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Ontonagon River Assessment

Brian J. Gunderman

and

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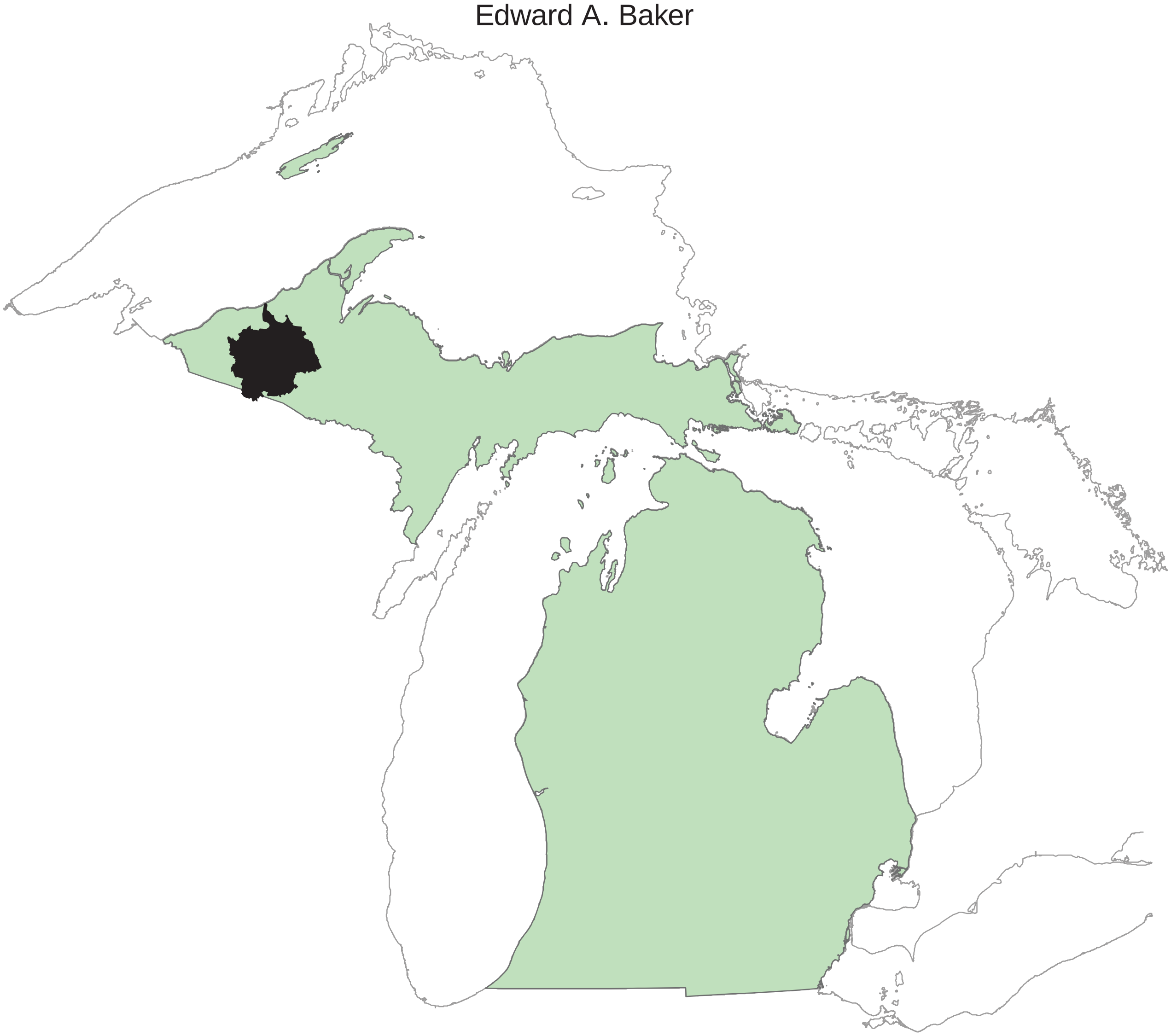

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Ontonagon River Assessment

Brian J. Gunderman
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EXECUTIVE SUMMARY

This river assessment is one of a series of documents being prepared by Michigan Department of Natural Resources (MDNR), Fisheries Division, for Michigan rivers. This report describes the physical and biological characteristics of the Ontonagon River, discusses how human activities have influenced the river, and serves as an information base for future management activities. Our approach is consistent with Fisheries Division's mission to "protect and enhance fish environments, habitat, and populations and other forms of aquatic life and to promote the optimum use of these resources for the benefit of the people of Michigan."

River assessments are intended to provide a comprehensive reference for citizens and agency personnel seeking information on a particular river. By compiling and synthesizing existing information, river assessments reveal the complex relationships between rivers, watershed landscapes, biological communities, and humans. This assessment shows the influence of humans on the Ontonagon River and provides an approach for identifying opportunities and addressing problems related to aquatic resources in the Ontonagon River watershed. We hope that this document will increase public awareness of the Ontonagon River and its challenges, and encourage citizens to become more actively involved in decision-making processes that provide sustainable benefits to the river and its users.

This document consists of three parts: an introduction, a river assessment, and management options. The river assessment is the nucleus of the report. It provides a description of the Ontonagon River and its watershed in thirteen sections: geography, history, geology, hydrology, soils and land use, channel morphology, dams and barriers, water quality, special jurisdictions, biological communities, fishery management, recreational use, and citizen involvement.

The management options part of the report identifies a variety of actions that could be taken to protect, restore, rehabilitate, or better understand the Ontonagon River. These management options are categorized and presented following the organization of the main sections of the river assessment. They are intended to provide a foundation for public discussion, assist in prioritization of projects, and facilitate planning of future management activities.

The Ontonagon River is located in the western Upper Peninsula of Michigan and drains an area of 1,362 square miles. Its watershed covers portions of five counties: Gogebic, Ontonagon, Houghton, Iron, and Vilas (Wisconsin). Although the main stem is relatively short, the combined length of the Ontonagon River and its tributaries is approximately 1,291 miles. There are 200 lakes larger than 10 acres within the Ontonagon River watershed. Lake Gogebic, with a surface area of 13,048 acres, is the largest lake in the Upper Peninsula.

For purpose of discussion, the Ontonagon River basin is divided into seven subwatersheds: upper Middle Branch (above Agate Falls), lower Middle Branch, Main Stem, East Branch, Cisco Branch, South Branch, and West Branch. Criteria used to set boundaries for the subwatersheds included drainage patterns, barriers to fish passage, confluences with major tributaries, and changes in geology or soil types.

The Ontonagon River watershed has a rich and varied history that can be traced back to the late Archaic Period (approximately 4,000 years ago). Prehistoric peoples mined copper within the basin and established hunting and fishing camps along the Ontonagon River and its tributaries. By the time of European settlement, Chippewa Indians had constructed elaborate weirs in the main stem to harvest lake sturgeon. European fur traders set up outposts within the watershed as early as the 1630s, but no permanent (European) settlements were established until the 1840s.

Two resources attracted European settlers to the region during the nineteenth century: copper and timber. Europeans had known about the rich copper deposits in the Ontonagon River basin since at least 1670, but the first profitable mine (in historic times) was not established until 1847. The main copper rush spanned only two decades, but mining activity continued at a reduced level until 1921. Soon after the copper boom subsided, the logging era began. During the 1880s and 1890s, the vast forests of the Ontonagon River basin were cut down and the main stem and its tributaries were used to transport logs to sawmills at the mouth of the river.

During the first half of the 20th century, various branches of the Ontonagon River were harnessed to provide hydroelectric power. Numerous farms were also founded during this period, but most were abandoned due to the harsh climate and infertile soils. The Ottawa National Forest, which includes roughly 57% of the Ontonagon River watershed, was established in the 1930s. In recent years, the lakes and streams of the Ontonagon River system have attracted thousands of visitors, and tourism has become an important part of the local economy.

The hydrology of the Ontonagon River system is strongly influenced by the surficial geology of the watershed. Coarse-textured materials predominate in the southern and extreme eastern and western portions of the basin. Water rapidly percolates through these materials, providing substantial groundwater inflow to streams in these areas. For example, the upper Middle Branch Ontonagon River and the headwaters of the East Branch Ontonagon River receive strong groundwater inflows that produce relatively stable water flows and temperatures. Large deposits of finer-textured materials exist in the north-central portion of the watershed. These materials are less permeable, so the South Branch, lower Middle Branch, and main stem Ontonagon rivers receive minimal groundwater inflow. Consequently, these streams have flashy flow regimes with rapidly varying water temperatures.

Soils influence the hydrology, channel morphology, and water quality of river systems. Sandy soils allow greater infiltration and groundwater production compared to relatively impermeable clay soils. In addition, sandy soils are more easily eroded than clay soils, so sedimentation and bank slumping can be major concerns in sandy watersheds. Sandy soils are common in the upper Middle Branch and Cisco Branch subwatersheds. The soils in the South Branch, lower Middle Branch, and Main Stem subwatersheds primarily are composed of finer particles such as clay and silt. Both sandy and silt-clay dominated soils are found in the East Branch and West Branch subwatersheds. Small regions of peat and muck dominated soils are scattered throughout the southern two-thirds of the basin.

Approximately 74% of the Ontonagon River watershed is forested; however, the species composition of the forest community has been altered by human activities. Acreage of lowland conifers has declined since European settlement of the region, while acreage of lowland hardwoods (primarily aspen) has increased dramatically. Wetlands are the second most abundant land cover type (15% of watershed area). Due to its remote location, wetland losses within the Ontonagon River basin have been less severe than in southern Michigan. Approximately 5% of the watershed is in agricultural use, and only 0.1% is classified as “urban/industrial.”

Gradient, or drop in elevation over distance, is an important indicator of fish habitat quality. The average gradient for the main stem and Middle Branch Ontonagon rivers is 11.1 ft/mi, which is considerably higher than the reported gradients for most Michigan rivers. Gradient varies throughout the watershed, ranging from 0.5 ft/mi at the mouth to 2,493 ft/mi at Victoria Falls. Gradient averages 12.6 ft/mi on the upper Middle Branch, 16.5 ft/mi on the lower Middle Branch, 2.4 ft/mi on the main stem, 12.2 ft/mi on the East Branch, 14.3 ft/mi on the Cisco Branch, 5.2 ft/mi on the South Branch, and 18.4 ft/mi on the West Branch.

The highest quality fish habitat generally is found in high gradient (5.0–69.9 ft/mi) stream reaches because a wide variety of water depths and velocities (i.e., habitat types) is available to fish in those areas. Relative abundance (expressed in percentage of stream length) of high gradient habitat varied widely between the different branches of the Ontonagon River system: main stem (12%), South Branch (31%), upper Middle Branch (47%), West Branch (73%), Cisco Branch (78%), East Branch (89%), and lower Middle Branch (98%). Although chutes and waterfalls (gradient ≥70 ft/mi) are present within the watershed, most of the remaining stream reaches have gradients lower than 5.0 ft/mi.

Fish habitat quality can also be evaluated by comparing channel cross-section measures with expected measures calculated from stream discharge data. Frequent flood events (e.g., from dam operations) create channels that are excessively wide. Unexpectedly narrow channels typically are caused by channelization or bank armoring. Most United States Geological Survey gauge sites in the Ontonagon River system have stream widths that are within the range predicted by average discharge values. The upper Middle Branch and Bond Falls Canal gauge sites have channel widths that are narrower than expected due to bridge construction and channelization activities.

There are 17 registered dams in the Ontonagon River watershed. Five of these dams are operated by the Upper Peninsula Power Company to facilitate power generation at the Victoria hydroelectric facility. Four dams are operated by various governmental organizations to enhance recreational opportunities, six dams are privately owned (i.e., for private lakes and ponds), and two dams are operated for other purposes.

Dams affect aquatic ecosystems by impeding fish spawning migrations, fragmenting resident fish populations, blocking downstream movement of large woody structure and detritus (e.g., small pieces of wood and leaves), disrupting the sediment balance above and below impoundments, altering flow regimes and channel morphology, and elevating stream water temperatures. Dams at lake outlets also prevent movement of fish between lake and stream habitats and may disrupt natural variations in water levels needed to maintain shoreline wetlands.

The Bond Falls Dam and Bond Falls Control Dam are operated to store water and divert flow from the Middle Branch into the South Branch via the Bond Falls Canal. (The South Branch ultimately flows into the West Branch a few miles upstream of the Victoria hydroelectric facility.) Operation of these dams strongly affects the seasonal flow patterns in the lower Middle Branch and the South Branch. The Cisco and Bergland dams are located at the outlets of natural lakes and are used to ensure a consistent water supply to the Victoria Dam and hydroelectric facility.

In 2003, the Federal Energy Regulatory Commission issued a new operating license for the five hydroelectric-related dams in the Ontonagon River watershed. This license specifies minimum flow releases from the Bond Falls Dam into the Middle Branch and Bond Falls Canal, and from Bergland Dam into the West Branch. The license also sets maximum allowable drawdowns for the Bond Falls Flowage and Victoria Reservoir. These new license conditions are expected to improve fish habitat quality in the impoundments and the stream reaches below the impoundments.

There are 24 named waterfalls and numerous unnamed waterfalls within the Ontonagon River basin. Some of the larger waterfalls (e.g., Bond, Agate, and Victoria falls) are natural barriers to fish movement. The two largest dams in the watershed, Bond Falls Dam and Victoria Dam, were constructed on low gradient stream reaches immediately upstream of major waterfalls.

In general, water quality in the Ontonagon River watershed is excellent, but poor land use practices have led to increased sediment in some areas. Because most of the dams within the basin are relatively small or were constructed at the outlet of natural lakes, thermal pollution from impoundments is a minor concern throughout most of the Ontonagon River system. Few factories and wastewater treatment plants are located within the watershed, with only eleven discharges permitted through the National Pollutant Discharge Elimination System.

Airborne mercury contamination affects the Ontonagon River and most other waters in Michigan. The rock surrounding many of the lakes and streams in the basin also provides a natural source of mercury to surface waters. Statewide fish consumption advisories apply to inland lakes and the Michigan Department of Community Health has issued additional fish consumption advisories for the Cisco Chain and Duck, Gogebic, and Langford lakes.

Numerous federal, state, and local units of government have jurisdictional responsibility over various portions of the Ontonagon River watershed. The Federal Energy Regulation Commission oversees operations at the five hydroelectric-related dams within the basin. About 57% of the watershed is in federal ownership and is managed by the United States Forest Service. The United States Fish and Wildlife Service is responsible for sea lamprey control in streams with Lake Superior access, and the United States Army Corps of Engineers possesses navigational jurisdiction over the lower Ontonagon River. Fishing and hunting regulations are established and enforced by the MDNR, and water quality regulations are administered by the Michigan Department of Environmental Quality. Local units of government influence the river through zoning restrictions and road commission activities.

Special restrictions on human activities have been established to protect areas with outstanding recreational or ecological values. Four of the five main branches of the Ontonagon River system have stream reaches that are classified as Federal Wild and Scenic Rivers, and twelve lakes are included in the federally designated Sylvania Wilderness Area.

Fisheries surveys conducted during the last 80 years have documented the presence of 74 fish species within the watershed, but identification was questionable for three of the species. Of the 71 species that have been positively identified, 60 are native to the Ontonagon River basin, five were intentionally introduced, and six colonized the drainage via canals, ballast water, or dispersal from previous introductions.

Coldwater fish species (e.g., brook trout and mottled sculpin) dominate the fish communities in groundwater-fed streams in the southern portion of the watershed. Water temperatures generally increase in a downstream direction, and coolwater fish species (e.g., walleye, smallmouth bass, and northern pike) become more common as the various branches approach the main stem. Several migratory fishes from Lake Superior (e.g., coho salmon and rainbow trout [steelhead]) spawn in portions of the East Branch, Middle Branch, West Branch, and the main stem.

Two threatened fish species are known to inhabit the Ontonagon River watershed: lake herring and lake sturgeon. Lake herring have been found in a few large lakes within the basin. Lake sturgeon were historically abundant in the Ontonagon River. Commercial overfishing and habitat degradation during the late 19th and early 20th centuries led to the extirpation of this species. The MDNR began stocking lake sturgeon in the main stem in 1998, but it will be several years before adult lake sturgeon are expected to begin reproducing in the Ontonagon River system.

Macroinvertebrates are an important indicator of water quality and are an integral part of the aquatic food web. Macroinvertebrate communities have been evaluated at 25 sites within the Ontonagon River system. The macroinvertebrate communities were rated as “excellent” at six sites, “acceptable” at 18 sites, and “poor” at one site.

Numerous species of mussels, amphibians, reptiles, birds, mammals, and plants occur within the Ontonagon River watershed, many of which are listed as threatened or of special concern. Several aquatic pest species have been found within the basin, including sea lamprey, ruffe, rusty crayfish, spiny water flea, Chinese mystery snail, and Eurasian water-milfoil.

Active fisheries management within the watershed began during the 1920s. For the first decade, fisheries management consisted primarily of surveying and documenting the fish populations within the basin and the human use of those populations. During the late 1930s and early 1940s, warmwater fish stocking became an important management tool. Walleye fry, largemouth and smallmouth bass, and bluegill were introduced into numerous lakes during this period. From 1945 to 1964, legal-sized trout were stocked into many of the streams in the Ontonagon River system. These high-cost stocking programs often produced only modest put-and-take fisheries, and trout stocking was greatly reduced after 1964. In recent years, trout stocking has been used to maintain or establish trout fisheries in several lakes and to enhance the steelhead fishery in the Ontonagon River.

During the mid-1980s, advancements in rearing operations and growing interest from anglers led to a rapid expansion of the MDNR walleye stocking program. Spring fingerling walleyes were stocked in numerous lakes during the last 25 years. Many of these stocking programs have been discontinued, but fisheries managers continue to use walleye stocking to maintain popular walleye fisheries and control the abundance and size structure of panfish populations.

Habitat protection and enhancement have been important components of fisheries management since the 1930s. Early habitat improvement projects primarily involved instream habitat work, such as installation of wing dams and other human-made structures. In recent years, resource managers have adopted a more holistic approach to habitat management. Riparian buffer strips are used to prevent sedimentation associated with timber harvest operations, and sediment traps are installed at problem locations to mitigate the effects of anthropogenic sedimentation on stream environments. New stream crossings are designed to withstand flood flows and facilitate fish passage. Hard-armoring techniques (e.g., riprap and bulkheads) are used sparingly, and more natural methods of stream bank protection (e.g., seeding and mulching, tree plantings, or whole tree revetments) are increasing in popularity. Beaver removals are prescribed to protect high-quality trout streams from thermal pollution, but beavers are allowed to persist in many warmwater streams. The various natural resource agencies also work with the Federal Energy Regulatory Commission to mitigate the effects of hydroelectric-related dams on aquatic ecosystems. Instream habitat projects still play a role in habitat management, but natural materials (such as root wads, boulders, or entire trees) are preferred over human-made structures.

Fishing regulations are one of the most broadly recognized tools for controlling the harvest, size structure, and abundance of fish populations. Restrictive regulations have been instituted to maintain high-quality smallmouth bass fisheries in the Sylvania Wilderness Area. Limitations on the use of live bait are enforced on some trout lakes to reduce the risk of colonization by undesirable species. Closed fishing seasons also protect many fish species from harvest during their most vulnerable periods (i.e., spawning).

The large tracts of publicly owned land in the Ontonagon River watershed provide a wide array of recreation opportunities. Popular outdoor activities within the basin include fishing, boating, water skiing and tubing, canoeing, kayaking, hunting, trapping, berry and mushroom picking, camping, swimming, off-road-vehicle (ORV) trail riding, snowmobiling, snowshoeing, cross-country skiing, hiking, bike riding, bird and wildlife watching, and waterfall viewing. Steep gradients and rock-strewn rapids make many stream reaches unsuitable for safe boating, so there are few boat launches on the Ontonagon River system. Boat launches have been constructed on over 30 lakes, and walk-in access is available for many additional lakes and streams.

Protecting and rehabilitating the aquatic resources in the Ontonagon River basin is a monumental task that cannot be accomplished solely through the actions of governmental agencies. Numerous citizen groups have been involved in watershed planning and aquatic habitat restoration projects during the last 70 years. As the human population grows and a greater percentage of the watershed is subdivided for residential and vacation homes, public involvement in natural resource protection will be critical for the long-term health of the watershed.

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Michigan Department of Natural Resources
Fisheries Special Report 46, 2008

ONTONAGON RIVER ASSESSMENT

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INTRODUCTION

This river assessment is one of a series of documents being prepared by the Michigan Department of Natural Resources (MDNR), Fisheries Division, 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 ecosystem. Our approach is consistent with the mission of MDNR, 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 aquatic 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 less able 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. 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 of the original structures or processes.

River assessments are based on ten guiding principles in the Fisheries Division Strategic Plan. 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 invasive 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 direct 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 important ecosystem components. 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, including topography. 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–**a description of both the surficial and bedrock geology of the area.
>
> **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 and habitat characteristics.
>
> **Soils and Land Use Patterns**–soils and land use in combination with climate 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, and 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.
>
> **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.
>
> **Special Jurisdictions**–stewardship and regulatory responsibilities under which a river is managed.
>
> **Biological Communities**–species present historically and today, in and near the river; we focus on fishes, however associated mussels, mammals and birds, key invertebrate animals, special concern, threatened and endangered species, and pest species are described where possible. This component is the foundation for the rest of the assessment. Maintenance of biodiversity is an important goal of natural resource management. Species occurrence,

extirpation, and distribution are 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 main stem 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 Fisheries Division or other agencies should address.

Throughout this assessment we use data and shape files downloaded from the Michigan Geographic Data Library, maintained by the Michigan Center for Geographic Information. These data provide measures of watershed surface area for numerous categories (e.g., soil types, land use, surficial geology), measures of distance (e.g., stream lengths), and creation of associated figures. We used Arc View GIS 3.2a or Arc GIS (Environmental Systems Research Institute, Inc.; Copyright) to display and analyze these data, and create the landscape figures presented in this report. Unless otherwise referenced, all such measures and associated figures reported within the sections of this report were derived from these data.

Management options follow the river assessment sections of this report, and list alternative actions that will protect, rehabilitate, and enhance the integrity of the river system. 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 April 8, 2008. A public meeting was held at the Ontonagon Village Office on April 28, 2008, and 25 people attended. Written comments were received through June 15, 2008. Comments were responded to in the Public Comment and Response section.

