rodents use the both upland and wetlands for feeding and refuge. Some vertebrate predators (such as mink) can have significant affects on fish (Alexander 1976).

Beavers are perhaps the most conspicuous mammal in the watershed because their tree cutting, dam building, and resultant stream floodings are very noticeable. Beavers are generalized herbivores, but exhibit a strong preference for particular plant species and size classes (Jenkins 1975 and 1979; Collins 1976). Denney (1952) summarized the food preferences of beavers throughout North America and reported that in order of preference, they selected aspen (*Populus tremuloides*), willow (*Salix* spp.), cottonwood (*Populus balsamifera*), and alder (*Alnus* spp.). About 12% of the vegetation on state land is aspen (see **Biological Communities, Terrestrial Plants**).

Beavers require a permanent supply of water and prefer a seasonably stable water level (Slough and Sadleir 1977). In riverine habitats, stream gradient is the most significant factor in determining suitability of habitat for beavers. Retzer et al. (1956) reported that 68% of the beaver colonies recorded in Colorado were in valleys with a stream gradient less than 6% (317 ft per mile). Valleys that were only as wide as the stream channel were unsuitable beaver habitat. Valley widths exceeding 150 feet were considered the most suitable. The Jordan River and tributaries have stable flows, channel gradient less than 6%, and in many locations wide valleys (see **Geology and Hydrology; Channel Morphology**).

The density of beaver colonies in favorable habitat typically ranges from 1 to 2 per square mile (Lawrence 1954; Aleksiuk 1968). The 127 square mile Jordan River watershed likely supports a sizeable population because of mostly favorable habitat. There are no population estimates available for beaver in the Jordan River watershed.

Fifty-two species of mammals are listed as likely to be found in the Jordan River watershed (Table 15; Kurta 1995). The woodland vole is listed as special concern by MNFI (Anonymous 2000b). Detailed information on distribution and abundance of many mammals in the Jordan River watershed is lacking. A comprehensive inventory of these mammals is recommended.

Terrestrial Plants

Terrestrial plants are an integral component of a watershed ecosystem. Plants are used by amphibians, reptiles, birds, mammals, and insects for breeding, feeding, and places of refuge. Humans also enjoy plants, especially trees for aesthetic viewing, recreation, and commercial use. Trees provide shade to cool stream temperatures, provide a source of instream woody structure, filter nutrients and sediments, and affect stream flows (see **Geology and Hydrology, Soils and Land Use**).

Vegetation on state land (31% of watershed) has been classified into dominant cover types (Table 16; MDNR Forest Management Division, unpublished data). Sixty six percent of state land is upland hardwood forest. Upland forest trees are predominately sugar maple, beech, basswood, and aspen. Aspen is managed for commercial uses (primarily paper pulp and particleboard) and for wildlife game species (whitetail deer, grouse, and woodcock). A minor component in this upland hardwood forest is white ash, yellow birch, ironwood, and black cherry.

Approximately 10% of state land is classified as mixed swamp conifer. Trees dominating this type of classification are white cedar, hemlock, balsam fir, and tamarack. They are found in close proximity to streams and are associated with poorly drained mucky, loamy, and sandy soils (see **Soils and Land Use**).

A review of the Michigan Natural Features Inventory (MNFI) database identified no plant species within the Jordan River watershed as endangered, threatened, or of special concern. However, the MNFI database is not comprehensive and is continuously updated, so definitive statements on the status of natural features within the watershed are unavailable. MNFI has also compiled a draft description of Michigan's Natural Community Types, but none have been identified within the Jordan River watershed.

Other Natural Features

The Jordan River watershed has two unique features not found in many other large watersheds in Michigan. The first is that there are only three natural lakes (Deer, Mud, and Satterly) in the 127 mi^2 watershed. The watershed is primarily a riverine system because of the steep topography. Emphasis for protection, enhancement, and management should be for riverine environments. Secondly, the watershed is only one of a few that appear to receive groundwater from other watersheds (see **Geology and Hydrology, Geology and Physiography**). Because of this unique feature it is imperative that activities in neighboring watersheds be monitored. Of special concern would be actions that may pollute or impair groundwater. An example would be that ground contamination in Mancelona (outside surface boundaries of watershed) might pollute a groundwater aquifer that eventually enters the Jordan River watershed.

Pest Species

Pest species are defined as those non-native species that pose a significant threat to native species or their habitat. Most species are not a significant threat unless present in high numbers.

Aquatic pests - present in the watershed
The sea lamprey (*Petromyzon marinus*) is the most serious pest inhabiting the Jordan River. During spring, adult sea lamprey migrate into tributary streams to spawn (Applegate 1950). They spawn on gravel riffles in the mainstem and tributary streams. Lamprey eggs hatch and the young larvae (ammocetes) burrow into soft sediments of streams and feed largely on suspended particles of detritus filtered from the water (Moore and Mallatt 1980; Mallatt 1981). Larvae live in the bottom for 3 to 7 years and metamorphose into the juvenile form (Applegate 1950; Wigley 1959; Lowe et al. 1973). Juveniles move from the stream to Lake Michigan and transform into the adult parasite. About 12-20 months is spent as an adult parasite in the Great Lakes or Lake Charlevoix (Applegate 1950). The adult attaches to the sides of adult fish with its sucker disc and sharp teeth. Its sharp tongue rasps through the skin of fish until it bleeds, and then feeds off the blood and other body fluids. It has been estimated that an adult sea lamprey can kill 40 pounds of fish during its life span. The adults return to the natal stream to spawn and die a few days after spawning (Applegate 1950).

Attempts to control sea lamprey in the Great Lakes began in 1950 with the installation of mechanical weirs and traps in Lake Superior and Huron (Applegate and Smith 1950). Barriers were extended to Lake Michigan tributary streams in 1954. An electric (alternating current) barrier was built on the Jordan River in 1956 between Birney and Deer Creek (E. Koon, USFWS, personal communication). It was operated only one year (1957) and was removed in August 1961. Operational safety and mortalities on fish species were cited as reasons the early electric barriers were abandoned.

USFWS crews survey Great Lakes tributary streams to assess densities and quantity of preferred habitat for young lamprey. A number of transformers (larvae that will leave a stream and mature into adults) was estimated for the Jordan River in 1997. The USFWS predicted that nearly twice as many lamprey are produced in Deer Creek (3,633 transformers) as in the Jordan River mainstem (1,812 transformers) from Pinney Bridge downstream to the electric barrier (E. Koon, USFWS, personal communication). The least productive area for lamprey reproduction appears to be below the electric barrier (294 transformers). Cost per transformer (total cost of treatment divided by number of transformers) is used to establish priority list of waters to be treated (E. Koon, USFWS, personal communication). High priority (low cost per transformer) streams are treated with the lampricide TFM (3-trifluoromethyl-4-nitrophenol) to kill or reduce the larval lamprey populations. Treatments are usually performed every three or four years to eliminate or reduce larval lamprey in the stream. Treatments usually occur any time from early spring through early fall.

TFM can negatively affect some aquatic communities. Gilderhus and Johnson (1980) found that lampricides cause some mortalities of aquatic earthworms, leeches, larval forms of mayflies (*Hexagenia* sp.), certain caddisflies, blackflies, and mudpuppies. Dobsonflies, alderflies, and dragonflies are particularly resistant to TFM (Maki et al. 1975). Resistance of mayflies depends upon species involved, pH, and total hardness of the treated water (Fremling 1975; Maki 1974; Chandler and Marking 1975). Smith (1967) documented 50% mortality of *Hexagenia* at a concentration of only 5 ppm. Crustaceans appear to be resistant to TFM (Maki et al. 1975). Torblaa (1968) and Haas (1970) showed a decline in benthic fauna immediately following TFM application. Torblaa (1968) reported recovery of the population within one year. Merna (1985) found that sensitive species of benthos were reduced in treatment areas of the Baldwin River, Lake County and some evidence of reduction (although not significant) in the Green (Antrim County) and Sturgeon rivers, Antrim and Otsego counties. However, the Betsie River, Benzie County showed no effect of TFM four years after treatment (Merna 1985).

Although the chemicals are selectively toxic to lamprey, they may cause some mortality to other fish. Spawning fish are most sensitive to lampricides. Adult suckers (both white and longnose), northern pike, brown trout, rainbow trout, brook trout, coho salmon, chinook salmon, brown bullhead, and walleye have been killed during chemical treatments (Dahl and McDonald 1980). Other species that may be affected are troutperch, logperch, and mudminnows (Smith et al. 1974). Forage fish most affected are common shiner, johnny darter, longnose dace, blacknose dace, spottail shiner, brook stickleback, and sculpin spp. (Dahl and McDonald 1980). Lake sturgeon juveniles are affected by TFM (Hay-Chmielewski and Whelan 1997). Merna (1985) found no evidence of adverse effects to brook, brown, or rainbow trout populations due to TFM treatment in the Sturgeon River, Otsego County.

Periodic mortalities from chemical treatments may not have any long-term effects on populations of fish or other aquatic invertebrates. Chemical treatments do not fragment the riverine habitat like mechanical or electric barriers. With chemical treatment, nothing changes in the habitat, only temporary changes in water quality. Until alternative solutions are found to control sea lamprey, fish kills will continue and are a cost of the operation.

TFM treatment on the Jordan River began in 1961 and has continued every 3-5 years, with the most recent in 2002 (E. Koon, USFWS, personal communication). Probable effects on invertebrates and fish in the Jordan River have lessened since 1961. First, there has been a reduction in treatment zone from near the headwaters in 1961 to just above Pinney Bridge in 1997 (Figure 1). This reduction was due to the addition of the electrical lamprey barrier. Second, there has been a reduction in hours of treatment from 19 hours (1961) to 12 hours (1997). Third, there has been a reduction in concentration from 15 ppm (1961) to 5.8 ppm (1997). Finally, the month of treatment has been moved from May to August to reduce effects on spring spawning fish and minimize effects on mayfly populations, especially the giant mayfly (*Hexagenia limbata*).

Concerns about chemical treatments to the Jordan River lead to the decision to construct a pulsed-DC electric barrier (done in 1988) on the Jordan River mainstem about 2 miles upstream from Lake Charlevoix. A generator was installed as backup power to the electric barrier in 1993. The electric barrier was upgraded in 1996-97 to improve blockage of adult lamprey (Swink 1999). Historically the barrier operated March 1 to July 15 but, beginning in 2000, it will be operated through the end of July since some lamprey are still migrating in late July (Swink 1999). MDNR, Fisheries Division built and maintains the electric barrier, while the USFWS operates the barrier.

Operational cost (electricity) for the electrical barrier in spring of 1999 was slightly less than $1,200 (E. Koon, USFWS, personal communication). TFM treatment cost (labor and chemical) for the Jordan River in 2002 was $181,000, down from $243,000 (full treatment). An entire system treatment runs from O'Brien's Pond to the mouth (21 miles), while the current treatment area is from Landslide Creek to the mouth (14 miles). An entire system treatment was less effective due to constant groundwater inflows and was more expensive; the reduced treatment was more effective and cheaper. With the electric barrier operation there is a loss of natural reproduction for some species of fish (suckers, steelhead, and other minnows) because they are not able to migrate upstream past the barrier. Some steelhead are able to "burst" through the electrical field. There are also costs associated with lost angling opportunities upstream of the barrier (see **Fisheries Management**).

Patricia Lake dam on Deer Creek stops adult sea lamprey from migrating upstream to suitable spawning and rearing habitat. Adult lampreys are collected below the dam in traps for assessment work. One hundred and eleven adult sea lamprey were collected in the assessment traps below Patricia Lake Dam in 2002 and the estimated number of adult sea lamprey in Deer Creek was 313 (E. Koon, USFWS, personal communication). In 2002, one hundred sixty eight adult sea lamprey were collected below the electrical barrier and the estimated number of spawners was 666. While the number of spawners seems low, the potential recruitment is tremendous. Assuming half were females, with an average egg production of 80,000, this yields 26.64 million larval lamprey, a demonic number.

The microscopic protozoan, *Myxobolus cerebralis*, is a parasite that causes "whirling" disease in salmonid fishes. The disease is named for the erratic, tail-chasing "whirling" in young fish that are startled. The organism disrupts a fish's central nervous system by damaging cartilage tissues surrounding the brain, causing head or skeletal deformities. The disease is not always fatal. Susceptibility varies not only among species but also among strains and individuals (Markiw 1992). The following salmonids are ranked in descending order of apparent susceptibility (O'Grodnick 1979; Hoffman 1990): brook trout, steelhead, chinook salmon, brown trout, coho salmon, and lake trout. Whirling disease originated in Europe and was accidentally transmitted to North America in the 1950s (Hoffman 1990). It was documented in the Jordan River in 1999 from trout collected at Pinney Bridge and Graves Crossing (J. Hnath, MDNR, personal communication).

Purple loosestrife (*Lythrum salicaria*) is a serious plant pest. The plant is widespread in Michigan wetlands. It spreads quickly once established in an area. It will dominate more valuable native plant species, and waterfowl, especially ducks, avoid wetlands that have become dominated with purple loosestrife (Lym 1997). Deer, muskrats, and other herbivorous foragers ignore mature purple loosestrife because it is too tough and woody (Anonymous 1991b). Control of purple loosestrife is difficult. Selective herbicides (glyphosate in the form of Rodeo, Casoron, and garlon) have been sprayed on the plants with some success (Balogh 1986; Lym 1997). Release of two leaf-feeding beetles (*Galerucella calmariensis* and *G. pusilla*), and a root-feeding weevil, *Hylobius transversovittatus*, that specifically eat purple loosestrife, have reduced but not eradicated purple loosestrife (Hight et al. 1995; Anonymous 2001b). Prevention of accidental or intentional introductions is the best method of control. Because the plant has an attractive flower, it is a favorite plant in gardens. People are perhaps the most likely means of transporting the plant to new areas.

Once in an area, wind, water, and animals may quickly hasten its dispersal. With approximately 2.7 million seeds per plant, purple loosestrife has the potential to spread rapidly (Lym 1997). Purple loosestrife has been identified along the lower Jordan River (J. Richter, FJRWI, personal communication).

Aquatic pests - possible threats
Several aquatic pest species have not been documented in the watershed but are established elsewhere in the Great Lakes watershed. Some are found in neighboring watersheds and may find their way into the Jordan River watershed. Following is a brief description of pests that pose the greatest future threats.

Eurasian milfoil (*Myriophyllum spicatum*) is a nuisance plant that frequently inhabits lake environments. Eurasian milfoil can become so prolific that it eliminates native species (Anonymous 2001c) and in some lakes it has interfered with boating and swimming. Boats and trailers can transport Eurasian milfoil. This pest is most likely to invade Deer Lake.

Zebra mussels (*Dreissena polymorpha*) are established in Lake Michigan and several inland waterways. Zebra mussels typically inhabit slower moving water, attaching to hard surfaces (Anonymous 2001d). Colonies of zebra mussels can completely cover their substrate. Zebra mussels can kill native mussels through suffocation. However, zebra mussels do filter large quantities of water and improve water clarity thus increasing the depth of macrophyte plants. Zebra mussels are present in Lake Charlevoix (Anonymous 2000c). Deer Lake is the most likely location for boats from infected waters to transport zebra mussel veligers.

Rusty crayfish (*Orconectes rusticus*) are a threat to the ecology of streams. They prefer streams with rocks, logs, and other instream structure (Gunderson 2001). They inhabit both pools and fast water. This crustacean can eliminate native crayfish species through competition for food and habitat. They can nearly eliminate native plant species through over-grazing. Rusty crayfish currently inhabit the Big Manistee River below Tippy Dam (Rozich 1998) and Lake Charlevoix (Dave Clapp, MDNR, personal communication) Anglers and bait dealers can unknowingly spread rusty crayfish. It is illegal to commercially take, possess, or sell rusty crayfish in Michigan (Anonymous 2000d).

The zooplankters, *Bythotrephes cederstroemi*, (sometimes called the "spiny water flea or BC) and *Cercophagus pengoi*, a cousin of BC, and the fishes, Eurasian ruffe (*Gymnocephalus cernuus*) and round goby (*Neogobius melanoslomus*), inhabit the Great Lakes. *Bythotrephes* invaded Lake Michigan by 1986 and are present in several large inland lakes, including Lake Charlevoix (Anonymous 1991c). *Cercophagus* invaded lake Michigan in 2001 and are also found in Lake Charlevoix. Adult ruffe were collected in Lake Huron near Alpena in 1995 (Jensen et al. 1996). The round goby was discovered in the St. Clair River in 1990 and by 1994 were found at South Haven in Lake Michigan (Marsden and Jude 1995). Both species are aggressive, pugnacious fish and feed voraciously. They eat eggs and fry of small fish such as sculpins, darters, and logperch. It is illegal to possess or transport live ruffe or round goby in Michigan (Anonymous 2000d). Round goby were discovered in Lake Charlevoix in 1999 (Dave Clapp, MDNR, personal communication).

Terrestrial pests
Many terrestrial insects can be found throughout the Jordan River Valley. Most species do not reach population densities that would categorize them as pests. Gypsy moth (*Lymantria dispar*), forest tent caterpillar (*Malacosoma disstria*), and Eastern tent caterpillar (*Malacosoma americanum*) are common defoliators of deciduous forests and shade tees. These can occur in epidemic numbers at irregular intervals. Normally, outbreaks last three to six years and then subside due to starvation or natural control factors such as parasites and predators. Some mortality within the oak-aspen forest type corresponds to repeated defoliation by gypsy moth.

In general terrestrial pests within the Jordan River watershed are considered insignificant with regards to their effect on forest health. Beech bark disease and the recent introduction of the Asian longhorn beetle (*Anoplophora glabripennis*) to the United States could pose the most serious treat to the Jordan River watershed and surrounding northern hardwood forests. Beech bark disease affects American beech (*Fagus grandifolia*) and results when bark is attacked and altered by the beech scale (*Cryptococcus fagisuga*) then is invaded and killed by fungi, primarily *Nectria coccinea* var. *faginata* (Houston and O'Brien 1983). As of this date, no confirmed collections of either of these pests have been identified.

Two introduced shrubs, Autumn olive (*Elaceaggnus umbellata*) and Japanese honeysuckle (*Lonicera japonica*) have recently been deemed undesirable by most conservationists. The MDNR, Forest Management Division no longer plants Autumn olive (D. Johnson, Forest Management Division, personal communication). Distributions of non-native plant species within the Jordan River watershed have not been well identified.

Fishery Management

The Jordan River and tributary streams are managed for resident trout fisheries. Brook trout and brown trout are found in the mainstem and in most tributaries in varying numbers. Steelhead, coho salmon, and chinook salmon are also found in streams not blocked by barriers. The electrical lamprey barrier blocks an unknown number of steelhead and salmon and is operated spring and fall. The mainstem and tributaries are also designated trout streams and many miles are designated blue ribbon trout streams.

Management history

Arctic grayling were the predominate sport fish species in the early 1800s (Norman 1887). In the 1880s, brook trout replaced the arctic grayling (Delta 1884; Norman 1887; Anonymous 1884; and Whitaker 1887). Rainbow and brown trout probably arrived in the 1880s and 1890s through stocking (see **Biological Communities**).

Fish stocking has always been a major activity in Michigan fish management. Fish culture and presumably stocking began with the establishment of a private brook trout hatchery in Clarkston (Oakland County), Michigan by N. S. Clark in 1867 (Anonymous 1974b). The first recorded stocking of brook trout in Michigan was in 1870 (Mershon 1923). In 1873 the Michigan Fish Commission was established and fish culture and stocking soon followed in attempt to restore depleted fish stocks (Anonymous 1974b).

Michigan has progressed through four eras in stocking fish (Anonymous 1974b). These eras are: fry (1873-1929), fingerling (1930-1949), legal-sized (1950-1964), and the present era of stocking sublegal-sized in waters that return at least as many pounds to the creel as are stocked (Anonymous 1974b). Fish stocking in the Jordan River followed this general pattern.

When artificial propagation started in the 1860s eggs were hatched and the fry stocked. Millions of fry were planted throughout the state during this fry era (Anonymous 1974b). It is unknown how many fry were stocked in the Jordan River watershed during this time period since records of fish stocking are lacking. In the 1920s the policy changed to stress stocking larger (fingerling) size fish. Fingerlings generally survived better than fry, especially in waters with some competing fish. By 1929 the fingerling program was no longer experimental. From the 1930s through the 1940s thousands of fingerling brook trout were stocked in the Jordan River and tributary streams (MDNR Fisheries Division records and Appendix 2). Beginning in the 1950s, the policy again changed to planting even larger (yearling and legal-sized) fish. Larger fish survived better and provided a better return to the creel. During the 1950s and 1960s many streams in the Jordan River watershed were stocked with adult- or legal-sized trout (MDNR Fisheries Division records and Appendix 2). However, in the early 1960s, both anglers and fish managers were becoming dissatisfied with the results of stocking legal-sized trout (Anonymous 1974b). Aesthetics became an important factor. People objected to catching “tame” hatchery fish. Legal-sized stockings attracted large crowds of anglers that quickly caught the stocked fish under less than sporting circumstances. Cost of the stocking program was also a factor. Studies in 1960 showed that the cost to produce a legal-sized trout to the creel was $1.00 per fish and was excessive (Anonymous 1974b). A new era began in the mid-1960s that discouraged stocking legal-sized trout because of high cost. Michigan hatcheries were stocking an average of 1,000,000 legal-sized trout per year from 1960-65. Beginning in 1966 average annual production fell to less than 50,000 legal size trout. The last year adult fish were stocked in the Jordan River was in 1965 (MDNR Fisheries Division records and Appendix 2). Since 1965 the policy has been to stock sub-legal trout because this size optimizes costs and benefits (Anonymous 2001e). The policy also directed that streams capable of supporting an acceptable sport fishery through natural reproduction should not be stocked. Emphasis should be placed on habitat restoration. Supplemental stockings may occur in streams lacking adequate natural reproduction or where angling mortality is excessive. In waters with high angling mortality, regulations (creel, gear, size, season) would be a more appropriate management strategy.

Brook Trout
Brook trout were stocked in the Jordan River mainstem from 1934-61 (MDNR, Fisheries Division records and Appendix 2). Fingerling size fish were stocked in large numbers from 1934-46, averaging about 22,500 fingerlings per year (Figure 22). Creel surveys were conducted during this same period of time to evaluate the stocking program (MDNR, Fisheries Division, unpublished data and Appendix 3). There was a slight positive linear relationship between the catch per hour of legal size brook trout and the number of fingerlings stocked one and two years earlier (Figure 23). However, the relationship was not statistically significant at the 90% confidence level (Pearson Correlation, P=0.410 and 0.549, n= 10) suggesting that harvest was actually not correlated to increased stocking of fingerling brook trout. Research concluded that fingerling brook trout did not survive when stocked in waters with naturally-produced trout. Stocking emphasis then shifted from fingerling to legal size fish.

The historical perception by anglers of the great fishery in the Jordan River (MDNR, Fisheries Division files) is influenced from the time when substantial numbers of legal and adult size fish were stocked (Appendix 2). Brook trout adults were stocked in the Jordan River from 1938-1960, the majority stocked from 1951-1960 (Figure 22). It was during this time that anglers remember great fishing in the Jordan River (MDNR, Fisheries Division files). There was a negative linear relationship between the catch per hour of legal size brook trout and the number of adults stocked (Figure 24). This relationship was statistically significant at the 90% confidence level (Pearson Correlation, P=0.007, N=26) suggesting that harvest of adult brook trout decreased as stocking increased. Stocking simply could not keep pace with the rapid increase in angler activity.

Brook trout have not been stocked in the Jordan River since 1964 and their numbers have generally increased. As mentioned earlier, a policy developed that fish should not be stocked in streams capable of supporting a fishery through natural reproduction. It was about this time that emphasis was directed more to rehabilitating the habitat to enhance naturally produced fish. It was also during this time that hatchery space was needed to rear and stock the introduced coho and chinook salmon (in 1966 and 1967). Trout rearing stations were also closed during this time because of high operational costs.

Brook trout are reproducing naturally in the Jordan River and tributary streams. This species is typically short lived (2-4 years) and generally small (Scott and Crossman 1973). Brook trout growth, in the Jordan River, is equal to the state average for stream fish (MDNR, Fisheries Division, unpublished data). They are most abundant upstream from the JRNFH (Table 10). Survey numbers range from 14 to 4,365 fish per acre, with an average of about 1,100 fish per acre, which is good when compared to other streams in the state. There is sufficient reproduction in the upper Jordan River to sustain a good fishery by today's standards. Brook trout numbers decrease downstream to where they are almost absent below the National Fish Hatchery.

Steelhead

Steelhead stocking in the Jordan River began in 1934 and has continued to the present (MDNR, Fisheries Division records and Appendix 2). Adult fish were stocked beginning in the 1930s, but were the predominant size-class throughout the 1950s and 1960s (Figure 25). Creel surveys were conducted during this time (1934-64) to evaluate the stocking program (MDNR, Fisheries Division, unpublished data, and Appendix 3). There was a slight positive linear relationship between catch per hour of legal size rainbow trout and stocking of adults (Figure 26). However, the relationship was not statistically significant at the 90% confidence level (Pearson Correlation, P=0.145, N=27) suggesting that harvest was not positively correlated to stocking of adults. Adult stockings were eliminated after 1965 due to changes in stocking policies mentioned earlier.

In the 1960s, there was renewed interest in steelhead (Borgeson and Tody 1967) which grew rapidly to a large size in the Great Lakes, and returned to natal or stocked streams to reproduce and provide outstanding angling opportunities. Control of adult sea lamprey (see **Biological Communities, Pest Species**) and abundant forage food in the Great Lakes (Borgeson and Tody 1967) improved growth and survival of steelhead. In the early 1970s there was a desire to provide a steelhead fishery in the Jordan River (MDNR, Fisheries Division files). Steelhead (winter strain) were first stocked (10,404 yearlings) in the Jordan River in 1972 (MDNR, Fisheries Division records and Appendix 2). Annual stockings have occurred since 1983; the last 10 years averaging 8,400 yearlings (7 to 8 inches). Steelhead are stocked at either Rogers or Webster Bridge.

There are no estimates of adult steelhead in the Jordan River. However, estimates of returning adults to the Jordan River may be calculated by comparing stocking and natural parr densities to two nearby rivers (Little Manistee and Betsie River) of similar size, habitat, and discharge.

Creel surveys for the Betsie River, Benzie County in 1986-88 showed a harvest of 1,000 to 3,000 adults between April and November (Rakoczy and Rogers 1987; Rakoczy and Rogers 1990). Numbers of steelhead stocked in previous years averaged 15,000 yearling smolts (MDNR, Fisheries Division records). Although estimates of natural reproduction were lacking for the Betsie River during this time, Newcomb (1998) estimated less than 3,000 steelhead smolts produced per year in the mid-1990s. If annual emigrations were at least 15,000, they produced a minimum stream harvest of 1,000 to 3,000 for a return rate of 7 to 20%. Using these survival rates (7-20%), the stocking 8,400 smolts in the Jordan River should produce a run of 588 to 1,680 adults.

Steelhead are reproducing naturally in the Jordan River (MDNR, Fisheries Division, unpublished data). Growth of steelhead parr in the Jordan River is equal to the state average for stream fish (MDNR, Fisheries Division, unpublished data). They are most abundant from just above the JRNFH (4^{th} crossing) downstream to Graves Crossing (Table 10). Steelhead numbers (fall parr) ranged from 179 to 1,798 fish per acre. The mean density for all 10 Jordan River stations sampled in 1987 and 1994 was 481 parr per acre. Seelbach (1993) estimated an annual mean density in the Little Manistee River of 1,202 parr per acre from 1981-83. The Little Manistee River has both higher densities and larger size. The calculated surface area for the Little Manistee River mainstem is 346.5 acres (Seelbach 1993) and the Jordan River is 219.7 acres (see **Channel Morphology**). Estimated production (surface area x density) of fall parr in the Jordan River is 105,680 and estimated production in the larger Little Manistee River is 416,493 parr. If the Little Manistee River produced an average adult run of 8,000 per year (MDNR, Fisheries Division, unpublished data) then the smaller Jordan River should produce annual runs of 2,030 naturally produced adults. Total adult returns (stocked plus naturally produced) could be in the range of 2,618 to 3,710 adults. These fish migrate from September through June and numbers at any one time do not cause problems associated with angler trespassing, litter, and snagging.

Steelhead parr at all index stations in the Jordan River were higher in 1987 than in 1994 (Table 10). These higher numbers may have been the result of more adults accessing suitable spawning and nursery habitat prior to construction of the adult salmon blocking weir (fall 1987) and the adult sea lamprey electric barrier (spring 1988). Seelbach (1993) estimated that 80% of the adult run in the Little Manistee River occurred in spring. If similar ratios occur in the Jordan River, then spring operation of the electric barrier could negatively affect the upstream fishery and natural reproduction. Passage of adult steelhead over the electric barrier in spring could increase reproduction thus eliminating the need to stock the Jordan River. However, many steelhead now pass through the electrical field and reproduce successfully.

Brown trout

A few thousand brown trout adults were periodically stocked in the Jordan River mainstem (1939 and 1947-1949) to supplement the large stockings of brook and rainbow trout (MDNR, Fisheries Division records and Appendix 2). During this period, many sportsmen’s groups helped the state rear and stock fish. These groups probably stocked unknown numbers of fish in conjunction with fish stocked by the state. The brown trout catch during these years of adult stocking was poor, partly due to limited stockings, but also because of the increased stocking and harvest of brook and rainbow trout that are more vulnerable to angling (MDNR, Fisheries Division, unpublished data and Appendix 3). The last period for brown trout stocking (yearling size fish) was 1970-1974. Stockings were discontinued because natural recruitment was believed to be adequate to maintain a modest fishery.

The Jordan River once had a potamodromous migration of large, very silvery brown trout, typical of other Great Lakes fish. As adults, these fish lived in Lake Charlevoix and Lake Michigan. The migration usually began in mid-June and continued through summer (MDNR, Fisheries Division files). The fishery occurred as far upstream as Graves Crossing. The fish remained in the river until after fall spawning, then presumably returned downstream to Lake Charlevoix and Lake Michigan, since there are no reports of large brown trout present in winter or early spring. In summer 1967, a fisheries survey found good numbers of these spawners (one per 100 foot of stream surveyed), and this continued into the mid 1970s. In the 1980s few of these fish were collected (MDNR, Fisheries Division files and angler reports).

Brown trout populations were estimated at 10 index stations on the Jordan River in 1987 and 1994 (MDNR, Fisheries Division, unpublished data and Table 10). Growth of brown trout in the Jordan River is slightly slower than the state average for stream fish (MDNR, Fisheries Division, unpublished data). Brown trout are most abundant from just above the JRNFH downstream to Pinney Bridge. The number of brown trout in the Jordan River ranged from 273 to 1,838 fish per acre with an average of 833, which is twice as good as the Little Manistee, a stream with a reputation for its brown trout fishery. Brown trout populations were estimated at six index stations on the Little Manistee River in 1995 and densities ranged from 140 to 598 fish per acre with an average of 394 (MDNR, Fisheries Division, unpublished data). Densities similar to the Little Manistee River were found in the Boardman River upstream from two hydroelectric dams. Mean density in the Boardman River from 1985-87 was 395 brown trout per acre (MDNR, Fisheries Division, unpublished data). Density of brown trout appears to nearly twice as high in the Jordan River as in the Little Manistee and Boardman rivers.

Chinook and coho salmon

Coho and chinook salmon were successfully introduced into Lake Michigan in 1966 and 1967 (Borgeson 1970; Anonymous 1974b). In 1967 adult coho salmon strayed into many streams from Muskegon to the Straits of Mackinac. Presumably chinook salmon followed the same pattern following initial stockings. Prior to 1970, salmon were uncommon in the Jordan River (MDNR, Fisheries Division files). Beginning in 1970 the salmon migrations increased until a substantial run had developed. This rapid increase was thought to be due to straying from stockings that occurred in Lake Michigan between Charlevoix and Petoskey in the early to mid 1970s (MDNR, Fisheries Division files).

Fall migrations of salmon begin in late August, peak in late September through early October, then diminish in November (Hay 1992; Pecor 1992). In some years there is a small coho salmon run in December (MDNR, Fisheries Division files). The increased numbers of salmon in the Jordan River during the late 1970s created an illegal snag fishery (MDNR, Fisheries Division files). The large numbers of anglers that pursued these salmon resulted in destruction of the fragile stream banks, accelerating sand erosion to the stream. Trespass and littering were common complaints on the river. To help eliminate the problems in the upper Jordan River, a temporary salmon-blocking weir was installed on the mainstem just below Deer Creek in 1977 and 1978. Salmon (mostly chinook) were harvested by MDNR, Fisheries Division in 1977 (4,335 fish) and 1978 (2,999 fish). In October 1977, it was estimated (by random visual counts) that there were about 800 salmon in the river upstream from the weir (MDNR, Fisheries Division, unpublished data). Estimated total return (harvest plus escapement) to the Jordan River in 1977 was 5,200 fish. Estimated return in 1978 was 4,900 fish based upon harvest and random visual counts of escaped fish upstream from the weir. In 1979 it was estimated that 2,300 fish returned to the river based upon visual observations along the river (MDNR, Fisheries Division, unpublished data).