A fisheries management plan will now be written. This plan will identify options chosen by Fisheries Division, based on our analysis and comments received. In general, a Fisheries Division management plan will focus on a shorter time, include options within the authority of Fisheries Division, and be adaptive.

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

Michigan Department of Natural Resources
Fisheries Division
Baraga Operations Service Center
427 US 41 North
Baraga, Michigan 49908

Comments received will be considered in preparing future updates of the Ontonagon River Assessment.

RIVER ASSESSMENT

Geography

The Ontonagon River is located in the western Upper Peninsula of Michigan and drains an area of 1,362 square miles (Figure 1). Its watershed includes portions of Gogebic, Houghton, Iron, and Ontonagon Counties in Michigan and Vilas County in Wisconsin. The river flows from south to north and enters Lake Superior at the village of Ontonagon. Much of the upper drainage consists of well-defined valleys. Near Lake Superior, the gradient lessens, and the river flows through a gently sloping plain.

The main stem of the Ontonagon River is formed by the confluence of its East and Middle branches near Rockland, Michigan. The larger of these two branches (the Middle Branch) originates in Crooked Lake near the Michigan-Wisconsin border just south of Watersmeet, Michigan at an elevation of 1,702 feet above sea level. The main stem is joined by the West Branch 1.5 miles downstream of the confluence of the East and Middle branches and flows another 22.5 miles before emptying into Lake Superior at an elevation of 602 feet above sea level. Although the main stem is relatively short, the basin also includes over 110 named tributaries and many unnamed tributaries totaling 1,291 miles (Table 1; Figure 2). The highest point in the watershed (1900 ft above sea level) is an unnamed hill south of Imp Lake. Precipitation that falls on the north side of this hill flows northward into the Ontonagon River, while precipitation that falls on the south side flows southward into the Wisconsin River.

There are 200 lakes and ponds larger than 10 acres within the Ontonagon River watershed (Table 2). The vast majority of these lakes are located in the southern portion of the basin, and many of the lakes have direct discharges to the river system.

The Ontonagon River watershed encompasses a large area and includes a multitude of streams with varying physical and ecological characteristics. To facilitate discussion of this diverse watershed, the Ontonagon River and its tributaries will be treated as seven distinct subwatersheds (Figure 3): Middle Branch – upper, Middle Branch – lower, Main Stem, East Branch, Cisco Branch, South Branch, and West Branch. Criteria used to set boundaries for the subwatersheds included drainage patterns, barriers to fish passage (such as waterfalls), confluences with major tributaries, and changes in geology or soil types.

In addition to the subwatershed groupings of the Ontonagon River watershed, we will discuss the river and its tributaries using the Valley Segment Ecological Classification (VSEC) system. This system was developed and used (1) to divide rivers into approximately 1- to 23-mile pieces (segments) that are ecologically similar, and then (2) to classify these segments of rivers throughout Michigan based on segment and watershed characteristics including gradient, temperature regime, discharge regime, catchment size, surficial geology, land use, expected fish communities, etc. (Seelbach et al. 2006, Baker 2006). This classification system enhances our understanding of the complex nature of river systems and permits the grouping of river segments by common attributes (e.g., small coldwater trout streams). The Ontonagon River and its tributaries were classified into 65 distinct valley segments (Baker 2006). Of these 65 valley segments, 27 were classified as coldwater segments capable of supporting trout, and 32 were classified as cool water segments capable of supporting marginal trout populations with minnows, suckers, and walleye more dominant in the fish communities. Four segments in the Ontonagon watershed are classified as warmwater segments with a corresponding fish community of redhorse, suckers, and walleye.

Middle Branch—upper

The upper portion of the Middle Branch Ontonagon River extends 43 miles from the origin at Crooked Lake to Agate Falls. Agate Falls is the upstream barrier for fish migrating from Lake Superior, so different fish communities exist above and below the falls. Bond Falls, located approximately 8 miles upstream of Agate Falls, is another barrier to fish passage. Despite this barrier, similar fish communities exist above and below Bond Falls, so both portions of the Middle Branch are included in this subwatershed. The upper Middle Branch and its tributaries were classified into 10 distinct segments using the VSEC system. Most segments are small, receive strong groundwater inflows, have relatively stable flows, and have fish communities dominated by coldwater species. Major tributaries to the upper Middle Branch include the Tamarack River and Duck, McGinty, Interior, and Deadman creeks. Numerous lakes are located within this subwatershed, including Bond Falls Flowage, Crooked Lake, Clark Lake, Duck Lake, and Tamarack Lake.

Middle Branch—lower

The lower portion of the Middle Branch Ontonagon River extends 25 miles from Agate Falls to the confluence with the East Branch Ontonagon River. There are 9 VSEC classified river segments in this subwatershed. Because this subwatershed occupies an area of extensive deposits of lacustrine clay and silt, segments have relatively flashier flows, higher turbidity, and are warmer than the upper Middle Branch. The fish communities in the lower Middle Branch include both coldwater and coolwater species. Three major tributaries flow into the lower Middle Branch: Trout Creek, Spring Creek, and the Baltimore River. Few lakes are located within this subwatershed.

Main Stem

This portion of the river includes the main stem Ontonagon River from the confluence of the East and Middle branches to the mouth (distance = 24 miles). Through most of this segment, the river is confined to a narrow well-developed valley of lacustrine clay and silt. Turbidity is high in the main stem, especially after rain events. Compared to the other branches within the river system, gradient in the main stem is relatively low (generally <5 ft/mi). The fish community in the main stem changes seasonally with the immigration and emigration of potamodromous species from Lake Superior. The only major tributary to the main stem is the West Branch Ontonagon River.

East Branch

The East Branch Ontonagon River originates in Gasley Lake and flows 54 miles to the confluence with the Middle Branch Ontonagon River. There are 18 distinct VSEC classified segments in this subwatershed. They flow through a mosaic of soil types and, as a result, these segments range from cold trout streams to relatively warm minnow-dominated communities. Groundwater inflows are moderate to strong in the upper segments of the East Branch, while the lower portion of the East Branch receives minimal groundwater inflows. Consequently, the upper reaches of the East Branch are less turbid and have more stable flows than the lower sections of the stream. Coldwater fish species predominate in the upper portions of the East Branch, while coolwater species are more abundant near the confluence with the Middle Branch. The vast majority of the East Branch is accessible to fish migrating from Lake Superior. Major tributaries to the East Branch include the Jumbo River and Smith, Stony, Beaver, Onion, Newholm, and Adventure creeks. Most of the lakes in this subwatershed are relatively small and have required few if any fish community or habitat manipulations. Some important exceptions to this generalization include Tepee, Bob, On-three, and Lower Dam lakes.

Cisco Branch

The Cisco Branch Ontonagon River arises in Cisco Lake and flows 31 miles to the confluence with Tenmile Creek. The 5 VSEC classified segments in the Cisco Branch subwatershed have low turbidity and relatively flashy flows. Above Kakabika Falls, the gradient is low and water temperatures are relatively warm. The fish communities in this portion include a mixture of coolwater and warmwater species. The gradient increases below Kakabika Falls, and the water temperature decreases due to groundwater seepage and the entrance of coldwater tributaries. Coldwater species seasonally inhabit the lower portion of the stream. There are two major tributaries to the Cisco Branch: Twomile Creek and Tenderfoot Creek. Numerous lakes are also found within the Cisco Branch subwatershed, including the Cisco Chain (composed of 14 interconnected lakes), Beatons, Langford, Whitefish, and Tenderfoot lakes.

South Branch

The South Branch Ontonagon River begins at the confluence of the Cisco Branch and Tenmile Creek and flows 32 miles before entering the West Branch Ontonagon River. The South Branch and its tributaries flow through large deposits of lacustrine clay and silt. These flashy streams were classified into 10 distinct segments. These segments receive minimal groundwater and are much more turbid than the Cisco Branch. Coolwater species dominate the fish communities in this subwatershed. Major tributaries to the South Branch include Tenmile Creek and Sucker Creek. The Bond Falls Canal (Roselawn Creek) shunts water from the Middle Branch Ontonagon River into Sucker Creek (see **History**). This shunt increases flow in the South Branch and West Branch Ontonagon rivers and increases power generation at the Victoria hydroelectric facility. Few lakes are located within the South Branch subwatershed.

West Branch

The West Branch Ontonagon River arises in Lake Gogebic and flows 35 miles to the confluence with the main stem Ontonagon River. The West Branch subwatershed streams have been classified into 8 distinct segments. Flows in the West Branch are strongly influenced by water releases from the Bergland and Bond Falls dams (see **Dams and Barriers**). The fish communities in this stream consist of a mixture of coolwater and warmwater species. Cascade Creek, Mill Creek, and the South Branch Ontonagon River are major tributaries to the West Branch. Two large lakes are directly connected to the West Branch: Lake Gogebic and the Victoria Reservoir. Lake Gogebic, with a surface area of 13,048 acres, is the largest inland lake in the Upper Peninsula.

History

After a series of glacial advances and retreats, the last great ice sheets left the Ontonagon River watershed approximately 11,000 years ago (Bailey and Smith 1981; Farrand 1988). As the ice retreated, the meltwaters carried away the lighter clay and silt particles, but the heavier sands and gravels were left behind in the southern portions of the basin (see **Geology**). The channels cut by these glacial meltwaters formed the basis for the modern drainage network in the Ontonagon River watershed.

The earliest archaeological evidence of human settlement within the watershed dates to around 2000 BCE during the Late Archaic period (B. Mead, Michigan Department of State, Office of the State Archaeologist, personal communication; Table 3). Fish were an important food source for these early inhabitants, and Late Archaic peoples used spears, fishhooks, gaffs, and other tools to capture fish in the Ontonagon River and Lake Superior (B. Mead, Michigan Department of State, Office of the State Archaeologist, personal communication). One of the principal materials used to make this fishing gear was copper.

Prehistoric peoples had mined copper from the Ontonagon region for millennia before the first modern mines were developed. It has been estimated that there are over 5,000 of these prehistoric copper pits around Lake Superior, and most of these pits have been found between Ontonagon and

Copper Harbor (Drier and Du Temple 1961). The copper in this area is so pure that early peoples could easily shape it into tools using cold hammering. Lake Superior copper artifacts have been discovered as far south as Mexico, indicating that prehistoric miners developed extensive trade networks (Johanson 1985).

During the Late Woodland period (around 1,000 years ago), fishing technology became more elaborate. Weirs were constructed on the Ontonagon River to facilitate harvest of lake sturgeon, and gill nets were used to capture whitefish and walleye. Late Woodland peoples also constructed earthen burial mounds over their dead, and some of these mounds have been found along the shores of Lake Gogebic (B. Mead, Michigan Department of State, Office of the State Archaeologist, personal communication).

The Chippewa (Ojibwa) people moved into the Ontonagon watershed during the late 16th or early 17th century (Danziger 1979). The main Chippewa village was at the mouth of the river where they spent the summer months fishing. Following the tradition of their predecessors, the Chippewa constructed elaborate weirs on the main stem during the lake sturgeon spawning season. Spawning lake sturgeon were allowed to pass upstream, and were hooked as they moved back downstream (Danziger 1979). The Chippewa also planted gardens near the shores of Lake Gogebic and other inland lakes during the spring, and returned to harvest their crops in autumn (B. Mead, Michigan Department of State, Office of the State Archaeologist, personal communication). During the winter, small hunting camps were established on various tributaries within the watershed.

The name “Ontonagon” is derived from the Chippewa language. According to legend, the name originated when a young girl dropped her bowl in the river and began running along the bank crying “On-to-nagon” or “My bowl is lost.” (Jamison 1948). European visitors apparently struggled with translation of this phrase. Thus, the name has been spelled in a variety of ways, including Nantounaganing, Nunda-Norgan, Donegan, Atounagon, and Nanton Nagun (Johanson 1996).

French fur traders were among the first Europeans to visit the Ontonagon River watershed. The fur trade in the Lake Superior region began during the 1630s (Jamison 1948), and the “River Nanton nagun” first appears on a map published in Paris in 1651 (Johanson 1985). Although many different animals were harvested by these early trappers, the beaver was the most targeted species. The organized fur trade persisted until around 1840. It is impossible to estimate how many beaver were harvested during these 200 years of exploitation, but various sources indicate that beaver were nearly extirpated from some areas (Jamison 1948). The dramatic decline in beaver populations presumably affected the fish communities in the Ontonagon River system through the removal of barriers to fish passage (beaver dams) and alteration of the hydrology and channel morphology of previously impounded streams.

The abundant deposits of mass copper in the Ontonagon River watershed also attracted attention from early European visitors. In 1670, Father Claude Dablon sent samples of Ontonagon copper to Paris (Johanson 1985). Pierre Le Seur started the first modern copper mine in the region in 1690, but personal problems with French officials caused him to quickly abandon his new venture (Johanson 1985). In 1766, Alexander Henry persuaded Chippewa guides to take him to the site of the great copper boulder. This giant mass of pure copper was located on the bank of the West Branch Ontonagon River in the area that is now flooded by the Victoria Reservoir. Henry was not able to remove the boulder, but he estimated the weight to be around 5 tons. During the winter of 1771–72, Henry and his crew attempted to mine copper in the river bank near the site of the famous boulder. Their efforts were largely unsuccessful, and the project was aborted when the tunnel collapsed during the spring floods (Johanson 1996).

The copper boulder also attracted other famous visitors. Henry Rowe Schoolcraft, the geologist and explorer who “discovered” the source of the Mississippi River, visited the site in 1819. Douglass Houghton (Michigan’s first state geologist) examined the specimen in 1840 and provided this cautionary note to potential prospectors (as quoted in Jamison 1948).

> While this mass of native copper cannot fail to excite much interest, from its size and purity, it must be borne in mind that it is a perfectly isolated mass, having no connection with any other; nor does the character of the country lead to the inference that veins of the metal occur in the immediate vicinity, though the mineral district crosses the country at a distance of a few miles.

The legendary boulder was finally removed by Julius Eldred in 1843 (Jamison 1948). This mass of pure copper currently resides in the Smithsonian Institution. After years of being cut and hacked by treasure seekers, the actual weight of the boulder was determined to be 3,708 lb (Johanson 1996).

Although the “great copper boulder” attracted much fanfare, the real copper rush did not begin until 1847. In that year, Samuel Knapp discovered a series of prehistoric copper pits near the present day town of Rockland. Knapp quickly recognized the significance of his discovery and founded the Minesota (spelling intentional) Mine at this location. The Minesota Mine became the richest project in the region, paying out $1,800,000 in dividends during its 22 years of operation (Lankton 1991). The largest mass of native copper ever recorded (527 tons) was discovered in this mine (Johanson 1996).

The success of the Minesota project prompted the establishment of numerous other mines within the northern portion of the watershed. Some of the most important mines were the Adventure, Mass, and Toltec mines near Adventure Creek and the Norwich, Ohio Trap Rock, and Victoria mines near the West Branch Ontonagon River. (The Victoria Mine is of particular importance from a watershed perspective and will be discussed in detail below.) Although a few mining companies continued operations well into the twentieth century, the copper boom came to a halt in 1865 when the end of the civil war caused copper prices to plummet (Johanson 1996).

Copper mining affected the Ontonagon River watershed in a variety of ways. Trees were cut down to provide timbers for the mines, and roads were constructed to transport copper and mining supplies. Waste rock from the mines was deposited on the surface. When this rock contained sulfur-bearing minerals (e.g., anhydrite, gypsum, or barite), these materials reacted with water to form sulfuric acid. Because several of the mines were located near streams, it is likely that some of this acid mine drainage reached the Ontonagon River system.

Commercial fishing activity near the mouth of the Ontonagon River probably commenced during the mid-1800s, but accurate records of early commercial fishing operations are lacking. By 1880, there were 134 commercial fishers operating between Ontonagon and L’Anse (Nute 1944). The numbers of commercial fishers began to decline after the turn of the century, but there were still 16 commercial fishing businesses operating out of Ontonagon in the 1930s (Doyle 1988). Lake trout and lake whitefish made up the bulk of the harvest from this port.

Commercial fishing probably was a major factor contributing to the extirpation of lake sturgeon in the Ontonagon River system. In the early days of the Great Lakes commercial fishery, lake sturgeon were regarded as a nuisance because they often ruined the nets of fishers targeting other species. Lake sturgeon were clubbed to death, thrown on land, and even used to fire steamboat boilers (Brousseau 1987). As markets were created for caviar and smoked lake sturgeon flesh, some commercial fishers began targeting lake sturgeon. Throughout most of the Great Lakes, lake sturgeon populations had been extirpated or severely reduced by the end of the nineteenth century (Tody 1974).

During the early days of European settlement, ship travel on Lake Superior provided the only link between the city of Ontonagon and the outside world. The Soo Locks were not in operation until 1855, so early explorers had to build new boats at Sault Ste. Marie or haul their vessel around the rapids. Even after the Soo Locks were completed, ship travel was seasonal, and winter meant long periods of isolation. During the open water period, a large sand bar prevented ships from entering the Ontonagon River, and cargo had to be “lightered” to shore in small boats (Jamison 1948). This method was cumbersome (especially for companies trying to export copper), so it is no surprise that harbor improvements were a major concern of early settlers.

Opening the Ontonagon River to commercial shipping traffic proved to be a formidable task. By 1852, James Carson had constructed the first pier at the mouth of the Ontonagon River (Jamison 1948). This pier was inadequate to meet the needs of the burgeoning population and was repeatedly washed away during storms. In 1855, the people of Ontonagon recruited Charles T. Harvey (the designer of the first Soo Lock) to remedy the situation. During his stay in Ontonagon, Harvey completed 900 ft of piers, dredged a 16 ft wide channel, and reduced the width of the sand bar from 800 ft to 200 ft (Anonymous 1883).

> Inadequate still were the improvements made by Harvey, but navigation managed as best it could with them. It was not until 1867 that improvements were begun by the federal government. But then wider channels, the elimination of the sand bar, more and better piers, and harbor lights came slowly but certainly. By 1880 two hundred thousand dollars had been spent. That year the federal harbor record shows one hundred twenty-one vessels in and out of Ontonagon. [From Jamison 1948.]

For early explorers, the Ontonagon River provided the only access to the southern portions of the watershed. A number of local roads were constructed by the mining companies during the 1850s, but a well-connected road system was lacking. (To give some indication of the winter travel conditions during this period, dog trains were used to deliver the mail from Green Bay to Ontonagon until 1864 [Jamison 1948].)

The first “highway” in the region was the Military Road which connected Fort Wilkins (Copper Harbor) to Fort Howard (Green Bay).

> In March, 1863, President Lincoln had signed the act of Congress which gave the two states of Michigan and Wisconsin land grants which enabled them to construct the “Military Road.” These states proceeded at once to let contracts, the contractors’ pay being in government lands, alternate sections on both sides of the route for three miles. Thus under this checkerboarded [sic] plan, a contractor received sixteen sections of land for every five miles of road built…. In the Ontonagon country, this is the road as we know it from Watersmeet to Rockland through Bruce Crossing. The present trunk line highway [Hwy 45] is almost identical with the Military Road in location. [From Jamison 1948.]

This “highway,” which was impassable in spring for many years, provided a much desired connection with the outside world. Fears of a British attack on the Lake Superior copper country were never realized, and the road served little military purpose. Nevertheless, the gorge where Highway 45 crosses the main stem Ontonagon River is still commonly referred to as “Military Hill.”

The government’s policy of paying contractors in land strongly influenced the pattern of land ownership in the western Upper Peninsula. For example, similar land grants were given to the Portage Lake and Lake Superior Ship Canal Land Company and the Ontonagon and Brule River Railroad. The federal government also granted the states large tracts of land for agricultural schools. Many investment companies scrambled to acquire these lands for timber production. Raphael Pumpelly, a land speculator with the Portage Lake and Lake Superior Ship Canal Land Company, describes the land acquisition process.

> The United States Government had made large grants of land to the states for agricultural schools, and issued the scrip to be used in selecting the land. Some of these states had sold the scrip, preferring the money to the land and, while the regular government price for lands in Michigan was $1.25 an acre, the Agricultural College scrip sold in the market for sixty cents an acre. [From Pumpelly 1918.]

The vast pine forests of the Ontonagon River watershed were only lightly exploited by early settlers. Trees were cut to produce mine timbers and lumber for houses, but there was little commercial harvest of timber prior to the 1880s. During the 1860s and 1870s, a number of developments occurred that drew new attention to the timber resources of the watershed. (1) Most of the land within the watershed was acquired by investment companies looking to make a quick profit. (2) The rebuilding and rapid expansion of Chicago after the Great Fire of 1871 created increased demand for lumber. (3) Harbor improvements at the mouth of the Ontonagon River made cargo loading and unloading a less laborious process.

In 1881, the newly established Ontonagon Lumber Company mill (located on the east bank of the main stem near the mouth) began producing 200,000 board feet of lumber daily (Johanson 1996). Sisson and Lilly established a slightly larger mill on the opposite bank of the river in 1882. These local companies were soon surpassed by the Diamond Match Company. By the mid-1880s, this giant corporation eventually controlled not only the mills, but also much of the land within the watershed. During the period of peak timber production (mid-1880s through the mid-1890s), the Diamond Match Company mills produced 100,000,000 board feet of lumber annually (Johanson 1985).

The various branches and tributaries in the Ontonagon River system were used to transport logs downstream to the mills. Some lumber companies used temporary dams to assist with log drives. Once sufficient water was stored behind the dam, the gates were opened, and the logs were flushed downstream. One such dam was constructed on the West Branch above Glenn Falls in the area currently inundated by the Victoria Reservoir (Lulich 1998).

Logging operations dramatically affected the watershed in a number of ways. Throughout much of the region, the forests had been replaced by stump fields and slash piles. Forest removal resulted in accelerated erosion and increased transport of sediment into the streams. This sediment increased turbidity and led to stream bed aggradation.

> The great River which had been the highway to the interior for first the Native People, then those of the successive races, was now running red with clay, as though the country it drained into the Big Lake was bleeding from within as each tree was torn from its bosom and taken away. [From Johanson 1996.]

Because rivers were the primary means of transportation during the 1880s, trees near streams were often the first to be cut down. In addition to reducing bank stability, removal of these trees exposed a larger area of the water surface to radiant sunlight. Thus, water temperatures increased after timber harvest was completed. Greater fluctuations in daily flow also resulted because trees were not present to slow movement of water into the streams.

The famous log drives substantially altered channel morphology. The rapid release of water from logging dams scoured the banks and streambed downstream. This rush of water, coupled with the “stampede” of logs, caused considerable mortality of fishes and other aquatic animals. Log jams were a common occurrence and in 1895, a massive log jam on the main stem allowed people to walk across the river without getting their feet wet (Johanson 1996).

Logging activity also provided the impetus for the construction of railroads within the watershed. By 1882, the Ontonagon and Brule River Railroad was completed between the cities of Ontonagon and Rockland. The Milwaukee and Northern Railroad connected with the Ontonagon and Brule River line in 1889, providing Ontonagon County with a direct rail connection to the major lumber markets in Chicago (Johanson 1996).

The Ontonagon logging era lasted only 15 years. A fire swept through the town of Ontonagon in 1896, destroying the Diamond Match Company mills. The pine forests of the region were severely depleted by that time, so the company's mills were never rebuilt. Logging activities never completely ceased within the watershed, and logging continues to be an important part of the local economy.

As the logging era ended, many of the stump fields were converted into farms. Agriculture provided food for mine workers as early as the 1850s, but the peak of agricultural activity in the watershed occurred between 1910 and 1920 (Jamison 1948). Today most of the remaining farms raise cattle for beef or milk production. The major crop produced in the watershed is birdsfoot trefoil (a small plant related to alfalfa that is a popular forage item for livestock producers). Due to the harsh climate, agricultural land never has covered a large percentage of the watershed, and many of the farms established during the early 1900s have since reverted to forest.

The Ontonagon River and its tributaries have been used for power generation since the early 1900s. One of the most elaborate systems for harnessing the river's energy was constructed at the Victoria Mine. The Victoria Mine was located adjacent to Glenn Falls on the West Branch Ontonagon River, so the mine's superintendent (Thomas Hooper) decided to build a dam to generate electricity. Construction of the dam and canal system began in 1902. The dam was completed, but the plans for the hydroelectric plant were abandoned in 1903 after Hooper visited a hydraulic compressor site in Norwich, Connecticut (Johanson 1993). Hooper was so impressed with the technology that he hired Charles Taylor to install a hydraulic compressor at Victoria. Work commenced on the compressor system in 1904, and the project was completed in 1906.

The new compressor used the dam and canal system previously constructed by Thomas Hooper. Some of the water reaching the dam passed downstream into the river below, while the rest was diverted into the canal system. At the end of the canal were three vertical shafts (each 334 ft deep) that led to an underground cavern. This cavern functioned as the air chamber for the compressor.

> As the water of the river fell down the intake tubes, air from the atmosphere was drawn down the tubes along with the water by venturi action,… with air being trapped in the water in the form of countless bubbles. These bubbles would rise to the roof of the air chamber underground, and by the weight of the columns of falling water, be compressed to 117.5 pounds per square inch. [From Johanson 1993.]

The compressed air was channeled through a series of pipes to provide pneumatic power for the mine and associated stamp mill. When compressed air production exceeded demands, the air was released through a safety "blow-off". (Ice formation around this discharge led to disastrous blow-backs during the winters of 1916 and 1930 [Johanson 1993].) After passing through the compressor, the water was released back into the river.

The Victoria Mine's compressor system worked well, but company officers were concerned that the system would not function effectively during low water conditions. To provide for a more consistent flow at Victoria, the company constructed another dam at the outlet of Lake Gogebic in 1906. Installation of this dam sparked a series of Lake Gogebic water level disputes that continues to this day (Lulich 1998).

The compressor system provided a cheap power source that allowed the Victoria Mine to outlast other area mines. The Victoria Mine finally closed operations in 1921, and the mine was sold to the Copper District Power Company in 1928 (Johanson 1993), who constructed the current dam slightly downstream of Hooper's dam by 1931. The new Victoria Dam (head = 120 ft) is much larger than the previous dam. Water reaching Victoria Dam is diverted into a pipeline that leads to the powerhouse. (The original pipeline was made of wood, but a steel pipeline was installed in 2001.) After passing through the turbines, the water is released back into the river. When the storage capacity of the dam is exceeded, water flows over the spillway into the original riverbed.

To increase water reserves for power generation, additional dams were built on the Ontonagon River system during the 1930s. The Cisco Dam was constructed at the Cisco Lake outlet in 1931, raising lake levels in the Cisco Chain approximately five feet. In 1938, the Bond Falls dam and canal system was completed. The Bond Falls project diverts water from the Middle Branch Ontonagon River through Bluff and Sucker creeks and into the South Branch Ontonagon River. The construction of the Victoria hydroelectric facility and associated dams brought electricity to much of the region, but the environmental effects of hydroelectric operations on the watershed have been substantial and long-lasting (see **Dams and Barriers**).

Another important development during the 1930s was the establishment of the Ottawa National Forest. The Ottawa National Forest was created in 1931. The original forest encompassed 253,551 acres. By 1937, the forest had been expanded to include approximately one million acres in the western Upper Peninsula. Roughly 50% of this land is located within the Ontonagon River watershed, and 57% of the land in the watershed is currently under federal ownership.

During the last half of the 20th century, tourism became a major contributor to the local economy. The myriad lakes and streams in the Ontonagon River watershed, coupled with the vast tracts of forest in the region, attract thousands of visitors every year. Waterfront properties are now highly desirable, and it is likely that there will be considerable development of residential and vacation homes in the watershed during the next few decades.

Geology

Biological communities within the Ontonagon River system have been strongly influenced by the physical characteristics of the watershed. The geology of the region is of particular importance because surficial geology largely determines the channel morphology, hydrologic stability, temperature regime, and water quality of the various streams within the watershed.

Surface Geology

Surficial materials affect river systems by determining how water enters the stream. Although rivers receive some water as direct precipitation, most water enters rivers as groundwater or surface runoff.

> Rain arriving at the soil surface infiltrates at a rate set by capillary action and permeability. When (1) precipitation rate exceeds infiltration rate or (2) the soil surface becomes saturated…, water accumulates and flows overland and downslope. [From Wiley and Seelbach 1997.]

The texture and composition of surficial materials determines the rate at which water is able to percolate through the ground. Coarse materials (e.g., sand and gravel) allow water to infiltrate rapidly. In areas with permeable soils, most water infiltrates the ground and enters streams at a steady rate. Finer materials (e.g., clay and organic matter) are less permeable, so streams that flow through these types of materials receive a large percentage of their water as surface runoff. Surface runoff (i.e., rainwater and snowmelt) flows into streams relatively quickly, and runoff volume varies by season. Thus, daily and seasonal flow variations are greater in streams that receive the majority of their water from surface runoff.

The permeability of adjacent surficial materials also affects water temperatures within a stream (Table 4). The temperature of groundwater at a given location closely approximates the mean annual air temperature. For the Ontonagon River system, this means that groundwater temperatures range from 36.7°F around the upper West Branch to 51.2°F near the confluence of the East and Middle branches (Mean monthly and annual maximum, minimum, and mean temperature 2000). The temperature of surface runoff, by contrast, is strongly influenced by the ambient air temperature. Thus, runoff water is warm during the summer, cold during spring snowmelt, and frozen during the winter. Groundwater inflows provide a thermal buffer against these temperature extremes, so coldwater and coolwater fish species are generally more abundant in streams that receive substantial groundwater inflows.

Middle Branch—upper

End moraines of coarse-textured till and glacial outwash sand and gravel compose the vast majority of the surficial materials in this subwatershed (Figures 4 and 5). These materials are highly permeable, and the upper Middle Branch receives strong groundwater inflows.

Middle Branch—lower

The lower Middle Branch flows through large deposits of lacustrine clay and silt, so surface runoff provides most of the water inflows to the Middle Branch in this region. End moraines of coarse-textured till are limited to the southern portion of the subwatershed near the headwaters of Trout Creek and the Baltimore River.

Main Stem

The upper end of the main stem is flanked by end moraines of coarse-textured till to the east and thin to discontinuous glacial till over bedrock to the west. Lacustrine clay and silt composes 83% of the surficial materials in the main stem subwatershed. Groundwater inflows to the main stem are minimal.

East Branch

A mosaic of surficial materials is found within the East Branch subwatershed. The permeability of these materials generally decreases from the headwaters to the confluence with the Middle Branch. Above Onion Creek, end moraines of coarse-textured till and glacial outwash sand and gravel are abundant. Between Onion Creek and Adventure Creek, the river flows through a large deposit of lacustrine sand and gravel. The lower reaches of the East Branch are surrounded by lacustrine clay and silt. Groundwater inflow is substantial above Onion Creek and minimal below Adventure Creek.

Cisco Branch

The upper (southern) portion of the Cisco Branch flows through coarse-textured glacial till and end moraines of coarse-textured glacial till. Near the confluence with Twomile Creek, the surficial materials transition to lacustrine clay and silt. Groundwater inflow is moderate throughout most of the Cisco Branch, with the strongest entering just above the confluence with Twomile Creek.

South Branch

Lacustrine clay and silt surround the entire length of the South Branch Ontonagon River, and surface runoff provides most of the water inflows to the South Branch. Bluff and Sucker creeks flow through end moraines of coarse-textured glacial till, so there is some groundwater inflow to these streams.

West Branch

The headwater streams south of Lake Gogebic flow through end moraines of coarse-textured glacial till. Groundwater inflow to these tributaries is strongest near the southern tip of Lake Gogebic. From Lake Gogebic to Mill Creek, the West Branch is flanked by deposits of coarse-textured glacial till. There is some groundwater inflow in this region (especially around Cascade Creek). Below Mill Creek, the West Branch flows through lacustrine clay and silt deposits. Groundwater inflow to the lower section of the stream is minimal.

Bedrock Geology

Bedrock geology has heavily influenced human settlement patterns and economic development within the Ontonagon River watershed. Large masses of pure copper have been found within the Portage Lake volcanic deposits in the northern portion of the watershed (Figure 6). These large copper deposits attracted prehistoric miners to the region and provided the main impetus for European settlement of the basin (see **History**). The Minesota, Victoria, and Adventure Mines all were founded over the basaltic lava flows of the Portage Lake series.

Hydrology

The hydrologic cycle of a watershed is affected by many factors, including climate, land use, surficial geology, evapotranspiration rates, topographic relief within the watershed, and dam operations. Consideration of hydrologic regime in a watershed is important because of the proximal influence hydrology has on the habitat, fish, and other biota present in a stream (Poff and Ward 1989). Generally speaking, streams with a stable hydrologic regime are characterized by high inflows of groundwater, low surface runoff, and consequently high base flow. In Michigan, these streams are typically cold- or coolwater streams that support relatively simple coldwater fish communities, including trout and salmon. On the other end of the spectrum, streams with an unstable or flashy hydrologic regime are characterized by low groundwater inflow, high surface runoff, and low base flow. In Michigan, these streams are typically warm streams that support more diverse warmwater fish communities.

Prior to discussing the hydrology of the Ontonagon River system, it is important to first understand a major change that has taken place in the water routing network of the watershed. In the early 1900s hydropower dam construction began in the Ontonagon River basin (see **History**). Hydropower dam operation alone is enough to alter the flow regime in a river system. However, in the case of the Ontonagon watershed, dam construction and operation also changed the way that water flows from the headwaters to Lake Superior. The Bond Falls Dam on the Middle Branch Ontonagon River was constructed for the purpose of capturing the water in the Middle Branch and diverting it, via the Bond Falls Canal and Sucker Creek, to the South Branch Ontonagon River and eventually through the Victoria Dam hydropower facility. Diverting flow from the Middle Branch to the South Branch has resulted in a much higher generating capacity at the Victoria Dam. However, the diversion has also resulted in radical changes to both the hydrology and ecology of the Middle Branch Ontonagon River downstream from Bond Falls as well as Sucker Creek and the South Branch Ontonagon River.

Climate

The climate of the Ontonagon River watershed varies from north to south. In the northern portion of the watershed, Lake Superior exerts a significant influence on the climate resulting in cooler summer temperatures, warmer winter temperatures, and higher snowfall than recorded in the southern half of the watershed, away from Lake Superior. The growing season is short and varies from approximately 140 days near Lake Superior to approximately 87 days in the southern portion of the watershed, which is roughly 1,000 ft above the level of Lake Superior (Albert 1995). Winters are relatively long and cold. Extreme minimum temperatures can be as low as -51°F, and snowfall can exceed 200 inches (Eichenlaub 1990). Average annual precipitation also varies across the watershed from 29 inches north of Kenton to 36 inches around Lake Gogebic. Annual evapotranspiration ranges from 16 to near 20 inches across the Ontonagon watershed, and runoff ranges from 14 to 16 inches (Hendrickson et al. 1973).

Annual Stream Flows

Discharge data were obtained from the United States Geological Survey (USGS) for stream flow gauges in the Ontonagon River watershed (Figure 7, Table 5). Although the annual flow regime in the Ontonagon River and tributaries is affected by hydropower-related dam operations, the annual flow pattern for the main stem Ontonagon River is typical of that for other streams in northern Michigan. Stream flow is greatest during the period of snowmelt in spring and is much lower at other times of the year (Figure 8). Mean discharge for the Ontonagon River at the USGS gauge site below the West Branch confluence was 1,380 cubic feet per second (cfs). The maximum discharge recorded at the same location was 42,000 cfs on August 22, 1942 and the minimum discharge was 170 cfs on August 14, 1991. It is important to note that seasonal and daily discharge recorded at this gauge site is influenced by the operation of the Bond Falls and Victoria dams. Ontonagon River water yield (defined as flow volume per watershed unit area) at this location averaged 1.03 cfs/mi^2. For comparison, most gauge sites in the Au Sable and Thunder Bay watersheds had yields lower than 1.0 cfs/mi^2 (Cwalinski et al. 2006; Zorn and Sendek 2001), whereas mean water yields for gauging stations on the Manistique River (which receives more annual precipitation than the Ontonagon River watershed) ranged from 1.03 cfs/mi^2 to 1.32 cfs/mi^2 (Madison and Lockwood 2004).

The East Branch is the only Ontonagon River tributary that is not affected by hydropower dam operations. The annual stream flow pattern is similar to that seen in the main stem; discharge is greatest during snowmelt in spring and is low at other times of the year (Figure 9). Average stream flow in the East Branch Ontonagon River was 257 cfs, and water yield averaged 0.94 cfs/mi^2 during the period of record.

As mentioned previously, the Middle Branch Ontonagon River is affected by the operation of the Bond Falls Dam. The annual stream flow pattern in the Middle Branch upstream of Bond Falls (Paulding gauge station) is similar to the main stem (Figure 10). The annual hydrograph includes the spring snowmelt peak and a smaller peak associated with fall rain events. Water yield for the Middle Branch subwatershed upstream from Bond Falls has averaged 1.03 cfs/mi^2 for the period of record. However, downstream from Bond Falls (Trout Creek gauge station) the annual stream flow pattern is obviously altered from what it would be in the absence of Bond Falls Dam (Figure 10). Downstream from Bond Falls the annual stream flow pattern does contain a peak during the spring snowmelt period, but the smaller peak corresponding to fall rain events is absent from the hydrograph. Also, the water yield for the Middle Branch downstream from Bond Falls has been reduced to 0.33 cfs/mi^2, only 32% of the water yield upstream of Bond Falls. Therefore, the Bond Falls diversion of water from the Middle Branch to the South Branch is removing approximately 68% of the Middle Branch flow. The effect of this diversion can also be seen in the South Branch. Although the annual stream flow pattern is similar to the other tributaries (Figure 10), the water yield for the South Branch is 1.42 cfs/mi^2, much higher than it would be in the absence of the diversion at Bond Falls Dam.

The Bond Falls Canal gauge monitors water diversions from the Middle Branch to the South Branch. The annual pattern of stream flow in the Bond Falls Canal is completely different from the natural patterns seen in the other tributaries within the watershed (Figure 10). High flows in the South and West branches reduce the need for water diversion during spring snowmelt. When flows naturally are low in the South and West branches (e.g., during summer), the Bond Falls diversion shunts greater volumes of water from the Middle Branch into the canal. Thus, the Bond Falls Canal stream flow pattern is characterized by high flows from summer through midwinter and low flows during late winter through spring.

Additional annual stream flow data for the Ontonagon watershed are available for the USGS gauges on the Cisco and West branches. The Cisco and West Branch gauges are both located at lake outlets. The annual stream flow patterns at these sites are affected by the operation of lake-level control structures (Figure 9), and therefore, the annual stream flow patterns do not closely resemble the patterns seen at other gauges in the watershed. Annual water yields were 0.90 cfs/mi^2 for the Cisco Branch and 1.05 cfs/mi^2 for the West Branch.

Seasonal Stream Flows

Indices of flow stability can be valuable tools in understanding river systems. One measure of flow stability is a standardized flow-exceedence curve. A standardized flow-exceedence curve is a plot of standardized discharge (discharge divided by the median discharge value) on the y-axis versus the percent of time that flow is equaled or exceeded on the x-axis (e.g., Figure 11). Flows that are equaled or exceeded 90% of the time are considered base flow and the higher the base flow value, the more stable the flow regime in a river. Flows that are equaled or exceeded 10% of the time are considered flood flows, and rivers with high flood flow values generally have flashy flow regimes.

The Ontonagon River and its tributaries exhibit a broad range of seasonal flow patterns (Figures 11–14, Table 6). Although this broad range may be attributed in part to the operation of hydropower-related dams, much of the variation can also be attributed to the geology and soils present in the subwatersheds. For example, coarse glacial tills and sandy soils that are highly permeable dominate the East Branch and upper Middle Branch subwatersheds. These streams have relatively high base flows (Figure 11) because precipitation falling in these subwatersheds infiltrates into the soil, and the groundwater is slowly released to the streams over a long period of time. In contrast, the West and Cisco branches have very low base flows that are due in part to the operation of lake-level control structures just upstream of the gauge locations. Because lake levels are held at an artificially high level, little water is released from the impoundments during the summer leading to much lower base flows.

Flood flow values are less variable across the Ontonagon River and tributaries (Figure 12). Standardized 10% exceedence flows vary from 2.3 to 3.0 in the free-flowing upper Middle Branch and East Branch respectively. The upper Middle Branch subwatershed has a higher percentage of permeable soils than the East Branch subwatershed. Thus, infiltration rates are higher in the upper Middle Branch subwatershed, resulting in lower flood flows.

Discharge patterns at the other gauge stations within the Ontonagon River watershed are affected by the Bond Falls diversion (Figures 13 and 14). The effects of the diversion are perhaps most obvious for the South Branch Ontonagon River. This runoff-driven stream flows through large deposits of lacustrine clay and silt, so it should have a flashy flow regime and a low base flow. In reality, the standardized 90% exceedence flow for the South Branch is similar to those observed for the groundwater-fed East Branch and upper Middle Branch systems because operation of the Bond Falls diversion artificially increases base flow in the South Branch.

The 10:90% exceedence flow ratio provides another useful index for comparing the flow stability of different streams. Streams with very stable annual flow regimes have low ratios of high:low flow yield (e.g., Au Sable and White rivers, Tables 6 and 7). Flashy streams, or those with unstable annual flow regimes, have high ratios of high:low flow yield (e.g., Kawkawlin River).

The Ontonagon River and its tributaries have annual flow regimes that are less stable than the White and Au Sable rivers, but are much more stable than the Kawkawlin River (Table 6). Flow ratios for the free-flowing portions of the East and Middle branches fall within the "good" range defined by Seelbach (MDNR, Fisheries Division, personal communication; Table 7). Gauge sites located immediately below dams (West and Cisco branches and the Bond Falls Canal) have the least stable flow regimes. As mentioned previously, the West and Cisco branches have unstable annual flow regimes primarily because operation of lake level controls on both of these streams maintain artificially high lake levels during summer by virtually eliminating outflow from lakes. Conversely, operation of the Bond Falls diversion increases flow stability at the South Branch and Middle Branch (Trout Creek) gauge sites.

Daily Stream Flows

Under natural conditions daily stream flows vary in relation to precipitation (or snowmelt) in a watershed. The rate of increase or decrease in daily stream flow depends primarily on the amount of precipitation and the infiltration rate of surrounding soils. Watersheds with soils that are highly permeable will have stable daily stream flow patterns. As with annual stream flow stability, daily stream flow stability is affected by dams, particularly hydropower dams.

Daily flow patterns in the Ontonagon River and its tributaries are similar for free-flowing reaches (Figure 15). The East Branch and upper Middle Branch (Paulding) hydrographs show discharge increases in response to major storm events and gradual decreases as surface runoff subsides. The upper Middle Branch has a more stable daily flow regime than the East Branch. Compared to the East Branch, the upper Middle Branch takes a longer time to reach peak discharge after a storm event, and it also takes a longer period of time for the discharge to decline to pre-storm levels. Again, this is due in large part to the higher proportion of permeable soils in the upper Middle Branch subwatershed.

The effect of the Bond Falls Dam and reservoir can be clearly seen from the daily discharge data for the Middle Branch near Trout Creek (downstream from Bond Falls). The daily hydrograph for this site is nearly flat and does not display the discharge peaks seen in the other streams in the Ontonagon watershed (Figure 15). In the case of the storm that occurred on August 22–23, 1979, the Bond Falls reservoir captured the entire increased flow and routed it through the Victoria Dam reservoir and generating station.

The daily stream flow patterns for the West and Cisco branches are also greatly affected by dam operations (Figure 16). Discharge peaks for these streams, such as the winter peaks observed for the Cisco Branch, do not correspond to storm events. Water releases from the Cisco Lake and Bergland dams are influenced by the water needs at the Victoria hydroelectric facility, so discharge peaks often correspond to periods when runoff inflows are low.

Although the Ontonagon River hydrology has been dramatically altered by dams and their operation, the future hydrologic cycle should more closely resemble the pre-dam cycle. The dams in the watershed that are operated by Upper Peninsula Power Company (UPPCo; Bond Falls Dam, Cisco Lake Dam, Bergland Dam, and Victoria Dam) were recently relicensed by the Federal Energy

Regulatory Commission (FERC) under conditions that were agreed to by UPPCo, MDNR, and other interested parties (Appendix A). The conditions of the new FERC license include minimum flows in the Middle Branch below Bond Falls and the West Branch below Lake Gogebic, and minimum and maximum flows in the Bond Falls Canal. In addition, target lake levels were set for Cisco Lake, Lake Gogebic, and the Bond Falls Flowage. These and the other negotiated changes hopefully will improve the aquatic and other natural resources in the Ontonagon River watershed.