Since 1979 no estimates have been made of the adult salmon runs in the Jordan River because of reduced workforce and low priority. In the late 1970s, return rates from stocked chinook in a Lake Michigan tributary were no better than 8% (Hay 1992). In 1979 it was estimated that a maximum of 13,000 chinook smolts were naturally produced in the Jordan River (Carl 1982). These naturally produced smolts would be expected to produce a return of 1,000 adults. However, adult runs during this period were from 2,300 (1979) to 5,200 (1977). The difference could be stray fish from other nearby rivers that are either stocked or naturally produced. Straying therefore could account for 50-80% of the adult runs. If similar numbers of smolts are still produced naturally in the river, then with current (1990s) return rates of 2% to 4 % (MDNR, Fisheries Division, unpublished data), the expected return of naturally produced fish would be 260 to 520 adult chinook. Adding in strays, the runs could be 500 to 2,600 fish. Runs of this smaller magnitude in a stream the size of the Jordan River should not produce problems associated with angler trespassing, littering, and snagging that was observed in the late 1970s.

In 1983, a stocking of 315,000 spring fingerling chinook salmon occurred in the Jordan River to help meet the demands of the fishery in northern Lake Michigan. The following year the stocking location was changed to Medusa Creek, a tributary to Lake Michigan near Charlevoix. It was expected that the salmon would return to Medusa Creek to be harvested. Chinook salmon (approximately 300,000 spring fingerlings) are still stocked annually in Medusa Creek and some of these fish probably stray into the Jordan River. In an effort to reduce straying, fingerling chinook salmon are held in a pond, connected to the stream, for several weeks prior to smolting to imprint them to the creek (MDNR, Fisheries Division, unpublished data).

Problems associated with chinook salmon continued through the 1980s in the Jordan River despite decreased run size. A second attempt to harvest salmon in the lower Jordan River (below confluence with Deer Creek) occurred from 1983-1986. Harvest operations were not successful, in part because of structural problems with the temporary weir. A decision was made in 1987 to construct a permanent salmon blocking weir at the mouth (Highway M-32 Bridge) of the Jordan River. MDNR, Fisheries Division operated the blocking weir each fall (September and October) 1987-98. Because of problems cleaning debris from the weir grates and safety concerns, it was decided to move fish blocking operations upstream to the electric lamprey barrier beginning fall 1999.

The electric lamprey barrier was constructed (in 1988) for blocking spawning-phase sea lamprey from migrating upriver from Lake Michigan from March 1 through July 15 (see **Biological Communities**, **pest species**). Since the electric barrier is also effective in stopping fish, it was activated from September through October of 1999 to stop migrating salmon. Operational dates will be similar to ones used when the physical barrier at M-32 Highway bridge was operated. This change in location of the salmon-blocking weir now opens an additional two miles of stream to fishing for potamodromous fish. There were no reported problems with the new fishery for salmon in the 2-mile section of the lower river. It is unknown how many or what percent of the run of salmon are blocked during fall at the electric weir. Fall 2000 operation indicated poor blockage of salmon, since salmon were observed upstream during weir operation. Steelhead, brown trout, and other species may also be blocked during fall operation of the electric barrier. No evaluations have done to determine effectiveness on blocking salmon or other species.

Coho salmon have not been stocked in the Jordan River watershed but extensive straying occurred shortly after initial 1966 stocking in Lake Michigan (Borgeson 1970). Coho salmon juveniles occur throughout the river but are predominantly in the same area as brown trout. Carl (1982) did not estimate mean densities of coho salmon in the Jordan River but did note that the stream appeared to produce more coho than chinook. Mean densities of coho salmon per acre in 1987 and 1994 were 432 fish per acre (Table 10). Most of these fish are parr and assuming that 20% survive the winter to smolt the following spring, the estimated production would be 86 smolts per acre. Assuming there are 220 acres of mainstem – upper Jordan River (147 acres) plus lower Jordan River (73 acres), there could be nearly 19,000 smolts produced in the Jordan River. Mean return rates from stocked coho in the Platte River from 1987-91 averaged 5.1% (Pecor 1992). Using this return rate the expected return of adults from these naturally produced smolts is about 969 fish. Coho straying into the Jordan River is probably minimal. Patriarche (1980) found that over 96% of adult coho returned to their stocked stream. Very few coho are harvested from the MDNR weir at nearby Medusa Creek, Charlevoix County (MDNR, Fisheries Division, unpublished data) despite stocking nearly 1,000,000 yearling coho in the Platte and Boardman rivers (MDNR, Fisheries Division records). These two rivers are within 30 miles of the Jordan River. Returns of about 969 adult coho salmon in a stream the size of the Jordan River should not create problems associated with angler trespass, litter, and snagging.

Competitive interactions and target-species management of river zones

The presence of naturalized salmonids (brown trout, steelhead, coho salmon, and chinook salmon) in the Jordan River has led to many debates over the interaction among these species and the native brook trout. To minimize the potential competition between fishes it would be necessary to separate them. Specific zones or sections of river would be identified and managed for certain target-species. To separate these zones, barriers have been proposed to prevent species from mixing. In the Jordan River there have been numerous attempts to zone the river. The earliest was the construction and operation of an alternating current (AC) electric weir in 1957 in the Jordan River mainstem between Deer and Birney creeks. The purpose was to monitor the magnitude of the spawning sea lamprey run and also prevent them from reproducing (E. Koon, USFWS, personal communication). This electric barrier was removed in 1961 due to safety concerns. Temporary salmon blocking weirs were constructed in 1977, 1978, and during 1983-1986 in the lower Jordan River to prevent salmon from potentially affecting trout populations and to eliminate problems of angler trespass, littering, and snagging upstream. In 1987 a permanent physical structure was constructed at the mouth of the

Jordan River to continue excluding salmon and steelhead. The next year (1988) the electric barrier (two miles upstream) was constructed and activated in spring to block adult spawning-phase sea lamprey and adult steelhead. In fall, 1999, the mechanical weir at the mouth of the Jordan was abandoned (for safety reasons) and the electric barrier activated to continue blocking salmon and steelhead. Moving the salmon blocking operation upstream about two miles (to the electric barrier) opened additional angling opportunities during fall. In recent years there has been a proposal to construct and operate another fish-blocking weir in the middle section (somewhere around Graves Crossing) of the Jordan River (S. Swan, MDNR, Fisheries Division, personal communication). The purpose of the proposed weir is to segregate brown trout from brook trout. By eliminating brown trout from the upper Jordan River it is expected that brook trout would extend their range further downstream. The plan was to create three fisheries management zones. The lowermost zone for salmon and steelhead, the middle zone for brown trout and the upper zone for brook trout. There are some benefits to zoning the river for target-species.

Reasons to zone the river
There are several reasons why it would be beneficial to zone the river to segregate species from one another. Zoning would reduce the potential for interspecific competition. The potential interspecific competition should be highest among species with similar life histories and habitat preferences that did not co-evolve together. Brook trout and arctic grayling were the only stream salmonids native to northern Michigan. Lake trout and whitefishes were potamodromous. Coho salmon, chinook salmon, and rainbow (steelhead) trout co-evolved in the Western United States, but not with the European brown trout.

Anglers and some fisheries managers are concerned that potamodromous salmonids may interact negatively with brown and brook trout. A research study on interactions between steelhead and resident brown trout in a small stream not accessible by potamodromous fish is currently in progress at MDNR, Hunt Creek Fisheries Research Station. Adult steelhead are stocked annually, and spawn, and add juveniles to the fish community in a stream containing primarily brown trout. Early results indicate that numbers of yearling size brown trout are reduced somewhat in the presence of steelhead spawning and juvenile populations (A. Nuhfer, Fisheries Division, personal communication).

There is concern among anglers that brown trout are displacing brook trout. Studies have shown competitive interactions between the two species. Fausch and White (1981) found that adult brown trout excluded adult brook trout from favorable stream positions. Alexander (1977) found that large brown trout eat more young brook trout than young brown trout when both live in the same section of stream. Brown trout have displaced brook trout from much of their original habitat in the northeast USA (Fausch and White 1986). Brook trout still predominate the uppermost 4.5 miles of the Jordan River, but are scarce in the middle sections that are dominated by brown trout (MDNR, Fisheries Division, unpublished data and Figure 27).

Fausch (1981) found that in competitive situations, juvenile coho salmon dominated juvenile brook trout and brown trout for advantageous stream positions, even if they were of equal size. He found that coho salmon were more efficient in capturing food and energy for growth. One stream that Fausch studied was the Green River, a tributary to the Jordan River. He found that coho salmon fry emerged about two weeks earlier and were slightly longer than brook trout or brown trout at emergence. Coho salmon maintained that size advantage throughout the first summer. The larger size of coho salmon gives them an even greater advantage over brook and brown trout. Stauffer (1977) found lower numbers of juvenile brook and brown trout when juvenile coho salmon were present in Lake Superior tributaries. Taube (1975) found a decrease in young-of-the-year brown trout in the presence of coho salmon, but there was negligible long-term decrease in resident trout because of compensatory survival to older ages in the nearby Platte River. Coho are found throughout the Jordan River, but seem to dominate the larger mainstem, from Pinney Bridge downstream (Figure 27).

Preventing potamodromous fish from accessing stream sections with brown trout and brook trout would reduce potential conflicts between angler groups. The seasonal increase in salmon anglers can be a source of frustration for trout anglers who prefer less, and not more, fishing activity.

Reasons not to zone the river
Access to a variety of habitats in a river can accommodate species with slightly different requirements for survival and reduce interspecific competition. Researchers studying interactions of salmonids have indicated that one key element to maintaining sympatric populations is the presence of woody structure. Fausch (1981) commented that instream cover affords visual isolation and somewhat lessens any competitive disadvantages that brown trout and brook trout exhibit when coho salmon are present. Ziegler (1988) observed that steelhead and brown trout are commonly associated with large woody structure in streams. Fausch and White (1986) observed that brown trout and brook trout spent considerable energy chasing fish away from preferred habitat when visual isolation was absent. Instream cover may be one of the key elements in the ability for these salmonids to coexist. The upper Jordan River contains an abundance of woody structure that should help different species coexist.

All salmon and trout are fall spawners except steelhead (Hubbs and Lagler 1947; Eddy 1957; Scott and Crossman 1973). Chinook salmon generally spawn earlier than coho salmon (Scott and Crossman 1973). There is some concern from anglers and fisheries managers about competition for available spawning habitat and superimposition of chinook salmon redds by coho salmon spawners. The fry emerge in early spring, but spend different periods living in nursery streams. Chinook salmon leave after 2-3 months (Carl 1980), whereas coho salmon remain in the stream for 12 months before leaving. Chinook juveniles that leave the stream early should have few interactions with other salmonids. Coho juvenile coexist with resident trout for one year.

Young-of-the-year steelhead had no significant effect on brown trout survival, abundance, or growth (Kocik 1992; A. Nuhfer, MDNR, Fisheries Division, personal communication). However, a current study of interactions between steelhead and brown trout at Hunt Creek Research Station suggests that there is a reduction in the number of age-1 brown trout (A. Nuhfer, MDNR, Fisheries Division, personal communication). Until the study is complete it is too early to determine if there is any effect on age-2 and older brown trout. Steelhead spawn in spring so the young emerge later, are smaller throughout their first year in the stream, and occupy a different niche in the stream than other salmonids (Everest and Chapman 1972). Juvenile steelhead that remain in the stream for 1 to 2 years (Stauffer 1972) evolved with coho salmon. Steelhead use riffle habitat and are unlikely to interact negatively with species that use pool habitats (brook trout, brown trout, and coho salmon). Brook trout, brown trout, and coho salmon or steelhead are most likely to interact as juveniles since they did not coevolve. Brook trout, brown trout, and steelhead along with coho salmon are found throughout the Jordan River (Table 10). Brook trout dominate the uppermost sections, brown trout in the middle sections and coho and steelhead in the lower reaches.

Streams that are not artificially zoned can still provide diverse angling opportunities. Anglers can enjoy catching different species throughout the river. That is because rivers are naturally zoned into ecologically-distinct units based upon the physical channel (and subsequent biological communities) as they flow through the landscape and changes at stream junctions, slope breaks, and boundaries of local landforms (Seelbach et al. 1997). In general, maximum biological production is achieved when there is connectivity of spawning, rearing, feeding, and refuge habitats (Schlosser 1991). This would include a connection to Lake Michigan for rearing and rapid growth of fishes. Diverse fish populations and fisheries tend to be more stable through time than single species fisheries. In the early 1980s chinook salmon were the most important species in Lake Michigan in terms of numbers and pounds of fish harvested (Rakoczy and Rogers 1987). Chinook salmon comprised slightly over 50% of all salmonids harvested. The population crashed in 1987 when the lake-wide densities decreased by 32% compared to 1986 (Rakoczy and Rogers 1988). If it had not been for other salmonid species in Lake Michigan, the entire sport fishery may have collapsed.

Streams not zoned are more productive due to nutrient replenishment. Salmon carcasses provide nutrients and energy to biota within aquatic and terrestrial ecosystems (Cederholm et al. 1999). It is a unique method of moving nutrients upstream into watersheds. Eggs and fry from salmon and other potamodromous species such as suckers are a source of food for aquatic and terrestrial animals. Nutrient levels (as measured by phosphorus concentrations) in the Jordan River are generally low, compared to trout streams sampled in northwest Lower Michigan (see **Water Quality**).

Reproduction of potamodromous species in these streams helps maintain a diverse and sustainable fishery in Lake Michigan. One of the guiding principles to establishing fish community objectives in Lake Michigan was to preserve and restore fish habitat (Eshenroder et al. 1995). In particular, rehabilitation of riverine spawning and nursery habitats used by potamodromous fishes should be a high priority for management agencies. The Jordan River and other tributary streams are important in helping to maintain ecological balance in Lake Michigan.

Fishes usually have the ability to segregate themselves. In the Jordan River, all four species of salmonids are present and appear to segregate to some degree (MDNR, Fisheries Division, unpublished data and Figure 27). Brook trout are dominant in the upper 4.5 miles of the mainstem. This is probably due to the smaller size of the stream (acknowledging partial obstructions for potamodromous fishes), abundance of large woody structure (visual isolation), colder water temperatures, and better spawning habitat (sand and small gravel) for brook trout. Brown trout seem to dominate the middle sections of the river. This may be due to larger stream size, better spawning substrate (larger gravel), and nursery habitat (larger woody structure) for brown trout. Although steelhead and coho salmon are found throughout the river they predominate in the lower sections of the river. The lower section is much wider, has less large woody structure, and contains riffles and pools preferred by these species. Difficulty in collecting fish in this larger section may account for the low survey numbers.

Zoning rivers is logistically impractical. Human attempts to zone rivers have been made in the past with numerous mechanical barriers to block salmon, but all have failed to stop all fish. Low head barriers (e.g., at Hunt Creek Research Station) are not completely effective in stopping brown trout. In many situations, clientele groups (e.g., brown trout anglers) don't want us to exclude brown trout from these headwater areas. Chemical treatments to kill everything are not very successful (MDNR, Fisheries Division, unpublished data). Usually a few individuals survive and quickly repopulate a stream. Manual removal (stream shocking) of brown trout in the Black River (northeast Lower Michigan) to encourage brook trout populations was partially successful (MDNR, Fisheries Division, unpublished data). Brown trout have recolonized portions of the river and remain present in low densities. Barrier construction and maintenance are a liability in terms of safety, cost, and labor (**see Fisheries Management, chinook and coho salmon**). Keeping weirs clean of just natural material (leaves and wood) is costly in terms of labor and potentially dangerous during flood conditions. Attempts to segregate brown and brook trout with bulkhead dams at MDNR Hunt Creek Fisheries Research Station have only been partially effective (A. Nuhfer, Fisheries Division, personal communication).

A discussion of the various management activities in the watershed is proposed by valley section.

Upper Jordan River

Anglers have easy access to most of the upper Jordan River. Brook trout dominate the uppermost 4.5 miles of river. Brook trout are easier to capture by anglers than other trout species (Schuck 1941;

Cooper 1951, 1952; Alexander and Peterson 1983). Thorpe et al. (1947) concluded that trout vulnerability from easiest to most difficult to catch in daytime fishing is brook, rainbow, and brown trout. Fishing pressure and harvest could affect the population of brook trout more easily that that of brown trout that are more common from just above the Jordan River National Fish Hatchery downstream to Graves Crossing. Anglers frequently blame lack of large fish on competition from other species, when in fact it may simply be angling pressure and harvest. Alexander and Nuhfer (1993) concluded that fishing regulations that reduce mortality of intensively fished brook trout in small streams should enhance the population of larger trout. It is recommended that a creel survey be conducted to determine angler harvest of brook and brown trout.

Excessive sand substrates have been identified as a factor affecting fish populations (see **Water Quality, Nonpoint Source Pollution**). The upper Jordan River flows through a valley of glacial outwash sand and gravel (see **Geology and Hydrology**). However, sediment erosion from roads, road stream crossings, and stream banks resulting from human activity has been identified along the Jordan River. In the late 1980s a plan was prepared and implemented that addressed some of this erosion. Several governmental agencies and private groups funded a project to: (1) place rock rip rap on eroding stream banks; (2) remove old beaver dams; (3) stabilize the Jordan River road bank with cedar posts; (4) plant vegetation in barren areas; (5) extend road culverts to lessen slope of stream bank; (6) construct steps to the river for anglers; and (7) construct four sand traps to remove sand already in the stream (MDNR, Fisheries Division files). There are two sand traps on the mainstem of the Jordan River and one each on Landslide and Stevens creeks. The traps have filled with sand and some gravel has been exposed below them. The traps had not been emptied in a few years because of difficulty in getting large excavating equipment to them, but the mainstem and Landslide Creek traps were emptied in 2002. These traps will continue to be emptied on a regular schedule. MDNR, Fisheries Division is responsible for maintenance of the sand traps. Evaluation of the sand traps has been by observations only.

Some fisheries biologists are beginning to question whether the sand bedload in the Jordan River is in fact excessive. The majority of the natural material in the Jordan River valley is sand with pockets of gravel nearer hills or moraines (see **Geology and Hydrology**). Gravel in the stream is commonly more evident where the stream channel touches or cuts into the base of a moraine. The river valley is wide, with a river that is downcutting and moving laterally within the valley. Evidence of lateral movement is cedar stumps in the middle of the stream. The stream is able to move laterally because the banks are predominately sand and easily eroded. The water that is diverted into the banks from fallen trees easily erodes the bank. The sand becomes bedload then moves slowly downstream. Evidence that sand moves downstream is seen in the filling of the sand traps. Pockets of gravel may appear in the channel as the stream down-cuts or simply moves laterally over gravel. Vertical soil borings in the stream channel and valley would help answer to what extent significant gravel deposits exist in the Jordan River valley.

Trout and salmon have been documented in all streams sampled within the Jordan River system (MDNR, Fisheries Division, unpublished data and Appendix 1). Fish surveys from 1926 through 1994 by MDNR, Fisheries Division found salmonids in the Jordan River mainstem, Six Tile, Section Thirteen, Landslide, Cascade, Stevens creeks, and Green River. Many surveys were prior to 1960 and need to be updated. Tributary streams and the mainstem upstream from Graves Crossing are classified Type 1 fishing regulations in the Michigan inland trout and salmon guide 2000 (Anonymous 2000e). Type 1 streams are open to fishing and possession of trout and salmon from the last Saturday in April through the end of September. All types of legal fishing tackle are permitted with a daily harvest of five fish, with no more than three fish 15 inches or larger. Size limits for Type 1 streams are: brook and brown trout seven inches; rainbow trout, coho salmon, chinook salmon, and pink salmon 10 inches; splake eight inches; lake trout 24 inches; and Atlantic salmon 15 inches (only one may be kept). Trout reproduce successfully in these streams and fishing during spawning season could impair reproductive success. Trout growth in these streams is relatively slow, so minimum size limits should also be small.

The upper Jordan River has not been stocked with trout or salmon in more than 30 years. There are no plans to stock the river, as natural reproduction appears adequate to maintain a good fishery by today's standards.

Satterly Lake is a small private lake in the headwaters of Green River. Drainage from the lake is intermittent. In fall of 2000 there was no water flowing from the lake. The lake level was below what appeared to be normal. MDNR, Fisheries Division has no fish survey data on file because this lake is privately owned. MDNR, Fisheries Division does not manage the fishery in Satterly Lake.

The Green River Trout Ranch did not rear trout in 2001. However, the dam that diverts water through a series of concrete raceways and earthen ponds blocks potamodromous fish from high gradient areas with good spawning gravel. The pond behind the dam is currently filled with sand. Removal of the dam and accumulated sand deposits behind it would rehabilitate high gradient spawning gravel for fish and habitat for other aquatic animals. However, without the dam, exotic fish and aquatic pest species have the potential to move upstream, but could be blocked by the electrical barrier.

Lower Jordan River

The lower Jordan River from Graves Crossing downstream is a much larger river. Some fishing occurs from boats but most activity is from wading or shore anglers. The lowermost sections are too deep to wade. Water quality and temperature are very suitable for trout and salmon.

There are considerably lower densities of brook trout and brown trout in the lower Jordan River than above Graves Crossing (Table 10). Densities in the lower Jordan River average about 18 fish per acre while above Graves Crossing the average is about 582 trout per acre. The densities for juvenile rainbow trout and coho salmon in the lower river (258 fish per acre) are about one half of the densities above Graves Crossing (507 fish per acre). Lower densities could be due to limited habitat (mainly instream large woody structure) or competition with other species.

As previously discussed, it is estimated that less than 4,000 adult steelhead run the river (spring and fall). Seelbach (1993) postulated that spring and fall steelhead runs in the Little Manistee River should be nearly equal. Most spring steelhead begin migration in late February or early March. Fishing upstream of the electric barrier will be for fish that migrate upstream past the weir prior to activation on March 15. Once the weir is activated, fish will be blocked until the end of July, thereby limiting most angling to the 2-mile stretch of river below the barrier. Earlier efforts to pass adult steelhead upstream of the weir with a portable fish ladder were not very successful (MDNR, Fisheries Division, unpublished data). Fish had a difficult time finding the ladder entrance in part because of they couldn't find the attraction water and it was suspected that they could feel the electric current near the ladder (MDNR, Fisheries Division, unpublished data). Passage of adult steelhead over the electric barrier (with an improved fish ladder) could increase natural reproduction and provide additional angling opportunities. The annual stocking of 8,300 steelhead yearlings could be eliminated if steelhead were passed upstream of the electric barrier. The state would save $6,200 ($0.75 per yearling x 8,300 yearlings) annually or stock these fish in other waters lacking good natural reproduction.

The Jordan River was unique in that it once supported a good run of lake-run brown trout during summer months (MDNR, Fisheries Division, unpublished data). These fish would remain in the river and provide good angling opportunities until they spawned in fall. These runs diminished until only a few were collected in the 1987 survey (MDNR, Fisheries Division, unpublished data). It is not known why the runs decreased. Any efforts to rehabilitate this unique lake-run brown trout fishery would be hampered by operation of the electric barrier through July unless adults were passed upstream.

Operation of the electric barrier from September 1 through October 31 currently blocks most salmon and some steelhead (MDNR, Fisheries Division, unpublished data). Peak chinook salmon runs occur during this period. Fall steelhead migrations start in October and peak in November. Peak coho salmon runs sometimes occur in November. The barrier has not been very effective in stopping chinook salmon. In fall 1999-2000, chinook salmon were observed by anglers upstream of the barrier as far as the JRNFH. While the barrier has not been totally effective in stopping salmon and the estimated return is less than 3,000 adults, efforts will continue to make it more effective.

Juvenile salmon, juvenile steelhead, and larger brown trout dominate the lower Jordan River, especially below the electric barrier. The mainstem of the Jordan River from Graves Crossing downstream to Lake Charlevoix is classified Type 4 fishing regulations in the Michigan inland trout and salmon guide 2000 (Anonymous 2000e). Type 4 streams are open year around with possession for brown trout, brook trout, and Atlantic salmon only from the last Saturday in April through September. Other species may be kept year around. Gear and daily harvest limits are the same as Type 1 regulations. Minimum size limits are: brook trout eight inches; brown trout, rainbow trout, splake, coho salmon, chinook salmon, and pink salmon 10 inches; lake trout 24 inches; and Atlantic salmon 15 inches (only one may be kept). This section of river receives seasonal potamodromous runs of salmon and trout and has extended fishing seasons for these fishes. Because there is limited reproduction of brook and brown trout, they are protected during the spawning season. Tributary streams in the lower Jordan River, however, are classified Type 1.

Mud Lake is a small private lake that is the headwaters of Bennett (Bartholomew) Creek (Figure 1). MDNR, Fisheries Division has no fish inventory data, in part because public access is lacking. Angler reports indicate that northern pike, largemouth bass, and panfish inhabit the lake. MDNR Fisheries Division does not manage the fishery of this lake.

Deer Creek

Deer Lake is the headwater of Deer Creek. Deer Lake has a legally established lake-level and control structure at the outlet (see **Dams and Barriers**). The lake has a public access site owned and operated by MDNR, Parks and Recreation Division. Deer Lake is 490 acres with a maximum depth of 22 feet. The lake does not stratify thermally and oxygen levels are adequate to support game fish populations (MDNR, Fisheries Division, unpublished data). Netting surveys in 1984 and 1985 found that the most abundant species were bluegill, rock bass, yellow perch, pumpkinseed, largemouth bass, and bullheads. There was a good size distribution of these species and at least 50% of the fish collected were of legal or acceptable size (MDNR, Fisheries Division, unpublished data). Anglers frequently complain of small northern pike that are growing slower than the state average and it has been added to the list of lakes where pike of any size may be retained. The lake is too shallow to support coldwater species of fish. The lake was stocked with coolwater and warmwater species until 1943 (Appendix 2). The lake is not currently stocked, as natural reproduction is adequate to maintain a modest fishery for warmwater species.

The mainstem of Deer Creek and tributary streams have not been inventoried in recent years. Information on fish and aquatic communities are from water quality studies (see **Biological Communities**) and angler reports. The stream is reported to be good fishing for brown trout, with an occasional brook trout. Tributary streams contain both species of trout. Deer Creek could provide more angling opportunities for brook and brown trout if there was better public access. Currently, public access is only available at public road crossings.

Patricia Lake was created in 1891 with the construction of a grist mill on Deer Creek (see **Dams and Barriers**). There are no fisheries collections on file with the MDNR since the lake does not have a public access site. A few angler reports indicate fishing for brown trout ranges from fair to poor. MDNR, Fisheries Division does not manage the fishery in this lake.

Deer Creek downstream from Patricia Lake dam has good water quality but data on water temperatures are lacking. The presence of warmwater sunfish species (rock bass and longear sunfish) would suggest that Patricia Lake increases downstream water temperature. The increased water temperature might also be due to lack of groundwater inflows in the lake plain geology. In spring there are steelhead, suckers, and sea lamprey. In autumn there are salmon and steelhead. During summer there are various species of warmwater fish (bass and panfish). This lower section of river receives moderate fishing pressure during potamodromous fish runs despite a lack of public access. This short stretch of river also produces large numbers of larval sea lamprey (see **Biological Communities, Aquatic Pests Present**). The United States Fish and Wildlife Service (USFWS) treats the river downstream from the dam with TFM to eradicate sea lamprey ammocetes (E. Koon, USFWS, personal communication).

Fish passage over the dam would increase natural reproduction of potamodromous species. If the river were open to fishing, angling opportunities would also increase, especially with the development of public access. Potamodromous fishing generates considerable angling activity. There are no creel surveys for Deer Creek. However, the estimated fishing activity for potamodromous fish (salmon and steelhead) in the Betsie River, Benzie County in 1987 was nearly 4,000 angler hours per river mile (Rakoczy and Rogers 1988). In contrast to potamodromous fisheries, intensively managed trout streams (no potamodromous fish) generated 1,200 angler hours per river mile (Bacon et al. 1958).

Removal of Patricia Lake dam would not only increase reproduction of potamodromous fish, increase angling opportunities upstream, but would also rehabilitate the high gradient spawning gravel for fish and habitat for aquatic invertebrates that is buried beneath Patricia Lake. It would also allow fish species that can't use fish ladders the opportunity to seasonally seek suitable areas for feeding, reproduction, and thermal refuge (see **Biological Communities**). However, removal of the dam would affect the salmon and steelhead fishing that currently exists below the dam. Fish would no longer congregate in large numbers below the dam. With no dam to stop spawning sea lamprey their population would increase, as they would have access to additional spawning habitat upstream from the dam. The USFWS would have to treat additional waters with TFM or construct another barrier specifically for sea lamprey downstream.

Deer Creek has not been stocked with trout since 1965 (Appendix 2). Natural reproduction upstream from Patricia Lake appears sufficient to maintain the modest fishery. Lack of public access limits angling for brown trout and brook trout. The extent of reproduction of trout or salmon below Patricia Lake dam is unknown. Stream inventories are needed in Deer Creek to determine the extent of natural reproduction and to assist in determining appropriate fishing regulations. Currently, tributary streams and the mainstem of Deer Creek are classified Type 1 in the Michigan inland trout and salmon guide 2000 (Anonymous 2000e).

Recreational Use

The Jordan River supports a large number of recreational activities. Many activities are focused on the river and its corridor. Seasonal weather and tourism trends have influence on the recreational uses. Specific recreational activities include: camping, fishing, swimming, hunting, trapping, mushrooming, hiking, photography, snowmobiling, cross country skiing, and canoeing. There are three designated and developed State of Michigan public canoe launches on the mainstem of the Jordan River. Graves Crossing Campground is operated by MDNR, Forest Management Division and MDNR, Parks and Recreation Division operates sites at Rogers Road and Webster Bridge (Figure 28). Other informal canoe launch sites are common and consist of road crossings or road endings at the stream. The road crossing at Old State Road (Chestonia Bridge) is the most widely used informal launch site. Launching of canoes from state land upstream from Graves Crossing is prohibited by MDNR (see **Special Jurisdictions**). Canoeing in this upper section of river would be very difficult due to abundance of instream woody structure. There are two designated State of Michigan campgrounds on the mainstem of the Jordan River, one at Graves Crossing and the other at Pinney Bridge (Figure 28). Both are operated and maintained by MDNR, Forest Management Division. The City of East Jordan operates the Sportsman Park near the mouth of the Jordan River.

The Jordan River mainstem and tributaries receive substantial fishing pressure during the regulated trout season. Brook trout and brown trout are the primary sport species pursued by anglers. Year-round fishing opportunities are available to anglers below Graves Crossing. Steelhead fishing is popular during spring and fall. Anglers also pursue salmon in the fall. There are three commercial fishing guide services using the river. These guides generally agree that although fishing is fair on the river, resident fish size is considered small relative to other watersheds such as the Manistee and Au Sable rivers (D. Monfort, Swiss Hideaway owner, personal communications).

Information about recreation in the Jordan River watershed was mostly compiled from conversations with MDNR personnel, owners of canoe liveries, anglers, hunters, campers, and bait and tackle dealers. Description of recreation and facilities are given in the following valley sections.

Upper Jordan River

There are 12 county roads providing vehicular access into the Jordan River Valley upstream from Graves Crossing (Anonymous 1975). Five roads provide drive-through access; the rest provide access to specific destinations, such as Deadman's Hill Scenic Overlook. The Pinney Bridge and Jordan River roads parallel the river corridor and provide visual and walk-in access to the river (Figure 4). Besides being the primary access to the Jordan River Valley, Pinney Bridge and Jordan River roads provide significant recreational opportunities for sight-seeing, color touring, and general aesthetic viewing of the river valley. The road system is heavily used throughout summer and in winter serves as a major snowmobile trail linking Bellaire, East Jordan, Elmira, and Alba.

The high percentage of public land ownership attracts a large number of hunters that pursue a variety of game species. Ruffed grouse, whitetail deer, woodcock, black bear, bobcat, and wild turkey are popular game species. In addition to hunting, trapping beaver, mink, raccoon, and otter is common along the river corridor.

Walk-in camping opportunities are available at Pinney Bridge State Forest Campground (Figure 28). The campground contains 15 campsites that are available on a self-registration and pay basis. Picnic tables and pit toilets are available. It is accessible from Pinney Bridge Road with limited parking available at the footbridge. The Jordan River Pathway was established to provide hiking and backpacking opportunities, as well as to show scenic, biological, and historical aspects of the Jordan River Valley (Figure 28). The pathway typically begins at Deadman's Hill Scenic Overlook and offers several options as to length of hike. Deadman's Hill loop is three miles, beginning and ending at the top of the overlook. The other segments can be hiked individually or in combination. All smaller segments start and end at county roads. Backpacking the entire pathway is a two-day hike, covering 18 miles. This is a strenuous hike that can be accomplished in one day, but those not in good physical condition should not attempt the one day hike. The end of the first day will place you at the Pinney Bridge campground, where you should plan to spend the night before continuing on the trail back to Deadman's Hill. The pathway is not suitable for cross-country skiing. Motorized vehicles and bicycles are prohibited on the pathway (Anonymous 1977). The Jordan River pathway can be accessed at Deadman's Hill Scenic Overlook where there is vehicle parking and pit toilets (Figure 28). In addition to the Jordan River Pathway, the Warner Creek Pathway is available for hiking and cross county skiing only. MDNR, Forest Management Division prohibits motorized vehicles on the pathway (Anonymous 1990). The Warner Creek Pathway is a 3.8-mile loop with parking available on the south side of County Road M32, 1.5 mile west of US 131 (Figure 28). Pamphlets on both pathways are available from MDNR, Forest Management Division, which operates and maintains these facilities.

Lower Jordan River

The lower Jordan River supports a small watercraft rental industry with two canoe liveries (Jordan River Outfitters and Swiss Hideaway). Jordan River Outfitters is located in the City of East Jordan and Swiss Hideaway at Graves Crossing. Tourism accounts for 90 percent of the canoe livery clientele (B. Monfort, Swiss Hideaway owner, personal communication). Local people also frequent the river. It is estimated that 3,000–5,000 canoes annually float the lower Jordan River. In addition, kayak and tube rental has become popular and adds an estimated 500–1,000 users to the river annually.