Flooding and Floodplains

Flood events dramatically affect the physical characteristics of the stream and its associated biological communities. Flood flows reshape river channels and facilitate the movement of sediment downstream and onto the floodplain. Water flowing onto the floodplain also expands the area available to fish for feeding and reproduction. Large floods may give fish access to waters (e.g., adjacent lakes) that previously were not accessible, thus permanently altering the species assemblage in the adjacent water bodies. Large woody structure and insects may also be washed into streams during flood events, providing cover and food for riverine fish species (Wesley 2005).

On the Ontonagon River system, floods occur naturally as the result of spring snowmelt and prolonged or extremely heavy rainfall. Ice dams at the river mouth have led to increased water levels during some previous floods. The construction and breaching of logging dams also resulted in numerous small floods on Ontonagon River tributaries during the late 1800s.

Land use practices within the watershed can alter the frequency and severity of flood events. The construction of impervious surfaces, such as roads and parking lots, reduces infiltration and increases the amount of water entering the stream as surface runoff. Filling wetlands and floodplains also reduces the water storage capacity of a watershed and increases the rate at which water enters the river. Improperly installed road crossings can further influence water levels by acting as temporary dams during flood events.

There have been several major floods in the lower (northern) Ontonagon River watershed during the last 100 years. Two of the most notable floods occurred in 1942 and 1963. During the night of August 21–22, 1942, an intense rainstorm struck the northwestern part of the watershed. Rainfall during this storm may have been as high as 14 inches in some areas (Noecker and Wiitala 1948). Stream flows rose dramatically, and a peak discharge of 42,000 cfs was recorded at the main stem (below the West Branch confluence) gauge on August 22, 1942. Bridges and culverts were washed out, and three lives were lost as a result of this flood (Noecker and Wiitala 1948). In April 1963, heavy runoff from snowmelt and the formation of ice dams near the river mouth led to severe flooding in the town of Ontonagon. Although the discharge was much lower (only 17,700 cfs) than in the 1942 flood, ice dams at the M-64 bridge caused water levels near the mouth to rise two feet higher than any known previous flood (Department of the Army 1970).

Because the Ontonagon River watershed is so sparsely populated, the economic effect of flood events is generally much lower than in the densely populated watersheds of southern Michigan. The village of Ontonagon and Ontonagon Township are the only municipalities in the watershed that participate in the National Flood Insurance Program (Federal Insurance Administration, Federal Emergency Management Agency 2006). Under this program, floodplain maps have been developed for the greater Ontonagon area. These maps are used by federal, state, and local agencies and private citizens to plan future developments and determine the need for flood insurance.

Soils and Land Use

Soils

Soils influence the hydrology, channel morphology, and water quality of river systems. Sandy soils allow greater infiltration and groundwater production compared to relatively impermeable clay soils. In addition, sandy soils are more easily eroded than clay soils, so sedimentation and bank slumping can be major concerns in sandy watersheds (see **Channel Morphology**). Soil type and distribution can also influence land use patterns within a watershed, as areas with fertile soils are more likely to be used for agricultural purposes.

The formation and composition of soils is determined by a variety of factors, including the parent material, climate, topography, biological factors, and disturbance regimes (e.g., glaciation or flood events; Owen and Chiras 1990). The influence of surficial geology (i.e., parent material) on soil type is clearly seen in the Ontonagon River watershed (Figures 4 and 17). Sandy soils predominate in the southern half of the watershed where the surficial materials consist largely of coarse-textured glacial till. Fine-textured soils are associated with the lacustrine clay and silt deposits in the northern half of the basin.

Soil type also plays a role in shaping plant community composition. The soils in the northern part of the watershed are classified as alfisols and are relatively fertile (Natural Resources Conservation Service 2006), and the dominant plant community in this region is deciduous forest. Most soils in the southern half of the watershed are classified as spodosols, which are more acidic and less fertile than alfisols (Natural Resources Conservation Service 2006). Coniferous forests are common in the southern (spodosol) portion of the basin.

Land Use

Compared to most other Michigan watersheds, the Ontonagon River watershed is sparsely populated. Population densities for the five counties in the watershed range from 6.0 people/mi^2 in Ontonagon County to 35.6 people/mi^2 in Houghton County (United States Census Bureau 2006). With the exception of Ontonagon County, the major population centers for the counties are outside of the Ontonagon River basin, so the average population density within the watershed is probably less than 10 people/mi^2. This is much lower than the statewide average of 175 people/mi^2 (United States Census Bureau 2006). Although the statewide population increased by 1.8% from 2000 to 2004, census data indicate that population density actually declined in the Ontonagon River watershed during that period (United States Census Bureau 2006).

Forests and wetlands covered almost the entire Ontonagon River watershed prior to settlement by Europeans. Sugar maple, hemlock, basswood, and yellow birch dominated most upland regions, while mixed conifer swamps (e.g., cedar, tamarack, hemlock, and black spruce) were common in lowland areas (Comer 1996). White pine was a notable component of the forest community throughout the watershed and was particularly common in the sand outwash deposits south of Watersmeet (Comer 1996).

Forest continues to be the dominant land cover type in the Ontonagon River watershed (Figures 18 and 19). The majority of the forestland in the watershed is included in the Ottawa National Forest, but private and commercial forests are also common (e.g., near Lake Gogebic). Human activities have dramatically altered the species composition of the forest community during the last two centuries. Acreage of lowland conifers has declined by approximately 50% since Europeans settled in the region, while the acreage of lowland hardwoods (primarily aspen) has increased by several hundred percent during the same period (Comer 1996). More frequent disturbance regimes (e.g., timber harvesting) and herbivory by a greatly increased whitetail deer population are major factors limiting regeneration of slow-growing coniferous species (Doepker 2003).

Wetlands are the second most abundant land cover type in the Ontonagon River watershed. Wetlands function as natural floodwater controls and groundwater recharge and discharge areas. Wetlands also filter pollutants and sediment, stabilize shorelines, and provide fish and wildlife habitat and recreation opportunities. The loss of wetlands has become a concern of national importance. During the last 200 years, wetland acreage in the lower 48 states has declined by 53% (Dahl 1990). Wetland acreage in Michigan has declined by 28–35%, with the greatest losses occurring in the southern half of the Lower Peninsula (Comer 1996). Due to its remote location, wetland losses in the Ontonagon River watershed probably have not exceeded 5% (Comer 1996).

Approximately 5% of the watershed is agricultural land. Most agricultural lands fall within the South Branch and lower Middle Branch subwatersheds, but some farming also occurs near Mass City (East Branch subwatershed). Beef production is the dominant agricultural enterprise in the area, but dairy farms are also common (Johanson 1996). Crops produced in the watershed include alfalfa, birdsfoot trefoil (a small plant related to alfalfa), and corn (Bruce Petersen, Natural Resources Conservation Service, personal communication).

An emerging land use issue in the Ontonagon River watershed is the sale, subdividing, and development of former commercial forest and power company lands. One of the most controversial scenarios is occurring along the Bond Falls Flowage. The UPPCo recently sold 960 acres of its nonproject lands to a real estate development company. (Note: The project lands surrounding the impoundment have not been sold. The distance from the project boundary to the shoreline of the impoundment is variable, but the average width of these riparian “buffers” is about 200 ft.) In 2007, UPPCo prepared a shoreline management plan outlining the company’s plans to provide dockage, pedestrian access, and viewing windows for adjacent property owners and submitted this plan to FERC. MDNR, other resource agencies, and various nonprofit organizations have reviewed this document and provided comments to FERC. FERC is in the process of evaluating the shoreline management activities to determine if they are consistent with the requirements of the current hydropower license.

Bridges and Other Stream Crossings

There are 662 road and utility stream crossings in the Ontonagon River watershed (MIRIS Base Data 1998; Table 8 and Figure 20). Road crossings (77%) are the most common type, followed by railroads (15%) and utilities (8%). These numbers are approximate, because newly developed roads (e.g., logging trails) and unauthorized stream crossings may not be represented in the MIRIS database.

Improperly installed stream crossings can adversely affect stream ecosystems in several ways. One of the most obvious effects of poor stream crossings is the fragmentation of fish populations (Angermeier et al. 2004; Gibson et al. 2005). Culverts are more likely to create fish barriers than other structures (Warren and Pardew 1998), but the low installation cost for culverts has led to their widespread use. Stream crossings may prevent fish passage through a variety of mechanisms. For example, perched culverts are barriers to upstream fish passage, particularly for nonjumping species. Undersized culverts can also impede upstream movement by creating a velocity barrier, especially for small fish (Gibson et al. 2005).

Sedimentation and streambank erosion are additional concerns associated with stream crossings. Raw streambanks typically are created during the installation of a new stream crossing. When these banks are not properly stabilized (e.g., with vegetation or rock riprap), accelerated erosion and bank slumping occurs. Stream crossings on gravel roads are of particular concern to fisheries managers. In hilly areas, diversions and infiltration basins may be needed to prevent sedimentation from road approaches. Road grading can also contribute large amounts of sediment to streams, but proper grading practices can substantially reduce sedimentation from road maintenance activities.

Another concern associated with stream crossings is the potential for pollution (both willful and accidental). Road salt, gasoline, and oil are some of the most common pollutants, but other chemicals could be introduced through accidental spills. Littering is a problem in many Upper Peninsula watersheds, and it is not uncommon for violators to dispose of household refuse at stream crossings.

In the past, open ditching has been used to install pipeline crossings. This method disturbs the stream bed and alters habitat for aquatic species. Newer methods of pipeline installation (e.g., directional drilling or bore and jacking) involve less alteration of aquatic habitat and are recommended by fisheries managers.

A thorough inventory of streambank erosion at bridge sites or improperly installed stream crossings has not been completed for the Ontonagon River watershed. In some other watersheds, sport fishing groups and other organizations have conducted stream crossing inventories and applied for grant funds to fix problem crossings (Wesley 2005).

Channel Morphology

Gradient

River gradient, measured as the drop in elevation (ft) per mile of river, is an important determinant of habitat in a river. Together with discharge, river gradient influences many of the physical characteristics of a stream, including channel sinuosity, water depth, and current velocity. Not surprisingly, stream gradient also influences fish species composition within a river system. For example, the distributions within a river of smallmouth bass (Edwards et al. 1983), creek chub (McMahon 1982), blacknose dace (Trial et al. 1983), northern pike (Inskip 1982), and largemouth bass (Stuber et al. 1982) have all been related to river gradient. Some species (e.g., brook trout) use high gradient reaches for spawning and lower gradient reaches for feeding and resting.

Because aquatic species often require different habitats during their various life stages, optimal river habitat is also diverse. The “best” river habitat is found in reaches with moderate gradient, because depths and velocities are most variable in those areas (Table 9).

Gradients for the main branches of the Ontonagon River system were estimated using the Maptech Terrain Navigator® program. This process utilized electronic versions of 1:24,000 scale topographic maps coupled with a tool for measuring distance. The stream length measurements from Terrain Navigator® did not always match those obtained from the National Hydrography Dataset (1999; Table 1). There was close agreement for the Middle and West branches of the Ontonagon River, but some discrepancies were observed on the other branches (especially the East Branch).

Compared to most other Michigan streams, the Ontonagon River has considerable gradient. The mean gradient for the main stem (including the Middle Branch) is 11.1 ft/mi. Gradients (in ft/mi) reported for other main stem rivers include 3.9 for the Au Sable River (Zorn and Sendek 2001), 3.0 for the Kalamazoo River (Wesley 2005), 1.3 for the Manistique River (Madison and Lockwood 2004), and 2.9 for the Flint River (Leonardi and Gruhn 2001).

Gradients between 10.0 ft/mi and 69.9 ft/mi, the “excellent” gradient category for fish habitat, are common in the upper portions of the Ontonagon River watershed. With the exception of the main stem, this gradient class makes up ≥20% of the river miles in each of the major branches of the Ontonagon River system. Low gradient reaches, though common in the main stem and South Branch, are virtually absent from some of the other branches (e.g., the East Branch).

In many large rivers in Michigan, valuable high gradient reaches of river have been lost as riverine fish habitat because they have been inundated under hydropower reservoirs. However, the Ontonagon River has lost very little high gradient habitat to dam construction. In fact, the two major dams in the Ontonagon watershed (Bond Falls and Victoria) were constructed at the sites of waterfalls and impound relatively low gradient reaches of river upstream from the falls sites. Also, dam construction in the Ontonagon River watershed has not resulted in a loss of usable habitat for migratory fishes from Lake Superior because the dams were constructed at falls that were natural barriers to upstream fish migration (see **Dams and Barriers**).

Specific Power

Specific stream power ω, with units of watts/m^2, measures the rate at which potential energy is supplied to an average square-meter area of the river channel. Power (in watts) is the rate at which work is done. (A force of 1 newton pushing a small rock a horizontal distance of 1 meter would represent 1 joule of energy expended or work performed; expending this much energy in 1 second would be 1 watt of power.) Specific power depends on discharge Q (in units of m^3/s), channel slope s (in m of drop per m of downstream distance), cross-sectional width w (in m), water density ρ (approximately 1,000 kg/m^3), and gravitational acceleration g (approximately 9.81 m/s^2). Specific power is expressed as:

$$\omega = \frac{\rho g Q s}{w}$$

Specific power is a useful index for evaluating the stability of a stream channel. Stream channels are dynamic and typically move laterally within their meander belts. The speed of this lateral movement is determined by the surrounding materials and the specific stream power at a given location.

Under natural conditions, stream channels are shaped by the erosion of surrounding particles (e.g., sand) and the transport and eventual deposition of these particles within the river channel or floodplain. The conditions needed to erode and transport these particles vary substantially. Sand particles are easily eroded and require moderate flow velocities for downstream transport (Hjulstrom 1935). Clay particles are more difficult to erode, but are easily transported even at low flow velocities. Once eroded, clay particles tend to stay in suspension until they reach an area where flow velocity essentially drops to zero (e.g., an impoundment or Lake Superior). Large particles (e.g., cobble) require considerable flow velocities for erosion and transport. In Michigan streams, movement of these large particles is generally limited to the spring high flow periods.

For streams flowing through sandy soils, stream bed movement occurs when specific power reaches 15 watts/m^2 (Madison and Lockwood 2004; M. Wiley, University of Michigan, personal communication). At this point, the river must decrease specific power by down cutting (decreasing slope) or moving laterally (i.e., increasing channel width or increasing sinuosity). The specific power needed to initiate stream bed movement is somewhat higher for rivers flowing through surficial materials other than sand (e.g., the large silt and clay deposits in the northern portion of the Ontonagon River watershed).

Human alterations of river channels often lead to changes in specific power. For example, channelized river segments generally are narrower and deeper than unaltered segments. Because the stream width has been reduced, the specific power in that location increases. Channelized river segments often are lined with riprap or concrete to prevent erosion, but this practice only pushes the erosive energy farther downstream. A similar circumstance occurs when an undersized culvert is installed at a stream crossing. The smaller width inside the culvert increases the specific power, and substantial erosion occurs on the downstream side of the culvert.

There is considerable variation in both gradient and specific power among the different stream reaches in the Ontonagon River watershed. The following sections include gradient and specific stream power information for each of the seven subwatersheds.

Middle Branch—upper

The upper Middle Branch drops 574 ft from the origin at Crooked Lake to the top of Agate Falls (Figure 21). Gradient averages 12.6 ft/mi in this segment and varies from 1.1 ft/mi in the Bond Falls Flowage to 1,546.7 ft/mi at Bond Falls. Approximately 50% of this segment falls within the gradient classes rated good or excellent in terms of fish habitat (Figure 22), but some low gradient reaches occur above Bond Falls.

Specific power at the USGS gauge site near Paulding was 8.6 watts/m^2 at 5% exceedence and 1.7 watts/m^2 at 95% exceedence (Figure 23). Specific power is 15 watts/m^2 at a discharge of 712 cfs. Flows of this magnitude occur in 6 of 10 years, so the stream channel is regularly reshaped in this area of sandy soils (see **Soils and Land Use**).

Middle Branch—lower

In this segment, the Middle Branch drops 469 ft from the top of Agate Falls to the confluence with the East Branch (Figure 21). Gradient is generally steep in the lower Middle Branch, averaging 16.5 ft/mi and ranging from 6.4 ft/mi to 458.3 ft/mi at Agate Falls. Nearly 98% of the lower Middle Branch is in the good to excellent gradient classes, with chutes and waterfalls on the remaining stream reaches (Figure 24).

Specific power at the gauge site near Trout Creek was 5.9 watts/m^2 at 5% exceedence and 1.9 watts/m^2 at 95% exceedence (Figure 25). For this site, specific power is 15 watts/m^2 at a discharge of 341 cfs. Due in part to the Bond Falls Diversion, flows greater than 341 cfs have only occurred during 5 of 10 years for the period of record.

Main Stem

The main stem drops 61 ft from the confluence of the East and Middle branches to the mouth at Lake Superior (Figure 21). The main stem has a much lower gradient than any of the branches within the Ontonagon River system. Gradient averages 2.4 ft/mi and varies from 0.5 ft/mi at the mouth to 5.4 ft/mi below the confluence with the West Branch. Gradient class is good for 12% of the main stem and poor to fair for the remaining 88% (Figure 26).

Specific power was calculated for both USGS gauge sites on the main stem. Specific power at the gauge site above the West Branch confluence was 10.0 watts/m^2 at 5% exceedence and 1.1 watts/m^2 at 95% exceedence (Figure 27). Specific power at this site is 15 watts/m^2 at 2,635 cfs. Flows of this magnitude have occurred every year for the period of record. For the USGS gauge site below the West Branch confluence, specific power was 31.4 watts/m^2 at 5% exceedence and 2.8 watts/m^2 at 95% exceedence (Figure 28).

East Branch

The East Branch falls 869 feet from the origin at Gasley Lake to the confluence with the Middle Branch (Figure 29). Stream gradient varies from 4.3 ft/mi to 92.7 ft/mi and averages 12.2 ft/mi. Good and excellent gradient reaches compose 89% of this stream, and low gradient reaches are essentially absent from the East Branch (Figure 30).

Specific power for the East Branch near Mass City was 10.4 watts/m^2 at 5% exceedence and 1.4 watts/m^2 at 95% exceedence (Figure 31). Specific power was 15 watts/m^2 at a discharge of 1,135 cfs. Flows greater than 1,135 cfs have occurred every year for the period of record.

Cisco Branch

The Cisco Branch drops 551 ft from Cisco Lake to the confluence with Tenmile Creek (beginning of South Branch; Figure 32). Gradient averages 14.3 ft/mi and varies from 3.6 ft/mi to 151.9 ft/mi. Good and excellent gradient reaches compose 78% of the Cisco Branch (Figure 33). As with the East Branch, low gradient reaches are virtually nonexistent on the Cisco Branch.

Specific power at the USGS gauge site near the Cisco Lake outlet was 3.6 watts/m^2 at 5% exceedence and 0.1 watts/m^2 at 95% exceedence (Figure 34). Flows of 538 watts/m^2 are needed to generate a specific power of 15 watts/m^2 at this site; however, the highest discharge recorded at this site was 288 cfs. The position of this gauge station at the headwaters of the Cisco Branch (only 51 mi^2 of watershed area), coupled with operation of the Cisco Lake Dam to maintain artificially high lake levels in the Cisco Chain, preclude the high stream flows needed to accomplish channel movement at this site.

South Branch

The South Branch falls 172 ft from the confluence of the Cisco Branch and Tenmile Creek to the confluence with the West Branch (Figure 32). Compared to the other branches within the Ontonagon River system, the South Branch is a relatively low gradient stream. Gradient averages 5.2 ft/mi in the South Branch and varies from 1.3 ft/mi to 28.2 ft/mi. Sixty-nine percent of the South Branch falls within the lowest gradient class (Figure 35). Stream gradient increases as the river approaches the West Branch, and the last ten miles of the stream received fish habitat ratings of good to excellent.

For the South Branch gauge site, specific power was 4.2 watts/m^2 at 5% exceedence and 0.5 watts/m^2 at 95% exceedence (Figure 36). Specific power is 15 watts/m^2 at a discharge of 5,026 cfs. Flows of this magnitude occur in 3 of 10 years. The stream channel is relatively stable in this location due to the gentle gradient and the cohesive nature of the surrounding soils (clay and silt).

West Branch

The West Branch drops 640 ft from Lake Gogebic to the confluence with the main stem (Figure 37). With a mean gradient of 18.4 ft/mi, the West Branch is the steepest branch in the Ontonagon River system. Gradient varies from 2.8 ft/mi in the Victoria Reservoir to 2,493.4 ft/mi (124.7 ft drop in 0.05 miles) at Victoria Falls. The stream reach impounded by Victoria Dam is the only low gradient reach in the West Branch. Seventy-three percent of the West Branch falls within the good or excellent gradient classes (Figure 38).

Specific power for the West Branch gauge site was 35.5 watts/m^2 at 5% exceedence and 0.2 watts/m^2 at 95% exceedence (Figure 39). Specific power was higher at this site than at any other gauge site in the watershed. Flows sufficient to generate 15 watts/m^2 occur nearly 15% of the time in this river segment.

Channel Cross Section

Channel cross section is another measure of channel morphology that can be used to determine if river habitat has become degraded. Under natural conditions channel cross section width is related to mean daily discharge according to the following equation:

$$\log_{10}(\text{Expected mean width}) = 0.741436 + 0.498473*\log_{10}(\text{mean daily discharge})$$

where width is channel width measured in feet and discharge is measured in cfs (G. Whelan, MDNR Fisheries Division, personal communication).

If a channel deviates from the expected value based on discharge, it can be an indication of problems in the watershed that are affecting instream habitat. For example, unstable flows will create a channel that is wide and shallow during base flow. Unusually high sediment loads can lead to channel widening (Alexander and Hansen 1988) and low sediment loads can lead to a deep, narrow channel. Other factors (culverts, bridges, erosion, channelization, etc.) can also lead to unexpected channel cross section widths.

The data necessary for evaluating channel width relative to discharge are scarce in the Ontonagon River watershed, but data are available at USGS gauge sites. Seven of the nine gauge sites had channel widths that were within the range predicted from the mean discharge values (Table 10). Observed channel widths were narrower than expected for the upper Middle Branch (Paulding) and Bond Falls Canal sites. The channel width for the upper Middle Branch gauge site probably was not representative of that stream segment because the gauge station is located just 25 ft downstream from the bridge on Forest Hwy 5250. The Bond Falls Canal was constructed by humans, and the flow regime is controlled by operation of the Bond Falls diversion. As typically observed for channelized river segments, the Bond Falls Canal is deeper and narrower than a natural stream channel.

Local residents report that channel widening occurred on the Middle Branch downstream of Agate Falls due to high-flow releases from the Bond Falls Dam during spring 2003 (G. Madison, MDNR, Fisheries Division, personal communication). No data are available for the stream reach immediately downstream of Agate Falls, but the observed channel width at the closest USGS gauge site (Trout Creek) did not deviate significantly from the expected width.

The fact that the channel cross sections are not drastically different from predicted indicates that channel morphology in the Ontonagon watershed is not seriously altered or degraded. This is not surprising given that much of the watershed remains undeveloped.

Dams and Barriers

There are 17 dams in the Ontonagon River watershed that are registered with MDEQ (Figure 40; Table 11). Five of these dams are operated by UPPCo to facilitate power generation at the Victoria hydroelectric facility. Four dams are operated by various governmental organizations to enhance recreational opportunities, six dams are privately owned (i.e., for private lakes and ponds), and two dams are operated for other purposes. An unknown number of small unregistered dams also exist within the watershed.

Dam construction within the Ontonagon River basin began in the 19th century. Numerous temporary dams were constructed during the 1800s to facilitate log drives, but little documentation remains regarding the number and locations of these dams. By the early 1900s, dams were also being used to facilitate power generation (see **History**), and all of the existing hydroelectric dams within the watershed were in place by 1938. Most of the private and recreational dams were built during the 1960s and 1970s, and no registered dams have been constructed since 1988.

In Michigan, dam construction and operation are regulated by two different agencies. The five hydroelectric-related dams within the watershed are regulated by FERC. Hydroelectric dam owners must obtain operating licenses from FERC. These licenses often specify a variety of conditions, such as minimum flow releases and target reservoir elevations. MDEQ is the primary regulatory agency for nonhydroelectric dams, as specified in the Natural Resources and Environmental Protection Act of 1994 (Public Act 451; see **Special Jurisdictions**).

The Dam Safety Section of MDEQ assigns hazard ratings to all dams in the watershed. Hazard ratings are determined primarily by the size of the dam and its location relative to human population centers.

> Failure of dams with a hazard rating of 1 would result in the loss of human life, those with a hazard rating of 2 would result in severe property damage, and those with a hazard rating of 3 are low head dams located in remote areas. [From Madison and Lockwood 2004.]

Three dams, Bond Falls, Bond Falls Control, and Victoria, are rated as Type 1; Trout Creek Dam is classified as Type 2. The 13 remaining dams have a hazard rating of 3.

The detrimental effects of dams on river ecosystems are well documented. One of the most obvious ways that dams influence stream communities is by restricting fish movements. Potamodromous fish species (e.g., coho salmon and steelhead) spend most of their lives in Lake Superior and use stream environments for spawning and nursery areas. In addition, river resident fishes (e.g., brook trout) typically exhibit seasonal movements to spawning areas and to find coldwater refuges during the summer months. Dam construction interferes with these movements and fragments fish populations within a river system.

Downstream movement of fish through dams can lead to mortality or injury, especially when the dam is equipped with hydroelectric turbines. A variety of stresses (e.g., pressure changes, blade contact, water velocity accelerations) can injure or kill fish that are entrained in hydroelectric facilities (Cada 1990).

Dams also interfere with the downstream movement of large woody structure and detritus (Shuman 1995). Large woody structure provides important habitat for fish and aquatic insects. Detritus (decaying organic matter) provides some of the nutrients needed to drive the food web in aquatic ecosystems. Not surprisingly, many studies have demonstrated that the diversity or density of fish and aquatic insects is reduced in stream reaches below impoundments (Trotzky and Gregory 1974; Cushman 1985; Bain et al. 1988).

The impoundments created by dams also act as large sediment traps. Dam construction reduces the stream gradient above dams and often causes sedimentation in stream reaches immediately above impoundments (Petts 1980). In addition, water released from impoundments is essentially “sediment-starved”. To restore the sediment balance, the stream must pick up sediment in the lower reaches of the stream. This results in accelerated erosion of the stream bed and banks below dams (Petts 1980).

Impoundments expose a large surface area of water to radiant sunlight. Thus, the warm surface waters leaving an impoundment typically increase water temperatures in the stream below (Wesley 2005). This alteration of water temperatures is especially noticeable during the summer months. Several fish species (e.g., brook trout, rainbow trout, and coho salmon) are not tolerant of high water temperatures, and temperature increases of only a few degrees can make a stream unsuitable for these species.

Another mechanism by which dams affect aquatic ecosystems is the alteration of natural flow regimes. Flow alteration is most obvious for hydropower peaking operations, but all dams alter stream flows to some extent. Changes in flow regimes can interfere with fish spawning activities (Auer 1996; Paragamian et al. 2005; Friday 2006) and alter channel morphology in downstream reaches (Ligon et al. 1995). In addition, dam operations affect the connectivity of the stream with its floodplain.

> The seasonal distribution of flow is also disrupted by reducing [the] incidence and severity of flooding. This reduces the inundation of floodplains causing a decrease in backwater habitat for fish spawning and juvenile rearing. The decrease in flooding also reduces the amount of food deposited into the river. Intense short-term flow fluctuations immediately below dams can strand aquatic organisms during severe low flows and destroy habitat during extremely high flows. [From Wesley and Duffy 1999.]

Because dams adversely affect stream ecosystems as described above, MDNR Fisheries Division generally opposes new dam construction. Fisheries Division also works with dam owners to minimize the negative effects of existing dams.

Dams are not the only barriers that restrict movement of aquatic organisms. Improperly constructed stream crossings (e.g., perched culverts) can block fish movements and fragment stream populations (see **Soils and Land Use**). In the Ontonagon River watershed, waterfalls also provide natural barriers to fish movement. There are 24 named waterfalls and a myriad of unnamed waterfalls within the Ontonagon River and its tributaries (Figure 41; Table 12). Although many of these waterfalls allow fish passage at least seasonally, the larger waterfalls (e.g., Bond, Agate, and Victoria Falls) are year-round barriers to upstream fish movement.

Middle Branch—upper

The two largest dams in this subwatershed are associated with the Bond Falls diversion. The Bond Falls Dam and Bond Falls Control Dam are operated by UPPCo to store water and divert flow from the Middle Branch to the South Branch via the Bond Falls Canal. Water yield calculations indicate that approximately two-thirds of the Middle Branch flow is routed to the South Branch through this diversion (see **Hydrology**).

Operation of the Bond Falls diversion strongly influences the seasonal flow patterns in the lower Middle Branch and the South Branch. All of UPPCo's dams in the Ontonagon River watershed were relicensed in 2003, and operational changes set forth in the new license should produce stream flows that more closely mimic a natural flow regime. Under the previous license, required minimum flows into the Middle Branch were 40 cfs during June through August, and 30 cfs during the remainder of the year. Under the new license, minimum flows to the Middle Branch were increased to 110 cfs in April, 100 cfs in May, 80 cfs in June through October, 90 cfs in November, and 80 cfs in December through March (Appendix A). The new license also specifies minimum and maximum water releases to the Bond Falls Canal.

The two dams at Bond Falls maintain a 2,160 acre impoundment known as the Bond Falls Flowage. Historically, this reservoir was drawn down as much as 20 ft during the winter months, decreasing the surface area of the reservoir to around 1,400 acres. Under the new license, the maximum allowable drawdown has been decreased to 8 ft. This change in operations will increase the amount of available winter habitat for fish and other aquatic organisms, and should increase overwinter survival of fish in the impoundment.

The temperature of the water released from the Bond Falls Flowage has been a major concern for fisheries managers. As mentioned above, dams that spill surface waters can substantially increase summer water temperatures in the stream below. The outlet at the Bond Falls Dam is located at a depth of 30 ft (at full pool), so the water discharged into the Middle Branch is noticeably cooler than water at the surface of the reservoir. Eschmeyer (1942) and Hazzard (1945) monitored water temperatures in the Middle Branch shortly after the dams were constructed. They found that water releases from the Bond Falls Flowage actually decreased summer stream temperatures below the impoundment.

Photo 1.–Bond Falls, Middle Branch Ontonagon River.

Although Bond Falls Dam is a barrier to fish migration, the dam was built just upstream of a natural barrier – Bond Falls. Thus, the dam itself does not significantly influence fish movement. The corresponding alteration of flow regimes, however, undoubtedly has affected movements of fish in the Middle Branch and South Branch Ontonagon rivers.

The only other dam within this subwatershed is the Wolf Lake Dam. This dam is located on a small tributary (Wolf Lake Creek) to the Middle Branch and is used to control the water level in Wolf Lake. Both the dam and the lake are privately owned.

There are three named waterfalls on the upper Middle Branch: Mex-i-min-e Falls, Little Falls, and Bond Falls. Bond Falls is the only one of these waterfalls that is considered a barrier to fish passage.

Middle Branch – lower

The Calderwood Pond Dam was constructed by MDNR in 1982 to create a walleye rearing pond, and the dam is currently owned by the United States Forest Service (USFS). Walleye fry were stocked in this pond during the 1980s. Contamination with competing species (dace and other minnows) was a continual problem, and few fish survived to be harvested as spring fingerlings. Calderwood Pond was converted to trout management in the late 1990s, and brown trout were stocked in the pond from 1998 through 2005. Netting surveys and angler reports indicated poor survival of stocked trout, and the plants were discontinued in 2006. Because the impoundment is not serving its intended purpose, the future management of this dam is currently under review by USFS and MDNR.

The Trout Creek Dam was originally constructed to create a mill pond for the local sawmill. The pond has become a local landmark, and Interior Township continues to operate the dam to maintain this popular resource. MDNR has stocked brook trout in Trout Creek Pond since 1998, and the pond receives heavy fishing pressure in the spring. Because Trout Creek is one of the best trout streams in the area, fish passage has been a major concern at this dam. To facilitate passage of fall spawning salmonids (e.g., brook trout and brown trout), a Denil fish ladder was installed at the dam in 1995. The fish ladder is still operating, but a systematic evaluation of fish movement through the ladder has not been conducted.

Photo 2.–Trout Creek Dam and fish ladder.

There are three named waterfalls in the lower Middle Branch subwatershed. Agate Falls is actually a series of cascading waterfalls that have a vertical drop of approximately 40 ft. This falls is the upstream barrier for fish migrating from Lake Superior, but anecdotal reports suggest that a few steelhead may be able to ascend the falls under the proper flow conditions. The other waterfall on the lower Middle Branch, Three Rapids Falls, is not a major barrier to fish passage. O Kun de Kun Falls is the upstream barrier for fish movement in the Baltimore River.

Main Stem

There are no dams in the main stem subwatershed. There are two small waterfalls (rapids) on the main stem, but neither of these falls is considered a barrier to fish passage.

East Branch

Lower Dam is located within the Ottawa National Forest. USFS operates this dam to provide additional boating and trout fishing opportunities for Forest visitors. Lower Dam and the other impoundments owned by USFS (Calderwood Pond, Robbins Pond, and Paulding Pond) are drawn down only when necessary for dam repair or pond maintenance (e.g., aquatic vegetation control or sediment removal). Lower Dam is the upstream barrier for fish migrating up the East Branch.

The only other dam within this subwatershed, Nordine Dam, is privately owned. This low-head dam was constructed on a tributary to the Jumbo River in 1970, creating a 26-acre impoundment.

There are three waterfalls on East Branch tributaries. Onion Falls is a major barrier to fish passage. Jumbo and Duppy Falls can be ascended by steelhead and coho salmon, but they may limit movements of other fish species.

Photo 3.–Agate Falls, Middle Branch Ontonagon River.

Cisco Branch

Cisco Dam controls the water level in the Cisco Lake Chain. The Copper District Power Company constructed this dam in 1931 to provide water for the Victoria hydroelectric facility, but MDNR, Fisheries Division files suggest that logging companies may have constructed wooden dams at the outlet prior to this date. The UPPCo acquired ownership of the Cisco Lake Dam and the Victoria hydroelectric facility in 1947.

The Cisco Dam raises lake levels in the Cisco Chain by 4–5 ft. The elevated lake levels provide some recreational benefit, as they increase the ability of boaters to travel between different lakes within the chain. Fluctuations in lake levels are relatively minor. For example, the target elevation range for Cisco Lake under the current license is 1,683.4–1,683.9 ft above sea level.

Operation of the Cisco Dam dramatically alters the flow regime in the Cisco Branch Ontonagon River (see **Hydrology**). In order to maintain the artificially high lake levels in the Cisco Chain, outflow from the dam often is reduced to less than 1 cfs during late summer (e.g., during 13 August – 18 September 2005). Water releases into the Cisco Branch are dictated primarily by water needs at the Victoria hydroelectric facility and target water levels in the Cisco Chain (as specified in the current FERC license), so flow patterns in the Cisco Branch vary substantially from the flow patterns in the other branches of the Ontonagon River system.

The Beatons Lake Dam was constructed by MDNR to prevent white suckers from entering Beatons Lake from Twomile Creek. (The original dam was constructed in 1967, but the existing structure was installed in 1988.) This dam has a head of only 3 ft, so it has minimal effect on the water level in Beatons Lake or the flow regime in Twomile Creek.

There are two waterfalls on the Cisco Branch: Kakabika Falls and Wolverine Falls. Neither of these waterfalls is considered a barrier to fish passage.

South Branch

There are five small dams on tributaries to the South Branch Ontonagon River. Two of these dams, Paulding Pond and Robbins Pond, are owned by USFS. Both of these dams were built during the 1950s to create ponds for trout fishing. Paulding Pond has supported a good trout fishery for many years. Trout historically did well in Robbins Pond, but stocking was halted in the mid-1990s due to excessive weed growth.

The other three dams on South Branch tributaries are privately owned. Little information is available regarding the operation of these small, low-head dams.

The two waterfalls (rapids) on the South Branch are not considered barriers to fish passage. Ajibikoka Falls and Rock Bluff Falls are larger waterfalls that probably restrict fish movements.

West Branch

Bergland Dam was built in 1906 to control the water supply for the Victoria hydroelectric facility. The dam artificially raises the water level in Lake Gogebic, and regulation of the water level has been a contentious issue since the dam was constructed. As with the Cisco Dam, UPPCo operates the dam to provide water for their hydroelectric plant, but they also strive to maintain the surface water level within a target range of 2 ft.

Operation of the Bergland Dam alters the flow regime in the West Branch so that it differs markedly from discharge patterns in the unregulated branches of the Ontonagon River system (e.g., East Branch; see **Hydrology**). To improve fish habitat in the West Branch, the current FERC license specifies minimum water releases from the Bergland Dam. The dual requirements of minimum flow releases and target lake levels could be conflicting during dry periods, so UPPCo, MDNR, and other interested parties are in the process of refining the minimum flow requirements to ensure that discharge requirements for the West Branch can be met without compromising recreational opportunities on Lake Gogebic.

A structure known as a Barr Fish Lock was installed in 1934 to facilitate upstream fish passage at the Bergland Dam. Few records remain regarding operation of this structure, but it appears that it was not very successful.

Victoria Dam is the focal point of UPPCo's hydroelectric operations in the Ontonagon River watershed. The existing dam was built in 1931 to replace the old Copper District Power Company dam at the same location (see **History**). Water reaching Victoria Dam is diverted into a steel pipeline that leads to the powerhouse. After passing through the turbines, the water is released back into the river approximately 1.6 miles downstream of the dam. When the storage capacity of the dam is exceeded, water flows over the spillway into the original riverbed. The current FERC license requires minimum flows of 82 cfs into the original stream channel from 01 May through 10 June. During the rest of the year, this bypassed reach of the West Branch is generally dewatered.

Entrainment of fish at the Victoria hydroelectric facility was evaluated from April, 1994 to February, 1995. The estimated annual entrainment for all species was 234,784 fish, and the estimated mortality was 71,141 fish (RMC Environmental Services 1995). The species most commonly entrained were yellow perch, golden shiner, common shiner, and black crappie. Small fish (≤4 in total length) made up over 93% of all estimated mortalities (RMC Environmental Services 1995).

Photo 4.–Victoria Dam, West Branch Ontonagon River.

During late spring through autumn, UPPCo maintains a target reservoir elevation of 907.1 ft above sea level to provide maximum head for power generation, but reservoir water levels often fluctuate as much as 3 ft per day. The Victoria impoundment is drawn down 14 ft (elevation = 893.1 ft above sea level) in March to allow deicing of spillway gates and provide additional storage for spring runoff. As discussed above for the Bond Falls Flowage, these winter drawdowns substantially reduce the amount of available habitat for fish and other aquatic organisms.

Trout Brook Dam is the only registered private dam in the West Branch subwatershed. Fisheries Division files indicate that this dam was built in the early 1960s to create a small trout pond. Trout Brook Dam is located about 250 ft upstream from the confluence of Trout Brook with Lake Gogebic.

Victoria Falls is the upstream barrier for fish migrating from Lake Superior. (Victoria Dam is located immediately above Victoria Falls, so the dam and falls act as one barrier.) There are three waterfalls on tributaries to Lake Gogebic and three additional waterfalls on tributaries to the West Branch. Some of these waterfalls may restrict fish movements, especially under low flow conditions.

Water Quality

In general, water quality in the Ontonagon River watershed is excellent and essentially unchanged since the time of settlement by Europeans. Three factors have favored the retention of high water quality within the basin: low human population density, sparse agricultural land, and minimal industrial development.

Sediment is the primary pollutant. The main stem Ontonagon River is naturally turbid, as evidenced by early historical accounts. Henry Rowe Schoolcraft (1992), who visited the region in 1820, left this description of the main stem. “Its waters have a reddish colour [sic], like those of the Arkansas, and are moderately turbid.”

Poor land use practices associated with stream crossings, road maintenance, and logging operations have led to increased erosion and sedimentation in some areas. MDNR, USFS, and other organizations have completed various habitat improvement projects to reduce sediment inflows and remove sediment that had entered the system as a result of human activities.

Thermal pollution is a concern for stream reaches immediately downstream of dams (see **Dams and Barriers**). Most of the dams are relatively small, and two of the larger dams (Cisco Dam and Bergland Dam) were built at the outlets of large natural lakes. Thus, thermal pollution probably has only minor effects on aquatic communities in the Ontonagon River system.

During the mining era (1847–1921), waste rock from copper mines was deposited on the surface (see **History**). When sulfur-bearing minerals were present in the waste rock, these materials reacted with water to form sulfuric acid. Several mines were located near streams, so some of this acid mine drainage may have reached the Ontonagon River system. The effects of acid mine drainage on fish communities within the Ontonagon River watershed are unknown, but recent studies indicate that most fish eggs cannot hatch in water with a pH $\leq$5 (United States Environmental Protection Agency 2007). Thus, acid mine drainage may have prevented reproduction of fish species in stream reaches immediately downstream of waste rock piles.

Airborne mercury contamination affects the Ontonagon River and most other waters in Michigan. The rock surrounding many of the lakes and streams in the western Upper Peninsula also provides a natural source of mercury to surface waters. Mercury accumulates in the tissues of fish (especially piscivorous species), and the effects of this mercury contamination on humans who consume fish is a matter of great public concern. Due to the broad geographic scale of mercury contamination, the Michigan Department of Community Health (2007) has issued statewide fish consumption advisories for several game fish species from inland lakes. Additional fish consumption advisories have been issued for walleye in the Cisco Chain and Duck, Gogebic, and Langford lakes in the Ontonagon River basin (Michigan Department of Community Health 2007).

NPDES Permit Program

Point source discharges to surface waters are regulated by the National Pollutant Discharge Elimination System (NPDES) permitting program. This is a federal permit system that is administered by the Michigan Department of Environmental Quality – Water Bureau. Under the NPDES program, point source discharges to state waters must be authorized by permit. These permits, which must be renewed every five years, specify limits on the amount and types of pollutants that can be discharged.

Permittees are required to sample their discharges for pollutants and report these results to MDEQ. In addition, MDEQ personnel periodically inspect the facilities to ensure compliance with permit conditions.

There are eleven active NPDES permits in the Ontonagon River watershed (Table 13; T. Mitchell, Michigan Department of Environmental Quality, Water Bureau, personal communication). Seven of these permits were issued for municipal waste water sewage lagoons, one was issued to the Ontonagon County Road Commission, and two were issued to private industries. In 2005, an additional permit was issued to the Michigan Department of Transportation for the M-64 bridge relocation project at the Ontonagon River in the village of Ontonagon.

NPDES Storm Water Permits

Storm water running through urban areas, industrial facilities, or construction sites can transport pollutants into adjacent lakes and streams. Storm water drainage systems from large impervious areas (e.g., parking lots) can concentrate runoff and transport it to the stream rapidly, leading to more flashy flow regimes and accelerated erosion of stream banks. The NPDES storm water permit system administered by MDEQ regulates storm water discharges to state waters. Pitlik and Wick, Inc. of Watersmeet, which manufactures asphalt for road and driveway paving, has the only active NPDES storm water permit.

MDEQ Procedure 51 Monitoring

The MDEQ staff surveyed the Ontonagon River watershed in 2003 using the methods outlined in Procedure 51 – Qualitative Biological and Habitat Protocols for Wadeable Streams and Rivers (Michigan Department of Environmental Quality 2002). This comprehensive sampling protocol was designed to evaluate macroinvertebrate communities, instream and riparian habitat, and water quality within the subject streams.

Macroinvertebrate community composition was evaluated at nine sites within the basin. The macroinvertebrate communities at six of these sites were rated “acceptable”, and three were rated “excellent” (Taft 2004).

> Macroinvertebrates such as mayflies, stoneflies, and caddisflies are important indicators of water quality because they have a long life history and are intolerant of pollution and low dissolved oxygen. Three orders of insects are often grouped together and termed EPT for their scientific names (mayflies – Ephemeroptera, stoneflies – Plecoptera, caddisflies – Trichoptera). [From Cwalinski et al. 2006.]

Stations that were rated “excellent” had macroinvertebrate communities that were dominated by EPT species.