Fishing pressure in this lower river is medium to heavy during seasonal runs of steelhead and salmon. During summer months there is less angling activity for resident brown trout. Floating, wading, and shore fishing are all common means of fishing. Some conflicts between user groups are seen on the Jordan River, especially between anglers and pleasure boaters.

Graves Crossing State Forest Campground is located 100 yards east of M-66 on the west bank of the Jordan River in Section 32 of Jordan Township. The campground is 10.0 river miles from East Jordan and was officially developed at its present location in 1968. There are 10 tent trailer campsites available for use on a self-register and pay basis. Maximum use occurs on most weekends (except winter) and holidays. Sportsman Park is located at the mouth of the Jordan River south of M32. Sportsman Park is a day use area used by anglers, canoeists, and people who simply enjoy the scenic beauty of the lower river wetlands.

Deer Creek

Recreational uses of Deer Creek are similar to those on the Jordan River mainstem. However, the high percentage of private land within this segment limits public use. Based upon local reports, hunting is the primary recreational use, with fishing and snowmobiling also common. Access to Deer Creek is primarily from road crossings. The Patricia Lake impoundment and Deer Lake provide a warmwater fishery. No public access exists on Patricia Lake. Deer Lake has a public access site maintained by the MDNR, Parks and Recreation Division.

Citizen Involvement

Citizen involvement in management of the Jordan River watershed occurs through their interaction with governmental agencies responsible for water quality, land use, and recreation. Governmental agencies most actively involved in the watershed are Michigan Department of Natural Resources, Michigan Department of Environmental Quality, United States Fish and Wildlife Service, Natural Resources Conservation Service, Antrim Conservation District, Antrim and Charlevoix Road Commissions (Table 17). Other non-governmental agencies and organizations involved in the watershed include: Michigan Council of Trout Unlimited, Michigan Salmon and Steelhead

Fisherman's Association, Tip of the Mitt Watershed Council, Ruffed Grouse Society, White-tails Unlimited, East Jordan Snowmobile Club, Conservation Resource Alliance, and Friends of the Jordan River Watershed, Inc.

The Jordan River has been fortunate having a local citizenry that has been proactive in setting the tone for river policies, protection, and uses. In 1966, the "Save the Jordan" steering committee drafted bylaws for an inter-municipal committee to protect the river under authority of State of Michigan Public Act 200 of 1957. On January 15, 1967, the Jordan River Watershed Commission (formally "Save the Jordan") became one of the first groups in Michigan formed for the purpose of maintaining and preserving a river. The Jordan River became the first Michigan river to be designated under the State Natural Rivers Act as a Wild and Scenic River by the MDNR, Natural Resources Commission in 1972 (see **Special Jurisdiction**). In late 1990, the group became known as the "Friends of the Jordan River Watershed, Inc.", a nonprofit corporation established under Section 501 (c) (3) of the Internal Revenue Code. Their mission is to conserve the natural resources and protect the environmental quality of the Jordan River and its watershed.

Friends of the Jordan River Watershed, Inc. (FJRWI) have been one of the leading non-governmental organizations in the watershed. They have been involved with issues of land use (exploration and development of hydrocarbons), recreation (trails and campgrounds), water quality (sediment erosion), and educational programs (on preserving the natural character of the river and watershed). The Antrim Conservation District (ACD) is another very active agency in the Jordan River watershed. ACD is dedicated to the conservation and implementation of best land management (agriculture and forestry) practices and, along with the Natural Resources Conservation Service and Tip of the Mitt Watershed Council, have served as lead agencies in developing plans, acquiring financial grants, and implementing projects. A majority of money for various water-related projects has been available through Section 319 of the Federal Clean Water Act of 1972 and the 1998 Clean Michigan Initiative (a $675-million bond). The initiative provided $50-million (state-wide) for nonpoint pollution. To date the Jordan River watershed has received nearly $160,000 from these two funding sources for planning and restoration projects (A. Baughman, Tip of the Mitt Watershed Council, personal communication). Many projects have focused on stabilizing erosion at road stream crossings and stream bank erosion from human activity.

MANAGEMENT OPTIONS

The Jordan River is a unique watershed. It has cold, clean water and extremely stable flows. There are only three natural lakes in the watershed. All streams within the watershed are designated trout waters and should continue to be managed for trout. In general, salmonid populations are very good, especially in the upper sections of the watershed. Management emphasis should be on protection of the watershed, surveys and inventory where information is lacking, and in some instances rehabilitation. The management options presented address the more important problems that are understood at present and are listed to help establish priorities for future management plans.

The options follow recommendations of Dewberry (1992) that outlined measures necessary to protect the health of river ecosystems. Dewberry stressed the importance of protecting and rehabilitating headwater streams, riparian areas, and floodplains. River systems must be viewed as a whole system as many important elements of fish and aquatic animal habitats are connected to one another.

The options presented are consistent with the mission statement of Fisheries Division. The mission is to protect and enhance public trust in populations and habitat of fishes and other forms of aquatic life, and promote optimum use of these resources for the benefit of the people of Michigan. The Division seeks to: protect and maintain healthy aquatic environments and fish communities and rehabilitate those now degraded; provide diverse public fishing opportunities to maximize the value to anglers; and foster and contribute to public and scientific understandings of fish, fishing, and fishery management.

There are three types of options for addressing problems: first are options that protect and preserve existing resources; second are options that require additional information through surveys; third are options to rehabilitate degraded resources.

Geology and Hydrology

The Jordan River has very stable flows due to high groundwater inflows resulting from large permeable glacial deposits and in addition to inflow of water from neighboring aquifers. Changes in land use that affect infiltration of precipitation to groundwater will likely have the greatest effect on the river.

Option: Protect flow stability of streams from effects of land use changes (increase in impervious surfaces from development practices), channelization, irrigation, and construction of dams and other activities that may disrupt the hydrologic cycle, by educating and working with planners, zoning boards, developers, drain commissioners, and land owners.

Option: Protect critical groundwater recharge areas by identifying them and developing a protection strategy. Identify major removals of groundwater and analyze potential effects on existing groundwater. Uses include agricultural, industrial, and residential irrigation within Antrim and Charlevoix counties.

Option: Protect wetlands and floodplains as water retention structures for high flow conditions. Identify areas of special concerns with regards to flooding.

Option: Protect flow stability by developing a hydrologic routing model for the entire river system that describes both ground and surface water routes in response to changes on the landscape. Such a model would allow various planning alternatives to be examined and drive future planning processes by providing fundamental information critical for proactive landscape and storm water management planning. It could also be used to identify critical tributary watersheds.

Option: Assess tributaries for sediment loading, land use changes, wetland protection, storm water run-off, and forest fragmentation, and determine their effects on the Jordan River flow regime.

Option: Assess status of woody structure within the river. Develop a stream hydrology plan to address woody vegetation within the stream and along the riparian zone for the protection and rehabilitation of habitat diversity.

Option: Assess beaver activities within the Jordan River watershed both past and present. Make a determination as to their effect on to stream hydrology and flow patterns.

Soils and Land Use

Soil type is an important component of hydrology and can also dictate land use patterns in a watershed. Historical logging changed the vegetative cover. Some cleared forestland was converted to agriculture. Current land use such as logging, agriculture, road construction, oil and gas development, recreation, and residential construction will likely continue to influence the river system.

Option: Protect undeveloped properties from intensive development though property tax incentives, conservation easements, transportation policies, zoning, and public purchase of open space. Protect sensitive areas such as wetlands, floodplains, steep slopes, riparian zones, etc, through the application of existing environmental laws.

Option: Support resource based economic development by encouraging best management of forests, lakes, streams, and minerals.

Option: Assist governmental units in planning and zoning issues.

Option: Address forest fragmentation though forests legacy, local conservation easements, and planning and zoning.

Option: Study the effect of oil and gas development within the Jordan River watershed.

Option: Use the Lake Charlevoix Road and Stream Inventory project to assess erosion and fish passage problems and implement corrective measures.

Dams and Barriers

There are three registered dams with MDEQ and an unknown number (probably less than 20) smaller human-made dams on tributaries. One dam was used for trout rearing (Green River Trout Farm), one controls a lake level (Deer Lake), and the third is a retired hydroelectric dam (Patricia Lake). It has been estimated that 30% of the culverts in the watershed are “perched” or undersized. The electrical barrier, located approximately two miles upstream from Lake Charlevoix, also blocks fish movements.

Dams and “perched” or undersized culverts affect the biological communities of the Jordan River. They fragment habit, alter fish and invertebrate habitat, impound high gradient habitat, trap sediments, warm surface waters, block fish movement, and interfere with migrations of mammals, reptiles, and amphibians that use stream corridors. Patricia Lake Dam and the electrical barrier have the positive effect of blocking adult sea lamprey.

Option: Protect existing connectivity of streams by opposing construction of new dams and use of undersized or improperly placed culverts.

Option: Protect connectivity of larger streams by requiring construction of bridges in lieu of culverts.

Option: Survey small and unregistered dams and perched culverts in the watershed, involving landowners in the process.

Option: Rehabilitate fragmented aquatic habitat by working with county road commissions and local property owners to replace “perched” and undersized culverts with structures that do not hinder fish and other animal movements.

Option: Rehabilitate free-flowing river conditions of the Jordan River by removing the old metal fish-blocking structure at Highway M-32 in the City of East Jordan.

Option: Rehabilitate free-flowing river conditions and rehabilitate high gradient habitat by encouraging dam owners to consider dam removal now or in the future. Work with owners to explore funding options, including escrowing money for future dam removal.

Option: Rehabilitate or enhance angling opportunities and natural reproduction of potamodromous fisheries by providing fish passage over Patricia Lake Dam and Green River Trout Ranch Dam, until they are removed.

Option: Rehabilitate river navigability on Deer Creek by providing canoe portage at Patricia Lake Dam.

Option: Rehabilitate potamodromous fisheries by removal of the electrical barrier when other methods are developed for controlling sea lamprey that have less effect on biological communities.

Option: Rehabilitate the headwaters of Warner Creek by total removal of the partially failed earthen dam creating O’Brien’s Pond and plant native vegetation to shade the stream.

Water Quality

Water quality is excellent in the Jordan River watershed. However, there are a few areas affected by increased nutrients (Jordan River below the JRNFH) and sediment. The Jordan River National Fish

Hatchery adds phosphorus to the river, although less than in the past. Immediately below the discharge there is a noticeable increase in algae growth. Agriculture and residential development (along the lower Jordan River and Deer Creek) have contributed some nutrients and sand. Recent inventories by the Charlevoix Conservation District indicate that road and stream crossings still contribute sand and that there still remains some bank erosion attributed to human activities.

Option: Protect water quality by limiting exploration and development of oil and gas resources in the stream corridor.

Option: Protect water quality by limiting construction of road and utility crossings in the stream corridor.

Option: Protect water quality by reducing inputs of nonpoint source pollutants (sand and nutrients). Work with farmers, developers, and residential landowners by encouraging them to implement best management practices.

Option: Protect water quality from sand sediment delivery by closing or relocating Pinney Bridge Road between Jordan River Road and Pinney Bridge.

Option: Protect surface water: groundwater flow ratio by identification of high infiltration areas and encourage land use that will protect these areas.

Option: Protect water quality by preserving and rehabilitating wetlands, floodplains, and green belt vegetation along stream corridors.

Option: Protect the river by preventing pollutants from entering the groundwater and surface waters by encouraging use of best management practices.

Option: Protect water quality in the Jordan River by working with the JRNFH to implement techniques to further reduce phosphorus discharge.

Option: Survey thermal effects of Patricia Lake Dam on Deer Creek. If the impoundment is affecting stream temperatures then consider augmenting the river with cooler water or removal of the dam to rehabilitate the stream temperature.

Option: Survey soils and groundwater for pollutants near those sites listed as sites of environmental contamination. Two sites (W & K Salvage; and East Jordan Tool and Die) were listed based solely upon activity at the site and their potential for contaminating soils and groundwater.

Option: Survey point and nonpoint sources of pollution (sediment and nutrients) and develop remedial action plans to correct problems.

Option: Continue monitoring the groundwater near East Jordan Coop Bulk Plant until contamination levels are reduced to where the site can be removed from the state list of contaminated sites.

Special Jurisdictions

Natural resources are managed by MDNR and environmental programs are regulated by MDEQ. In 1972, the Jordan River became the first river in Michigan to be designated a state “wild-scenic river” under authority of the State Natural Rivers Act (1970 P.A. 231). County road commissions in two counties maintain many roads in the watershed. Charlevoix County Drain Commissioner maintains the legal lake level on Deer Lake. Townships regulate some land use activities within the watershed and the City of East Jordan borders the lowermost section of the Jordan River.

Option: Protect existing water quality by ensuring (through public participation) parts of NREPA of 1994 are enforced by regulatory agencies.

Option: Protect additional streams by expansion of Natural Rivers Zoning to include the Jordan River downstream from Rogers Bridge and Deer Creek.

Option: Protect existing aquatic habitat by working with other MDNR divisions in establishing criteria for establishment of a natural and old growth area along the Jordan River.

Option: Protect stream habitat diversity and water quality by discouraging designation of County Drains.

Option: Rehabilitate river navigability on the lower Jordan River by removing the metal beams at the M-32 Bridge. The metal beams are no longer needed to support salmon blocking grates.

Biological Communities

The Jordan River was once famous for its native Arctic grayling, but they disappeared by the late 1880s, presumably from loss of habitat, over harvest, and competition from brook trout. Nonindigenous salmonids soon filled the void vacated by Arctic grayling. Brown trout, steelhead, chinook salmon, and coho salmon became established in the watershed. Sand bedload deposition in their spawning, feeding, and nursery areas has had some effect on these species. Dams and barriers have affected their distribution and limited angling opportunities. Twenty three percent of the upland hardwoods have been converted to agriculture or residential development. Of the 162 species of birds thought to inhabit the Jordan River watershed, fifteen are listed as threatened or of special concern by MNFI. The bald eagle is also listed as threatened under the Federal Endangered Species Act. Their declines are thought to be from loss of habitat necessary for at least part of their life cycle.

Introduction of pest or nuisance species has affected fish and aquatic communities. Most noticeable is the invasion of the sea lamprey. Its predation once decimated sport fish populations in the Great Lakes. Lamprey control (chemical treatments, physical and electric barriers) has also had an affect on biological communities in the Jordan River watershed.

Option: Protect existing high gradient areas (gravel dominated spawning areas and habitat for invertebrates) by opposing construction of dams.

Option: Protect native and naturalized species from predation and competition from introduction of pest species (e.g., sea lamprey, zebra mussel, purple loosestrife, rusty crayfish, gobies and Eurasian milfoil), by curtailing their spread through chemical, biological, or physical control and educating the public about the dangers of introducing pest species.

Option: Protect the riparian zone (used by mammals, birds, reptiles, and amphibians) by encouraging building setbacks, and greenbelts through local zoning, and state (expansion of Natural Rivers designation) and federal statutes.

Option: Survey present fish communities (including non-salmonids), aquatic invertebrates, reptiles, amphibians, mammals, and bird distributions and status within the watershed.

Option: Survey distribution and status of species known to occur (by MNFI) in the Jordan River watershed and listed as special concern (northern goshawk), threatened (osprey and bald eagle), or endangered; and develop plans for protection of critical habitat.

Option: Survey distribution of nuisance plant and animals within the watershed.

Option: Survey point and nonpoint sources of pollution (sediment and nutrients) that affect fish spawning, feeding, cover, and invertebrate populations. Develop remedial action plans to correct problems if they are identified.

Option: Rehabilitate fish populations of potamodromous fishes by removal of unnecessary dams and barriers, or provide fish passage (both upstream and downstream) for salmonids and warmwater species (e.g., suckers).

Option: Rehabilitate high gradient areas (for fish spawning and production of invertebrates) and fragmented habitats (to allow fishes to migrate for feeding, spawning and refuge) by removal of unnecessary dams and barriers (including perched and undersized culverts).

Fishery Management

Angling is good in the Jordan River. Brook and brown trout dominate the upper reaches of the Jordan River. Potamodromous species dominate the lower Jordan River during spring and fall. Brown trout and brook trout dominate Deer Creek upstream from Patricia Lake. Presence of adult sea lamprey, and management actions to reduce their numbers, have an effect on fisheries in the river. Sand in the system affects fish communities. Fragmentation of the river by dams and barriers reduces biological diversity and limits angling opportunities. Angling opportunities could be enhanced with additional public access on Deer Creek.

Option: Survey angler use (creel surveys) throughout the watershed.

Option: Survey all road and stream crossings and work with owners to correct problems of sedimentation and barriers to movement of fish and aquatic invertebrates.

Option: Survey distribution and recruitment of coho salmon, chinook salmon, steelhead, brook trout, and brown trout in mainstem and major tributaries.

Option: Survey the watershed for point and nonpoint sources of pollution that affect fish spawning habitat and develop plans to correct problems if they are identified.

Option: Survey streams in the watershed for human-made dams and work with landowners to remove unnecessary structures.

Option: Survey aquatic and fisheries communities in Deer Creek upstream from Patricia Lake and downstream to assess effects of the dam.

Option: Survey beaver populations and effects on stream temperature and flow. Identify stream segments and tributaries where beaver are detrimental to fish and other aquatic invertebrates. Implement DNR Beaver Management Policy.

Option: Survey distribution of gravel below the sand substrate in the mainstem of the Jordan River by soil borings in the stream channel. Information would be useful in efforts to control sand bedload from point and nonpoint sources versus recognizing what may be natural deposition.

Option: Protect existing gravel by stabilizing eroding stream banks, road crossings, and other nonpoint sources.

Option: Rehabilitate fish migration potential and improve recreational opportunities in Deer Creek by acquiring public property upstream from Patricia Lake dam and providing passage of potamodromous fish.

Option: Rehabilitate fish spawning and aquatic invertebrate habitat (gravel riffles) in the river by construction of new and maintenance of existing sand traps to collect and remove sand bedload.

Option: Rehabilitate stream continuity and high gradient fish spawning habitat by removing unnecessary dams and when dams fail, oppose reconstruction, for example the Green River Trout Ranch dam.

Option: Rehabilitate fish migration by providing fish passage over the electric sea lamprey barrier in spring. Passage of adult steelhead could increase reproduction thus eliminating the need to stock the river. Passage of potamodromous brown trout could reestablish this unique summer fishery. A fish ladder with barrier plates for blocking sea lamprey is being evaluated at an electric sea lamprey barrier on the Pere Marquette River, Mason County. Continue development of alternative methods for controlling sea lamprey that have less effect on fish, including removal of the electric barrier.

Option: Rehabilitate fish migration; enhance natural reproduction and angling opportunities by not operating the electric sea lamprey barrier in fall.

Recreational Use

The Jordan River supports a large variety of recreational activities. Many activities are centered on the river and its corridor. Specific recreational activities include: fishing, canoeing, swimming, hunting, trapping, mushrooming, hiking, photography, and snowmobiling.

Option: Survey level of use by anglers, watercraft users, hunters, campers, hikers, and snowmobile users in the Jordan River watershed.

Option: Survey hunting opportunities in relation to vegetation management within the Jordan River Valley.

Option: Protect the river by supporting efforts to reduce conflicts among user groups (e.g. anglers and canoeists).

Option: Protect the river corridor by maintaining existing designated state pathways and campgrounds.

Option: Protect the river by maintaining scenic overlooks of the Jordan River Valley and existing roadways.

Option: Protect the river by maintaining the existing designated public access sites on the Jordan River to eliminate erosion of sediment into the river and removal of terrestrial vegetation. Discourage heavy use on non-designated access sites.

Option: Improve recreational fishing opportunities in the Jordan River and Deer Creek by removing the electric barrier and Patricia Lake Dam or providing fish passage for upstream migration of fishes from Lake Charlevoix and Lake Michigan.

Option: Improve recreational activities on Deer Creek by providing public access.

Citizen Involvement

The Jordan River and its watershed enjoy a rich history of citizen's involvement. There are a number of active citizen groups and organizations with special interests within the Jordan River watershed (Table 17).

Option: Support programs that encourage local citizen involvement in issues affecting the Jordan River watershed.

Option: Provide leadership and technical assistance to local groups and organizations.

Option: Encourage and support scientifically sound habitat improvement and rehabilitation projects conducted by local groups or organizations.

Option: Improve and implement strategies to educate the community to the benefits of river ecosystems, wetlands, and floodplains by supporting local conservation organizations.

Option: Work with local land conservancy and conservation districts in the identification and acquisition of properties contiguous to state lands within the watershed. Use conservation easements to further land protection efforts within the watershed.

Option: Explain and educate public on scientific management goals and objectives (i.e. timber harvesting, wildlife projects, and eco-system management principals) by encouraging public participation in the annual "Forest Compartment Reviews". Forest Compartment Reviews are a process involving private and public participation in management of forest resources in specific land management areas referred to as compartments.

Option: Encourage increased education and outreach efforts targeted toward increasing knowledge of, compliance with, and support of the State Natural Rivers zoning rules.

PUBLIC COMMENT AND RESPONSE

The draft assessment was distributed during early fall, 2002. The draft was sent to all management unit offices of MDNR and MDEQ in the watershed and selected statewide offices. Copies were distributed to federal, state, and regional agencies as well as all units of local government (townships, villages, and cities) in the watershed. County offices of the Board of Commissioners, Drain Commission, Road Commission, NRCS, Soil and Water Conservation, U. S. Fish and Wildlife Service, and MSU Cooperative Extension Service also received copies. Other organizations receiving copies included the Friends of Jordan River, Trout Unlimited, Tip of the Mitt Watershed Council, Conservation Resource Alliance, Charlevoix Snowmobile Club, East Jordan Snowmobilers, the Frey Foundation, Michigan Trail Riders Association, Friends of the Boyne River, Alba Sportsman Club, and Northland Sportsman's Club. A letter explaining the purpose of the assessment and requesting review comments was enclosed with all copies.

Copies were also sent to public libraries in East Jordan and Charlevoix. It was requested that these copies would be kept in the reference section to assure they would be available. Copies for distribution were available at the Cadillac and Traverse City Fisheries Division offices. Bound copies of the full assessment were sent to any person or group requesting one.

A public meeting to receive comments concerning the draft assessment was held on October 23, 2002 in East Jordan. A MDNR news release was issued on October 14, 2002 regarding the purpose of the Jordan River Assessment and the date, time and location of the public meeting. Several daily and weekly newspapers and radio and television stations in the area were sent notification of this meeting and they published or aired the notice. A total of thirty-four people attended the meeting.

Although the official comment period ended November 31, 2002, comments received up to a month after that date were included. All comments received were considered. The suggested change was either incorporated into the final assessment or listed with the reason it was not included.

Introduction

Comment: Various comments were made supporting the watershed assessment process and complimenting the Division on the effort. Reviewers often requested copies of the final assessment.

> Response: These comments are acknowledged and appreciated. The final assessment will be distributed similar to the draft. Copies will also be sent to everyone who requested one.

Comment: The comment period should be longer.

> Response: The comment period was extended through the end of the calendar year and was as long as all previous assessments. Future comments will be kept on file.

Comment: Many typos, errors, and omissions were found in the draft assessment.

> Response: Thank you for pointing these out. In large documents it is inherently difficult to find all errors. With your help, hopefully most have been caught.

Watershed Assessment

No comments were received under this section.

Geography

No comments were received under this section.

History

No comments were received under this section.

Geology and Hydrology

No comments were received under this section.

Soils and Land Use Patterns

Comment: The State of Michigan should purchase headwaters properties to protect the watershed, especially an 80 acre tract.

> Response: The state is always looking to consolidate ownership. We will look into this eighty acre tract.

Comment: The road along (almost in) the river, from Pinney Bridge upstream should be closed to public use. It serves no necessary purpose and is the primary---virtually only---source of sediment in the upper river. If the county cannot be coerced into closing the road, the DNR should recruit conservationists to join it in an EPA lawsuit against the county.

> Response: Pinney Bridge road, between Cascade Road and Jordan River Road, does not contribute significant amounts of sediment to the stream. Closing a portion of the road is something we are willing to explore.

Channel Morphology

Comment: Sand and sediment are the severest problem in the Jordan River and tributaries. The DNR need to make soil borings, as they found gravel/logs when the existing sand traps were dug. When will the sand traps be emptied again?

> Response: We recognize sedimentation is a problem in the Jordan River and have worked to reduce inputs. The traps were not emptied for a period due to a condemned bridge. They were emptied in late 2002 and are scheduled for spring of 2004, and as needed after that.

Comment: The river assessment mentioned sand traps on the river system, but did not mention the most effective sand trap on the system, (sic)…the dam at the Green River Trout Farm (GRTF). It is a distinct benefit of the dam.

Response: Yes, while it does act as a sediment trap, there are many other detrimental effects of the dam. Also, Mr. Webber, former owner of the GRTF, would periodically open the gate and flush all the sediment downstream to prevent it from filling in his ponds/raceways (S. Hallberg, GRTF, personal communication). The state is in the process of working with the current owner to reduce the ecosystem impacts of the GRTF and the dam.

Comment: Build diversion wings (above Graves) to allow headwaters to rechannelize and gravel to be exposed.

Response: Diversion wings actually cause erosion be deflecting energy. Bank stabilization combined with sand traps will expose more gravel. Removal of “some” of the woody structure will allow stream to return to a single channel.

Comment: Increase structures from Old State Road downstream…more woody structures and man-made islands.

Response: We will inventory fish habitat and add where appropriate. This is one of the management options.

Dams and Barriers

Comment: Comments were received referring to working with the landowners to remove the three existing dams on the system, but the Green River Trout Farm (GRTF) dam was the only one named specifically.

Response: We will work with all owners and look at the feasibility of removing the dams. At this writing we are working with the GRTF owners to look at removing their dam in the future.

Water Quality

Comment: Before the building of the Federal Fish Hatchery the water quality of the Jordan was noticeably better.

Response: Fisheries Division is aware of the high phosphorus discharge coming from the Jordan River National Fish Hatchery. In July 2000, Surface Water Quality Division-MDEQ, through the NPDES permitting process reduced the phosphorus discharge from 2,800 to 2000 pounds per year. We will continue to work with MDEQ to further the phosphorus loading.

Comment: O’Brien’s Pond, a waterfowl impoundment, delivers 89° F water to Warner Creek and removal would reestablish a fine brook trout stream.

Response: Since the earthen dam is partially failed, Fisheries Division will look at total removal and add a management option to restore the free-flowing nature of Warner Creek.

Comment: Streamside vegetation needs to be added providing shade and a cooling effect.

Response: There is a management option, under Water Quality, to preserve and rehabilitate wetlands, floodplains, and green belt vegetation along stream corridors.

Comment: The contamination to the stream from 2-cycle snowmobile engine emissions is not addressed.

Response: We have no scientific evidence emissions from 2-cycle engines are having a detrimental effect on water quality in the upper Jordan River. We will work with MDEQ to monitor emissions and effects.

Special Jurisdictions

Comment: Most county drains have an overall detrimental impact on water resources. However, with "progressive" drain commissioners establishing a "legal drain", it could work to protect water quality by implementing BMP's to deal with runoff problems.

Response: We seek to work cooperatively with all drain commissioners. We also work with MDEQ, NRCS, and County Road Commissions to implement BMP's.

Comment: The DNR forced natural rivers zoning on us.

Response: The designation of the Jordan River as a state natural river was done according to proper policy and procedure with meetings and comments from all points of view.

Comment: The last paragraph on page 65 states: The Green River Trout Farm (GRTF) did not rear trout in 2001. This is incorrect, as cited by Administrative Law Judge Schafer in April 2002 hearing.

Response: The sentence should have said: The GRTF did not rear trout commercially in 2001 and this correction will be made.

Comment: My primary comment deals with the method in which the current Natural River Zoning Board is nominated. The constitution of the group, as well as the way in which it is established is totally contrary to common sense. Consider the following points:

1. None of the current members lives on, or owns property along the Jordan River or its tributaries.

2. Two voting members are employees of the MDNR – a potential conflict of interest.

3. One alternate (Ralph Hay) resides in a different county, perhaps 30 miles from the watershed.

4. Two voting members belong to the Friends of the Jordan, which certainly has an agenda.

Those of us who have had dealings with this group realize the shortcomings of its makeup. In the interest of fairness and common sense, I believe that at least half of the NRZRB needs to consist of stakeholders. Since the group is overseen by Dan Pearson (DNR), it is counterproductive to have voting members that are also DNR employees.

Response: The MDNR has no control over how or whom the county, townships, or watershed groups choose as their representative on the zoning review board. MDNR has only one voting member, as Dan Pearson is the administrator and does not have a vote.

Biological Communities

Comment: Too many beaver in heading.

Response: Fisheries Division along with Wildlife Division will implement the Department Beaver Management Policy and control beaver numbers in critical headwaters areas and important tributaries.

Fishery Management

Comment: Almost forty year old data was used for trout stream designation/classification.

Response: Although some of the data is old, it is still applicable, in that it shows that at one point in time the "designated stream" was capable of holding trout and if they are now absent, we can rehabilitate to original condition. Also, it shows we need to resurvey many areas of the watershed.

Comment: More flies/artificial fishing areas are needed in the Jordan River Watershed.

Response: HB 5556 was passed and signed into law in 2002 which gave the DNR authority to expand "Quality Fishing Regulations" to 212 stream miles. We are in the process of developing criteria and then present this information to the public and accept nominations, in addition to our own, for designation to implement in April 2005.

Comment: Concerned the lamprey barrier not good for health of the Jordan River. It is not effective in stopping lamprey, as we still treat river; suckers and other native species are being blocked by the lamprey barrier.; we are fragmenting fish populations, especially trout perch, a native forage fish.

Response: We recognize that currently some species of fish are blocked and short term that is a necessary evil. Long term we need to construct a fish ladder around the electrical barrier, similar to the one on the Pere Marquette River that has proven to be very effective in passing non-jumping species like suckers.

Comment: The fish distribution maps are wrong.

Response: We will check the maps for and look for errors, but without specifics, we cannot respond appropriately.

Comment: The electrical weir is particularly offensive. It is ugly, it ruins a section of the river visually, it creates a portage place, which tears up the banks and promotes littering, it does not keep lampreys out of the stream, it kills beneficial fish, and lampricide is still required.

Response: The lamprey barrier is a necessary evil and is a trade-off for a larger, more expensive and more biologically damaging chemical treatment. A treatment, prior to the lamprey barrier, would be near Jordan River National Fish Hatchery to the mouth, but is now limited from Landslide Creek to the mouth. A dollar savings of about $100,000 every four years is realized from the use of the barrier, as funding for control of sea lamprey is not unlimited and needs to be used wisely. We hope to fine tune the lamprey barrier to the point where the U. S. Fish and Wildlife Service will have to treat below the weir only.

Recreational Use

Comment: There is a need for more trails.

Response: We will relay this request to Forest Management Division and assist them in properly locating trails.

Comment: There are too many canoes, tubes, and rafts allowed on the river per day during the summer months. A reservation system is needed.

Response: There is a committee looking at the commercial use of state lands. The committee's recommendations should be available in late 2004. In the interim, we will work with the liveries to try to avoid conflicts and effects.

Comment: The old state culvert bridge site is being used as a partying, launching, and camping site, with the area becoming a mess.

Response: The Forest Management Division manages the lands along the Jordan River and we will bring this to their attention.

Comment: The public lands in the Jordan Valley are managed under a multi-use philosophy. The goals set forth are intended to protect the aesthetics and diversity of the forest and aquatic ecosystems while providing recreational use on a sustainable basis. Vehicular traffic, watercraft uses, ORVs, camping, hiking and snowmobile trails, and timber harvests are the issues that have received the most attention.

Watercraft use is the one activity for which no policies or restrictions have been imposed even though the Jordan River Management Plan 1972 (Natural Rivers) allows for no more than 37 rental watercraft. The numbers of rental and personal watercraft have dramatically increased in recent years and pose a large concern for the river, property owners and anglers. Excessive numbers coupled with a "theme park" attitude by some has resulted in stream bank erosion, increased water turbidity, trespass, vandalism, litter, fecal contamination and conflicts with anglers and those simply seeking quiet solitude.

The Friends of the Jordan recently participated in a detailed survey of problem areas along the river and the report of comments, observations and recommendations are included in the Lake Charlevoix Watershed Management Project. Both, restrictions on fragile sites and improved access on more suitable sites are recommended along with remedies for degraded areas. Further steps suggested include; improved public awareness and "river etiquette" through signage and maps, better communications with canoe liveries, outfitters and bait shops, banning of glass containers, requirements to bag and tie down carry-ons, restrictions on numbers or times of watercraft use, increased law enforcement presence and establishing a river watch program. Legal jurisdiction and enforcement remain uncertain and needs to be clarified. Other recreational activities and uses need to be monitored and proper authorities identified if needed to rectify problems should they occur.

> Response: The management options listed will go a long way in answering your concerns cited in your comment. Fisheries and Forest Management Divisions will work with the Friends of the Jordan to cooperatively solve problems and develop a sound recreational management plan.

Citizen Involvement

No comments were received under this section.

Management Options

Comment: There are so many management options….what happens now?

> Response: We will consider all of the listed management options and write a five year management plan, which will include some options. This plan will be reviewed and updated at least every five years. This river assessment is intended to not only guide DNR efforts for restoring, protecting, and rehabilitating the Jordan River, but also to provide guidance for other organizations.

Comment: What happened to the prior management plan? Will this pre-empt it?

> Response: The “new” management plan will complement and build upon the existing plan.

Comment: How long before the management plan will be written?

> Response: The management plan will be written immediately after the river assessment is finalized.