Water chemistry samples were collected at 11 sites within the Ontonagon River watershed. Although no chemicals were found at levels exceeding Michigan Water Quality Standards, analysis of the samples indicated that the Ontonagon River system has very soft water. Alkalinities for the various streams ranged from 46 mg/L for Pelton Creek to 82 mg/L for the Middle Branch at Watersmeet (Taft 2004). Soft water systems have limited buffering capacities, and several lakes within the basin are acidic. During the 1980s, MDNR contracted Living Lakes Inc. to apply lime to some of these lakes (e.g., Bob and Long lakes) to raise the pH to slightly above neutral. These lime applications only caused temporary pH changes. For example, Bob Lake was limed twice, and after both treatments the lake returned to its pretreatment pH in less than ten years (MDNR, Fisheries Division files).

Water Quality Legislation

Most state laws administered by MDEQ – Water Bureau are contained in Parts 31 (Water Resources Protection), 41 (Sewerage Systems), and 88 (Water Pollution Prevention and Monitoring) of the Natural Resources and Environmental Protection Act, Act 451 of 1994. Public Act 451 can be viewed on the Michigan Legislature web site at www.legislature.mi.gov.

> [The MDEQ – Water Bureau] also administers parts of the Federal Clean Water Act (CWA) including the National Pollutant Discharge Elimination System and Section 319.… The CWA is a 1977 amendment to the Federal Water Pollution Control Act of 1972, which set the basic structure for regulating discharges of pollutants to waters of the United States. The law gave EPA [Environmental Protection Agency] the authority to set effluent standards on an industry basis (technology-based) and continued the requirements to set water quality standards for all contaminants in surface waters. The CWA makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit (NPDES) is obtained under the Act. The 1977 amendments focused on toxic pollutants. In 1987, the CWA was reauthorized and again focused on toxic substances, authorized citizen suit provisions, and funded sewage treatment plants … under the Construction Grants Program.
>
> The CWA contains provisions for the delegation of many permitting, administrative, and enforcement aspects of the law by EPA to state governments. In states [such as Michigan] with the authority to implement CWA programs, EPA still retains oversight responsibilities. [From Madison and Lockwood 2004.]

Stream Classification

In 1967, MDNR, Fisheries Division instituted a stream classification system based on water temperature, stream size, habitat quality, and riparian development. This classification system was developed to help resource managers establish water quality standards, evaluate stream recreation values, determine priorities for fishing or boating access and riparian land acquisitions, identify stream reaches with the greatest needs for improvement or preservation, develop appropriate fishing regulations, and detect potential dam and impoundment problems.

Coldwater stream reaches encompass 389 mi (30%) of the Ontonagon River system (Figure 42). Portions of the upper Middle Branch, the Baltimore River, and several small tributaries to the East Branch and Lake Gogebic were classified as top quality coldwater reaches. The main stem, South Branch, and West Branch are primarily warmwater systems.

Baker (2006) developed a new landscape-based classification system for stream valley segments in Michigan’s Upper Peninsula using an approach that was originally developed for Lower Peninsula streams (Seelbach et al. 2006). Attributes such as stream size, temperature, hydrology, gradient, water chemistry, fish community, and Great Lakes connectivity were used to delineate and classify 65 discrete valley segments within the Ontonagon River watershed. Two of these valley segments are covered by the Bond Falls and Victoria impoundments.

For the purposes of this assessment, valley segment classifications will be discussed in relation to stream size and temperature. Valley segments were divided into four size categories based on the catchment area at the midpoint of the segment: small (headwater) = 10–40 mi^2, medium = 40–179 mi^2, large = 180–620 mi^2, and very large = >620 mi^2. Valley segments were also classified into three temperature categories based on the mean stream temperature during the first three weeks of July: cold = <66°F, cool = 66–72°F, and warm = >72° F. Because brook trout rarely are abundant in streams with mean July water temperatures greater than 66°F (A. Nuhfer, MDNR, Fisheries Division, personal communication), streams classified as "cold" are considered to have the most potential for trout production.

Cold headwater valley segments make up 26% of the total river miles within the Ontonagon River basin (Table 14). These valley segments are distributed primarily in the southern half of the watershed (Figure 43). Cold medium valley segments exist on the upper reaches of the East and Middle branches. The East Branch (between Kenton and Mass City) is the only cold large stream in the basin.

Cool small streams (29% of total) are common in the central portion of the watershed. Cool medium valley segments exist on Ten Mile Creek, Trout Creek, the Baltimore River, and the lower Cisco Branch. The South Branch, lower Middle Branch, and the lower East Branch are cool large streams, whereas the main stem and the lower West Branch (downstream of the South Branch confluence) are considered cool very large streams.

The upper portions of the Cisco and West branches are classified as warm medium streams. The only warm large valley segment in the watershed is on the West Branch between the Mill Creek and South Branch confluences.

Special Jurisdictions

Several different governmental entities have jurisdiction over various portions of the Ontonagon River watershed. The regulations instituted by these organizations greatly influence human development in the watershed.

United States Army Corps of Engineers

The United States Army Corps of Engineers, Detroit District, possesses navigational jurisdiction over United States waters up to the ordinary high water mark for Lake Superior (603.1 ft above sea level). The Corps' management authorities are derived from the following laws.

> **Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403)** prohibits the obstruction or alteration of navigable waters of the United States without a permit from the Corps of Engineers.
>
> **Section 404 of the Clean Water Act (33 U.S.C. 1344, [Section 301])** … prohibits the discharge of dredged or fill material into the waters of the United States without a permit from the Corps of Engineers. [From Madison and Lockwood 2004.]

The Corps of Engineers is also responsible for maintaining shipping channels at various Great Lakes ports. The lower Ontonagon River, from the mouth to the old M-64 bridge (which was removed in 2006), is regularly dredged by the Corps to facilitate ship traffic and coal delivery to the fiber mill (Stone Container) in Ontonagon.

Navigable Waters

Issues pertaining to navigability and public use of navigable waters have been debated for many years, and water laws continue to evolve through legislative processes and judicial action. Currently, a navigable inland stream is defined as (1) any stream declared navigable by the Michigan Supreme Court; (2) any stream included within the list of navigable waters regulated by the Corps of Engineers 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; (4) any stream having an average flow of approximately 41 cfs, an average width of 30 feet, an average depth of about 1 foot, capacity for floatage during spring 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 commerce or travel; or (6) any stream meandered by the General Land Office Survey in the mid-1800s (Anonymous 1993).

The lower Ontonagon River from the mouth to the first railroad bridge (0.76 miles upstream from the mouth) is included within the list of navigable waters under the jurisdiction of the Corps of Engineers. Although no streams within the basin have been declared navigable by the Michigan Supreme Court, many streams could be considered navigable based on criteria 3 through 6.

In Michigan, the right to public use of navigable waters includes the right to float the stream and the right of trespass upon submerged soil (but not on the adjacent uplands). The public also has the right to fish in navigable streams, subject to state regulations.

Federally Regulated Dams

Under the Federal Power Act of 1935, all hydroelectric dams are required to obtain operating licenses through FERC. Before FERC issues a new license for a dam within the Ontonagon River basin, various resource agencies and stakeholder groups (e.g., MDNR, MDEQ, USFWS, USFS, Trout Unlimited, Keweenaw Bay Indian Community, local sport fishing groups, and lake associations) have an opportunity to articulate their concerns regarding the proposed dam operations. After a lengthy review process, all five of the hydroelectric-related dams in the Ontonagon River watershed were relicensed in August 2003 (Appendix A).

Wild and Scenic Rivers

Four of the five main branches in the Ontonagon River system have stream reaches that are designated as Federal Wild and Scenic Rivers under the National Wild and Scenic Rivers Act (Public Law 90-542). The purpose of this act is to ensure that “certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations.” This Act specifies a variety of restrictions on human activities (e.g., dam construction and road development) along designated stream reaches that are designed to preserve the wild character of these streams. The Wild and Scenic River designation only applies to federal lands, so designated stream reaches generally flow mostly or entirely through National Forest land.

Under the National Wild and Scenic Rivers Act, designated river reaches are assigned to one of three categories: wild, scenic, or recreational. Wild rivers are free of impoundments, have shorelines that are essentially undeveloped, and are generally inaccessible except by trails. Scenic rivers are also free of impoundments and have largely undeveloped shorelines, but road construction has made these rivers readily accessible. Recreational rivers often have some development along their shorelines, may have undergone some diversion or impoundment in the past, and are readily accessible by train or automobile. In the Ontonagon River system, 42.9 miles are classified as wild, 41.0 miles are classified as scenic, and 73.5 miles are classified as recreational. These designated river reaches include portions of the East, Middle, West, and Cisco branches of the Ontonagon River (Figure 44).

National Forest

Much of the Ontonagon River watershed is located within the Ottawa National Forest and is under the jurisdiction of USFS. The Ottawa National Forest was established in 1931 and currently encompasses nearly one million acres of land in the western Upper Peninsula. The forest is managed from the supervisory office in Ironwood and four district offices in Iron River, Watersmeet, Kenton, and Ontonagon. The Ottawa Visitor Center, located at the junction of US-2 and US-45 in Watersmeet, provides visitors with information on the natural resources and recreational opportunities within the forest. In addition, the J. W. Tourney Nursery (also in Watersmeet) raises tree seedlings for seven national forests in Michigan, Wisconsin, and Minnesota. USFS manages eight campgrounds within the Ontonagon River watershed (Table 15).

Three wilderness areas (Sylvania, McCormick, and Sturgeon River Gorge) exist within the Ottawa National Forest, and one of these, the Sylvania Wilderness, is located in the Ontonagon River watershed (Figure 44). The Sylvania Wilderness encompasses an area of 18,327 acres and includes 34 named lakes. Public use of this area includes fishing, canoeing, hiking, and primitive camping. Motors are prohibited on all Sylvania lakes except Crooked Lake, where electric motors are allowed. A combination of high minimum size limits, reduced bag limits, and gear restrictions have been used by MDNR to maintain high quality fisheries in Sylvania lakes. In particular, the catch-and-release fisheries for smallmouth bass in several Sylvania lakes have received widespread recognition.

The USFS Fisheries Program evaluates aquatic habitat conditions and performs habitat improvement projects on waters within the Ottawa National Forest. Fisheries Program personnel also conduct fish community surveys and assist MDNR with various fisheries projects within the Ontonagon River watershed.

United States Fish and Wildlife Service

The USFWS Marquette Biological Station maintains responsibility for sea lamprey control and assessment activities on Lake Superior tributaries. USFWS Ashland Fishery Resources Office also conducts fisheries surveys and habitat improvement projects on United States waters within the Lake Superior basin.

State Government

The two state agencies that have the most influence on land and water management activities within the Ontonagon River watershed are MDNR and MDEQ. MDNR is responsible for managing fish, wildlife, and forestry resources, and MDEQ institutes and enforces water quality standards. For the Wisconsin portion of the watershed, the Wisconsin Department of Natural Resources (WDNR) performs roles similar to those of MDNR and MDEQ in Michigan.

Michigan Department of Natural Resources

Various divisions of MDNR are involved in managing the natural resources within the Ontonagon River watershed. MDNR offices located in Baraga, Crystal Falls, Marquette, and Twin Lakes all have some management jurisdiction within the watershed.

As outlined in the Sikes Act (Public Law 86-797), MDNR, Fisheries Division is the lead authority for fisheries management in Michigan waters (including those waters that are within the Ottawa National Forest). Fisheries Division activities include fish stocking, fish community assessments, and aquatic habitat restoration. In addition, Fisheries Division establishes fishing regulations in Michigan waters. Amphibians and reptiles also fall under the jurisdiction of MDNR, Fisheries Division.

Hunting and trapping activities within the watershed are supervised by MDNR, Wildlife Division. Wildlife Division activities include monitoring populations of game animals, instituting and evaluating hunting and trapping regulations, and working with MDNR, Forest, Mineral and Fire Management Division (FMFM) to protect and enhance wildlife habitat in the western Upper Peninsula.

The MDNR, FMFM manages silvicultural and recreational activities within the Copper Country State Forest. FMFM maintains snowmobile and off-road vehicle trails, plans and oversees logging operations, and maintains hiking pathways and campgrounds on state lands. In the Ontonagon River watershed, state forest land largely is limited to the area around Mill Creek (Main Stem subwatershed).

The MDNR, Parks and Recreation Division operates Lake Gogebic State Park on the west shore of Lake Gogebic. This park spans 360 acres and includes nearly one mile of lake frontage. Parks and Recreation Division also oversees access to two state scenic sites: Bond Falls and Agate Falls on the Middle Branch Ontonagon River. In addition, Parks and Recreation Division maintains jurisdiction over 11 public boat launches in the watershed (see **Recreational Use**).

Fishing and hunting regulations are enforced by MDNR Law Enforcement Division. Law Enforcement Division works with Fisheries and Wildlife divisions to develop regulations that are biologically sound and practical to implement.

Michigan Department of Environmental Quality

The MDEQ is the primary regulatory authority for administering the Michigan Natural Resources and Environmental Protection Act of 1994 (Public Act 451) as it pertains to water quality issues (Table 16). Among other things, this Act gives the State the authority to protect and conserve its water resources, to identify sites of environmental contamination, and to request responsible parties to take actions to repair affected areas. Examples of activities that require MDEQ approval include dredging, installation of dams or stream crossings, and shoreline modifications (e.g., riprap installation).

Local Government

Local units of government have authority to implement special ordinances and zoning restrictions that can influence land use patterns within the basin. County road commissions also influence sediment inflows to streams through their road construction and maintenance activities. County drain commissioners are responsible for maintaining legally established drains under the Michigan Drain Code Act of 1956 (Act 40). Ontonagon County is the only county within the watershed that does not have a drain commissioner. Due to scarcity of suitable agricultural land and the remote location of the Ontonagon River, there are no designated drains in the watershed.

University of Notre Dame

University of Notre Dame owns several thousand acres of land in the southern portion of the Cisco Branch subwatershed. Tenderfoot Creek bisects the Notre Dame property, and numerous lakes (e.g., Bay, Long, and Bergner lakes) are located entirely within the university's ownership. These lakes are closed to the public, which allows researchers to conduct controlled experiments that would not be practical to perform on public waters.

Biological Communities

Original Fish Communities

Little information is available regarding the fish communities that existed in the Ontonagon River basin prior to settlement by Europeans. Archeological research and descriptions by early European visitors provided basic information on the major fish species used by humans. Distributions of nongame species were reconstructed primarily from regional (usually Lake Superior wide) descriptions of native fish fauna.

The main species mentioned by virtually all early European visitors to the area was lake sturgeon. Lake sturgeon typically spend most of their lives in Lake Superior and return to their native rivers to spawn during spring. The Chippewa constructed elaborate weirs to facilitate harvest of spawning lake sturgeon in the Ontonagon River (Danziger 1979; Jamison 1948; Lulich 1998). Lake sturgeon were allowed to pass upstream through a small opening in the weir. This opening was eventually closed, and the fish were harvested during their downstream migration. Lake sturgeon were so abundant in the Ontonagon River that they provided the main means of subsistence for the Chippewa (Schoolcraft 1992).

At least two different weir sites were used by the Chippewa. Henry Rowe Schoolcraft described a weir located four miles upstream of the river mouth (Schoolcraft 1992), and Lt. James Allen observed a similar weir approximately 17 miles from the mouth (B. Mead, Michigan Department of State, Office of the State Archaeologist, personal communication). These historical accounts indicate that lake sturgeon migrated through most of the main stem. Previous authors (Harkness and Dymond 1961) have observed that lake sturgeon often migrate as far upstream as possible before spawning. "All accounts agree in suggesting that sturgeon pass through minor rapids in the course of a spawning river and only spawn in rapids at the foot of falls which bar their further progress upstream."

If Harkness and Dymond were correct, then lake sturgeon probably spawned below Victoria Falls (West Branch), Agate Falls (Middle Branch), and perhaps Onion or Duppy falls (East Branch subwatershed).

Additional fish species harvested by the Chippewa included lake trout, lake whitefish, lake herring, round whitefish, walleye, white sucker, yellow perch, and northern pike (Cleland 1982; Jamison 1948; B. Mead, Michigan Department of State, Office of the State Archaeologist, personal communication). Although the Chippewa harvested fish from a variety of waters within the Ontonagon River basin, it appears that most fishing activity was concentrated near the mouth of the main stem (B. Mead, Michigan Department of State, Office of the State Archaeologist, personal communication).

Coon (1999) estimated that 69 fish species were native to the Lake Superior basin. Many of these species occupied the Ontonagon River system, at least on a seasonal basis. Brook trout resided in cold groundwater-fed streams, while coolwater fishes (e.g., northern pike and smallmouth bass) were found in the lakes and lower stream reaches within the watershed.

Numerous Lake Superior fish species used the Ontonagon River and its tributaries for spawning and nursery habitat. Lake sturgeon, white sucker, longnose sucker, shorthead redhorse, and walleye ascended the river in the spring. Lake trout, lake whitefish, lake herring, and round whitefish moved into the main stem during fall, and burbot probably migrated into the Ontonagon River during winter. Waterfalls prevented upstream movement of fish into some streams. Major barriers to fish passage included Agate Falls (Middle Branch), Victoria Falls (West Branch), O Kun de Kun Falls (Baltimore River), and Onion Falls (Onion Creek; Figure 41).

Factors Affecting Fish Communities

Many changes have occurred in the Ontonagon River watershed since the arrival of Europeans. As populations expanded, human activities in the region resulted in physical alterations of the stream channel and changes in the species composition of aquatic communities.

The intensive removal of beaver during the fur trading era (approximately 1630 to 1840) presumably altered the hydrology, channel morphology, and temperature regimes in many of the smaller streams within the Ontonagon River watershed. Declining numbers of beaver dams likely reduced water temperatures, exposed larger areas of gravel substrate, and reduced fragmentation of fish populations. Brook trout abundance probably increased as a result of these habitat changes, but abundance of some other fish (e.g., bluegill, yellow perch, and northern redbelly dace) and wildlife (e.g., ducks and herons) species may have declined.

Logging operations during the late 1800s dramatically affected the Ontonagon River watershed (see **History**). Removal of trees from riparian areas led to increased erosion of stream banks and subsequent inflow of sediment to the stream. The absence of shade trees also caused water temperatures to increase, and removal of large woody structure decreased habitat for fish and aquatic invertebrates. Removal of trees from the riparian zone and adjacent uplands also increased the rate at which water entered the stream during storm events, resulting in a flashier flow regime.

River logging drives substantially altered the morphology of stream channels. The rapid release of logs and water from logging dams led to extensive scouring of the stream bed and banks downstream. These human-caused flood events also resulted in mortality of fishes and other aquatic animals.

Logging continues to be a major industry in the Ontonagon River watershed. Most modern logging companies employ best management practices (e.g., riparian buffer strips) to minimize negative effects on streams, lakes, and wetlands, but poor land use practices by some loggers still contribute large amounts of sediment to adjacent waters.

Commercial overfishing during the late 19th century and early 20th century also affected fish communities in the Ontonagon River watershed. Although accurate records of commercial harvest were not recorded until the 1880s, it appears that habitat degradation (i.e., from logging operations) and commercial harvest had already depleted many Great Lakes fish populations by that time. Michigan Fisheries Superintendent Walter D. Marks provided this description of Great Lakes commercial fisheries in 1884.

> The fishing grounds are one after the other fished out, and then new places sought where the same process is repeated. If each ground, as it becomes unprofitable for large operations was actually abandoned and allowed to rest, it would undoubtedly be slowly restored to productiveness by natural processes, because the fishing would become unprofitable before the last fish was taken, but this seldom happens. [From Tody 1974.]

Lake trout and lake whitefish composed the bulk of the commercial harvest near the mouth of the Ontonagon River (Nute 1944). Although primarily lake-dwelling species, these fishes seasonally occupied the lower reaches of the main stem and were important food sources for the Chippewa.

Commercial fishing probably was a major factor contributing to the extirpation of lake sturgeon in the Ontonagon River system. In the early days of the Great Lakes commercial fishery, lake sturgeon were regarded as a nuisance and often were clubbed to death or thrown on land (Brousseau 1987). As markets were created for caviar and smoked lake sturgeon flesh, a targeted lake sturgeon fishery developed. This fishery was short-lived, however, because the life history characteristics of lake sturgeon (late age of maturity and infrequent spawning after maturity) make them particularly vulnerable to overexploitation. By 1900, most lake sturgeon populations around the Great Lakes had been extirpated or severely depleted (Tody 1974).

Temporary logging dams were constructed in a variety of streams during the late 1800s, but the first “permanent” dam was not built until after the turn of the century (see **Dams and Barriers**). Victoria Dam and the associated Taylor compressor were in operation by 1906. In 1931, the original Victoria Dam was replaced by the new Victoria Dam and hydroelectric facility. The four dams (Cisco, Bergland, Bond Falls, and Bond Falls Control) associated with the Victoria hydroelectric facility were all in place by 1938.

Dam construction has affected the Ontonagon River and its tributaries through a variety of mechanisms. Dams interfere with fish migrations, alter flow regimes, reduce the frequency and severity of flooding, and block the downstream movement of sediment, large woody structure, and detritus. Impounding water behind dams also exposes a larger surface area of water to radiant sunlight, leading to increased evaporation rates and elevated water temperatures in the stream below.

Operation of the Bond Falls diversion has dramatically altered the hydrology of the Middle Branch, South Branch, and West Branch of the Ontonagon River (see **Hydrology**). Although all dams alter flow regimes to some extent, the Bond Falls diversion actually shunts water from the Middle Branch into the South Branch. Previous studies have demonstrated that alterations in stream flow patterns can affect fish spawning activities (Auer 1996; Paragamian et al. 2005; Friday 2006). During the recent FERC relicensing process for the Bond Falls Development, MDNR and other interested parties negotiated with UPPCo to provide water releases into the Middle Branch that more closely approximate a natural flow regime (Appendix A).

The introduction of nonnative species has markedly altered the fish assemblages. Some of these species were intentionally introduced to create additional fishing opportunities. Intentionally introduced species, such as rainbow trout, brown trout, and coho salmon, have become major components of the fish community in many stream reaches. Three species (common carp, pink salmon, and Atlantic salmon) that were introduced into other regions of the Great Lakes basin have also been collected near the mouth of the Ontonagon River. Additional fish species have gained access to Lake Superior and the Ontonagon River via the Welland Canal around Niagara Falls and associated ship traffic. The most notable aquatic invasive species is the sea lamprey, which has established populations in many streams that have Great Lakes access.

Various other human activities have modified fish communities within the basin. For example, the construction of road stream crossings has affected fish communities by interfering with fish movements, fragmenting fish populations, and increasing sediment to streams (see **Soils and Land Use**). Harbor improvement activities (e.g., dredging and bank stabilization) have also affected fish communities in the lower main stem by increasing the water depth and altering the morphology of the river channel.

Present Fish Communities

Biological surveys conducted since the 1920s have documented the presence of 74 fish species in the Ontonagon River watershed (Table 17). Many fish species are widely distributed within the basin, while others are restricted to isolated lakes or stream reaches (Appendix B). The recorded distributions are only rough approximations, however, because detailed survey information is only available for a small percentage of the waters in the basin. Little or no data are available for remote regions of the watershed, including many of the smaller lakes and tributaries.

A few of the species included in MDNR, Fisheries Division records may have been misidentified. For example, the juvenile northern longear sunfish reported in Thousand Island Lake probably was a misidentified bluegill or pumpkinseed. Records from numerous MDNR surveys and the University of Michigan, Museums Fisheries Library indicate that longear sunfish are not present in the Upper Peninsula, whereas bluegill and pumpkinseed are common in Thousand Island Lake. Shiners (family Cyprinidae) are notoriously difficult to assign to species, and it is likely that some of the shiners collected in the Ontonagon River watershed have been misidentified. For example, the spotfin shiners documented in Perch Lake actually may have been spottail shiners or perhaps common shiners which are known to inhabit Perch Lake. In addition, researchers did not always distinguish between bullhead species on survey forms, and in some instances it appears that the same species was identified as black bullhead and brown bullhead during consecutive surveys at the same location. Similarly, researchers rarely discriminated between the two species of native lampreys, coding them both as "*Ichthyomyzon* spp."

A particularly intriguing situation regarding fish identification has occurred on Clark Lake (upper Middle Branch subwatershed). In 1966, MDNR researchers collected 7 margined madtoms in this lake. Identification of these specimens was corroborated by Dr. William R. Taylor, one of the leading experts in *Noturus* species. Margined madtoms subsequently were collected in Clark Lake in 1986 and 1989. Within the Great Lakes basin, margined madtoms are only native to a few southern Lake Ontario tributaries. There are no other known populations of margined madtoms within hundreds of miles of the Clark Lake population. In an interesting twist to this story, a similar fish species, the stonecat, was reported in Clark Lake during surveys conducted in 1997 and 2000. Stonecats are native to portions of the Lower Peninsula and northern Wisconsin, but no there are no other known stonecat populations in the Upper Peninsula. It is possible that the "stonecats" reported during recent surveys were misidentified margined madtoms. However, it also is plausible that stonecats were inadvertently transferred to Clark Lake by anglers. Voucher specimens should be collected during future surveys to facilitate positive identification of samples.

The distribution of fish species is strongly influenced by physical attributes such as water temperature, stream size, hydrology, and gradient. Water temperature and stream size are two of the most important factors determining the distribution of fishes. For example, coldwater species (e.g., brook trout) typically are found in groundwater-fed streams that remain cold throughout the summer, whereas coolwater species (e.g., yellow perch) can survive in streams with wider temperature fluctuations. Lake sturgeon and Chinook salmon generally are found in large rivers, whereas brook trout and mottled sculpin more commonly inhabit small- to medium-sized streams. Because fish distributions are so strongly influenced by physical habitat, Fisheries Division's valley segment classification system can be used to generate expected fish communities in streams with little or no survey data. The valley segment model can also be used to identify fish communities that differ markedly from the expected species composition, perhaps due to human activities.

Although the following discussion is restricted to riverine fish communities, productive fisheries exist in many of the lakes within the Ontonagon River watershed. The fish communities in these lakes typically consist of a mixture of coolwater and warmwater species. Game fish species present in these lakes include northern pike, muskellunge, pumpkinseed, bluegill, smallmouth bass, largemouth bass, black crappie, yellow perch, and walleye. Lake trout and lake herring inhabit some of the larger lakes in the basin (e.g., Clark Lake), but these species are generally found only in low numbers. Nongame species commonly found in lakes include white sucker, creek chub, golden shiner, common shiner, mottled sculpin, and johnny darter.

Middle Branch—upper

Twenty-five fish species have been collected in the upper Middle Branch. Most of the stream valley segments within this subwatershed are classified as cold headwaters and have fish communities dominated by coldwater species (Figure 43).

From the origin at Crooked Lake to US-2, coolwater and warmwater fish species compose a large percentage of the fish community. Downstream from US-2, the influx of cold water from springs and tributaries (e.g., Duck Creek) creates better habitat conditions for trout and other coldwater species. Brook trout are abundant in the Middle Branch near Watersmeet. Mottled sculpin, blacknose dace, and white sucker are also common in this stream reach.

Both brook trout and brown trout are found between Bond Falls and Agate Falls, with brook trout being the more abundant species. Other common species in this river segment include longnose dace, blacknose dace, and mottled sculpin. This stream reach is classified as a cool large stream. The valley segment model identified this reach as “marginal trout” water, with brown trout as the primary game fish species. In this instance, survey data indicate that brook trout abundance is higher than the model predicted.

Duck and McGinty creeks are major coldwater tributaries to the upper Middle Branch. The fish communities in these streams consist largely of brook trout, mottled sculpin, and creek chub. The Tamarack River is classified as a cool small stream. This river supports a modest brook trout population (which may have to move into the Middle Branch to find thermal refugia during summer). Mottled sculpin, creek chub, hornyhead chub, and longnose dace are also common in the Tamarack River.

Middle Branch—lower

The lower Middle Branch and most of its tributaries are classified as coolwater streams. Groundwater inflows subside as the stream flows northward, so resident coldwater species are more abundant in the upper end of this river segment. The lower Middle Branch is accessible to fish species migrating from Lake Superior, and the species composition of the fish community varies throughout the year.

Due to the scarcity of road access to the lower Middle Branch, fisheries surveys have only been conducted on the stream reach immediately below Agate Falls. Seventeen fish species have been captured at this location. Brook trout and some brown trout reside below Agate Falls throughout the year. Steelhead, coho salmon, and potamodromous brown trout also use the lower Middle Branch as spawning and nursery habitat. Additional fish species collected below Agate Falls include mottled sculpin, white sucker, creek chub, and smallmouth bass.

Under the valley segment classification system, the lower Middle Branch is expected to be a marginal trout stream with brown trout as the dominant trout species. Based on survey data and angler reports, brown trout make up a substantial portion of the salmonid community in the lower Middle Branch, so the model predictions are accurate for this stream.

The headwaters of Trout Creek is the only coldwater stream reach in the lower Middle Branch subwatershed. When this stream was surveyed in 2004, brook trout, blacknose dace, creek chub, and northern redbelly dace were found to be common (J. Pagel, USFS, Ottawa National Forest, personal communication). The downstream half of Trout Creek is considered a cool medium stream. During the 2006 survey, a few brown trout were collected in this valley segment, but coolwater and warmwater fish composed the bulk of the fish community.

The Baltimore River is another major tributary to the lower Middle Branch. The only substantial groundwater inflows are at the headwaters, so the Baltimore River and all of its tributaries are classified as coolwater streams. Thirteen fish species have been found in this stream, including brook trout, brown trout, steelhead, white sucker, trout perch, and slimy sculpin. Based on the valley segment model, trout were not expected to reside in the Baltimore River system. The limited data available suggest that the Baltimore River and its tributaries are marginal trout streams, but trout are able to find localized areas (e.g., small groundwater seeps) with suitable habitat.

Main Stem

The fish community in the main stem Ontonagon River changes seasonally due to the migratory patterns of potamodromous fishes from Lake Superior. Spring migrants include steelhead, walleye, and muskellunge. In the fall, brown trout, coho salmon, and Chinook salmon enter the main stem. A number of other fishes occupy the main stem year-round, including warmwater species such as black crappie, rock bass, and brown bullhead. Overall, 39 species have been collected in the main stem.

Lake sturgeon were reintroduced into the Ontonagon River in 1998 (see **Fishery Management**). Although it is much too soon to expect the return of adult lake sturgeon, numerous juveniles have been captured during sampling efforts in the lower river (Fillmore 2003).

East Branch

The East Branch is considered a coldwater stream for most of its length, with predicted fish communities dominated by brook trout and brown trout. Surveys indicate that brook trout, brown trout (resident and potamodromous), coho salmon, and steelhead are the main game fish species in the East Branch. Blacknose dace, longnose dace, slimy sculpin, white sucker, and creek chub are also commonly encountered in this stream. Resident trout are most abundant in the stream reach from Lower Dam to Sparrow Rapids (Kenton). Trout abundance decreases below Sparrow Rapids, and warmwater fish species dominate the fish community downstream from Newholm Creek.

Several coldwater tributaries flow into the East Branch. Potamodromous steelhead, coho salmon, and brown trout use most of these tributaries for spawning, but Onion Falls blocks upstream movement of fish into the Onion River. East Branch tributaries generally have strong populations of wild brook trout. The Keweenaw Bay Indian Community Natural Resources Department has recently developed a new hatchery strain of brook trout from the Jumbo River population for stocking in various Lake Superior tributaries, including some streams within the Ontonagon River basin (see **Fishery Management**). A variety of nongame species also inhabit East Branch tributaries, including blacknose dace, creek chub, mottled sculpin, longnose dace, and white sucker.

Cisco Branch

The Cisco Branch is classified as a warm medium stream. In 2006, the mean July water temperature at the Forest Route 6930 crossing (about 2 miles upstream of Twomile Creek) was 71.1°F, so the temperature classification for this stream is questionable. The valley segment model identified the various reaches of the Cisco Branch as “creek chub” or “white sucker” water, with predicted fish communities consisting of minnow species and other warmwater fishes.

Survey data indicate that warmwater fish species predominate in the upper Cisco Branch from Cisco Lake downstream to Kakabika Falls. Common fish species in this stream reach include hornyhead chub, creek chub, longnose dace, common shiner, and johnny darter (Doepke 1998). Groundwater seepage and the entrance of several coldwater tributaries moderate water temperatures in the lower Cisco Branch. During the 2006 MDNR survey of the lower Cisco Branch, only warmwater species (e.g., creek chub, blacknose dace, longnose dace, and hornyhead chub) were collected. The water temperature at the time of the survey was 69°F, which is above the optimal temperature for brook trout. Anecdotal reports indicate that brook trout have been caught in the Cisco Branch, but it appears that these fish move to coldwater tributaries (e.g., Twomile Creek) during the hot summer months.

There are two major tributaries to the Cisco Branch: Tenderfoot Creek and Twomile Creek. Both of these creeks are classified as cool small streams. Although the valley segment model suggests that Tenderfoot Creek provides marginal habitat conditions for brook trout, electrofishing surveys have revealed a warmwater fish community consisting primarily of creek chub, hornyhead chub, white sucker, blacknose dace, and bluntnose minnow. Temperature monitoring conducted during June–August 1981 indicates that summer water temperatures are marginal for trout survival (J. Edde, USFS, Ottawa National Forest, personal communication). Twomile Creek is a coldwater stream that receives most of its groundwater inflows in the lower half of the river. Fisheries surveys conducted on the upper reaches of Twomile Creek indicated a warmwater fish community dominated by blacknose dace, creek chub, and slimy sculpin. Brook trout, mottled sculpin, longnose dace, and blacknose dace are commonly encountered in the lower portion of Twomile Creek. The fish community in the lower reaches of Twomile Creek closely resembles the predicted fish assemblage from the valley segment model.

South Branch

With the exception of a short river segment above Eighteen Mile Rapids, the South Branch is considered to be a cool large stream. Due to the absence of trout and the scarcity of vehicular access, the South Branch receives light fishing pressure. The absence of a suitable boat launch has also prevented biologists from conducting electrofishing surveys on this stream. A brief netting survey during September 2007 indicated the presence of muskellunge, smallmouth bass, rock bass, burbot, creek chub, and common shiner near the town of Ewen. Fishing reports suggest that northern pike, bluegill, yellow perch, and walleye are also harvested in the South Branch. The valley segment model indicates suitable habitat conditions for a “river minnow” species assemblage.

Sucker Creek flows into the South Branch near Eighteen Mile Rapids. The upper portion of Sucker Creek is a cool small stream that supports populations of brook trout, common shiner, creek chub, and blacknose dace. Groundwater inflows subside as the stream approaches the South Branch, and water temperatures in the lower reaches are less suitable for coldwater species. Tenmile Creek is a coolwater tributary to the South Branch with a fish community consisting of blacknose dace, mottled sculpin, creek chub, and white sucker.

West Branch

The West Branch varies in size from “medium” near Bergland to “very large” below Victoria Reservoir (Figure 43). The valley segments upstream of the South Branch confluence are classified as warmwater, whereas the stream reach below the South Branch is classified as a coolwater stream. Hornyhead chub, creek chub, and common shiner were the three most abundant species collected during the most recent electrofishing survey on this stream (Taft 1999). Walleye, smallmouth bass, and northern pike are also known to inhabit the West Branch.

Cascade Creek is the only major coldwater tributary to the West Branch. Brook trout, mottled sculpin, white sucker, and several minnow species have been captured in this stream. Mill Creek, which flows into the West Branch below the Cascade Creek confluence, is a cool small stream. No fisheries surveys have been conducted on this system, but the valley segment model indicates a “creek minnow” assemblage that includes species such as creek chub and brook stickleback.

Mussels

Little is known about the status and distribution of freshwater mussels in the Ontonagon River watershed, but data from Cummings and Mayer (1992) and MDNR, Fisheries Division files suggest that 15 species of native mussels could reside within the basin (Table 18.) One exotic mussel species, the zebra mussel *Dreissena polymorpha*, has been found in the lower main stem near the mouth (see *Aquatic Pest Species*). A comprehensive inventory of mussel distributions within the watershed is needed.

Aquatic Invertebrates (except mussels)

Aquatic invertebrates are an important food source for many fish species, and they play a vital role in the cycling of nutrients in stream ecosystems. In addition, invertebrate species vary in their tolerances to environmental conditions such as temperature, substrate, nutrient levels, and current velocity (McCafferty 1998). Thus, the diversity and abundance of macroinvertebrate taxa are widely used to evaluate water quality and habitat conditions in streams.

Researchers from MDEQ conducted qualitative biological surveys on various portions of the Ontonagon River watershed in 1995, 1998, and 2003 (Taft 1995; Taft 1998; Taft 1999; Taft 2004). These surveys followed the protocols outlined in Procedure 51, which were designed to assess the abundance and diversity of fish and macroinvertebrate taxa and to evaluate various parameters (e.g., substrate, instream cover, and channel morphology) associated with the physical habitat in the stream (see Michigan Department of Environmental Quality 2002 for the most recent version of Procedure 51). After macroinvertebrate sampling and identification were completed, each sampling site was assigned a rating (excellent, acceptable, or poor) based on the number of macroinvertebrate taxa collected and the taxonomic composition of the macroinvertebrate community.

During MDEQ surveys, the macroinvertebrate communities at most sites were rated as “acceptable” (Tables 19 and 20). Six stations received “excellent” macroinvertebrate scores: Bluff Creek, Cascade Creek, Marshall Creek, Trout Brook, Spargo Creek, and Twomile Creek. Many of the macroinvertebrate families collected in the Ontonagon River system are intolerant of warm water temperatures and low dissolved oxygen levels (Taft 2004). The presence of these organisms is indicative of high water quality within the watershed (see **Water Quality**).

Amphibians and Reptiles

Nine species of frogs and toads, and six species of salamanders reside in the Ontonagon River watershed (Table 21). Five species of snakes have also been found in the basin. None of these species are listed as endangered, threatened, or of special concern.

Six turtle species are found within the watershed, including five species typically associated with aquatic habitats. Three species from the Ontonagon River basin are listed as being of “special concern” by the State of Michigan: wood turtle, eastern box turtle, and Blanding’s turtle. Primary threats to these species include nest predation, traffic fatalities, habitat loss, poaching, and incidental collection by the general public (Harding 1997).

Birds

The rivers, lakes, and wetlands of the Ontonagon River watershed provide habitat for a wide variety of birds. Several species of ducks and geese nest along the Ontonagon River and its tributaries.

Herons forage along the stream edges, and swallows feed on insects emerging from the river. Woodcock and Ruffed Grouse reside along the riparian corridors, and numerous other birds use these corridors during migration. Common Loons breed on many lakes within the watershed, while male Red-winged Blackbirds establish territories in the adjacent marshes. A variety of raptors also inhabit the basin, including Osprey and Bald Eagle.

A total of 180 bird species have been found within the watershed, including 6 birds listed as threatened and 14 birds listed as special concern species by the State of Michigan (Table 22). One state endangered species, the Peregrine Falcon, is known to inhabit the Ontonagon River basin.

A few Double-crested Cormorants have been observed within the watershed (e.g., at Lake Gogebic). These fish-eating birds form large nesting colonies on islands in Lake Michigan and Lake Huron, and predation by cormorants has been identified as a possible factor leading to local declines in game fish abundance. No nesting colonies have been found within the Ontonagon River watershed, and it does not appear that Double-crested Cormorants are having a measurable effect on fish populations within the basin at this time.

Another fish-eating bird, the American White Pelican, occasionally has been observed in the Upper Peninsula (McPeek and Adams 1994). No specific reports of American White Pelicans in the Ontonagon River watershed have been documented.

Mammals

The large tracts of forest present within the watershed are occupied by numerous mammal species (Table 23), including popular game animals such as black bear, white-tailed deer, eastern cottontail, and snowshoe hare. Several fur-bearing mammals, such as American beaver, mink, fisher, northern river otter, coyote, red fox, and common gray fox, also inhabit the basin. Two state special concern species, moose and eastern pipistrelle (a bat), have been found within the Ontonagon River watershed. One mammal species, gray wolf, was listed as threatened at the federal level. Wolves in the western Great Lakes region (including the Upper Peninsula) were removed from the federal list of threatened species on 12 March 2007. A federal judge overturned this decision on 29 September 2008, so the gray wolf is once again a federally threatened species. Cougar sightings have also been reported throughout the western Upper Peninsula, but attempts to scientifically document the presence of wild cougars in this region have been unsuccessful.

The waters of the Ontonagon River basin and their associated riparian zones are used by a variety of mammal species. Beavers feed on aspen growing along stream banks and use the logs from these trees to construct their dams. Wetlands along streams provide excellent habitat for muskrats and are popular yarding areas for white-tailed deer. The fish and aquatic invertebrates produced in the Ontonagon River system are also consumed by several species of mammals (e.g., northern river otter, mink, and common raccoon).

Other Natural Features of Concern

Sixty species in the Ontonagon River watershed are classified as endangered, threatened, or of special concern by the State of Michigan (Table 24; Anonymous 2006a). This group includes two fishes, twenty-one birds, three mammals, three turtles, three invertebrates, and twenty-eight plants. Two rare species of lichens, anzia lichen and treeflute, also occur within the watershed. In addition, six rare community types (bedrock glade, dry-mesic northern forest, dry nonacid cliff, moist nonacid cliff, mesic northern forest, and poor conifer swamp), two unusual geographic features (extrusive igneous feature and meander), and a great blue heron rookery have been identified in the Ontonagon River basin.

Many of the listed plant species found in the watershed are associated with rare community types. For example, flat oat grass, purple clematis, and pine drops are typically found in dry-mesic northern forests, while assiniboia sedge, male fern, ginseng, showy orchis, and fairy bells occur in mesic northern forests (Anonymous 2006a). Three other listed plant species grow along the shores of softwater lakes: American shore-grass, hedge-hyssop, and small yellow pond-lily (Anonymous 2006a).

From a global perspective, none of the listed species appear to be in immediate danger of extinction. Many organisms that are listed as special concern or threatened species in Michigan are relatively common in other areas (i.e., species with a G5 global ranking, meaning demonstrably secure).

Aquatic Pest Species

The most destructive and widely established aquatic pest species in the Ontonagon River basin is the sea lamprey. Sea lampreys are a parasitic fish that entered the Great Lakes in 1921 when the Welland Canal was opened to allow ship traffic to bypass Niagara Falls. Parasitism by sea lampreys was a major factor leading to declines in lake trout and whitefish abundance throughout the Great Lakes during the 1920s through the 1950s. Since the mid-1950s, a variety of methods have been employed to control lamprey populations and mitigate their effects on Great Lakes fisheries. The recent restoration of lake trout populations in Lake Superior probably would not have occurred in the absence of these control efforts.

In the Ontonagon River watershed, sea lampreys have access to the entire main stem and the lower portions of the West, Middle, and East branches. The upstream limits of sea lamprey distribution for each stream are as follows: West Branch – Victoria Dam, Middle Branch – Agate Falls, and East Branch – Lower Dam (Robert Kahl, U. S. Fish and Wildlife Service, Marquette Sea Lamprey Control Office, personal communication). Sea lampreys are also present in the downstream reaches of at least 12 tributaries, including Beaver Creek and the Jumbo River. Since 1960, TFM (3-trifluoromethyl-4-nitrophenol) treatments have been conducted (generally every 2–4 years) to reduce sea lamprey abundance in this system.

The ruffe is another exotic invader that has the potential to negatively affect native fish populations in the Ontonagon River. Ruffe were introduced into western Lake Superior through ballast water discharged from ocean-going vessels. These fish were first collected in Duluth Harbor in 1986. By 1991, ruffe had become the most abundant species in Duluth Harbor (Ruffe Task Force 1992). The first ruffe was captured in the Ontonagon River main stem during June 1994 (Kindt et al. 1996). In 2003, researchers from USFWS and Michigan Technological University captured 151 ruffe in the main stem, suggesting that ruffe are reproducing in this system (Czypinski et al. 2004).

The United States Fish and Wildlife Service captured a common carp in the lower Ontonagon River during their 1994 ruffe surveillance survey (Slade et al. 1995). Carp were also reported during the 2002 creel survey on the Cisco Chain (Hanchin et al. 2008), but the identification of these specimens was questionable. A pacu was captured in the lower Ontonagon River during the summer of 2006. The pacu (which is native to the Amazon River basin) is a popular aquarium species, so the individual collected in the main stem probably was a pet fish that had been released into the river. Pacu require water temperatures in excess of 70°F, so released pacu are not expected to survive through a winter in the Ontonagon River. Additional aquatic invasive fish species present in Lake Superior that could enter the Ontonagon River watershed include round goby and three-spine stickleback.