Comment: There are limited options for “preserving” the Jordan River.

> Response: We feel the combination of the assessment, management plan, and Natural Rivers zoning will preserve, enhance, and restore the Jordan River watershed.

Comment: Consider management options that first protect and preserve existing resources, second, options that rehabilitate degraded resources and third, options that gather more information (surveys).

> Response: This strategy will be considered in writing a five year management plan, which will also consider resources and available funding.

Comment: Similar options are sometimes listed under several different topic areas.

Response: Yes, there is some duplication, but a management option may be applicable to several areas.

GLOSSARY

aggradation – the accumulation of bed materials

ammocete – juvenile sea lampreys that burrow in stream substrates for 3 - 6 years before emigrating to Lake Michigan

assimilate – to take in and make use of

base flow – the relatively constant groundwater discharge to a stream system

basin – a drainage area, including both land and water, from which water flows toward a central collector such as a stream or lake at a lower elevation; synonymous with watershed

catchment – watershed upstream from a specific stream site

cfs – cubic feet per second, a common measurement of stream or river water discharge

channel morphology – a study of the structure and form of stream and river channels including width, depth, and bottom type

confluence – place where two or more streams join into one

coniferous – cone-bearing, typically evergreen, trees

deciduous – vegetation that sheds its foliage annually

detrimental – harmful

detritus – debris (e.g., small pieces of wood or leaves) broken away by the action of water

development lease – land classification for leasable mineral rights; surface sites that can be developed for extraction of subsurface minerals

ecosystem – the biological community considered together with the non-living factors of its environment as an integrated unit

endangered species – a species that is in danger of extinction throughout all or a significant portion of its range

exceedence discharge – a stream discharge that is equaled or exceeded by the stream for a given percentage of time. For example, for 90% of the year the stream's discharge is equal to or greater than its 90% exceedence flow value. Consequently, the 90% exceedence flow represents a stream's summer-low (base) flow

exotic species – successfully reproducing organisms transported by humans into regions where they did not previously exist

fauna –animals of a specific region or time

FCMP – Fish Contaminant Monitoring Program

fingerling – fish less than 1-year old that are the size of a human finger

floodplain – a relatively flat valley floor that extends to the valley walls and is periodically flooded by high river flows

glacial – of, or produced by, a glacier

GLEAS – Michigan Department of Environmental Quality, Great Lakes Environmental and Assessment Section

gradient – drop in elevation over a specified length of river

gradient class – an index of hydraulic diversity in streams

groundwater –water beneath the surface of the ground that is the source of spring and well water and supplies steady baseflow to streams

hydrograph – a graph of the water level or rate of flow of a stream as a function of time, showing daily or seasonal change

hydrogeologic – pertaining to groundwater and the type of geological material (clay, gravel, and bedrock) that influences groundwater flows

hydrology – the science dealing with properties, distribution, and circulation of water

impervious – not permitting penetration or passage

impoundment – water of a river system that has been held up by a dam, creating an artificial lake

indigenous – a species that is native to a particular area

infiltration – permitting penetration or passage

invertebrate – an animal having no backbone or internal skeleton

land cover – primary character or use of an area of land (i.e., forest, wetland, agriculture, urban, etc.)

lentic – pertaining to, or living in, still water

loam – a soil consisting of an easily crumbled mixture containing clay, silt, sand, and some organic material

mainstem – mainstream of a river

mainstem valley section – a reach of river with similar physical, chemical, and ecological characteristics, that flows through a particular landscape

mainstream – the primary branch of a river or stream

MDCH – Michigan Department of Community Health

MDEQ – Michigan Department of Environmental Quality

MDNR – Michigan Department of Natural Resources

meander – a winding, curving stream segment

median – a value such that one-half of all other related values are either below or above it

MNFI – Michigan Natural Features Inventory

moraine – an unsorted deposit (often a ridge) of rocks, gravel, sand, clay, etc. carried and deposited directly by a glacier

naturalized – animals or plants previously introduced into a region that have become permanently established, as though they were native

niche – the position or function of an organism in a community of plants and animals

non-development lease – leasable mineral rights where no surface drilling sites will be allowed; these leases prevent removal of minerals by others without compensation to the owner

non-leasable lease – no mineral rights are to be conveyed; this does not protect minerals from removal by others; no compensation is given to the owner

nonpoint source pollution – pollution to a water course that is not attributable to a single, well-defined source, e.g., sediment inputs resulting from poor land use

NPDES – National Pollution Discharge Elimination System

outwash – glacial deposits that have been well sorted by flowing water; outwash deposits typically consist of sand, gravel, and larger material, with the finer-textured silts and clays washed away

perched culvert – improperly placed culvert that fragments habitat by creating a significant drop between a culvert outlet and a stream surface

permeable – soils with coarse particles that allow passage of water

pest species – species that are a nuisance or detrimental to the health of an aquatic community, or interfere with management objectives

physiography – the science of physical geography (landform and texture)

point source pollution – pollution to a water course that is attributable to a single, well-defined source, e.g., the outfall of a pipe

potamodromous – fish that migrate from fresh water lakes up fresh water rivers to spawn; in the context of this report it refers to fish that migrate into the Jordan River from Lake Michigan or Lake Charlevoix

recruitment – addition of new individuals to a population through reproduction or immigration

riffles – a shallow area extending across the bed of a stream where water flows swiftly so that the surface is broken in waves

riparian – owner of property that fronts on a river or lake

riverine – of or pertaining to a river

run habitat – fast non-turbulent water

salmonids – collective group of all trout and salmon in the family Salmonidae

sedimentation – a process of depositing silt, sand, and gravel on a stream or river bottom

surficial – referring to something on or at the surface

SWQD – Surface Water Quality Division

sympatric – referring to organisms that can live together

TFM – 3-trifluoromethyl-4-nitrophenol, a chemical used to control sea lamprey in streams connected to the Great Lakes

threatened species – a species that is likely to become an endangered species within a short period of time throughout all or a significant portion of its range

till – unstratified, unsorted glacial deposits of clay, sand, gravel, cobble, and boulders

topography – the configuration of the earth's surface including its relief and the position of its natural features

tributary – a smaller stream feeding into a larger stream, river, or lake

USDA – United States Department of Agriculture

USGS – United States Geological Survey

veliger – the free-swimming larval stage of some aquatic invertebrates, including zebra mussels

watershed – a drainage area or basin, both land and water, that flow toward a central collector such as a stream, river, or lake at a lower elevation

wetland – those areas inundated or saturated by surface or groundwater at a frequency and duration that support types of vegetation typically adapted for life in saturated soil; including swamps, marshes, and bogs

yearling – fish that were born during the previous calendar year

young-of-the-year – fish that were born during the current calendar year

zooplankton – floating or drifting animals in a body of water

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Paul W. Seelbach, Editor
Alan D. Sutton, Graphics
Ellen S. Grove, Desktop Publisher

Approved by E. M. Hay-Chmielewski

TABLES

Table 1.–Numbers of bridges and culverts, by mainstem valley section and township, for the Jordan River watershed. Data from Anonymous (2001a).

Valley section & township	Bridges	Single culvert	Twin culverts	Triple culverts
Upper Jordan River				
Warner		4		2
Chestonia	6	9		1
Lower Jordan River				
Jordan	2	18	2	
Echo	1	9		
South Arm	1	3	1	1
Deer Creek				
South Arm	1			
Wilson	1	22	1	
Warner	1	3		
Total	13	68	4	4

Table 2.–Information on dams and impoundments in the Jordan River watershed. Bold are design criteria, but actual head on Deer Lake water control structure less than six inches. Asterisk refers to an estimated value. Key to current purpose: retired hydro (RH), recreation (R), lake-level control (LC), or water supply (S), Key to hazard type: 1=high, 2=significant, and 3=low. High hazard means loss of life would occur, significant hazard means large amount of property damage would occur. Data from Michigan Department of Environmental Quality, Land and Water Management Division, Lansing, and Michigan Department of Natural Resources, Fisheries Division, Lansing.

Stream and dam name	Date built	Current purpose	Owner	Head (ft)	Surface acres	Storage (acre-feet)	Average depth (ft)	Hazard type
Green River								
Green River Trout Farm Dam	1950	S	Private	*6	*1	*3	*3	3
Deer Creek								
Deer Lk Water Level Control	1973	LC	Private	**2**	490	**785**	**1.6**	3
Patricia Lake Dam	1900	RH,R	Private	13	65	440	6.8	2

Table 3.–Designated trout streams (Fisheries Order No. FO 210.03) in the Jordan River watershed. Streams are designated upstream of the town, range, and section number unless specified otherwise. Most stream names from Anonymous (1983). Names in parentheses are from Anonymous (1988b).

Valley section, county, and stream	Location
Deer Creek	
Charlevoix	
Deer Creek	Upstream from T32N, R7W, Sec. 26
Unnamed Creek	T32N, R6W, Sec.30
Two Unnamed Creeks	T32N, R6W, Sec. 29
Three Unnamed Creeks	T32N, R6W, Sec. 28
Unnamed Creek	T32N, R6W, Sec. 27
Marvon Creek	T32N, R6W, Sec. 27
Nemecheck Creek	T32N, R6W, Sec. 34
Brown Creek	T32N, R6W, Sec. 27
Eaton Creek	T32N, R6W, Sec. 26
Warner Creek	T32N, R6W, Sec. 25
Hog Creek	T32N, R6W, Sec. 25
Collins Creek	T32N, R6W, Sec. 24
Lower Jordan River	
Charlevoix and Antrim	
Jordan River	Upstream from T32N, R7W, Sec. 23
Lanway Creek	T32N, R7W, Sec. 26
Jones Creek	T32N, R7W, Sec. 27
Birney Creek	T32N, R7W, Sec. 35
Bennett (Bartholomew) Creek	T31N, R7W, Sec. 1
(Todd) Creek	T32N, R7W, Sec. 36
Bartholomew (Unnamed) Creek	T31N, R7W, Sec. 12
Severance Creek	T31N, R6W, Sec. 7
Webster Creek	T31N, R6W, Sec. 7
Two Unnamed Creeks	T31N, R6W, Sec. 7
(Gook) Creek	T31N, R6W, Sec. 17
Lilak Creek	T31N, R6W, Sec. 17
(Martin) Creek	T31N, R6W, Sec. 20
Mill Creek	T31N, R6W, Sec. 20
(Sutton) Creek	T31N, R6W, Sec. 20
Two Unnamed Creeks	T31N, R6W, Sec. 20
Cokirs Creek	T31N, R6W, Sec. 29
Scott Creek	T31N, R6W, Sec. 29
(Tutstone) Creek	T31N, R6W, Sec. 29
Two Unnamed Creeks	T31N, R6W, Sec. 32

Table 3.–Continued.

Valley section, county, and stream	Location
Upper Jordan River	
Antrim	
Green River	T30N, R6W, Sec. 5
Unnamed Creek	T30N, R6W, Sec. 5
Stevens Creek	T30N, R6W, Sec. 9
Two Unnamed Creeks	T30N, R6W, Sec. 4
Landslide Creek	T30N, R6W, Sec. 10
Cascade Creek	T30N, R6W, Sec. 10
Section 13 Creek	T30N, R6W, Sec. 11
Unnamed creek	T30N, R6W, Sec. 2
Six Tile Creek	T30N, R5W, Sec. 6
Five Tile Creek	T30N, R5W, Sec. 6
Unnamed Creek	T31N, R5W, Sec. 30

Table 4.–Monthly maximum river temperatures (°F) in the Jordan River at Webster Bridge. "SE"=standard error of the mean. Data were from the United States Geological Survey, gauge station #04127800. Maximum allowable temperature for cold water streams is from Michigan Department of Environmental Quality, Surface Water Quality Division, Lansing.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1967	36	35	42	49	60	64	63	63	57	55.4	42.8	39.2
1968	35.6	35.6	46.4	53.6	59	64.4	66.2	64.4	57.2	57.2	44.6	37.4
1969	37.4	35.6	39.2	48.2	60.8	62.6	64.4	64.4	64.4	55.4	47.3	37.4
1970	34.7	35.6	37.4	59	58.1	64.4	63.5	63.5	60.8	54.5	46.4	39.2
1971	34.7	36.5	39.2	50	58.1	67.1	63.5	59.9	60.8	58.1	47.3	38.3
1972	36.5	35.6	39.2	50.9	59.9	61.7	67.1	61.7	58.1	51.8	42.8	36.5
1973	38.3	37.4	44.6	54.5	54.5	64.4	65.3	62.6	62.6	55.4	47.3	42.8
1974		39.2	40.1	54.5	58.1	59.9	67.1	62.6	60.8	51.8	49.1	37.4
1975	36.5	38.3	40.1	50	59.9	64.4	65.3	62.6	58.1	53.6	48.2	39.2
1976	35.6	39.2	41.9	57.2	54.5	63.5	68	62.6	57.2	50	41	35.6
1977	32.9	35.6	40.1	54.5	64.4	61.7	67.1	60.8	59	51.8	51.8	38.3
1978	36.5	36.5	41	50	62.6	63.5	63.5	59	56.3	48.2		
1979		33.8	37.4	54.5							51.8	37.4
1980	34.7	35.6	41				63.5			49.1	43.7	37.4
1981	35.6		43.7	50	58.1	64.4	64.4	62.6	59.9	47.3	46.4	37.4
1982	32	36.5		50	60.8	59.9	65.3	63.5	60.8	58.1	50	47.3
1983	37.4	40.1	44.6		57.2			64.4				
Average (+/- 2/SE)	35.6 (0.9)	36.6 (0.9)	41.1 (1.3)	52.4 (1.7)	59.1 (1.4)	63.3 (1.0)	65.1 (0.8)	62.5 (0.8)	59.5 (1.3)	53.2 (1.8)	46.7 (1.7)	38.7 (1.4)
Regulatory Standard	38	38	43	54	65	68	68	68	63	56	48	40

Table 5.–Miscellaneous water chemistry data from the Jordan River watershed. JRNFH=Jordan River National Fish Hatchery. Bold indicates values that exceed range typical of trout streams in the northwest Lower Peninsula of Michigan (Anonymous 1994e). Blanks indicate missing data. Data were from the Michigan Department of Environmental Quality, Surface Water Quality Division, Lansing.

Location	Year	pH	Dissolved oxygen mg/l	Total phosphorus mg/l	Ammonia Nitrogen mg/l	Nitrate + Nitrite mg/l	Total Kjeldahl nitrogen mg/l
Jordan River, upstream from JRNFH	1968			0.007-.019	0.01-.03	0.5-1.1	
Jordan River, just below JRNFH	1968			0.026	**0.17**	1.8	
Jordan River, 600 ft. below JRNFH	1968			0.019-**.069**	0.04-**.08**	1.4-1.9	
Jordan River, Pinney Bridge	1968			0.015	0.01	1.2	
Jordan River, Chestonia Bridge	1968			0.008	0.02	0.67	
Jordan River, upstream from JRNFH	1983			0.009	0.041	0.84	0.29
Jordan River,1000 ft. below JRNFH	1983			0.011	0.013	0.86	0.32
Jordan River, upstream from JRNFH	1984				0.009	1	0.31
Jordan River, 400 ft. below JRNFH	1984				**0.071**	1.35	0.35
Jordan River,1600 ft. below JRNFH	1984				0.021	1.15	0.27
Jordan River, 600 ft. below JRNFH	1985			**0.13**	0.16	1.8	0.57
Jordan River, upstream from JRNFH	1993			0.003	0.011	0.99	0.14
Jordan River, 5000 ft. below JRNFH	1993			0.008	0.013	1.54	0.14
Sutton's Creek (various sites)	1973	8.0-8.4	7.4-9.5				
Mill Creek (various sites)	1973	8.1	8.1-8.8				
Deer Creek, @ outlet from Deer Lake	1990			0.011	0.019	0.007	0.46
Collins Creek, @ Korthase Road	1990			0.004	0.015	0.15	0.38
Deer Creek, @ Barber Road	1990			0.004	0.006	0.24	0.43
Warner Creek, @ M-32	1990			0.005	0.003	0.62	0.23
Hog Creek, @ Karthase Road	1990			**0.13**	0.002	0.68	0.22
Warner Creek, @ Barber Road	1990			0.027	0.013	0.34	0.31
Eaton Creek, @ Barber Road	1990			0.009	0.003	0.163	0.2
Deer Creek, @ Marvon Road	1990			0.008	0.001	0.44	0.47
Deer Creek, @ Bergman Road	1990			0.007	0.003	0.43	0.47
Deer Creek, @ Fuller Road	1990			0.004	0.001	0.42	0.39
Deer Creek, @ Pearsall Road	1990			0.01	0.001	0.41	0.27
Trout streams-NW Lower Michigan				0.004-0.032	0.006-0.054		

Table 6.–Statutes administered by Michigan Department of Environmental Quality, Land and Water Management and Surface Water Quality divisions that protect the aquatic resource. N.R.E.P. Act = Natural Resources and Environmental Protection Act (1994 PA 451).

State of Michigan acts	Description of acts
Public Health Code (1978 PA 386, as amended)	Aquatic Nuisance Control: regulates the use of substances for the treatment of swimmer's itch, and excessive aquatic plants and algae.
Part 13 N.R.E.P. Act	Floodplain Regulatory Authority: regulates activities that occupy, fill, and/or grade lands within floodplains of rivers.
Part 31 N.R.E.P. Act	Water Resource Protection: regulates discharges to surface waters according to set water quality standards.
Part 41 N.R.E.P. Act	Sewerage Systems: regulates wastewater or sewer system facilities.
Part 91 N.R.E.P. Act	Soil Erosion and Sedimentation Control: regulates any earth change that disturbs one of more acres, or is within 500 feet of a lake or stream.
Part 301 N.R.E.P. Act	Inland Lakes and Streams: this part regulates structure placement or removal, dredging, filling below the ordinary high water mark, and operating or constructing a marina in lakes and streams.
Part 303 N.R.E.P. Act	Wetland Protection: regulates dredging, filling, and structure placement within wetlands.
Part 307 N.R.E.P. Act	Inland Lake Level: regulates the establishment of legal lake levels and lake level control structures.
Part 309 N.R.E.P. Act	Inland Improvement: regulates the establishment of lake boards and revolving funds to protect and improve lakes.
Part 315 N.RE.P. Act	Dam Safety: establishes a program to maintain a statewide inventory of dams, and provides staff to inspect dams to evaluate the integrity of the structures.

Table 7.–Federal statutes administered by Michigan Department of Environmental Quality, Land and Water Management Division that protect the aquatic resource.

US Federal Acts
Federal Water Pollution Control Act, Section 314 (PL 92-55)
Clean Water Act, Section 402 and 404 (PL 95-2117)
River and Harbor Act, Section 10 (1899)

Table 8.–List of fishes in the Jordan River watershed. Species origin and status: N = native, I = introduced, C = colonized, O = extirpated, P = recent observation, U = historic record, current status unknown. Origin was determined by Bailey and Smith (1981). Status from Michigan Department of Natural Resources, Fisheries Division, Lansing; Michigan Department of Environmental Quality, Surface Water Quality Division, Lansing; and United States Fish and Wildlife Service, Sea Lamprey Management Unit, Ludington, Michigan.

Common family name Common species name	Scientific name	Origin	Status
Lampreys			
chestnut lamprey	*Ichthyomyzon castaneus*	N	P
silver lamprey	*Ichthyomyzon unicuspis*	N	P
American brook lamprey	*Lampetra appendix*	N	P
sea lamprey	*Petromyzon marinus*	C	P
Bowfins			
bowfin	*Amia calva*	N	P
Herring			
alewife	*Alosa pseudoharengus*	C	P
Carps and minnows			
common carp	*Cyprinus carpio*	I	P
brassy minnow	*Hybognathus hankinsoni*	N	P
common shiner	*Luxilus cornutus*	N	U
pearl dace	*Margariscus margarita*	N	P
hornyhead chub	*Nocomis biguttatus*	N	P
golden shiner	*Notemigonus crysoleucas*	N	P
emerald shiner	*Notropis atherinoides*	N	P
blacknose shiner	*Notropis heterolepis*	N	P
spottail shiner	*Notropis hudsonius*	N	P
sand shiner	*Notropis stramineus*	N	P
mimic shiner	*Notropis volucellus*	N	U
finescale dace	*Phoxinus neogaeus*	N	U
bluntnose minnow	*Pimephales notatus*	N	P
fathead minnow	*Pimephales promelas*	N	P
blacknose dace	*Rhinichthys atratulus*	N	P
longnose dace	*Rhinichthys cataractae*	N	P
creek chub	*Semotilus atromaculatus*	N	P
Suckers			
white sucker	*Catostomus commersoni*	N	P
golden redhorse	*Moxostoma erythrurum*	N	P
Catfishes			
black bullhead	*Ameiurus melas.*	N	P
brown bullhead	*Ameiurus nebulosus*	N	P
stonecat	*Noturus flavus*	N	P

Table 8.–Continued.

Common family name Common species name	Scientific name	Origin	Status
Pikes			
northern pike	*Esox lucius*	N	P
Mudminnows			
central mudminnow	*Umbra limi*	N	P
Smelts			
rainbow smelt	*Osmerus mordax*	I	P
Trouts			
coho salmon	*Oncorhynchus kisutch*	I	P
rainbow trout	*Oncorhynchus mykiss*	I	P
chinook salmon	*Oncorhynchus tshawytscha*	I	P
brown trout	*Salmo trutta*	I	P
brook trout	*Salvelinus fontinalis*	N	P
lake trout	*Salvelinus namaycush*	N	P
Arctic grayling	*Thymallus arcticus*	N	O
Trout-perches			
trout-perch	*Percopsis omiscomaycus*	N	P
Cods			
burbot	*Lota lota*	N	P
Killifishes			
banded killifish	*Fundulus diaphanus*	N	U
Sticklebacks			
brook stickleback	*Culaea inconstans*	N	P
Sculpins			
mottled sculpin	*Cottus bairdi*	N	P
slimy sculpin	*Cottus cognatus*	N	P
Sunfishes			
rock bass	*Ambloplites rupestris*	N	P
pumpkinseed	*Lepomis gibbosus*	N	P
bluegill	*Lepomis macrochirus*	N	P
longear sunfish	*Lepomis megalotis*	N	P
smallmouth bass	*Micropterus dolomieu*	N	P
largemouth bass	*Micropterus salmoides*	N	P
black crappie	*Pomoxis nigromaculatus*	N	P
Perches			
Iowa darter	*Etheostoma exile*	N	P
johnny darter	*Etheostoma nigrum*	N	P
yellow perch	*Perca flavescens*	N	P
logperch	*Percina caprodes*	N	P
walleye	*Stizostedion vitreum*	N	P

Table 9.–Non-indigenous fish species in the Jordan River watershed. Data were from the Michigan Department of Natural Resources, Fisheries Division, Lansing.

Common name	Scientific name
sea lamprey	*Petromyzon marinus*
alewife	*Alosa pseudoharengus*
common carp	*Cyprinus carpio*
rainbow smelt	*Osmerus mordax*
coho salmon	*Oncorhynchus kisutch*
rainbow trout	*Oncorhynchus mykiss*
chinook salmon	*Oncorhynchus tshawytscha*
brown trout	*Salmo trutta*

Table 10.–Estimated salmonid population densities at several stations in the mainstem of the Jordan River, summer 1987 and 1994. Steelhead and coho salmon estimates are fall parr and do not include adults. Stations listed from upstream to downstream. Estimates derived using Bailey's modification of the Peterson mark-and-recapture method. Data were from the Michigan Department of Natural Resources, Fisheries Division, Lansing. River mileage is upstream from Lake Charlevoix and is from Anonymous (1983). Number and pounds of fish are per acre; no. = number.

River section,	Brook trout				Brown trout				Rainbow trout				Coho salmon				Total			
site description, and	1987		1994		1987		1994		1987		1994		1987		1994		1987		1994	
river mileage	lbs	no.	lbs	no.	lbs	no.	lbs	no.	lbs	no.	lbs	no.	lbs	no.	lbs	no.	lbs	no.	lbs	no.
Upper																				
2nd road crossing																				
21.4	40.7	1270	94.4	4365	56.9	378	12.5	494	21.4	1467	7.1	54	9.9	733	0	0	128.9	3848	114	4913
3rd road crossing																				
20.5	29	715	54.2	1788	18.4	183	10.9	116	15.1	268	4.3	198	1.6	113	8.3	519	64.1	1279	77.7	2621
Stairway																				
18.1	2.7	64	14.5	555	39.7	566	21.1	308	16.6	242	2.6	40	0.3	111	0.7	42	59.3	983	38.9	945
4th road crossing																				
16.6	1.1	19	0.9	14	43.4	1598	45.3	1394	21.9	661	7	328	2.4	694	5.8	389	68.8	2972	59	2125
Average	18.4	517	41	1680.5	39.6	681.2	22.4	578	18.7	659.5	5.2	155	3.6	412.7	3.7	237.5	80.3	2270.5	72.4	2651
Middle																				
Old bridge																				
15.1	0	0	0.1	3	100.9	749	105.3	1838	50.3	1798	9.1	179	0.7	62	12	589	151.9	2609	126.5	2609
Old railroad crossing																				
13.5	0	0	0.5	5	52.5	349	50.3	533	27.7	1033	7.5	337	0	0	5.2	341	80.2	1382	63.5	1216
Pinney bridge																				
12.4	0	0	0.3	7	43	273	83.1	722	52.8	1023	9.9	202	5.7	2089	6	365	101.5	3385	99.3	1296
Graves crossing																				
10.0	0.6	16	1.6	33	13.1	117	16.5	165	24.1	472	5.2	253	0.4	686	10.4	931	38.2	1291	33.7	1382
Average	0.1	4.0	0.6	12	52.4	372	63.8	814.5	38.7	1081.5	7.9	242.7	1.7	709.2	8.4	556.5	92.9	2166.7	80.7	1625.7
Lower																				
Chestonia bridge																				
7.9	0	0	0.2	3	6.9	38	12.7	58	14.3	581	0.9	14	0.4	458	4.5	201	21.6	1077	18.3	276
Webster bridge																				
4.6	0	0	0.4	4	4.9	12	9.4	31	12.3	469	1.6	15	1.8	277	1.3	48	19	758	12.7	98
Average	0	0	0.3	3.5	5.9	25	11	44.5	13.3	525	1.2	14.5	1.1	367.5	2.9	124.5	20.3	917.5	15.5	187
All stations																				
Average	7.4	208.4	16.7	677.7	38.0	426.3	36.7	565.9	25.7	801.4	5.5	162.0	2.3	522.3	5.4	342.5	73.4	1958.4	64.4	1748.1

Table 11.–Estimated fall population densities of pooled data for brook, brown, and rainbow trout and coho salmon in northern Michigan streams. Bold are Jordan River mainstem stations. Data from Gowing and Alexander (1980), and Michigan Department of Natural Resources, Fisheries Division, Traverse City. Number following station descriptions are river miles upstream from Lake Charlevoix.

Stream	Watershed	lbs/acre	Rank	Number of Species
Williamsburg Creek	Elk River	160	1	3
Jordan River (Old bridge – 15.1)	**Jordan River**	**139**	**2**	**4**
S. Branch Boardman River	Boardman River	134	3	2
Jordan River (2nd crossing – 21.4)	**Jordan River**	**121**	**4**	**4**
Mainstem Au Sable River	Au Sable River	116	5	3
Houghton Creek	Rifle River	101	6	1
Jordan River (Pinney bridge – 12.4)	**Jordan River**	**100**	**7**	**4**
Poplar Creek	Manistee River	79	8	3
Jordan River (Old railroad – 13.5)	**Jordan River**	**72**	**9**	**4**
Jordan River (3rd crossing – 20.5)	**Jordan River**	**71**	**10**	**4**
L. S. Br. Pere Marquette River	Pere Marquette River	67	11	2
N. Branch Au Sable River	Au Sable River	66	12	2
Jordan River (4th crossing – 16.6)	**Jordan River**	**64**	**13**	**4**
N. Branch Boardman River	Boardman River	63	14	2
Mainstem Boardman River	Boardman River	59	15	2
Hunt Creek	Thunder Bay River	57	16	1
S. Branch Au Sable River	Au Sable River	56	17	2
Gamble Creek	Rifle River	55	18	1
Jordan River (Stairway – 18.1)	**Jordan River**	**49**	**19**	**4**
Jordan River (Graves crossing – 10.0)	**Jordan River**	**36**	**20**	**4**
Pigeon River	Cheboygan River	29	21	2
Rifle River	Rifle River	22	22	1
Jordan River (Chestonia bridge – 7.9)	**Jordan River**	**20**	**23**	**4**
Jordan River (Webster bridge – 4.6)	**Jordan River**	**16**	**24**	**4**
Average		73		
Minimum		16		
Maximum		160		

Table 12.–Distribution of aquatic invertebrates in the Jordan River. "X" represents locations where invertebrate groups were found; dash (–) indicates a group was not found in any studies. Invertebrate families or species that are most sensitive are indicated by an asterisk (*****). Phylum names are in bold. JRNFH = Jordan River National Fish Hatchery. Data are from the Michigan Department of Natural Resources, Fisheries Division, Lansing and the Michigan Department of Environmental Quality, Surface Water Quality Division, Lansing.

	Location													
	Upper								Lower	Deer Creek				
Taxa	upstream JRNFH	downstream JRNFH	near Pinney Bridge	Five Tile Creek	Six Tile Creek	Landslide Creek	Green River near Hwy. M-66	Green River near Pinney Road	Suttons Creek	near Barber Road	near Marvon Road	Collins Creek near Korthase Road	Warner Creek near Barber Road	Eaton Creek near Barber Road
Platyhelminthes (flatworms)	–	–	X	–	–	–	–	X	–	–	–	–	–	–
Annelida (segmented worms)														
Hirudinea (leeches)	–	–	–	–	–	–	–	–	–	–	X	X	–	X
Oligochaeta (aquatic earthworms)	X	X	X	–	–	–	–	X	X	–	–	–	–	–
Nematoda (roundworms)	–	X	–	–	–	–	–	–	–	–	–	–	–	–
Arthropoda														
Crustacea														
Isopoda (sowbugs)	–	–	X	–	–	–	–	X	–	X	–	–	–	X
Amphipoda (scuds)														
unidentified	X	X	X	–	–	–	–	X	–	X	X	–	X	X
Gammarus sp.	–	X	X	–	–	–	–	–	X	–	–	–	–	–
Hyalella azteca	–	X	X	X	–	–	–	–	–	–	–	–	–	–
Decapoda (crayfish)	–	–	–	–	–	–	–	–	–	X	X	–	X	–
Insecta														
Plecoptera (stoneflies)														
Chloroperiidae*****	–	X	–	–	–	–	–	–	–	–	X	–	–	–
Nemouridae*****														
unidentified	X	X	–	–	–	–	–	–	–	–	–	–	X	X
Nemoura sp.	–	–	–	–	X	–	–	–	X	–	–	–	–	–
Allocapnia sp.	–	–	–	–	–	–	–	–	X	–	–	–	–	–
Amphinemura sp.	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Pteronarcyidae*****														
unidentified	X	X	X	–	–	–	–	X	–	–	–	X	X	–
Pteronarcys sp.	X	–	–	X	–	–	–	–	–	–	–	–	–	–
Perlodidae*****														
unidentified	–	–	X	–	–	–	–	X	–	–	–	–	–	–
Isoperla sp.	X	X	X	X	X	X	X	X	X	–	–	–	–	–
Isogenoides sp.	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Perlidae	X	–	–	–	–	–	–	–	–	–	–	–	–	–
Taeniopterygidae*****	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Number of taxa (stoneflies)	5	4	3	2	2	1	3	6	3	0	1	1	2	1

Table 12.–Continued.

Taxa	Location: Upper – upstream JRNFH	Upper – downstream JRNFH	Upper – near Pinney Bridge	Upper – Five Tile Creek	Upper – Six Tile Creek	Upper – Landslide Creek	Upper – Green River near Hwy. M-66	Upper – Green River near Pinney Road	Lower – Suttons Creek	Deer Creek – near Barber Road	Deer Creek – near Marvon Road	Deer Creek – Collins Creek near Korthase Road	Deer Creek – Warner Creek near Barber Road	Deer Creek – Eaton Creek near Barber Road
Ephemeroptera (mayflies)														
Baetiscidae	–	–	–	–	–	–	–	–	–	–	–	–	X	–
Baetidae*														
unidentified	X	X	X	–	X	X	–	X	–	–	X	X	X	–
Baetis sp.	–	X	–	X	–	X	–	X	X	–	–	–	–	–
Baetis tricaudatus	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Baetis flavistriga	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Baetis pygmaeus	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Ephemeridae*	–	X	X	–	–	–	–	X	–	–	X	X	X	–
Ephemerallidae*														
unidentified	X	X	X	–	–	–	–	X	–	X	–	–	–	X
Ephemerella sp.	X	X	X	–	–	X	–	–	X	–	–	–	–	–
Ephemerella aurivilli	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Ephemerella needhami	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Ephemerella excrucians	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Ephemerella dorothea	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Leptophlebiidae*														
unidentified	–	–	X	–	–	–	–	–	–	–	–	–	–	–
Paraleptophlebia sp.	X	X	X	–	–	–	X	X	–	–	–	–	–	–
Heptageniidae*														
unidentified	X	X	X	–	–	–	–	X	–	X	–	X	X	X
Epeorus vitrea	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Heptagenia sp.	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Rithrogenia impersonata	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Stenonema sp.	X	X	X	–	–	X	–	–	–	–	–	–	–	–
Number of taxa (mayflies)	6	8	8	1	1	4	9	16	2	2	2	3	4	2
Trichoptera (caddisflies)														
unidentified	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Brachycentridae*														
unidentified	X	X	X	–	–	–	–	X	–	X	X	X	X	–
Brachycentrus sp.	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Brachycentrus americanus	X	X	X	–	X	X	–	–	–	–	–	–	–	–
Brachycentrus lateralis	–	–	X	–	–	–	–	–	–	–	–	–	–	–
Hydroptilidae*														
Hydroptila sp.	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Hydropsychidae*														
unidentified	X	–	X	–	–	–	X	X	–	X	X	X	–	X
Hydropsyche sp.	X	X	–	–	–	X	–	–	–	–	–	–	–	–
Cheumatopsyche sp.	X	–	–	X	–	–	–	X	–	–	–	–	–	–
Parapsyche sp.	–	–	–	–	–	–	–	–	X	–	–	–	–	–

Table 12.–Continued.

Taxa	Location: Upper – upstream JRNFH	Upper – downstream JRNFH	Upper – near Pinney Bridge	Upper – Five Tile Creek	Upper – Six Tile Creek	Upper – Landslide Creek	Upper – Green River near Hwy. M-66	Upper – Green River near Pinney Road	Lower – Suttons Creek	Deer Creek – near Barber Road	Deer Creek – near Marvon Road	Deer Creek – Collins Creek near Korthase Road	Deer Creek – Warner Creek near Barber Road	Deer Creek – Eaton Creek near Barber Road
Lepidostomatidae*														
unidentified	–	–	X	–	–	–	–	X	–	–	–	–	–	–
Lepidostoma sp.	X	X	X	–	–	–	X	–	–	–	–	–	–	–
Psychomyiidae*	–	X	–	–	–	X	–	–	–	X	–	–	X	X
Limnephilidae*														
unidentified	X	X	X	–	–	–	–	X	–	–	–	–	X	–
Limnephilus sp.	–	–	–	–	–	–	–	–	X	–	–	–	–	–
Neophylax sp.	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Rhyacophilidae*														
unidentified	–	–	X	–	–	–	–	–	–	–	–	–	–	–
Rhyacophila sp.	–	–	–	X	–	X	–	–	X	–	–	–	–	–
Rhyacophila acropedes	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Agapetus sp.	–	–	–	–	–	–	–	–	X	–	–	–	–	–
Philopotamidae														
unidentified	–	X	X	–	–	–	–	X	–	–	–	–	–	–
Dolophilodes sp.*	–	–	–	–	–	–	X	–	–	–	–	–	–	–
Phryganeidae	–	–	–	–	–	–	–	–	–	–	X	–	X	–
Glossosomatidae*														
unidentified	–	–	–	–	–	–	–	X	–	–	–	–	–	X
Glossosoma sp.	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Leptoceridae*	–	–	X	–	–	–	–	–	–	–	–	–	–	–
Molannidae*	X	X	–	–	–	–	–	–	–	–	–	X	–	–
Helicopsychidae*	–	–	–	–	–	–	–	–	–	–	X	X	X	–
Number of taxa (caddisflies)	8	8	10	2	0	4	7	13	4	3	4	4	5	3
Diptera (flies, midges)														
Chironomidae	X	X	X	X	X	–	X	X	–	X	X	X	X	X
Simuliidae*														
unidentified	X	X	X	–	X	X	–	X	–	X	–	X	X	X
Simulium sp.	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Tipulidae														
unidentified	–	–	–	–	–	–	–	X	–	–	X	–	–	X
Tipula sp.	–	–	–	–	–	–	–	–	X	–	–	–	–	–
Antocha sp.	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Pedicia sp.	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Dicranota sp.	–	–	–	–	–	–	X	X	X	–	–	–	–	–
Tendipedidae														
Brillia sp.	–	–	–	–	–	–	–	–	X	–	–	–	–	–
Athericidae	X	X	X	–	–	–	–	–	–	–	–	–	–	–
Ceratopogonidae	–	X	–	–	–	–	–	–	–	–	–	–	–	–

Table 12.–Continued.

	Location													
	Upper								Lower	Deer Creek				
Taxa	upstream JRNFH	downstream JRNFH	near Pinney Bridge	Five Tile Creek	Six Tile Creek	Landslide Creek	Green River near Hwy. M-66	Green River near Pinney Road	Suttons Creek	near Barber Road	near Marvon Road	Collins Creek near Korthase Road	Warner Creek near Barber Road	Eaton Creek near Barber Road
Heleidae														
unidentified	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Palpomyia sp.	–	–	–	–	–	–	–	–	X	–	–	–	–	–
Empididae														
unidentified	–	X	–	–	–	–	X	X	–	–	–	–	–	–
Hemerodromia sp.	–	–	–	–	–	–	–	–	X	–	–	–	–	–
Rhagionidae														
Atherix variegata	X	X	X	–	–	–	–	–	–	–	–	–	–	–
Tabanidae	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Muscidae	–	–	–	–	–	–	–	–	–	–	–	X	–	–
Coleoptera (beetles)														
Hydrophilidae	–	–	–	–	–	–	–	–	X	–	–	–	–	–
Gyrinidae	–	–	–	–	–	–	–	–	–	–	X	–	–	–
Dytiscidae	–	–	–	–	–	–	–	–	–	–	–	–	–	X
Elmidae														
unidentified	X	X	X	–	–	–	–	X	–	–	X	–	–	–
Dubiraphia sp.	–	–	–	–	–	–	–	–	X	–	–	–	–	–
Optioservus sp.	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Optioservus fastiditus	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Odonata (dragonflies)														
Calopterygidae	X	–	–	–	–	–	–	–	–	–	X	–	X	–
Coenagrionidae	–	–	–	–	–	–	–	–	–	–	–	X	–	–
Aeshnidae	–	–	–	–	–	–	–	–	–	X	–	X	X	–
Cordulegastridae	–	–	–	–	–	–	–	X	–	–	–	–	X	X
Hemiptera (true bugs)														
Belostomatidae														
unidentified	–	–	–	–	–	–	–	–	–	–	X	–	–	–
Belastoma sp.	–	–	–	–	–	–	–	–	–	–	X	–	–	–
Mesoveliidae	–	–	X	–	–	–	–	–	–	–	–	–	–	–
Corixidae	–	–	–	–	–	–	–	X	–	–	X	–	–	–
Gerridae	X	X	X	–	–	–	–	X	–	X	–	–	–	X
Megaloptera														
Sialidae (alderflies)														
Sialis sp.	–	–	X	–	–	–	–	–	–	–	–	–	–	–
Corydalidae (dobsonflies)														
unidentified	X	–	–	–	–	–	–	–	–	–	–	–	–	–
Nigronia sp.	–	–	X	–	–	–	–	–	–	X	–	X	X	–
Arachnida														
Hydracarina (water mites)														
unidentified	X	–	–	–	–	–	–	–	–	–	–	–	–	–
Diplodontus despiciens	–	–	–	–	–	–	–	–	X	–	–	–	–	–

Table 12.–Continued.

	Location													
	Upper								Lower	Deer Creek				
Taxa	upstream JRNFH	downstream JRNFH	near Pinney Bridge	Five Tile Creek	Six Tile Creek	Landslide Creek	Green River near Hwy. M-66	Green River near Pinney Road	Suttons Creek	near Barber Road	near Marvon Road	Collins Creek near Korthase Road	Warner Creek near Barber Road	Eaton Creek near Barber Road
Mollusca														
Gastropoda (snails)														
unidentified	–	–	–	–	–	–	–	–	X	X	X	X	–	–
Lymnaeidae	–	–	X	–	–	–	–	–	–	–	–	–	–	–
Physidae														
Physa sp.	–	X	X	–	–	–	–	–	–	–	X	X	X	–
Viviparidae														
Campeloma sp.	–	–	–	–	–	–	–	–	–	–	X	–	–	–
Ancylidae														
Ferrissia sp.	–	–	–	–	–	–	–	–	–	–	X	X	–	–
Pelecypoda (clams)														
Sphaeriidae														
Sphaerium sp.	–	–	X	–	–	–	–	X	–	–	X	–	–	–
Pisidium sp.	X	X	X	–	–	–	–	–	–	–	–	–	–	–

Table 13.–List of reptiles and amphibians that require an aquatic environment, likely to be found in the Jordan River watershed. * denotes that species are listed as "special concern" by Michigan Department of Natural Resources, Wildlife Bureau, Michigan Natural Features Inventory. Data are from: Harding and Holman (1990); Harding and Holman (1992); and Holman et al. (1989)–range maps.

Common name	Scientific name
Reptiles (turtles)	
snapping turtle	*Chelydra serpentina*
wood turtle*	*Clemmys insculpta*
Blanding's turtle*	*Emydoidea blandingii*
common map turtle	*Graptemys geographica*
painted turtle	*Chrysemys picta*
spiny softshell turtle	*Apalone spinifera*
Reptiles (snakes and lizards)	
northern water snake	*Nerodia sipedon sipedon*
brown snake	*Storeria dekayi*
northern red-bellied snake	*Storeria occipitomaculata occipitomaculata*
eastern garter snake	*Thamnophis sirtalis sirtalis*
northern ribbon snake	*Thamnophis sauritus septentrionalis*
northern ring-necked snake	*Diadophis punctatus edwardsi*
eastern hog-nosed snake	*Heterodon platirhinos*
blue racer snake	*Coluber constrictor foxii*
eastern milk snake	*Lampropeltis triangulum triangulum*
smooth green snake	*Liochlorophis vernalis*
eastern massasauga rattlesnake*	*Sistrurus catenatus catenatus*
five-lined skink	*Eumeces fasciatus*
Amphibians (salamanders)	
mudpuppy	*Necturus maculosus maculosus*
blue-spotted salamander	*Ambystoma laterale*
spotted salamander	*Ambystoma maculatum*
eastern tiger salamander	*Ambystoma tigrinum tigrinum*
eastern newt	*Notophthalmus viridescens*
red-backed salamander	*Plethodon cinereus*
four-toed salamander	*Hemidactylium scutatum*
Amphibians (toads and frogs)	
eastern american toad	*Bufo americanus americanus*
Fowler's toad	*Bufo woodhousi fowleri*
western chorus frog	*Pseudacris triseriata triseriata*
northern spring peeper	*Pseudacris crucifer crucifer*
eastern gray treefrog	*Hyla versicolor*
Cope's gray treefrog	*Hyla chrysoscelis*
green frog	*Rana clamitans melanota*
bullfrog	*Rana catesbeiana*
northern leopard frog	*Rana pipiens*
pickerel frog	*Rana palustris*
wood frog	*Rana sylvatica*

Table 14.–Birds likely to occur in the Jordan River watershed. * denotes "special concern" species and ** denotes "threatened" species as listed by the Michigan Department of Natural Resources, Wildlife Bureau, Natural Features Inventory, Lansing. The bald eagle is also listed as "threatened" under Federal Endangered Species Act. Breeding status: X = confirmed breeding in the watershed. Data from: Brewer et al. (1991)–range maps; Peterson (1980)–range maps; and Michigan Department of Natural Resources, Wildlife Bureau, Lansing.

Common name	Scientific name	Breeding status
Eastern screech-owl	*Otus asio*	
Tufted titmouse	*Paurs bicolor*	
Double-crested cormorant	*Phalacrocorax auritus*	
Common goldeneye	*Bucephala clangula*	
Common merganser	*Mergus merganser*	
Red-breasted merganser	*Mergus serrator*	
Spruce grouse*	*Dendragapus canadensis*	
Yellow rail**	*Coturnicops noveboracensis*	
Snowy owl	*Nyctea scandiaca*	
Olive-sided flycatcher	*Contopus borealis*	
Common raven	*Corvus corax*	
Swainson's thrush	*Catharus ustulatus*	
Northern shrike	*Lanius excubitor*	
Yellow-rumped warbler	*Dendroica coronata*	
Connecticut warbler	*Oporornis agilis*	
White-throated sparrow	*Zonotrichia albicollis*	
Red crossbill	*Loxia curvirostra*	
Evening grosbeak	*Coccothraustes vespertinus*	
Common loon**	*Gavia immer*	
Pied-billed grebe	*Podilymbus podiceps*	
American bittern*	*Botaurus lentiginosus*	
Least bittern**	*Ixobeyhus exilis*	
Great-blue heron	*Ardea herodias*	
Green-backed heron	*Butorides striatus*	
Canada goose	*Branta canadensis*	X
Wood duck	*Aix sponsa*	
Green-winged teal	*Anas crecca*	
American black duck	*Anas rubripes*	
Mallard	*Anas platyrhynchos*	X
Blue-wing teal	*Anas discors*	
Gadwall	*Anas strepera*	
Redhead	*Aythya americana*	
Ring-necked duck	*Aythya collaris*	
Hooded merganser	*Lophodytes cucullatus*	
Turkey vulture	*Cathartes aura*	
Osprey**	*Pandion haliaetus*	
Bald eagle**	*Haliaeetus leucocephalus*	
Northern harrier*	*Circus cyaneus*	
Sharp-shinned hawk	*Accipiter striatus*	
Cooper's hawk*	*Accipiter cooperii*	

Table 14.–Continued.

Common name	Scientific name	Breeding status
Northern goshawk*	*Accipiter gentilis*	X
Red-shouldered hawk**	*Buteo lineatus*	
Broad-winged hawk	*Buteo platypterus*	
Red-tailed hawk	*Buteo jamaicensis*	
Rough-legged hawk	*Buteo lagopus*	
American kestrel	*Falco sparverius*	X
Ruffed grouse	*Bonasa umbellus*	X
Wild turkey	*Meleagris galloparo*	X
Virginia rail	*Rallus limicola*	
Sora	*Porzana carolina*	
American coot	*Fulica americana*	
Killdeer	*Charadrius vociferus*	X
Spotted sandpiper	*Actitis macularia*	
Upland sandpiper	*Bartramis longicauda*	
Common snipe	*Gallinago gallinago*	
American woodcock	*Scolopax minor*	X
Western sandpiper	*Calidris mauri*	
Ring-billed gull	*Larus delawarensis*	X
Herring gull	*Larus argentatus*	X
Mourning dove	*Zenaida macroura*	X
Black-billed cuckoo	*Coccyzus erythropthalmus*	
Yellow-billed cuckoo	*Coccyzus americanus*	X
Great horned owl	*Bubo virginianus*	X
Barred owl	*Strix varia*	X
Long-eared owl**	*Asio otus*	X
Northern saw-whet owl	*Aegolius acadicus*	
Common nighthawk	*Chordeiles minor*	X
Whip-poor-will	*Caprimulgus vociferus*	X
Chimney swift	*Chaetura pelagica*	
Ruby-throated hummingbird	*Archilochus colubris*	X
Belted kingfisher	*Ceryle alcyon*	
Red-headed woodpecker	*Melanerpes erythrocephalus*	X
Yellow-bellied sapsucker	*Sphyrapicus varius*	X
Downy woodpecker	*Picoides pubescens*	
Hairy woodpecker	*Picoides villosus*	
Northern flicker	*Colaptes auratus*	X
Pileated woodpecker	*Dryocopus pileatus*	X
Eastern wood pewee	*Contopus sordidulus*	
Alder flycatcher	*Empidonax alnorum*	
Willow flycatcher	*Empidonax traillii*	
Least flycatcher	*Empidonax minimus*	
Eastern phoebe	*Sayornis phoebe*	X
Great crested flycatcher	*Myiarchus crinitus*	X
Eastern kingbird	*Tyrannus tyrannus*	X
Horned lark	*Ermophila alpestris*	
Purple martin	*Progne subis*	
Tree swallow	*Iridoprocne bicolor*	X

Table 14.–Continued.

Common name	Scientific name	Breeding status
Northern rough-winged swallow	*Stelgidopteryx serripennis*	X
Bank swallow	*Riparia riparia*	X
Barn swallow	*Hirundo rustica*	X
Blue jay	*Cyanocitta cristata*	X
American crow	*Corvus brachyrhynchos*	
Black-capped chickadee	*Parus atricapillus*	X
Red-breasted nuthatch	*Sitta canadensis*	
White-breasted nuthatch	*Sitta carolinensis*	X
Brown creeper	*Certhia americana*	
House wren	*Troglodytes aedon*	
Winter wren	*Troglodytes troglodytes*	
Sedge wren	*Cistothorus platensis*	
Marsh wren*	*Cistothorus palustris*	
Golden-crowned kinglet	*Regulus satrapa*	
Eastern bluebird	*Sialia sialis*	X
Veery	*Catharus fuscescens*	
Hermit thrush	*Catharus guttatus*	
Wood thrush	*Hylocichla mustelina*	
American robin	*Turdus migratorius*	X
Gray catbird	*Dumetella carolinensis*	X
Brown thrasher	*Toxostoma rufum*	X
Cedar waxwing	*Bombucilla cedrorum*	X
Solitary vireo	*Vireo solitarius*	
Warbling vireo	*Vireo gilvus*	
Red-eyed vireo	*Vireo olivaceus*	
Golden-winged warbler	*Vermivora chrysoptera*	
Nashville warbler	*Vermivora ruficapilla*	
Yellow warbler	*Dendroica petechia*	
Chestnut-sided warbler	*Dendroica pensylvanica*	
Magnolia warbler	*Dendroica magnolia*	
Black-throated blue warbler	*Dendroica caerulescens*	
Black-throated green warbler	*Dendroica virens*	
Blackburnian warbler	*Dendroica fusca*	
Pine warbler	*Dendroica pinus*	
Black and white warbler	*Mniotilta varia*	
American redstart	*Setophaga ruticilla*	X
Ovenbird	*Seiurus aurocapillus*	X
Northern waterthrush	*Seiurus noveboracensis*	
Mourning warbler	*Oporornis philadelphia*	
Common yellowthroat	*Geothlypis trichas*	X
Canada warbler	*Wilsonia canadensis*	
Scarlet tanager	*Piranga olivacea*	
Northern cardinal	*Richmondena cardinalis*	X
Rose-breasted grosbeak	*Pheuticus ludovicianus*	X
Indigo bunting	*Passerina cyahea*	X
Rufous-sided towhee	*Pipilo erythrophthalmus*	
Chipping sparrow	*Spizella passerina*	X

Table 14.–Continued.

Common name	Scientific name	Breeding status
Field sparrow	*Spizella pusilla*	
Vesper sparrow	*Pooecetes gramineus*	
Savannah sparrow	*Passerculus sandwichensis*	
Grasshopper sparrow*	*Ammodramus savannarum*	
Song sparrow	*Melospiza melodia*	X
Lincoln's sparrow	*Melospiza lincolnii*	
Swamp sparrow	*Melospiza georgina*	
American tree sparrow	*Spizella arborea*	
Fox sparrow	*Passerella iliaca*	
Dark-eyed junco	*Junco hyemalis*	
Snow bunting	*Plectrophenax nivalis*	
Bobolink	*Dolichonyx oryzivorus*	X
Red-winged blackbird	*Aselaius phoeniceus*	X
Eastern meadowlark	*Sturnella magna*	X
Western meadowlark*	*Sturnella neglecta*	
Brewer's blackbird	*Euphagus cyanocephalus*	
Common grackle	*Quiscalus quiscula*	X
Brown-headed cowbird	*Molothrus ater*	X
Northern oriole	*Icterus galbula*	X
Purple finch	*Carpodacus purpureus*	
Pine grosbeak	*Pinicola enucleator*	
Pine siskin	*Carduelis pinus*	
American goldfinch	*Spinus tristis*	
Mute swan	*Cygnus olor*	X
Rock dove	*Columba livia*	X
European starling	*Sturnus vulgaris*	X
White-throated sparrow	*Zonotrichia albicollis*	X
House sparrow	*Passer domesticus*	X

Table 15.–Mammals likely to occur in the Jordan River watershed. Species designated with * are listed as special concern by Michigan Department of Natural Resources, Wildlife Bureau, Natural Features Inventory. Data from Kurta (1995)–range maps and Michigan Department of Natural Resources, Wildlife Bureau, Lansing.

Common name	**Scientific name**
pygmy shrew	*Sorex hoyi*
water shrew	*Sorex palustris*
snowshoe hare	*Lepus americanus*
deer mouse	*Peromyscus maniculatus*
southern red-backed vole	*Clethrionomys gapperi*
woodland jumping mouse	*Napaeozapus insignis*
black bear	*Ursus americanus*
eastern mole	*Scalopus aquaticus*
woodland vole*	*Microtus pinetorum*
elk	*Cervus elaphus*
Virginia opossum	*Didelphus marsupialis*
masked shrew	*Sorex cinereus*
northern short-tailed shrew	*Blarina brevicauda*
star-nosed mole	*Condylura cristata*
northern bat	*Myotis septentrionalis*
little brown bat	*Myotis lucifugus*
silver-haired bat	*Lasionycteris noctivagans*
big brown bat	*Epesicus fuscus*
red bat	*Lasiurus borealis*
hoary bat	*Lasiurus cinereus*
eastern cottontail	*Sylvilagus floridanus*
eastern chipmunk	*Tamias striatus*
woodchuck	*Marmota monax*
thirteen-lined ground squirrel	*Citellus tridecemineatus*
eastern gray squirrel	*Sciurus carolinensis*
eastern fox squirrel	*Sciurus niger*
red squirrel	*Tamiasciurus hudsonicus*
northern flying squirrel	*Glaucomys sabrinus*
southern flying squirrel	*Glaucomys volans*
American beaver	*Castor canadensis*
white-footed mouse	*Peromyscus leucopus*
meadow vole	*Microtus pennsylvanicus*
muskrat	*Ondatra zibethicus*
southern bog lemming	*Synaptomys cooperi*
meadow jumping mouse	*Zapus hudsonius*
common porcupine	*Erethizon dorsatum*
coyote	*Canis latrans*
red fox	*Vulpes vulpes*
common gray fox	*Urocyon cinereoargenteus*
common raccoon	*Procyon lotor*

Table 15.–Continued.

Common name	Scientific name
ermine	*Mustela erminea*
long-tailed weasel	*Mustela frenata*
least weasel	*Mustela nivalis*
mink	*Mustela vison*
American badger	*Taxidea taxus*
striped skunk	*Mephitis mephitis*
northern river otter	*Lutra canadensis*
bobcat	*Lynx rufus*
house mouse	*Mus musculus*
norway rat	*Rattus norvegicus*
American martin	*Martes americana*
white-tailed deer	*Odocoileus virginianus*

Table 16.–Vegetative cover in 2000, on State of Michigan land within the Jordan River watershed. Data were from the Michigan Department of Natural Resources, Forest Management Division, Gaylord.

Plant cover	Acres	Percentage
upland hardwood	13690	54.08
aspen	3137	12.00
mixed swamp conifer	2759	10.00
unmapped or other	1969	7.63
grass	1554	6.00
swamp hardwood	623	2.41
lowland brush	589	2.28
upland brush	333	1.29
marsh	181	0.70
cedar	172	0.66
water	172	0.66
black spruce	139	0.50
red pine	125	0.48
spruce/fir	99	0.38
white pine	75	0.29
lowland poplar	53	0.20
hemlock	47	0.18
tamarack	28	0.11
treed bog	26	0.10
bog marsh	10	0.04
jack pine	10	0.04
Total	25791	100.03

Table 17.–Organizations with interests in the Jordan River watershed.

Organization name
Antrim Conservation District
Antrim County Road Commission
City of East Jordan
Charlevoix Conservation District
Conservation Resource Alliance (formerly Northwest Michigan Resource Conservation and Development Council)
Ducks Unlimited
Friends of the Jordan River Watershed, Inc.
Fry Foundation
Harder Foundation
Jordan River Natural Rivers Council
MDEQ–Land & Water Management Division
MDEQ–Surface Water Quality Division
MDNR–Fisheries Division
MDNR–Forest Management Division
MDNR–Parks and Recreation Division
MDNR–Wildlife Division
Michigan Bear hunters association
Michigan Fur trappers association
Natural Resources Conservation Service
Ruffed Grouse Society
Tip-of-the-Mitt Watershed Council
Trout Unlimited–Challenge Chapter
Trout Unlimited–Headwaters Chapter
Trout Unlimited–Paul Young Chapter
USFWS- Jordan River National Fish Hatchery
USFWS–Lamprey Control Section
White-tails Unlimited

FIGURES

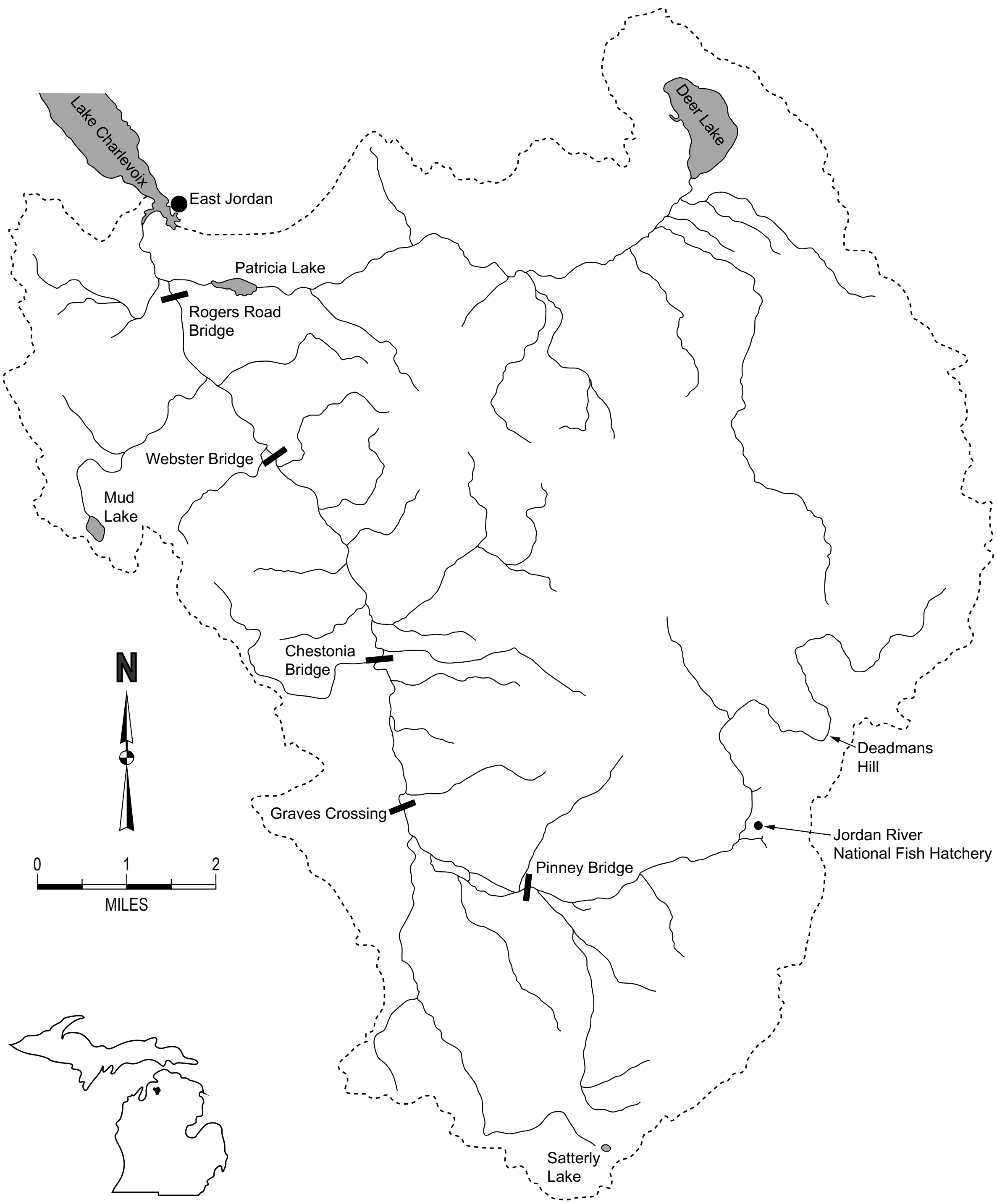
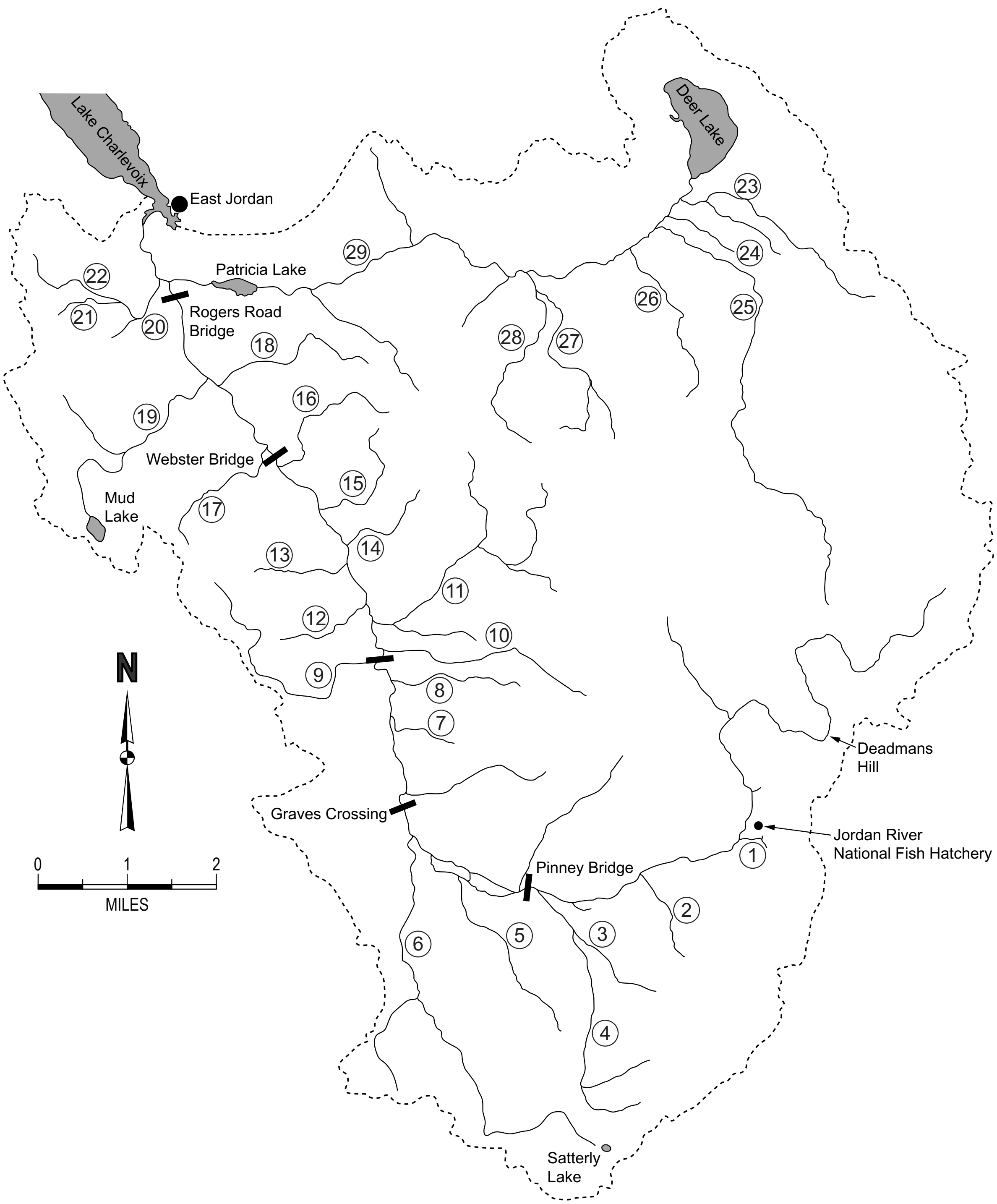


Figure 1.–The Jordan River watershed.

1. Six Tile Creek
2. Section 13 Creek
3. Landslide Creek
4. Cascade Creek
5. Stevens Creek
6. Green River
7. Tutstone Creek
8. Scott Creek
9. Cokirs Creek
10. Sutton Creek
11. Mill Creek
12. Martin Creek
13. Lilak Creek
14. Gook Creek
15. Webster Creek
16. Severance Creek
17. Bartholomew Creek
18. Todd Creek
19. Bennett (Bartholomew) Creek
20. Birney Creek
21. Lanaway Creek
22. Jones Creek
23. Collins Creek
24. Hog Creek
25. Warner Creek
26. Eaton Creek
27. Marvon Creek
28. Nemecheck Creek
29. Deer Creek

Figure 2.–Major named tributaries to the Jordan River. Stream names from Anonymous (1983). Parenthesis indicates another name from Anonymous (1988b).


Lake Charlevoix
East Jordan
Deer Lake
23
24
25
26
27
28
29
Patricia Lake
22
21
20
Rogers Road
Bridge
18
16
19
Webster Bridge
15
Mud
Lake
17
13
14
11
12
10
9
8
7
N
0
1
2
MILES
Graves Crossing
Pinney Bridge
Deadmans
Hill
Jordan River
National Fish Hatchery
1
2
3
4
5
6
Satterly
Lake

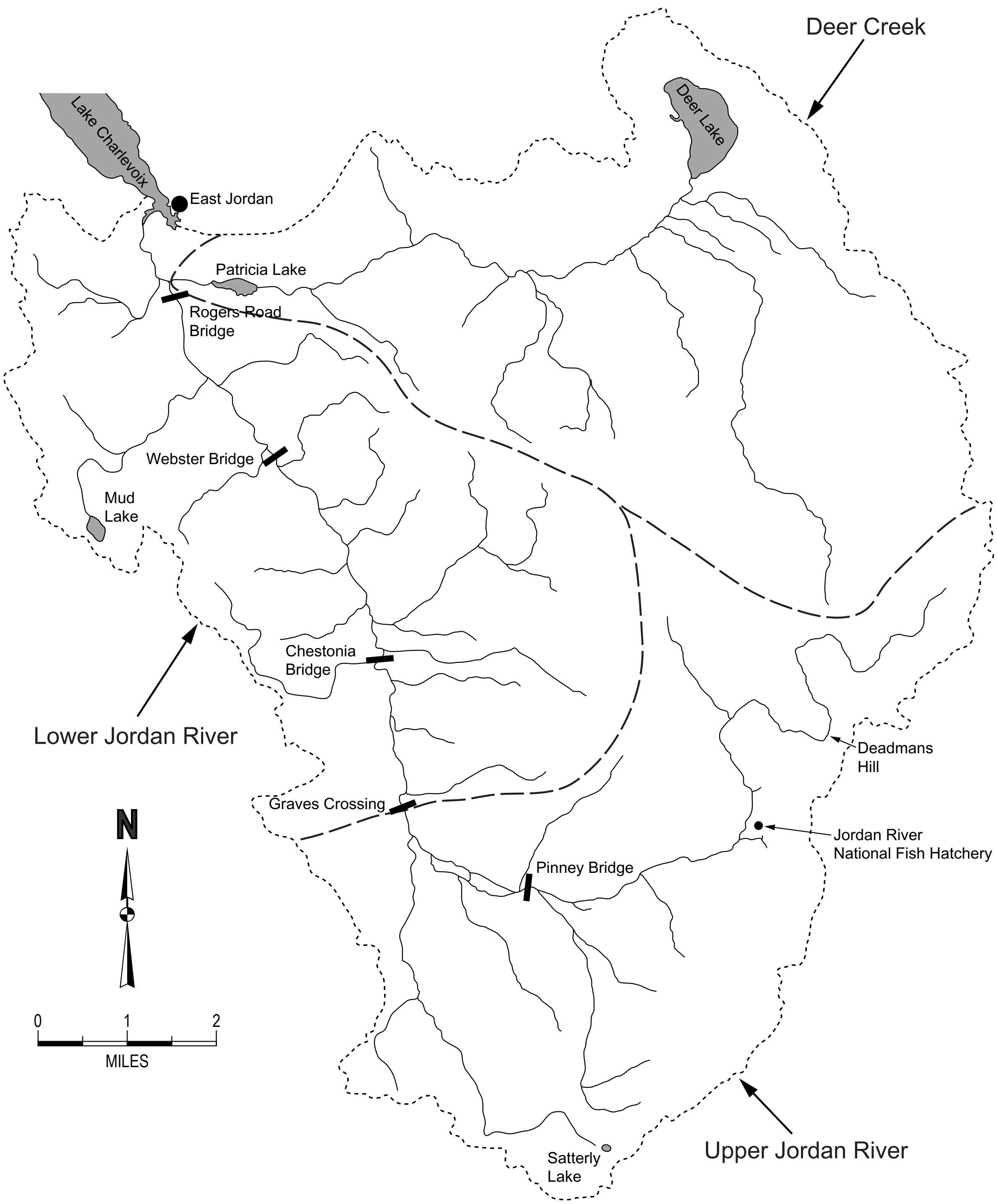


Figure 3.–Mainstem valley sections of the Jordan River.

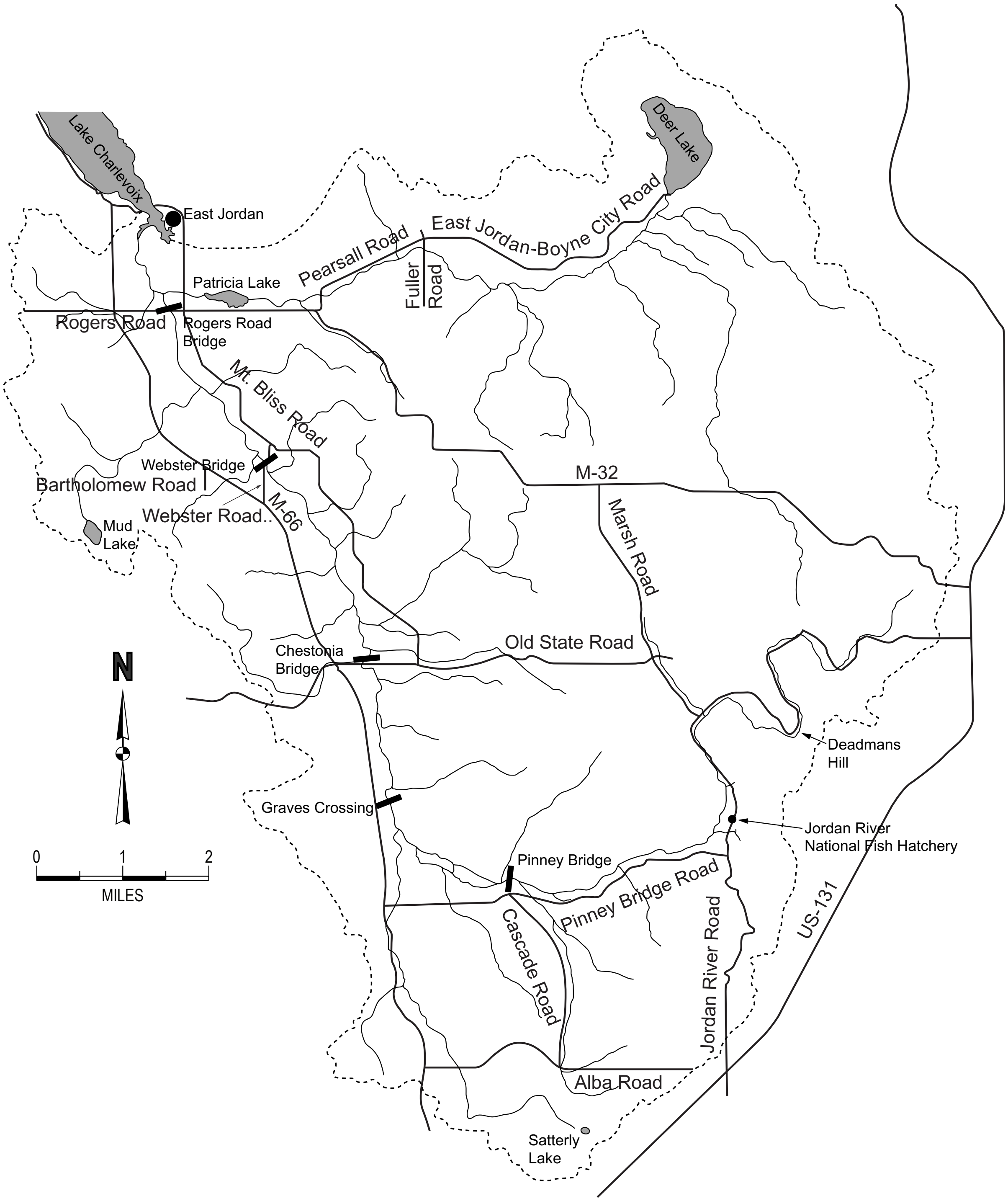


Figure 4.–Major roads within the Jordan River watershed.

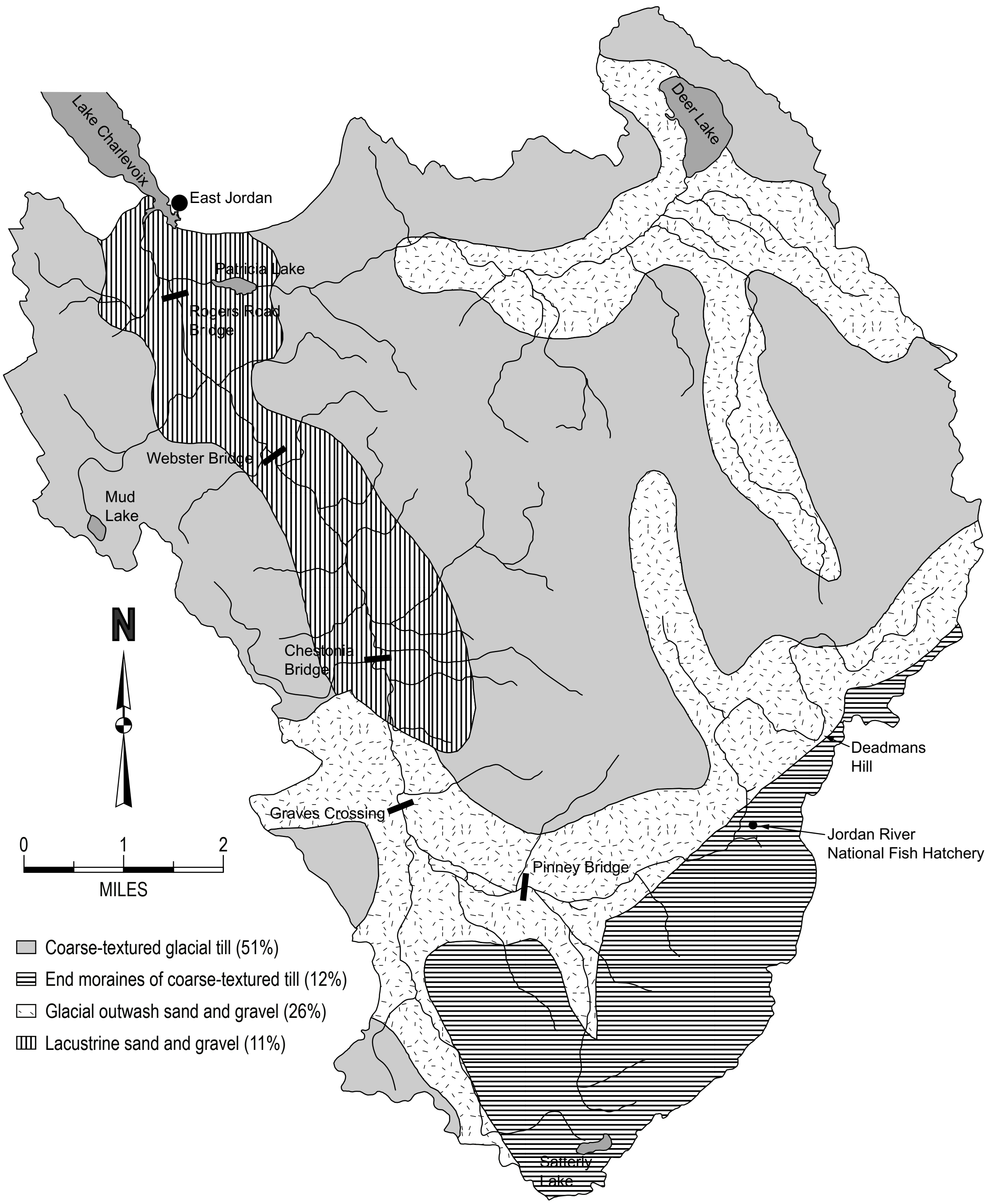


Figure 5.–Surficial geology of the Jordan River watershed. Data from Michigan Department of Natural Resources, Quaternary Geology map (Farrand and Bell 1982), Spacial Information Resource Center, Roscommon, Michigan.

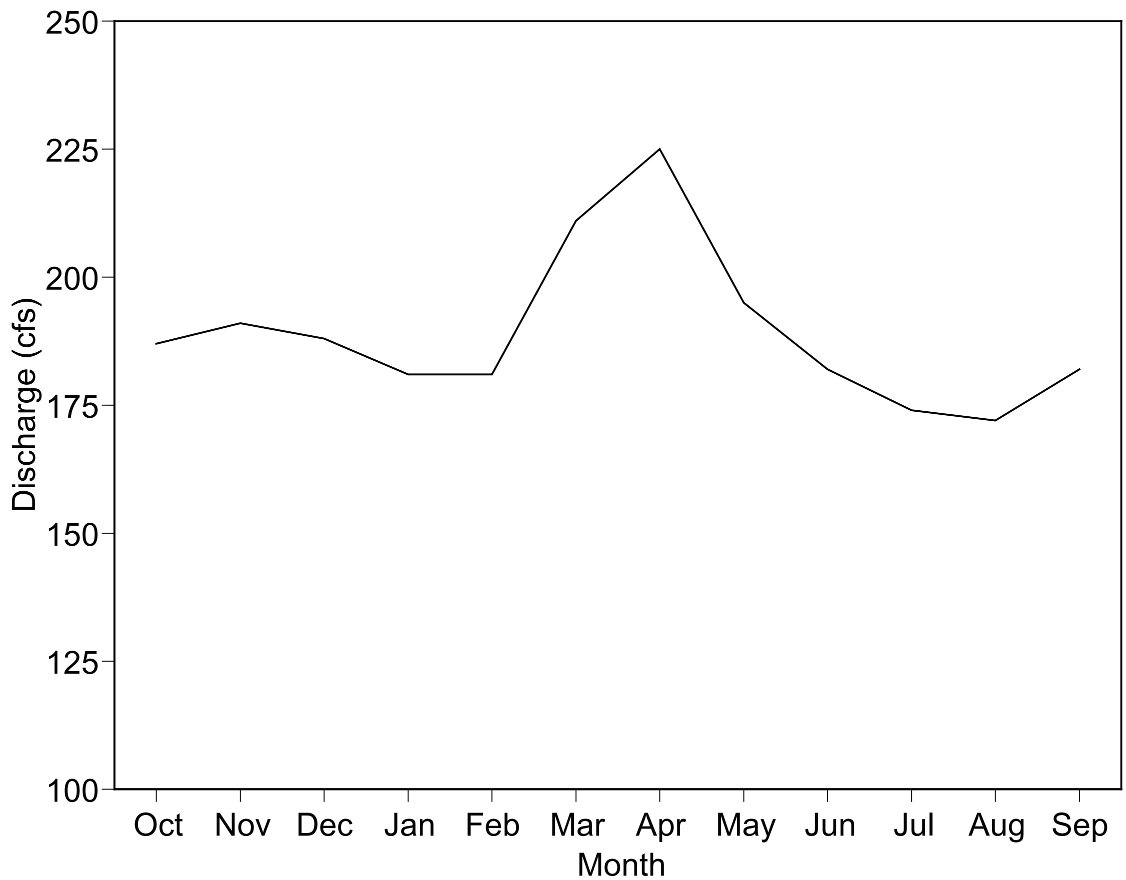


Figure 6.–Mean monthly discharge for Jordan River near East Jordan for period of record (1967-97). Data are shown from October through September, a traditional water year. Data are from United States Geological Survey, stream discharge records (gauge number 04127800).

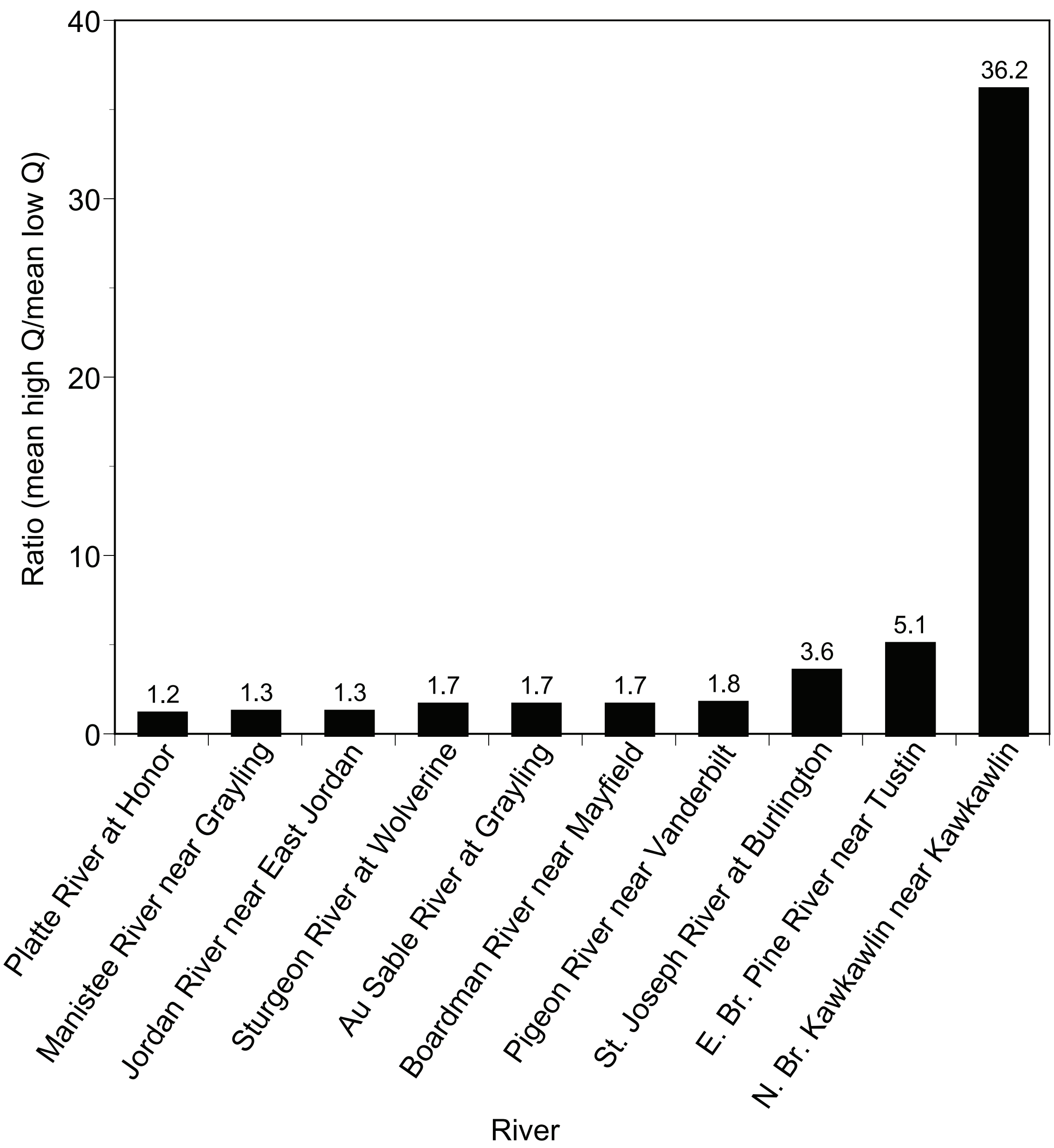


Figure 7.–Ratio of means of monthly streamflows (Q) for months with highest and lowest mean flows for period of record. Data are from United States Geological Survey, stream discharge records.

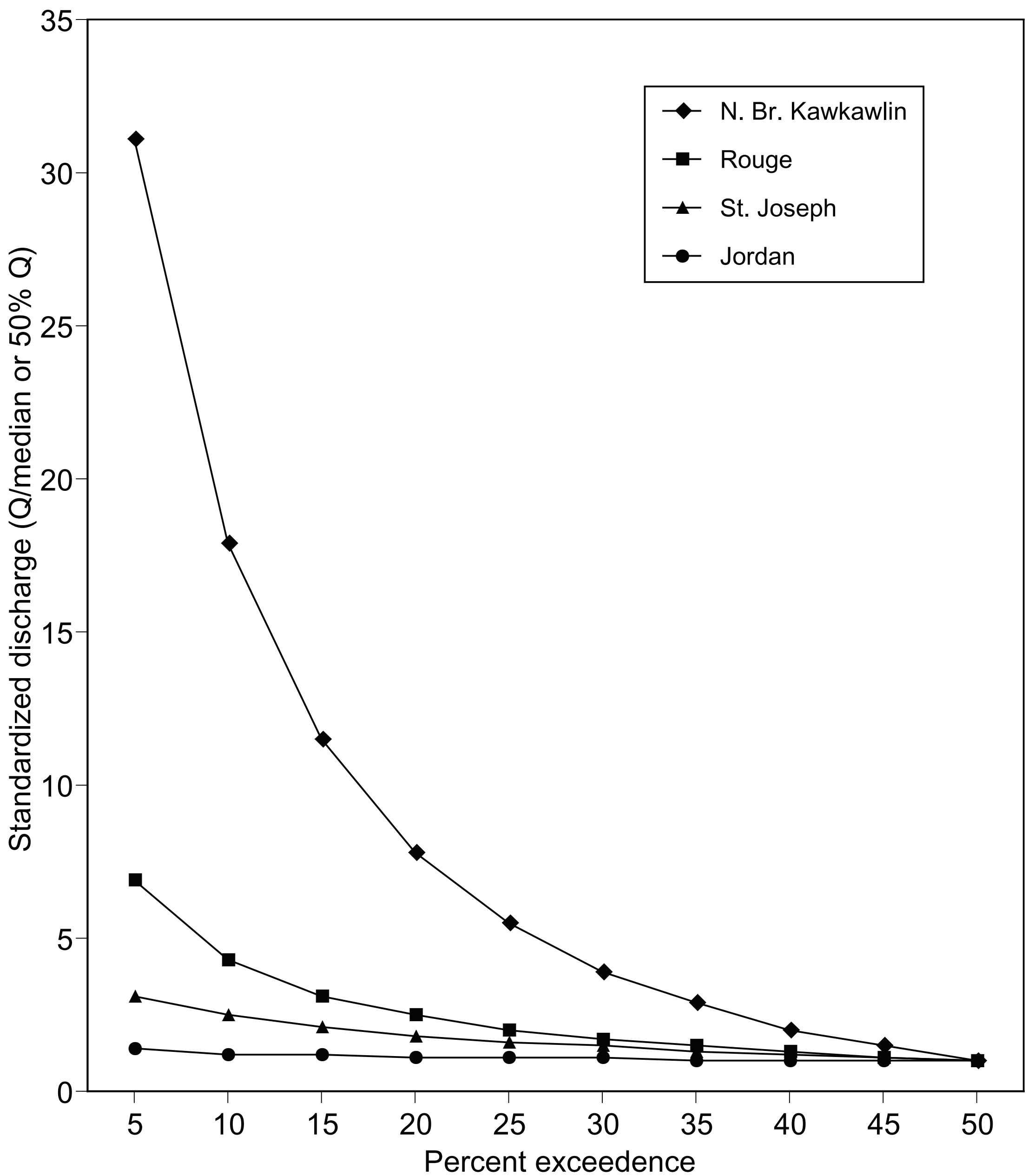


Figure 8.–Standardized high flow exceedence curves for four Michigan rivers. Standardized discharge is the discharge (Q) / median(50% Q) discharge. Exceedence curves represent the probability of a discharge being equaled or exceeded for a given value. Data from United States Geological Survey gauge stations for period of record.

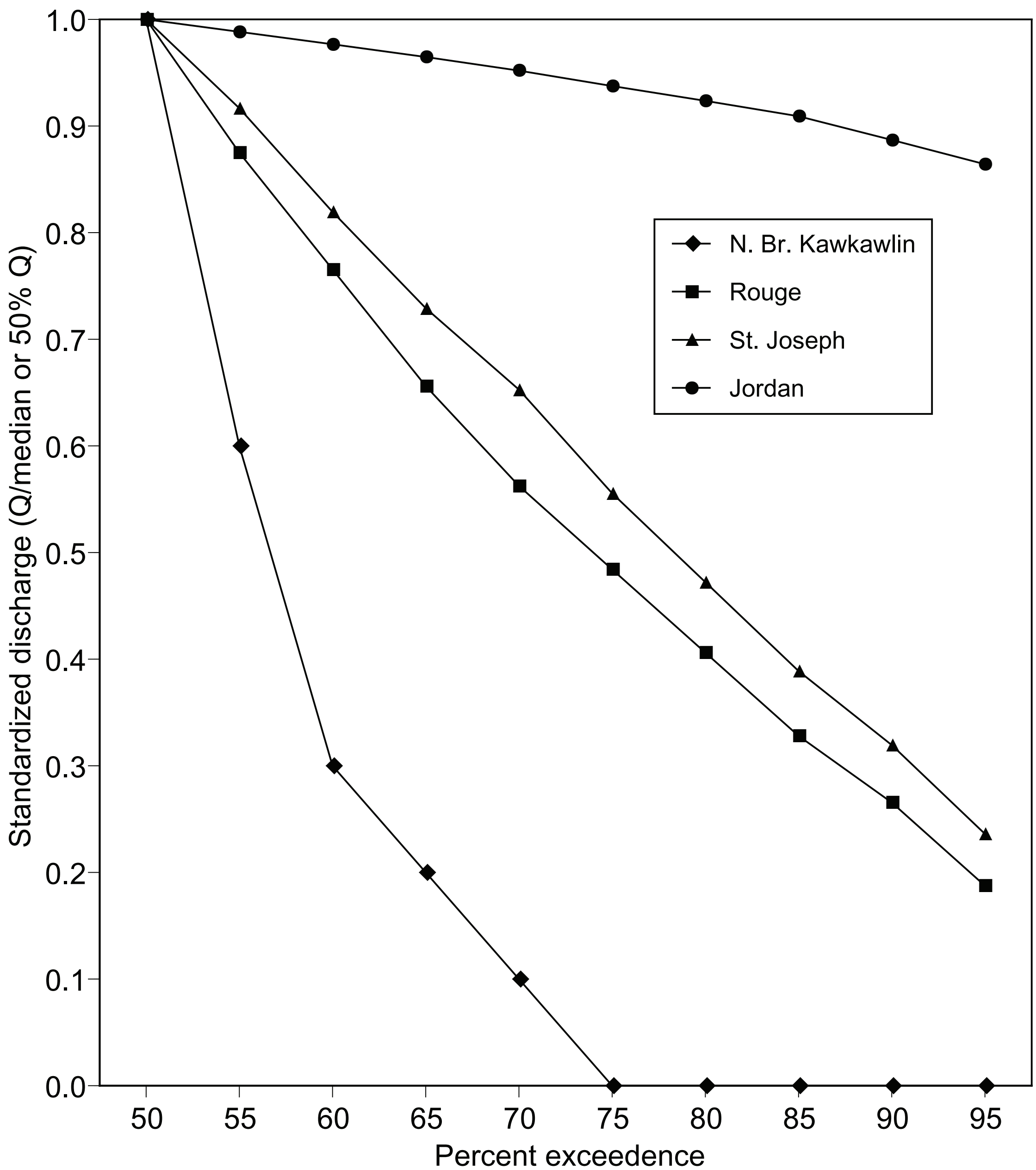


Figure 9.–Standardized low flow exceedence curves for four Michigan rivers. Standardized discharge is the discharge (Q) / median(50% Q) discharge. Exceedence curves represent the probability of a discharge being equaled or exceeded for a given value. Data from United States Geological Survey gauge stations for period of record.

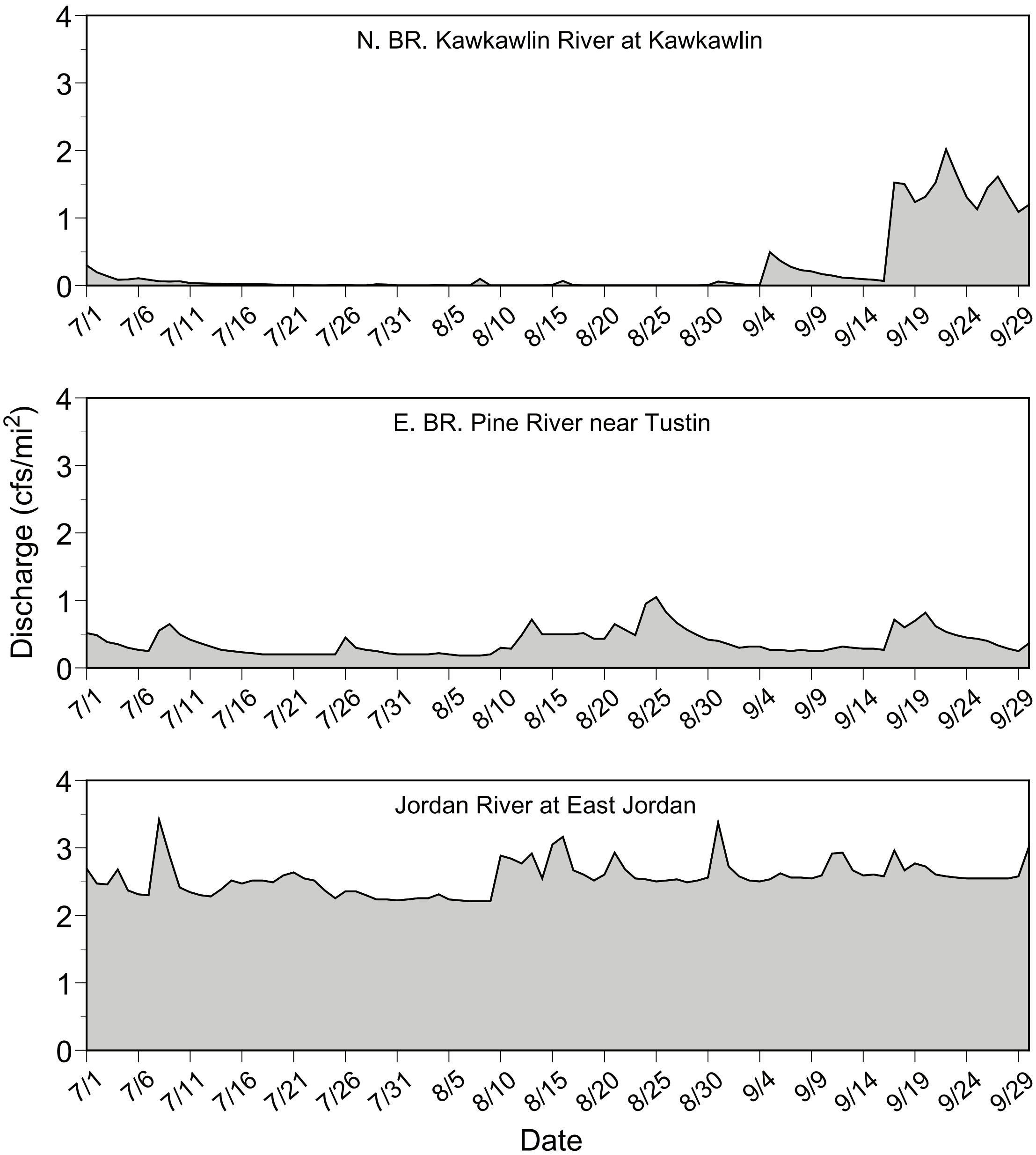


Figure 10.–Hydrographs during a typical July, August, and September period for rivers in Michigan's Lower Peninsula showing a range in surface runoff and baseflow regimes. N. Br. Kawkawlin River data from 1981, E. Br. Pine River and Jordan River data from 1997. Data from United States Geological Survey gauging stations: N. Br. Kawkawlin River, ID# 04143500; E. Br. Pine River, ID# 04124500; and Jordan River, ID# 04127800.

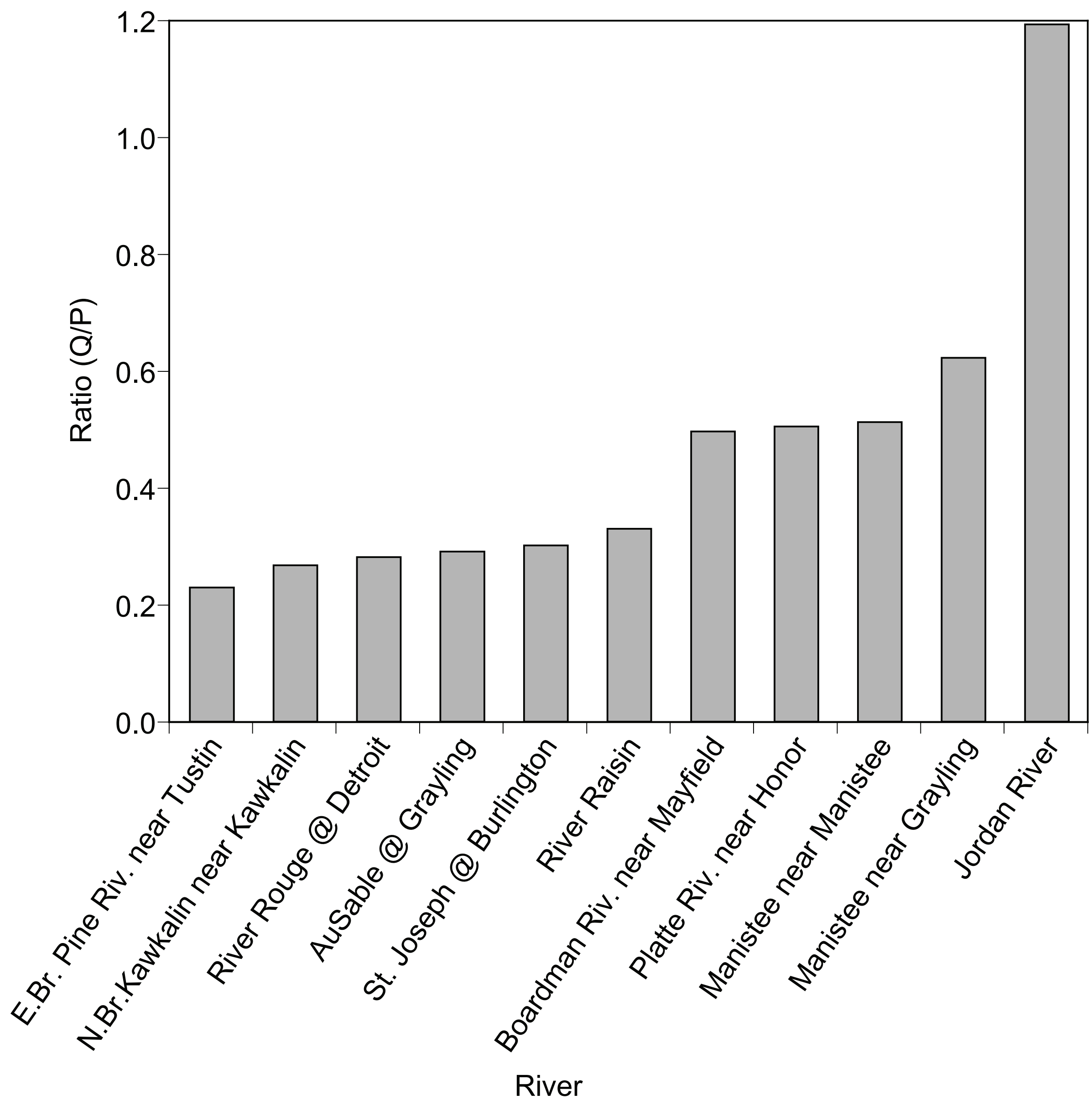


Figure 11.–Ratio of flow (Q) to precipitation (P) in the catchment basin for several rivers in Michigan. Flow expressed as inches of precipitation in the watershed. Data from United States Geological Survey, stream discharge records.

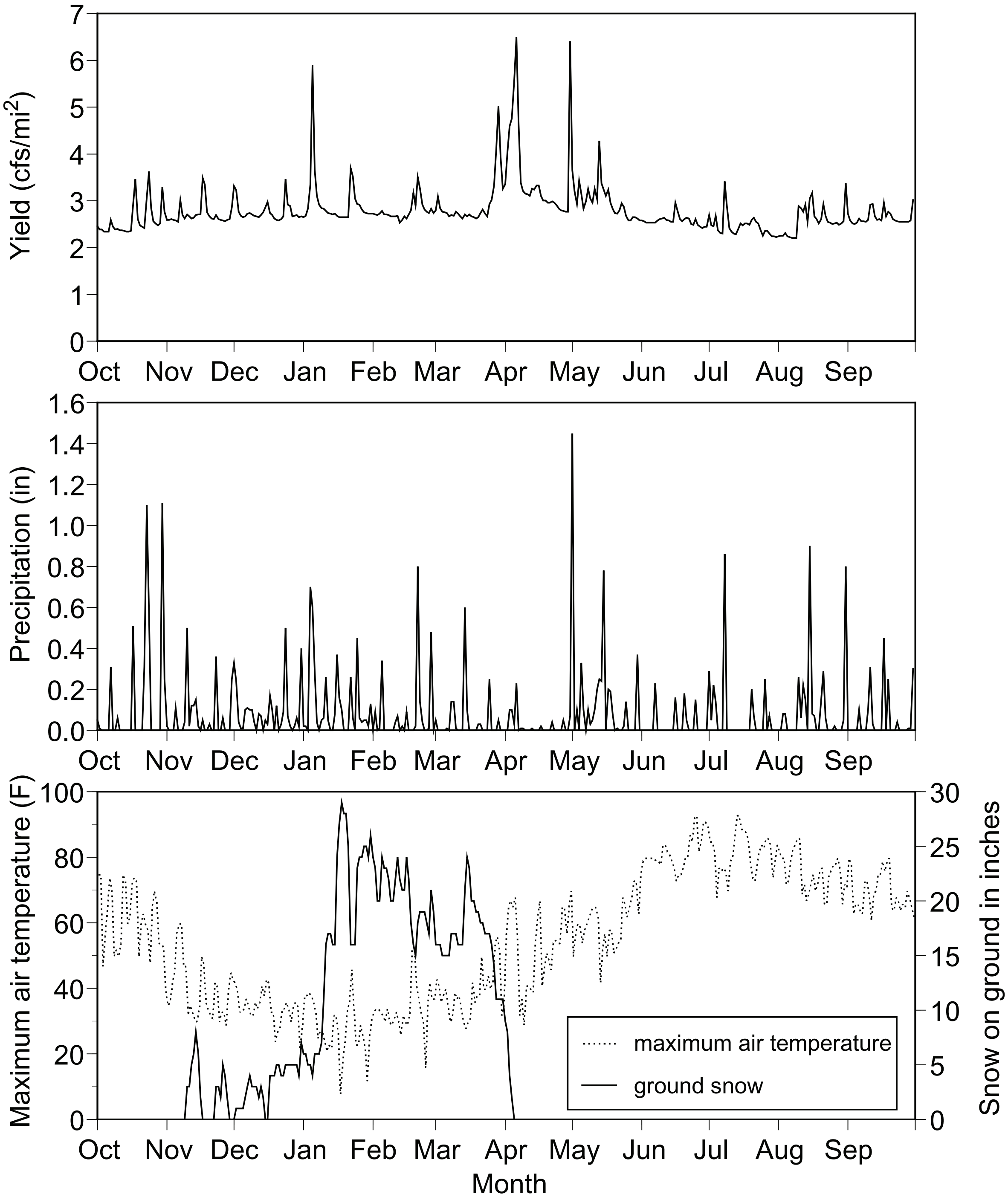


Figure 12.–Jordan River water yield, precipitation, maximum air temperature and snow pack near East Jordan for water year 1997. Data from United States Geological Survey, stream discharge records and National Oceanic and Atmospheric Administration.

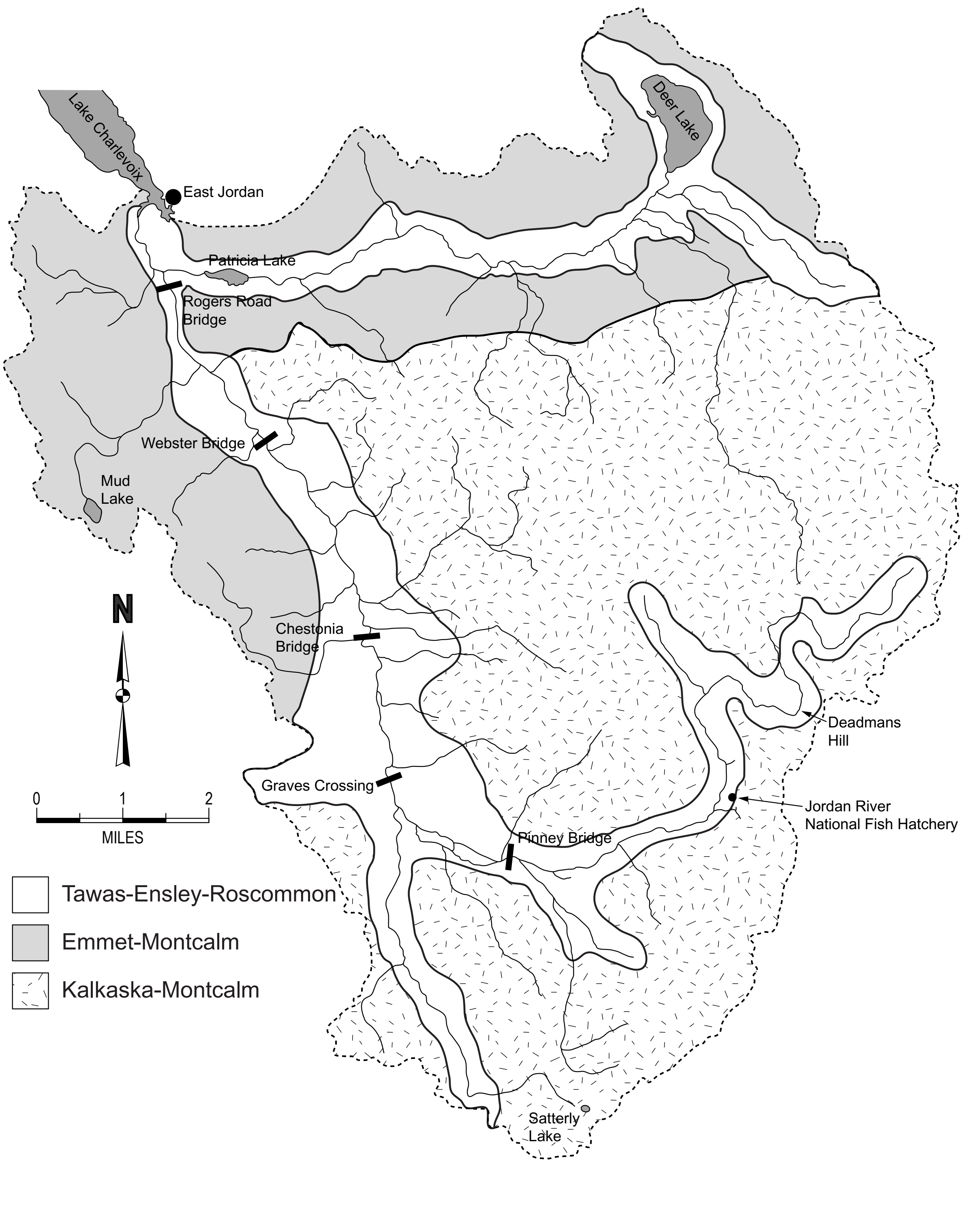


Figure 13.–Soil groups in the Jordan River watershed. Data from anonymous (1978).

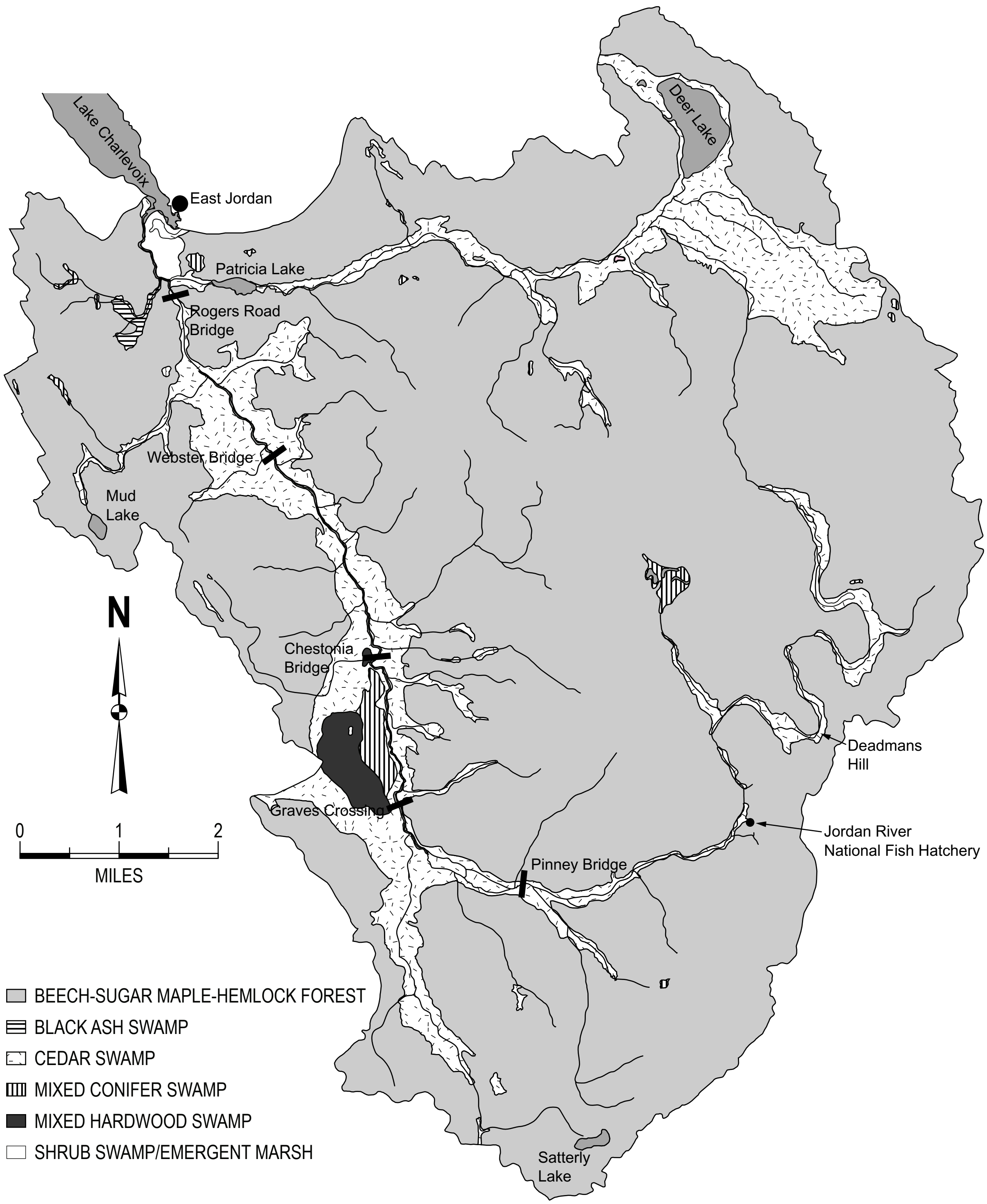


Figure 14.–Original land cover of the Jordan River watershed circa 1800. Data provided by Michigan Department of Natural Resources, Spatial Information Resource Center, unpublished data, Roscommon.

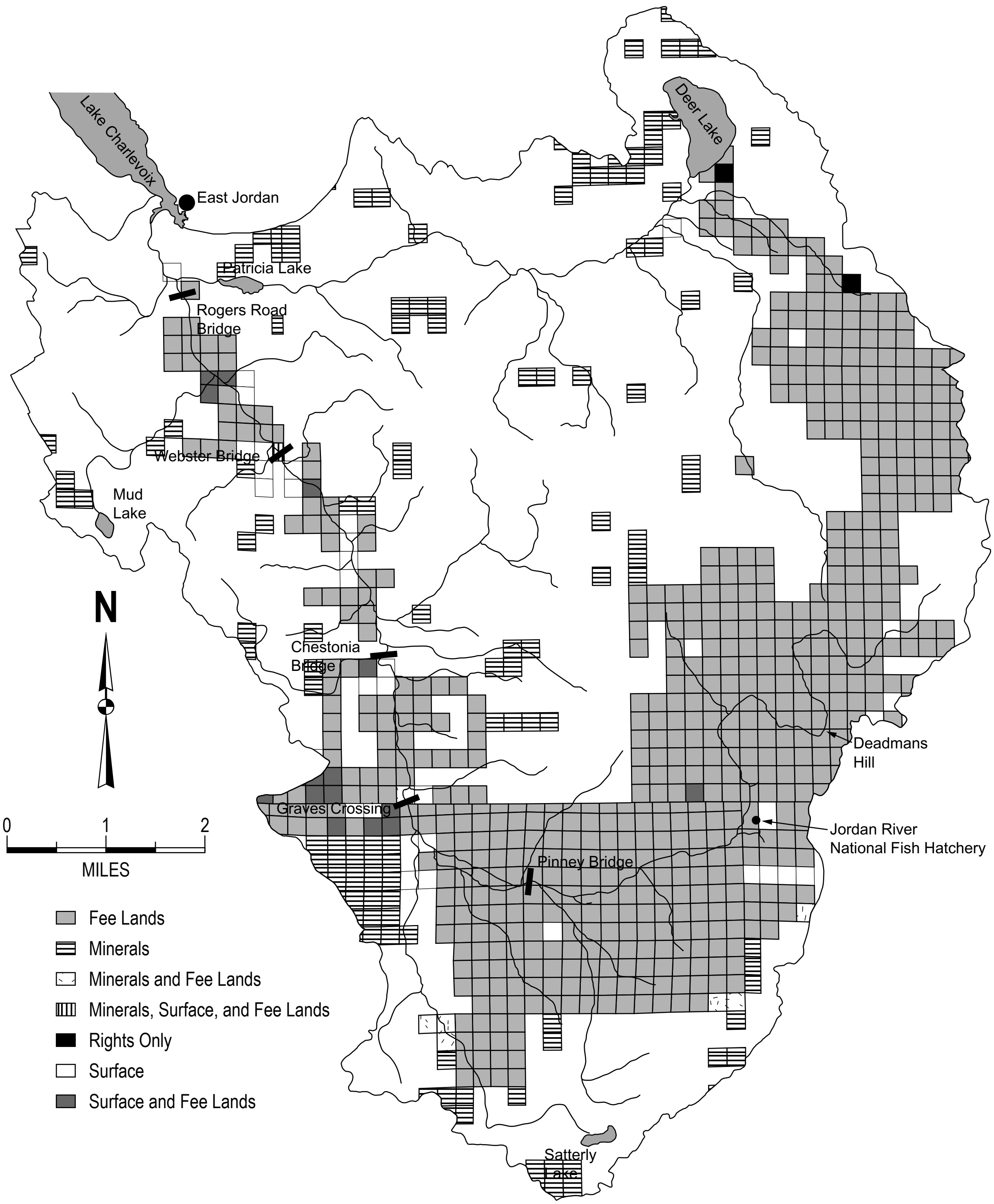


Figure 15.–State of Michigan land ownership in the Jordan River watershed. Data provided by Michigan Department of Natural Resources, Spatial Information Resource Center, unpublished data, Roscommon.

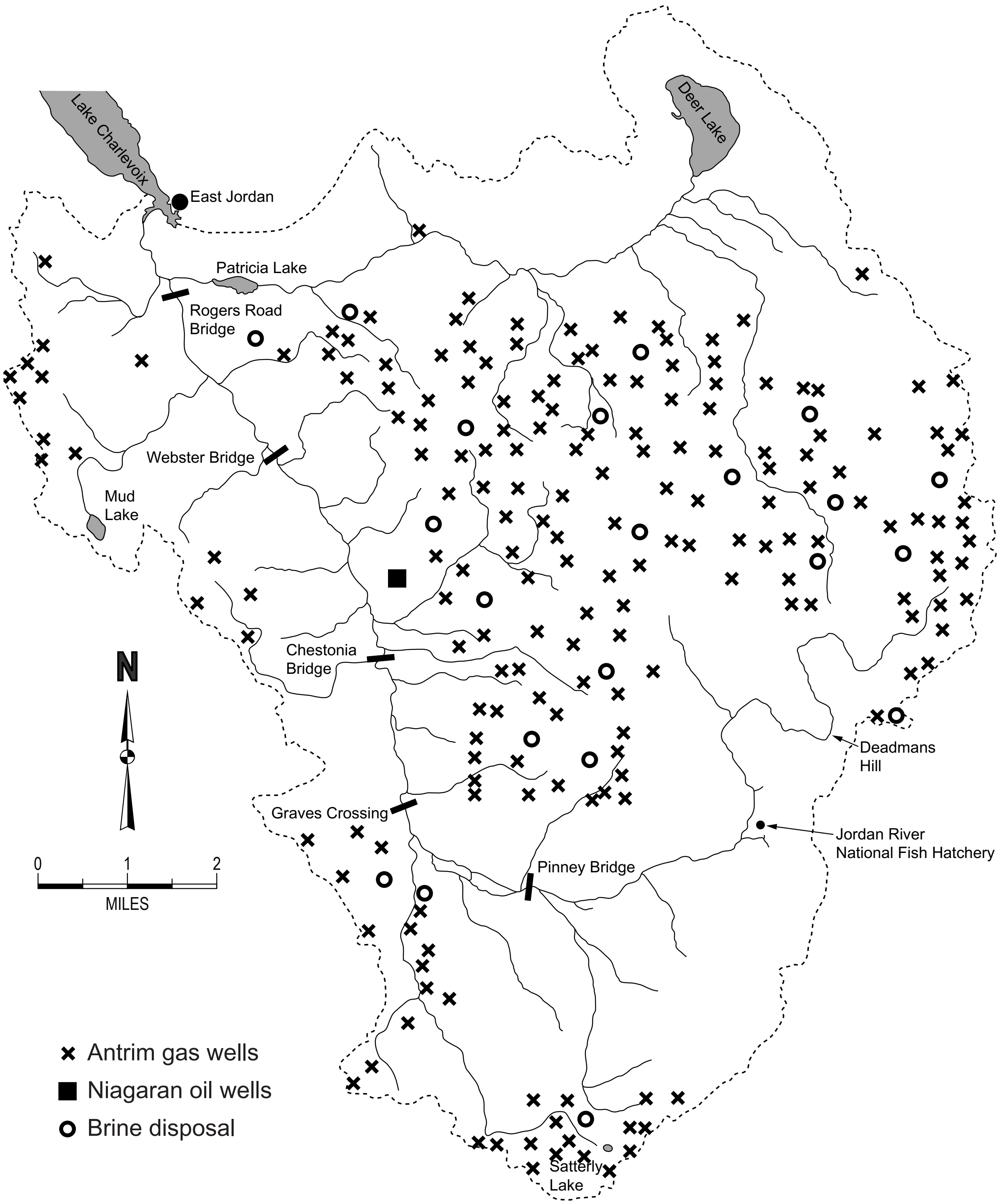


Figure16.–Location of hydrocarbon wells in the Jordan River watershed. Data provided by Michigan Department of Natural Resources, Spatial Information Resource Center, unpublished data, Roscommon.

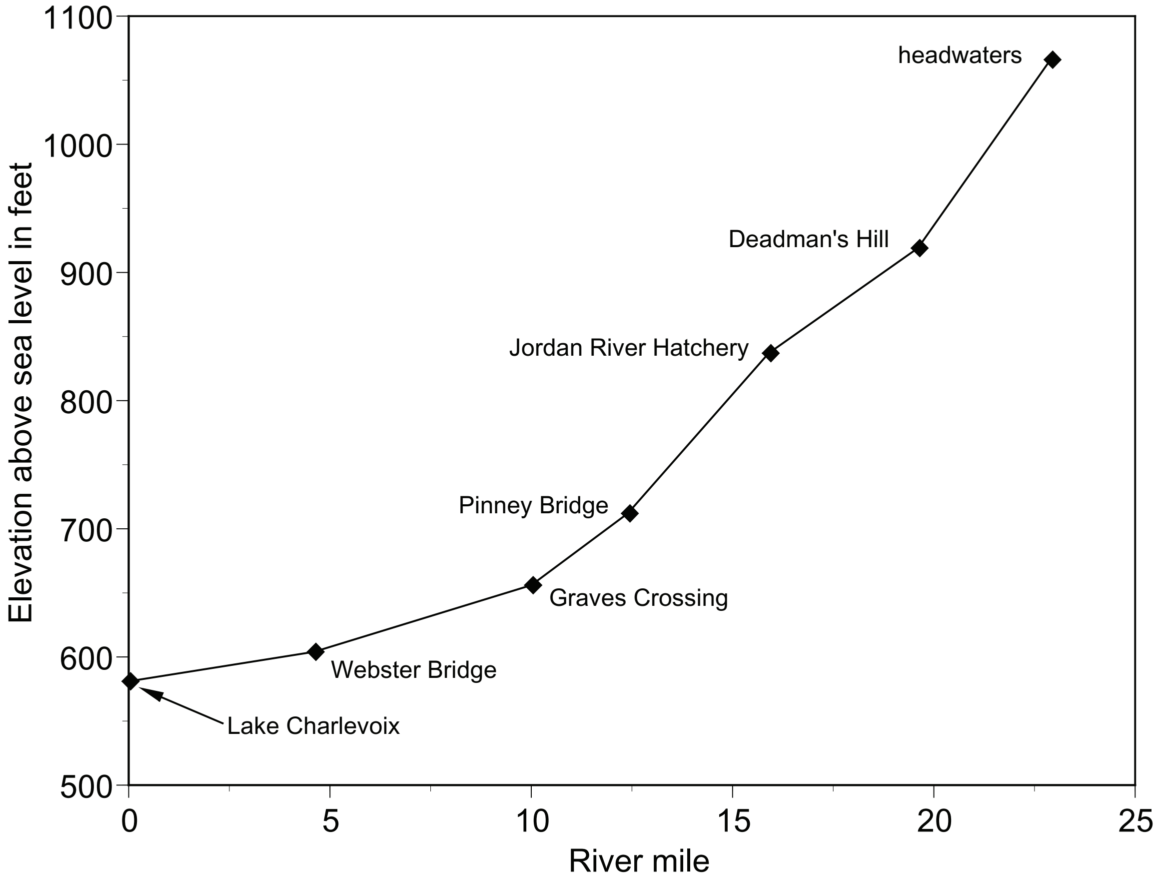


Figure 17.–Elevation changes, by river mile, from headwaters to mouth of Jordan River. Data from Michigan Department of Natural Resources, Fisheries Division, Ann Arbor.

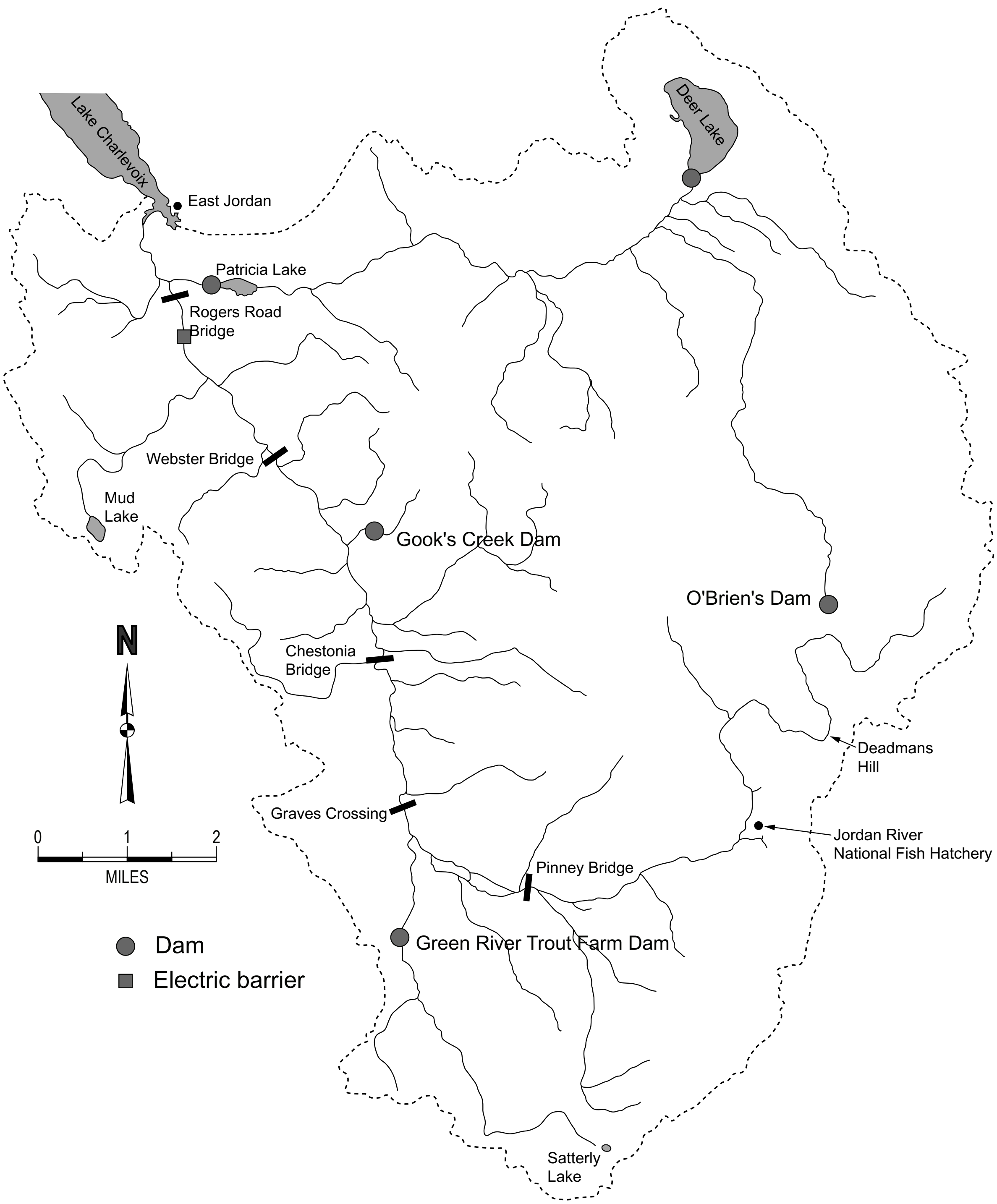


Figure 18.–Location of known dams and electric barrier in the Jordan River watershed. Remnants of Obrien's Dam still impounds some water. Data from Michigan Department of Natural Resources, Fisheries Division.

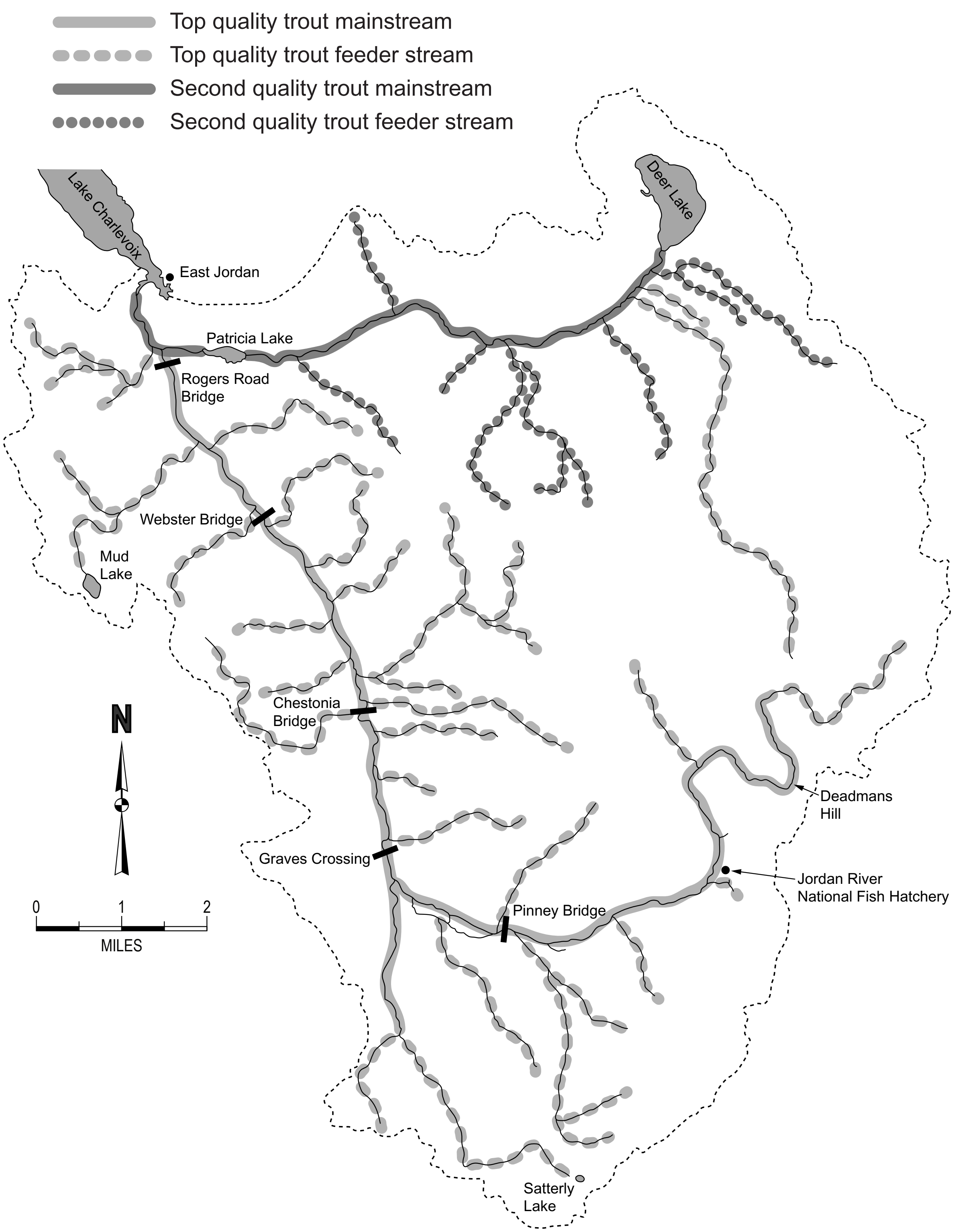


Figure 19.–Michigan Department of Natural Resources, Fisheries Division, stream classification, 1967. Data from Anonymous (1967).

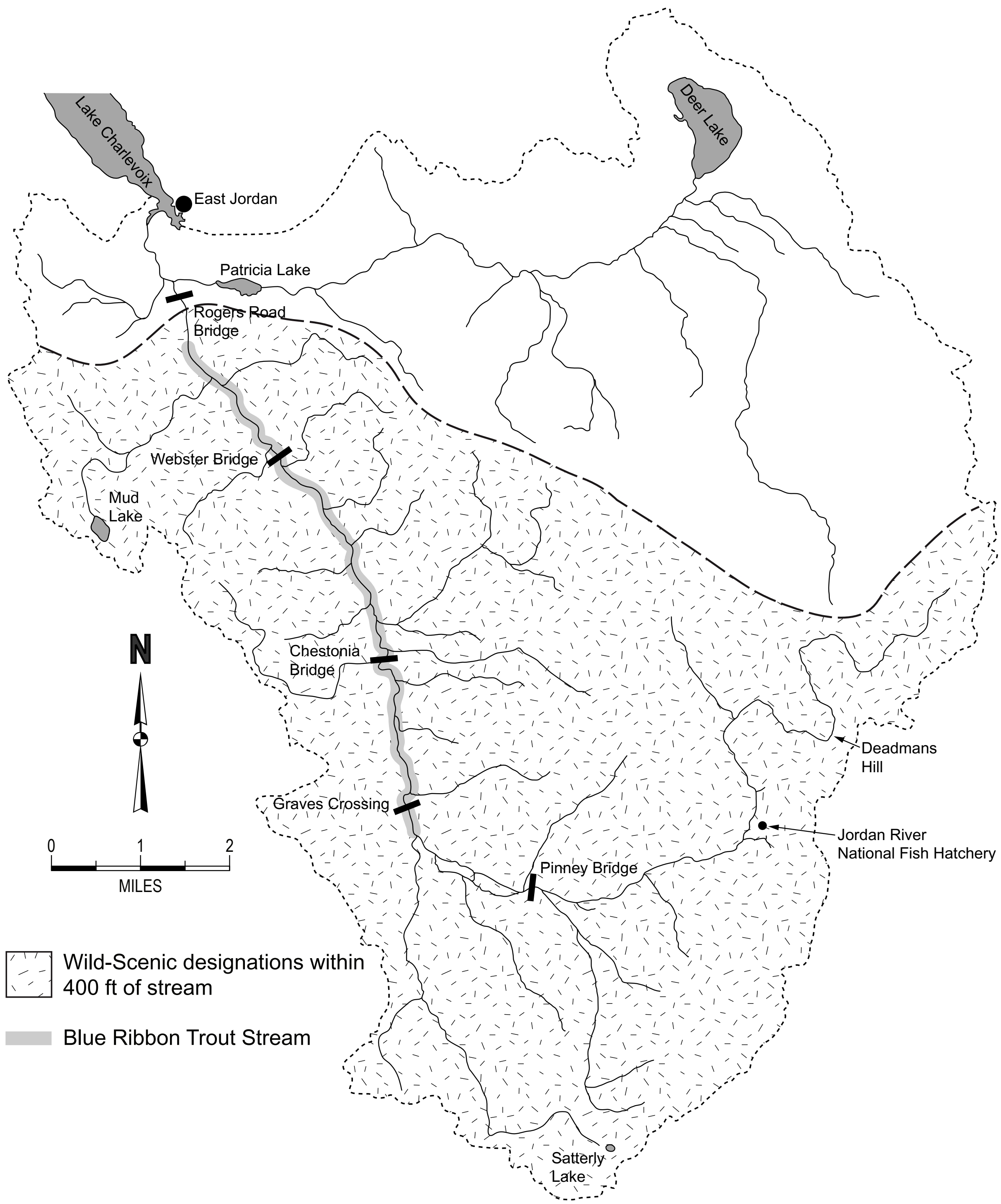


Figure 20.–State designated wild-scenic and “Blue Ribbon Trout Stream” in the Jordan River watershed. Data from Anonymous (1974a) and Michigan Department of Natural Resources, Fisheries Division, Lansing.

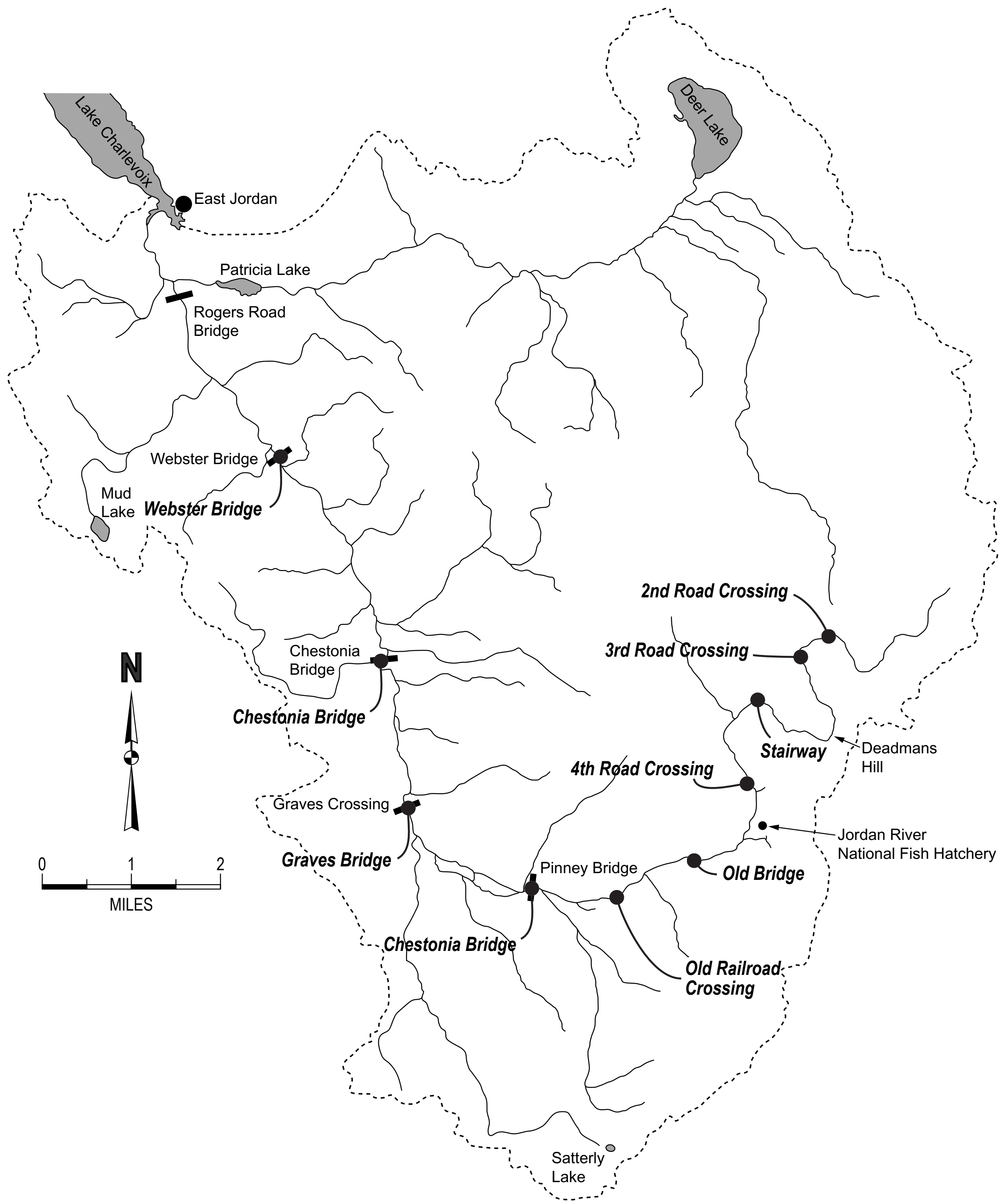


Figure 21.–Location of salmonid fish population densities in the mainstem of the Jordan River, summer 1987 and 1994. Data from Michigan Department of Natural Resources, Fisheries Division, Lansing.

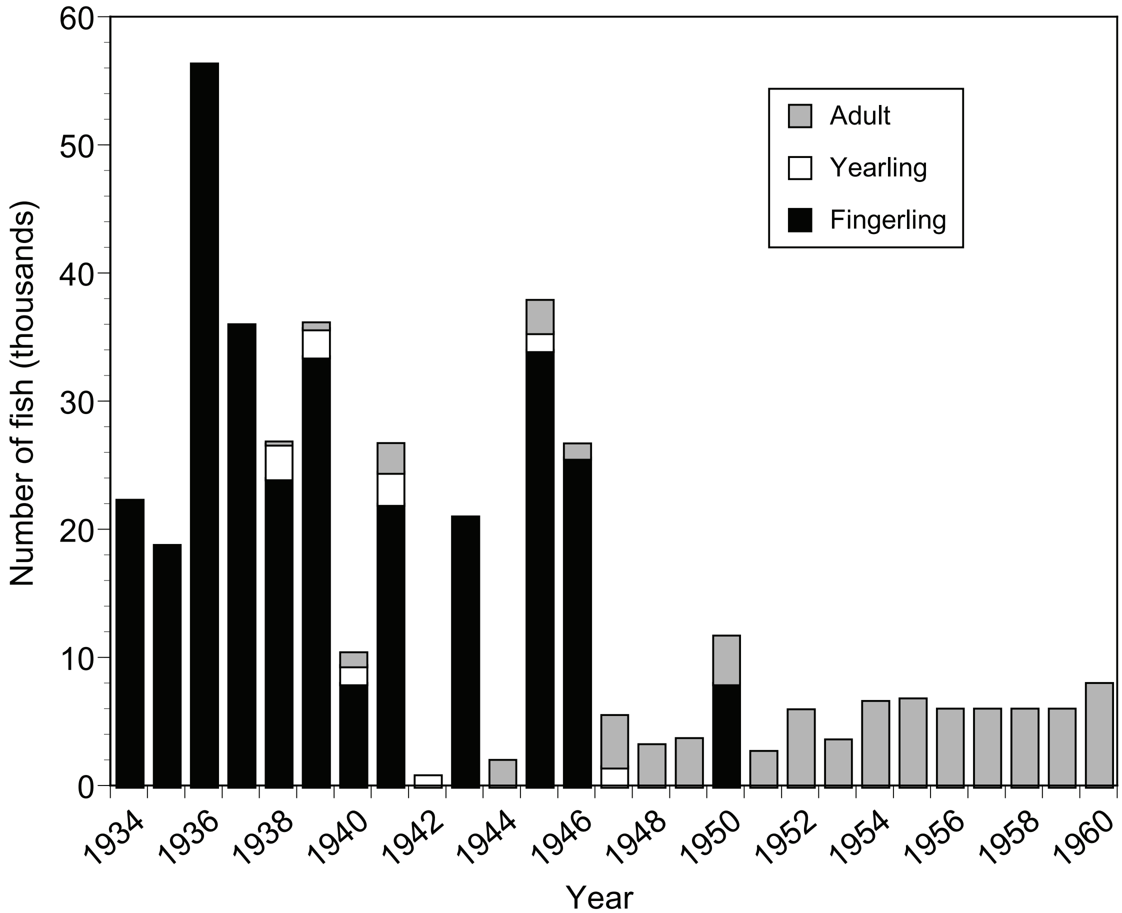


Figure 22.–Brook trout stockings in the mainstem of the Jordan River, 1934-60. Data from Michigan Department of Natural Resources, Fisheries Division, Lansing.

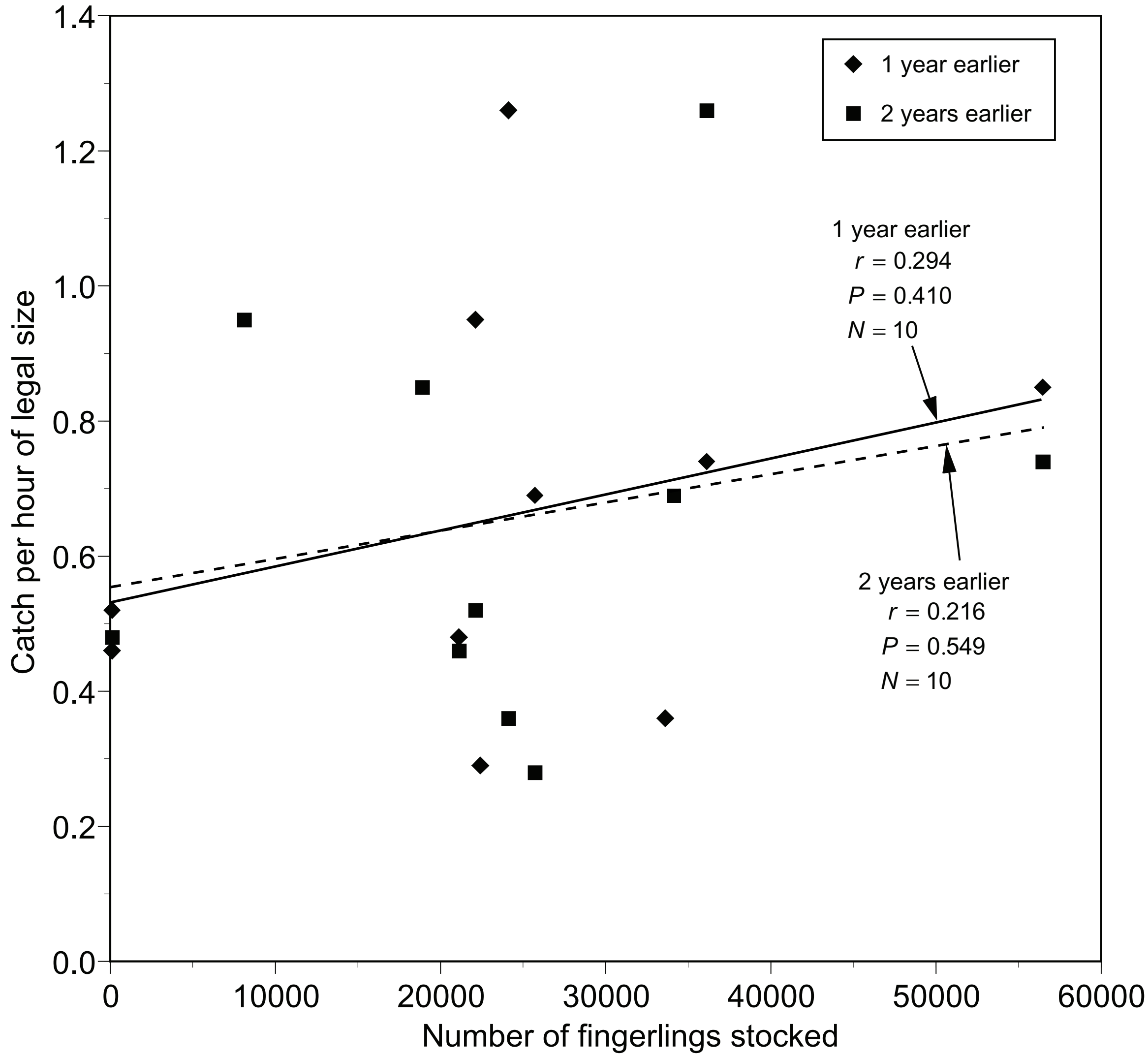


Figure 23.–Relationship between number of fingerling brook trout stocked one and two years earlier and catch per unit of effort for the mainstem of the Jordan River, 1934-46. Data from Michigan Department of Natural Resources, Fisheries Division, Lansing.

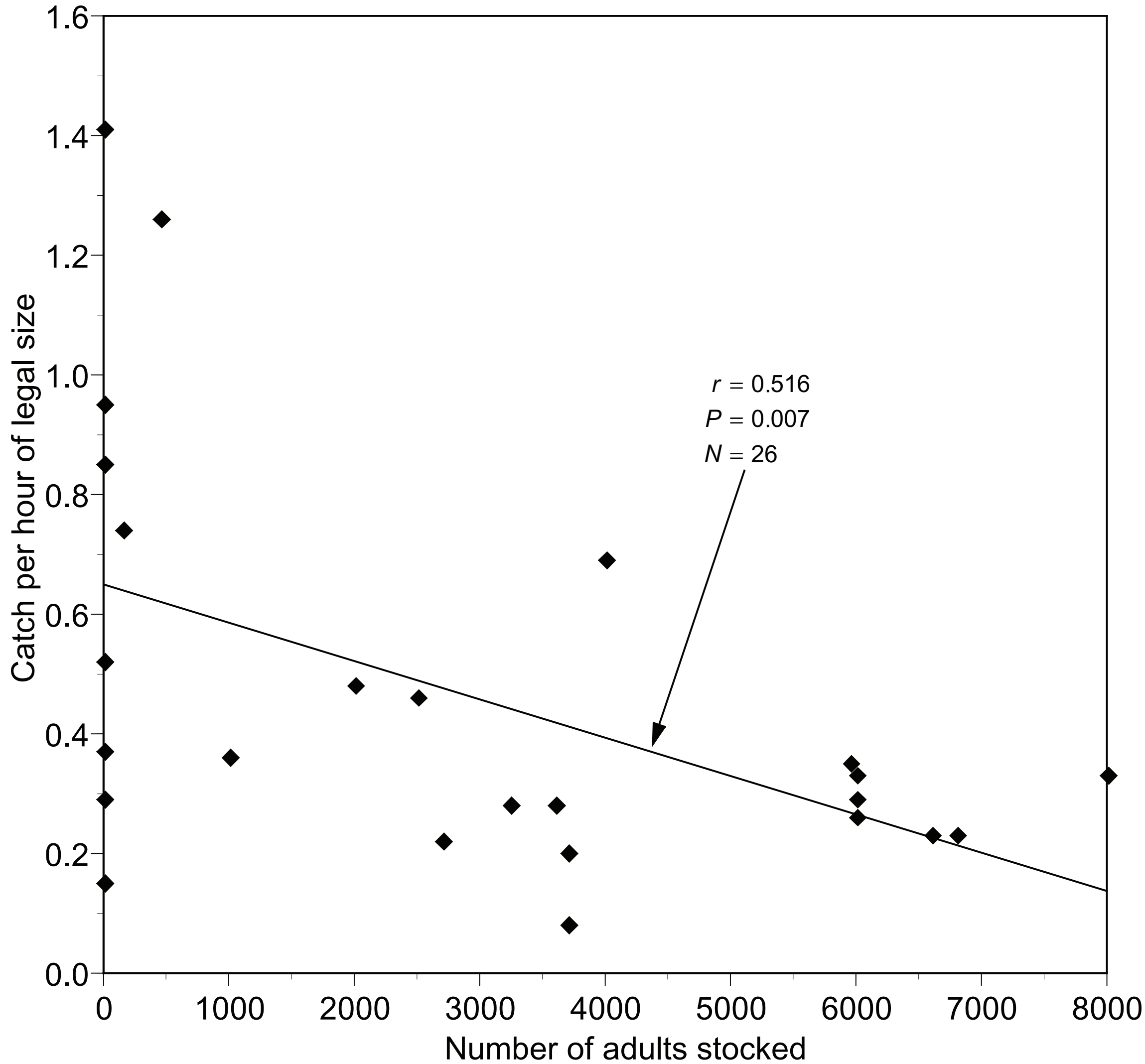


Figure 24.–Relationship between number of adult brook trout stocked and catch per unit of effort for the mainstem of the Jordan River, 1934-64. Data from Michigan Department of Natural Resources, Fisheries Division, Lansing.

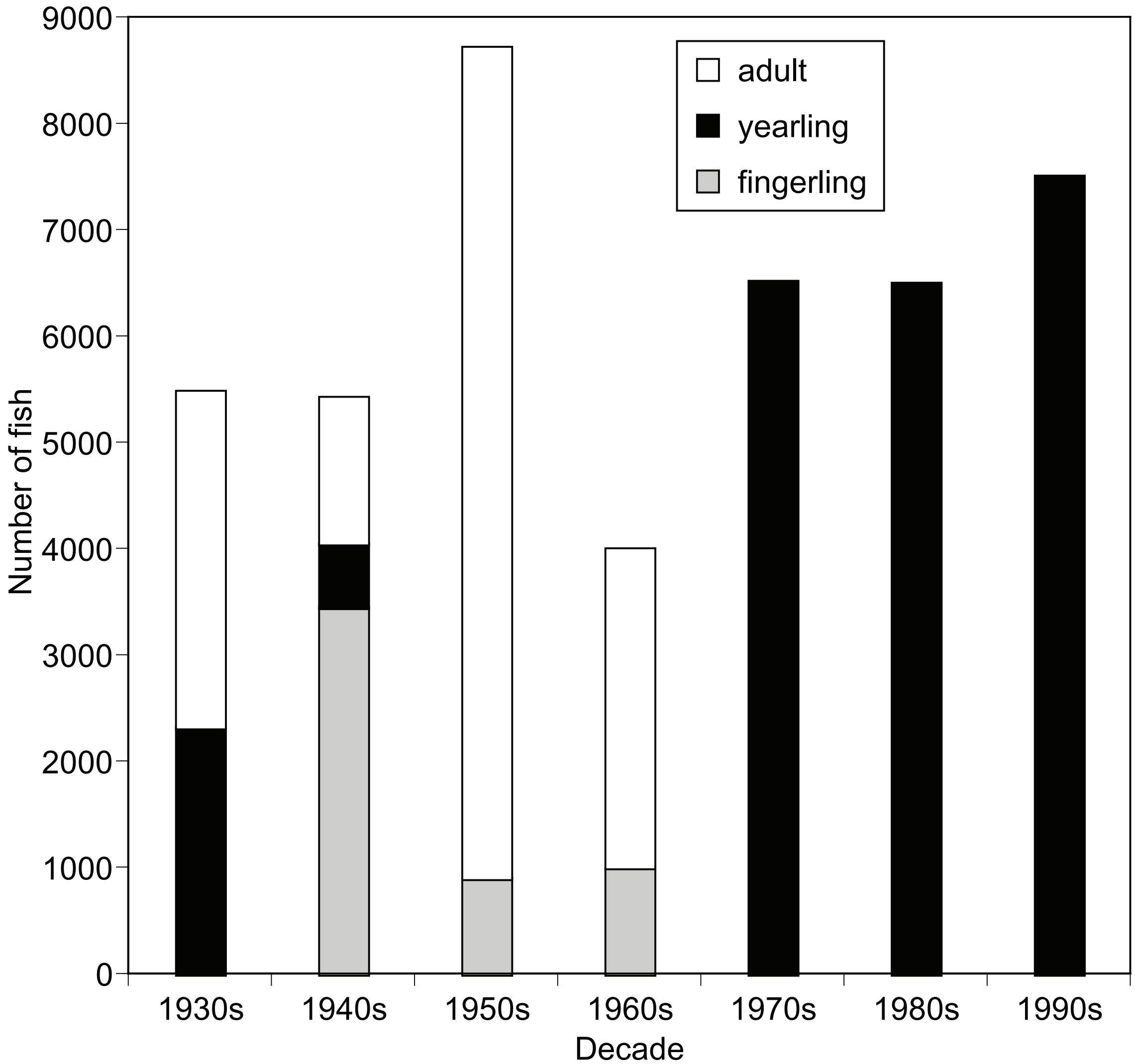


Figure 25.–Mean number of rainbow trout stocked in the mainstem of the Jordan River by decade. Data from Michigan Department of Natural Resources, Fisheries Division, Lansing.

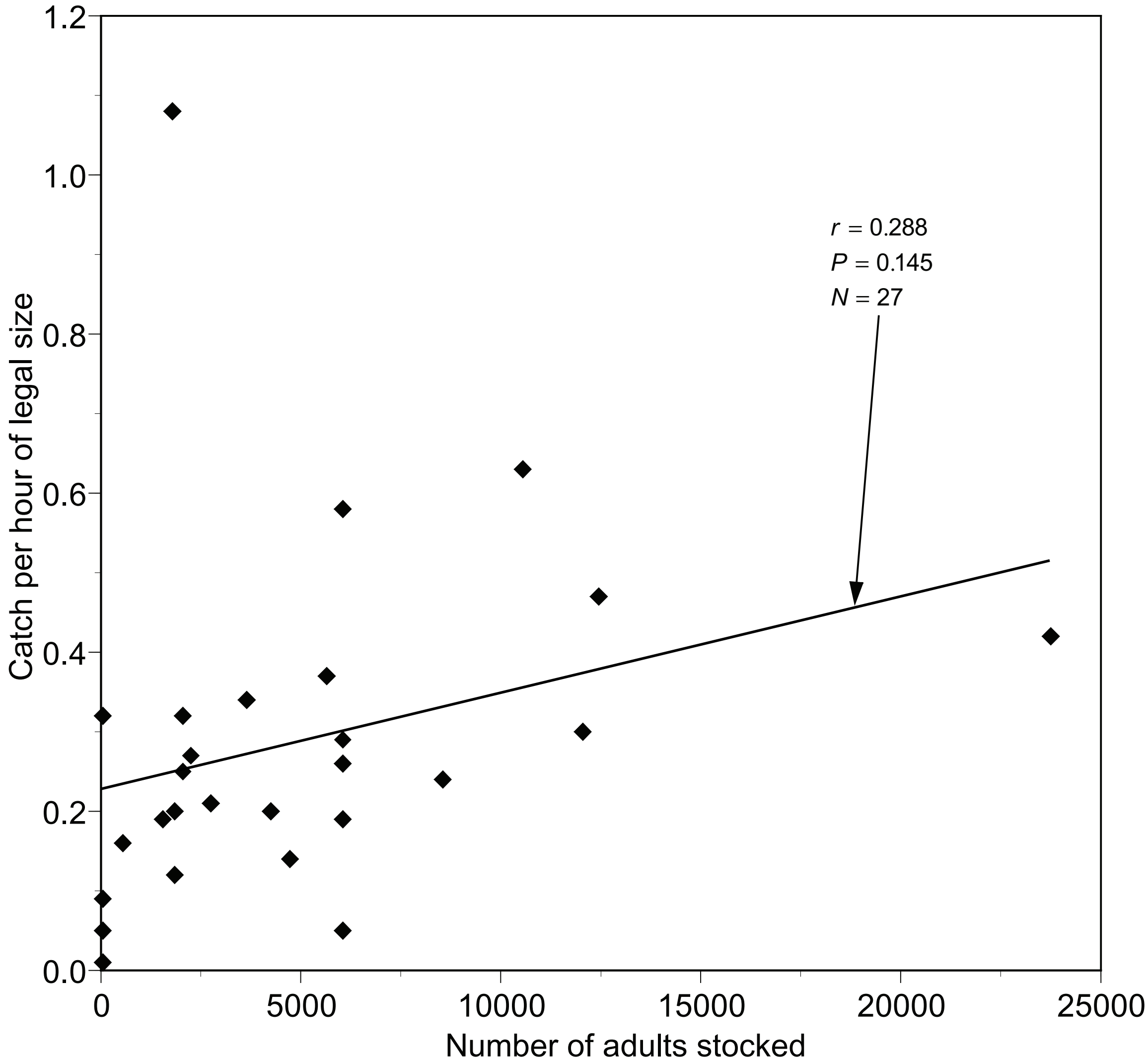


Figure 26.–Relationship between number of adult rainbow trout stocked and catch per unit of effort for the mainstem of the Jordan River, 1934-64. Data from Michigan Department of Natural Resources, Fisheries Division, Lansing.

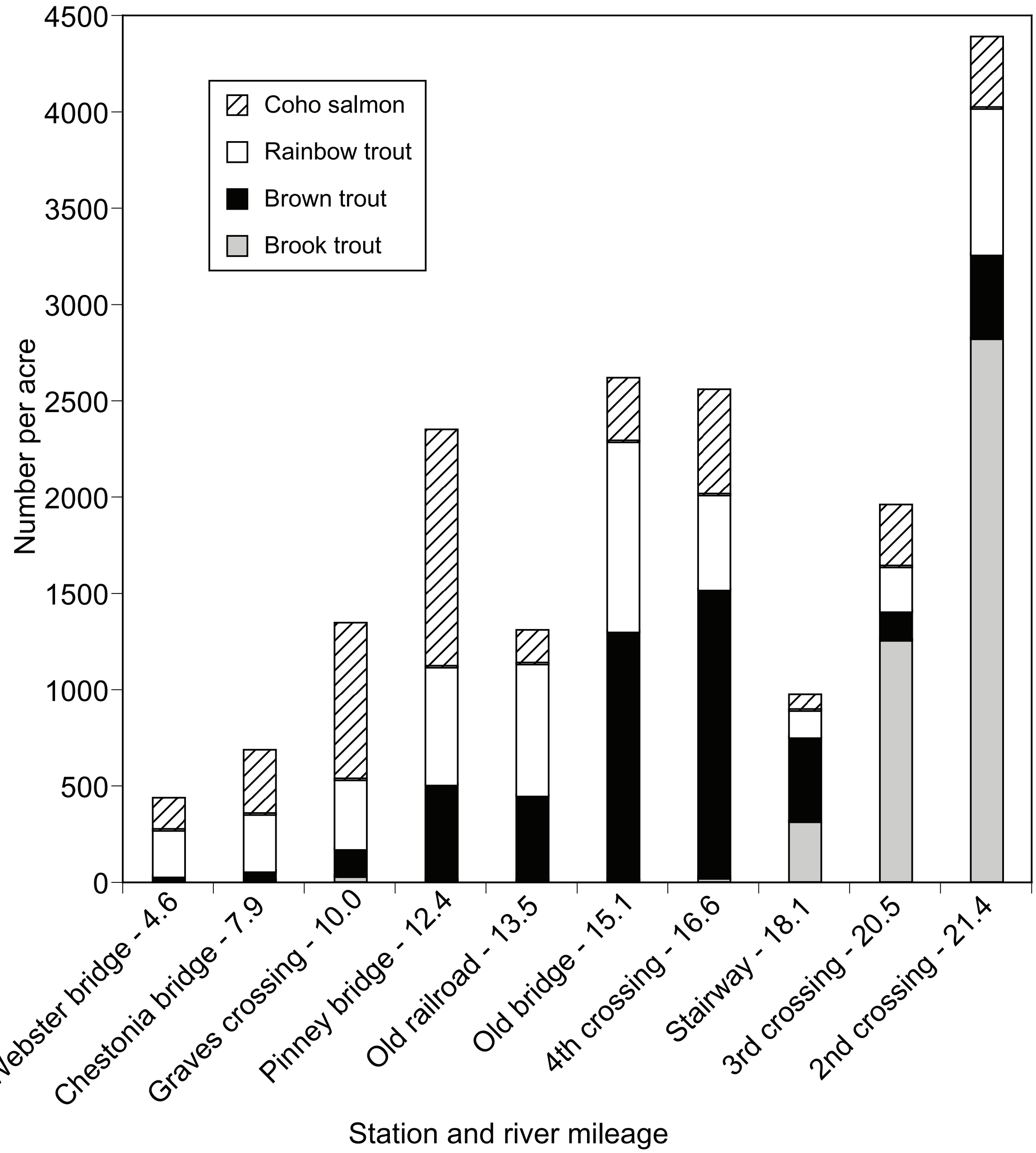


Figure 27.–Mean summer density of salmonids per acre at several stations in the mainstem of the Jordan River (1987 and 1994). Data from Michigan Department of Natrural Resources, Fisheries Division, Lansing. Estimates derived using Bailey's modification of the Peterson mark-and-recapture method. Stations listed from downstream to upstream. Number following station is river mileage upstream from Lake Charlevoix and measured from Anonymous (1983).

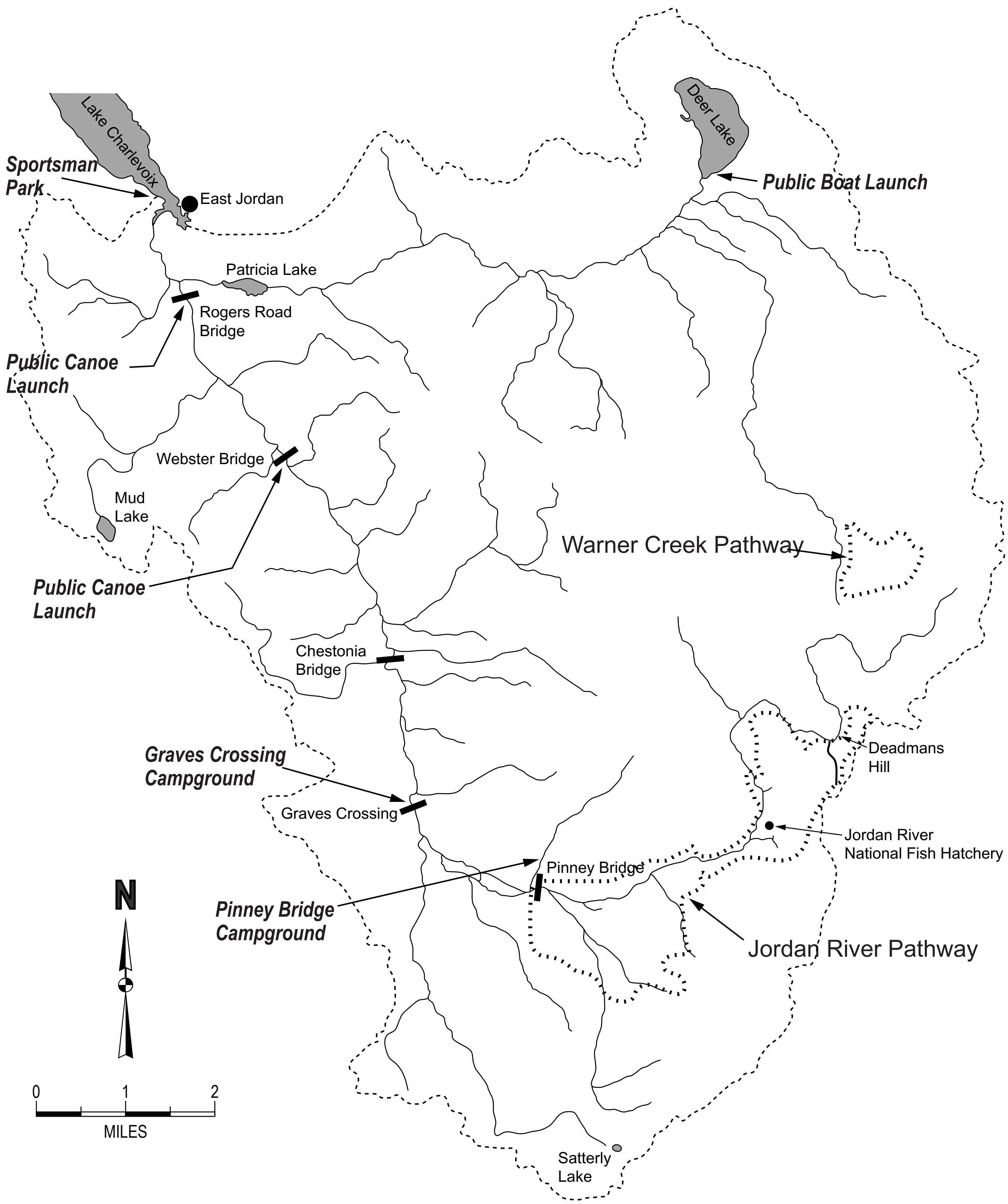


Figure 28.–Designated public access sites along the Jordan River mainstem and Deer Lake. Jordan River and Warner Creek pathways, Data from Michigan Department of Natural Resources and East Jordan.