Rusty crayfish have been found in Crooked Lake, Tamarack Lake, and the Bond Falls Flowage on the upper Middle Branch, and in the Cisco Chain at the headwaters of the Cisco Branch Ontonagon River (Anonymous 2006b). The species has also been observed in the Bond Falls Canal and in the Middle Branch below the Bond Falls Flowage (G. Lamberti, University of Notre Dame, personal communication). Rusty crayfish are native to the Ohio River basin, but the species recently has become established in several other watersheds in the upper Midwest. Anglers commonly transport crayfish for use as bait, and this method of transport has been suggested as the primary means of rusty crayfish dispersal in the Great Lakes region (Gunderson 1995). Rusty crayfish can affect aquatic ecosystems by displacing native crayfish species, destroying aquatic plant beds, reducing macroinvertebrate density, and decreasing fish reproductive success through egg predation (Gunderson 1995).

Eurasian water-milfoil is an exotic plant species that has become established in several lakes within the Ontonagon River basin. At this time, Eurasian water-milfoil has been found in Langford, Clearwater, and Forest lakes within the Cisco Branch subwatershed, and Crooked, Duck, and Bass lakes in the upper Middle Branch subwatershed (Anonymous 2006b). Eurasian water-milfoil forms dense mats of vegetation that interfere with boating, swimming, and fishing. These dense milfoil beds also crowd out native plant species, increase the nighttime oxygen demand, and reduce available habitat for fish, invertebrates, and waterfowl. Two other exotic plant species, curlyleaf pondweed and purple loosestrife (predominantly a wetland species), have been found in the southern portion of the Ontonagon River basin. Curlyleaf pondweed and purple loosestrife can crowd out native vegetation, indirectly reducing abundance of the vertebrate and invertebrate organisms that rely on native plants for food or cover.

Three aquatic invasive invertebrates have been identified in the Ontonagon River system. Spiny water fleas have been found in Lake Gogebic, and zebra mussels have become established near the mouth of the main stem Ontonagon River. Both of these exotic invaders can affect aquatic ecosystems by altering the abundance and diversity of planktonic organisms. Mystery snails have been found in Lake Gogebic and in several lakes within the Cisco Branch subwatershed. These snails are popular in the aquarium trade, so they may have been introduced into the basin through the release of pet snails. Although the effects of mystery snails on aquatic ecosystems are still being determined, it appears that they may displace native snails and alter aquatic food webs.

Infectious pancreatic necrosis (IPN) virus has been isolated from fish produced in a private hatchery near Watersmeet. The IPN virus has been shown to cause substantial mortality of fry and fingerling salmonids in other areas (Murray et al. 2003). Fisheries managers are concerned that the IPN virus may have been introduced into the upper Middle Branch from the infected facility. The virus has not been detected in the Middle Branch; however, no comprehensive fish health surveys have been conducted on this system.

Viral hemorrhagic septicemia (VHS) virus was detected in the Great Lakes in 2003. This virus originally was reported from the maritime provinces of Canada and may have entered the Great Lakes via ballast water discharge (G. Whelan, MDNR, Fisheries Division, personal communication). The VHS virus has caused substantial fish kills in the lower Great Lakes (Erie, Huron, and Lake St. Clair) and in a few inland lakes in New York, Wisconsin, and the Lower Peninsula of Michigan. Fish infected with VHS often exhibit hemorrhaging in the skin (red patches) and around the eyes. On June 28, 2007, MDNR instituted new regulations (Fisheries Order 245) regarding the use of fish or fish eggs as bait. The purpose of the new regulations is to prevent (or at least delay) the spread of VHS to new waters. To date, VHS has not been detected in the Lake Superior watershed.

Fishery Management

Fisheries management in the Ontonagon River basin has been shaped by a variety of factors, including the physical characteristics of the watershed, anthropogenic habitat alterations, native fish species assemblage, social values, advancements in biological knowledge, and changes in hatchery production and distribution capabilities. Some of these factors have been relatively stable through time (e.g., physical characteristics of the watershed), while others are continuously evolving (e.g., social values and fish production capabilities).

Active fisheries management within the watershed began during the 1920s. For the first decade, fisheries management consisted primarily of surveying and documenting the fish populations within the basin and the human use of those populations. By the late 1930s, warmwater fish stocking had become a popular method for manipulating fish community structure. During the late 1930s through the early 1940s, walleye fry, largemouth and smallmouth bass, and bluegill were stocked into numerous lakes. While many of these introductions were unsuccessful, some warmwater fish plants did establish naturally reproducing populations.

By the mid-1940s, trout stocking had become a prominent fisheries management tool. After World War II, the state fish hatchery system expanded rapidly to include nearly 100 hatcheries and fish rearing stations (Anonymous 1974). From 1945 through 1964, legal-sized trout were stocked into many streams.

The stocking of legal-sized trout into streams provided short-term put-and-take fisheries. These high-cost stocking programs often yielded minimal returns to the creel (Shetter et al. 1964). In addition, the existence of naturally reproducing trout populations within many stream reaches made continued stocking unnecessary.

Since the mid-1960s, trout stocking primarily has been used to create additional fishing opportunities on inland lakes. Because there typically is little or no natural reproduction of trout in these lakes (due to the absence of suitable spawning habitat), continued stocking is needed to maintain these popular fisheries.

During the mid-1980s, advancements in rearing operations and growing interest from anglers led to a rapid expansion of the MDNR walleye stocking program. Spring fingerling walleyes have been introduced into numerous lakes within the watershed during the last 25 years. The objectives of these walleye stocking programs generally have fallen within one or more of the following categories: (1) create a new walleye fishery, (2) supplement an existing fishery in a system where natural reproduction is minimal, or (3) alter the abundance and size structure of panfish populations. In some instances, survival of stocked walleye was poor, and the stocking programs were discontinued. The remaining stocking programs are routinely evaluated to determine if they are meeting management objectives.

In some situations, fisheries managers have used complete or selective fish removals to alter the species or size composition of fish communities. For example, rotenone treatments have been conducted to eliminate competing species (e.g., yellow perch) from single-species trout lakes. Manual removals have been used to reduce panfish abundance and improve growth rates in stunted panfish lakes. Manual removals of rough fish have also been conducted to restore the predator-prey ratio to a more desirable level.

Habitat management techniques have also evolved during the last 80 years. Instream habitat management programs first became popular during the 1930s (Madison and Lockwood 2004). Logging activities during the late 1800s had severely reduced recruitment of large woody structure into streams (see **History**), so early habitat improvement projects focused on providing cover for game fish (primarily trout). Providing cover for game fish is still a major goal of many modern habitat improvement projects, but the methods used to achieve that objective have changed. Modern projects generally incorporate natural materials (e.g., root wads or whole trees) whereas the early fish cover structures often were constructed with lumber which provided less habitat complexity and fewer “hiding places” for stream fishes. The gradual reforestation of the watershed and utilization of best management practices (e.g., riparian buffer strips) have also increased natural recruitment of large woody structure into the Ontonagon River system.

Stabilizing eroding stream banks has been a major concern for fisheries managers and riparian landowners. For many years, hard armoring techniques (e.g., riprap and bulkheads) were used to control bank erosion. These techniques have become less common in recent years because: (1) they interfere with the natural migration of the stream channel, (2) hard-armored banks provide poor habitat for amphibians and reptiles (e.g., wood turtles), and (3) they reflect the kinetic energy of the water, which frequently leads to accelerated erosion downstream. Soft-armoring techniques (e.g., seeding and mulching, tree plantings, or whole tree revetments) are growing in popularity because they provide erosion control without producing the side effects outlined above. Through the MDEQ permitting process, MDEQ and Fisheries Division personnel have worked to educate riparian landowners and road commissions about the benefits of soft-armoring techniques.

Fisheries managers have also installed sand traps (artificial pools excavated by backhoes) to reduce the sand bedload in several stream reaches within the Ontonagon River system. Sand traps have been installed on Duck Creek, Twomile Creek, and the upper Middle Branch. USFS maintains two sand traps on Twomile Creek; USFS and MDNR personnel continue to monitor this stream to determine effects of sand traps on stream substrate and brook trout abundance.

The construction of dams to create additional trout fishing opportunities was a common practice during the 1950s and 1960s. Fisheries Division abandoned this practice when numerous studies revealed the negative effects of dams on river ecosystems (see **Dams and Barriers**). The small impoundments created by these dams typically provided good fisheries for several years, but sediment deposition has reduced the suitability of the reservoirs for trout management.

Fisheries Division, Wildlife Division, FMFM, Parks and Recreation Division, and Law Enforcement Division have worked cooperatively to manage the abundance and distribution of beaver within the Ontonagon River watershed. In 2001, the MDNR beaver management policy (Policy No. 39.21-20) was adopted. As outlined in this policy, MDNR manages for the less common resource (high quality coldwater streams). Fisheries Division recently developed a list of coldwater streams that are considered high priority candidates for active beaver control. When construction of beaver dams alters water temperatures and substrate conditions in these streams making the habitat less suitable for trout production, removal of beavers and beaver dams may be implemented. (It is important to note that Fisheries Division’s goal is not to eliminate beaver from all coldwater streams, but rather to reduce beaver abundance when beaver activity is degrading high quality trout fisheries.) Although beaver activity often is detrimental to trout populations, beaver ponds provide valuable habitat for many plant and animal species. Thus, beaver colonization of coolwater streams (or cold streams ≥50 ft wide) typically is not discouraged.

The most common method of reducing beaver abundance is through manipulation of their primary food source – aspen. Aspen is a shade intolerant species that thrives in recently disturbed areas. Shade tolerant species (e.g., eastern hemlock and sugar maple) generally replace aspen as a forest matures. Retention of uncut buffer strips is used to discourage aspen regeneration along trout streams that flow through state land. Although the standard minimum buffer strip width is 100 ft, wider buffer strips (generally 300 ft) are left along high priority trout streams to further reduce the available food supply for beaver.

When beavers become established in an area in which their presence is not desired, additional control efforts may be necessary. For example, MDNR staff or volunteers have worked to remove beaver dams on several streams within the Ontonagon River basin. To reduce beaver abundance, MDNR personnel have worked with local trappers to remove beaver during the legal trapping season. When these methods are not feasible or are insufficient, MDNR issues beaver damage control permits to allow trapping outside of the normal harvest season.

Fishing regulations are one of the most broadly recognized tools for controlling the harvest, size structure, and abundance of fish populations. Special regulations have been instituted to maintain high quality smallmouth bass fisheries in the Sylvania Wilderness Area. Limitations on the use of live bait are enforced on some trout lakes to reduce the risk of colonization by undesirable species. Closed fishing seasons also protect many fish species from harvest during their most vulnerable (i.e., spawning) periods. Current trout fishing regulations are described in Appendix C.

For the last 80 years, MDNR has used fisheries surveys to formulate and evaluate management strategies. These surveys provide information on the abundance, size structure, sex ratio, distribution, growth, and harvest of fish species within the watershed. Waters that receive intense fishing pressure or are regularly stocked generally have been surveyed more frequently than less intensively exploited systems (e.g., small tributary streams).

The MDNR is the primary fisheries management authority for the Ontonagon River watershed (except the Wisconsin portion of the watershed, which falls under the jurisdiction of WDNR); however, a variety of other agencies and constituent groups have participated in fisheries programs under the leadership of MDNR. USFS has completed a large number of habitat improvement projects in lakes and streams within the Ottawa National Forest. USFS also completes fisheries surveys within the watershed and provides the results of these surveys to MDNR. The United States Fish and Wildlife Service routinely performs sea lamprey assessment and control efforts in streams with Lake Superior access and conducts trawling surveys for aquatic invasive species in the lower main stem. The Keweenaw Bay Indian Community – Natural Resources Department (KBIC) has stocked Jumbo River strain brook trout in several streams within the Ontonagon River basin. A few lake associations and sport fishing clubs have paid for private fish stocking programs within the watershed. (Note: Agencies and other entities interested in stocking fish in public waters or lakes connected to public waters must obtain a fish stocking permit from MDNR before fish are planted.) The Great Lakes Indian Fish and Wildlife Commission and the Lac Vieux Desert Band of Chippewa Indians (LVD) have collaborated with MDNR to set tribal walleye spearing quotas for various lakes in the southern half of the Ontonagon River watershed. The Great Lakes Indian Fish and Wildlife Commission also performs spring spawning surveys and fall recruitment surveys for walleye on this same set of lakes.

The following sections provide a summary of fisheries management activities within the various subwatersheds of the Ontonagon River basin. A comprehensive discussion of all fisheries management activities within the basin is beyond the scope of this document, so only the more intensively managed waters within each subwatershed are discussed below.

Middle Branch—upper

The upper Middle Branch has a long and varied fisheries management history. Several coldwater tributaries flow into the Middle Branch, and some of these tributaries also provide popular trout fisheries. There are 72 lakes within the upper Middle Branch subwatershed. Fisheries management summaries are provided for a subset of these lakes.

Upper Middle Branch Ontonagon River.–The upper Middle Branch is one of the most popular trout streams within the Ontonagon River basin. The stream reaches between US-2 and Forest Route 5250 and between Bond Falls and Agate Falls are widely recognized for producing large brook trout.

Brook trout, rainbow trout, and brown trout were stocked in the upper Middle Branch until 1964. Brook trout were stocked above and below Bond Falls during the 1980s and 1990s (Table 25). Brown trout were planted below Bond Falls during 1985–97, but these plants were discontinued to reduce competition with wild brook trout.

The MDNR has completed numerous fisheries surveys on the upper Middle Branch since 1942. One of the most detailed studies on this stream was conducted by Wagner et al. (1994). Wagner et al. (1994) used a combination of electrofishing and creel surveys to evaluate the effects of stocking on the population density and harvest of brook trout in the upper Middle Branch near Watersmeet. The catch rate (in fish/angler hour) was significantly higher during years when yearling brook trout were planted (Wagner et al. 1994). Overwinter survival of stocked brook trout was essentially zero, so the trout plants only created a put-and-take fishery. Fisheries managers generally expect more pounds of fish to be harvested than were stocked in the receiving water (Borgeson 1987). The estimated weight of hatchery trout harvested in the upper Middle Branch was only 15.9% of the total weight at stocking (Wagner et al. 1994). Due to the poor returns from fish stocking and the presence of a strong naturally reproducing brook trout population, the annual brook trout plants in the upper Middle Branch have been discontinued.

The upper Middle Branch currently is classified under the Type 2 trout fishing regulations (Table C.1). Past survey and creel data indicate that this stream has the potential to produce large brook trout. Anecdotal observations suggest that fishing pressure has been increasing on the upper Middle Branch, and the Type 2 regulations were instituted on this stream to retain production of “quality-size” brook trout.

The MDNR and cooperating organizations have conducted a wide variety of habitat improvement projects in the upper Middle Branch, with most of the work occurring between US-2 and the town of Watersmeet. Habitat improvement projects on this stream reach have included the installation of wing deflectors and bank cover structures, beaver removal, sand trap excavation and maintenance, tag alder removal, and addition of spawning gravel. MDNR also collaborated with the Ontonagon County Chapter of Michigan Steelheaders to install 60 fish cover structures in the Middle Branch between Bond and Agate Falls in 1984.

Because the portion of the Middle Branch below Bond Falls is strongly affected by operation of the Bond Falls diversion, MDNR has been a major participant in the FERC relicensing process for the Bond Falls Development (which includes all five hydroelectric-related dams within the watershed; see **Dams and Barriers**). The new minimum flow conditions specified in the 2003 license are expected to positively affect the brook trout fishery between Bond and Agate Falls.

Tributaries.–Duck Creek has provided a quality brook trout fishery for many years. Brook trout were stocked in this stream annually from 1951 to 1963. Since that time, the trout fishery has been sustained by natural reproduction. USFS conducted an intensive beaver removal project on Duck Creek during 1989–91, and MDNR installed a sediment trap below US-2 in 1993. Duck Creek receives considerable fishing pressure for a stream of its size, so special regulations were enacted in 1989 to preserve this popular fishery. Type 6 trout stream regulations currently are in place on the lower 6 miles of Duck Creek. Only artificial lures may be used on this stream reach, the minimum size limit for brook trout is 10 inches, and the possession limit is two fish. MDNR continues to monitor the brook trout population in Duck Creek to determine if the existing regulations are meeting the population objectives for this stream.

The Tamarack River is the largest tributary to the upper Middle Branch. Although the Tamarack River is classified as Type 1 trout water, this stream is only occupied by trout on a seasonal basis.

> This gentle brown colored stream becomes too warm for trout in June and it receives little fishing pressure after that time. Brook trout migrate upstream [during the fall], sometimes as far as Tamarack Lake where ice fishermen catch them in good numbers. Fish up to two pounds have been reported. [From Juetten 1973.]

Several small coldwater tributaries flow into the upper Middle Branch. Deadman, Interior, McGinty, Morrison, Sargents, Henderson, Zig Zag, and Marathon creeks are classified as Type 1 trout streams. These streams provide spawning and nursery areas for brook trout. Most of the trout collected during surveys on these streams have been young-of-year or yearling fish, but a few legal-sized brook trout have been found. Fishing pressure on these streams is generally light; however, fishing reports from local residents suggest that large brook trout are occasionally caught in the beaver ponds that are so ubiquitous on these tributaries. Marion, Boniface, and Wolf Lake creeks are coolwater streams that flow out of inland lakes. Nongame fishes (primarily minnows and suckers) dominate the fish communities in these streams, but coolwater and warmwater game fish (e.g., largemouth bass and yellow perch) occasionally move into these streams from their source lakes (Juetten 1973).

Lakes.–Numerous surveys have revealed that panfish are abundant in Allen Lake, but stunting has been a persistent problem for fisheries managers. Stocking of spring fingerling walleye and USFS manual removal of small bluegills and pumpkinseeds have not resulted in noticeable improvements in the size structure of the panfish populations in this system (Table 26). Surveys completed in 2000 and 2004 indicated that survival of stocked walleye has been poor, so MDNR is reevaluating the management strategy for this lake.

Despite its name, Bass Lake does not have a large bass population. Few largemouth bass have been found during most surveys, and legal-sized fish have rarely been encountered. Northern pike abundance appears to have increased dramatically in the last decade, and the lake has provided good fishing for this species. Bass Lake generally produces large numbers of panfish. Few trophy-sized panfish are encountered, but small "keeper-sized" fish are abundant. Bluegill and pumpkinseed have been the dominant panfish species for many years, but black crappies were also found in good numbers during the 2005 fisheries survey. Muskellunge were introduced into Bass Lake in 1963, and the lake was managed as a muskellunge broodstock lake from 1967 to 1980. Survival of stocked muskellunge was marginal, and Bass Lake was removed from the muskellunge broodstock list in 1980.

The MDNR completed an intensive fisheries survey on the Bond Falls Flowage in 2003 as part of the Large Lakes Survey Program (LLSP). This survey consisted of a spring tagging effort for walleyes and northern pike, and a creel survey to evaluate angler harvest of all species and estimate annual exploitation rates for walleye and northern pike. The single-census population estimates for adult walleyes and northern pike were 6.1 fish/acre and 3.1 fish/acre, respectively (Hanchin, in press). The recommended minimum population goal for these species is 2.0 fish/acre (Dexter and O'Neal 2004). Thus, for the Bond Falls Flowage, both walleye and northern pike were present in sufficient numbers to support popular fisheries. The mean growth indices during the 2003 survey were -3.3 for walleye and -0.6 for northern pike (Hanchin, in press). Growth indices between -1 and +1 are considered average, while growth indices lower than -1 indicate that growth is well below the state average. Growth of Bond Falls walleyes, though much slower than the state average, was similar to that of walleye in other large lakes in the western Upper Peninsula. The estimated annual exploitation rates were 35% for walleye and 27% for northern pike (Hanchin, in press). Annual exploitation rates determined for other walleye populations as part of the LLSP ranged from 3% to 32% (Hanchin et al. 2008). Harvest of walleye in the Bond Falls Flowage was higher than expected, but the population estimates suggest that this level of harvest may be sustainable. Further monitoring is necessary to ensure that the walleye population in this system is not overexploited. The annual exploitation rate for northern pike was below the range reported by Hanchin et al. (2008), so overharvest of pike does not appear to be a problem.

A fish community survey conducted during June–August 2003 indicated that piscivores made up a disproportionate percentage (63%) of the total biomass in the Bond Falls Flowage. The annual winter drawdowns probably have contributed to the scarcity of forage fish in this reservoir. Because all of the fish in this system have been crowded into a much smaller area during the winter, the predation pressure has been greatly intensified. The reduced winter drawdowns specified in the 2003 FERC license should lessen the severity of this situation and allow the forage base to recover (Appendix A).

Castle Lake has been stocked with brook trout nearly every year since 1965. Surveys repeatedly have indicated that legal-size trout are abundant in this lake, and angler reports generally have been favorable. Castle Lake is a unique trout lake because it has never been chemically treated to remove undesirable species. The use of minnows as bait has been prohibited since 1965, and it appears that this prohibition has eliminated the need for chemical reclamation.

Walleye have been stocked in Dinner Lake on a periodic basis since 1983. Although the initial results of the walleye introduction were encouraging, surveys conducted during the last ten years suggest that survival from recent walleye plants has been minimal. This lake has strong populations of largemouth bass, smallmouth bass, and panfish, and the fish community appears to be well-balanced (biomass = 57% panfish, 41% piscivores, and <2% rough fish during the 2004 survey). To avoid disrupting this well-balanced community, walleye stocking will be discontinued. Northern pike entered Dinner Lake in the mid-1990s. The origin of these fish is uncertain, but they may have entered the lake via an unauthorized introduction by private citizens. Only five northern pike were found during the 2004 survey, and the absence of juvenile pike in the catch suggests that there has been little (if any) natural reproduction of this species in Dinner Lake.

Duck Lake consistently has provided good fishing opportunities for bluegill, black crappie, pumpkinseed, and smallmouth bass. Walleye and northern pike were first captured in this lake in 1968. These fish may have moved upstream from the Middle Branch Ontonagon River or been introduced through an unauthorized stocking event. Both walleye and northern pike have become major components of the fish community in Duck Lake, and the walleye in particular have been popular with anglers. In 1990, MDNR initiated a supplemental stocking program to augment the existing walleye fishery in this system.

Since the 1930s, Imp Lake has been managed to provide a two-story fishery (trout and coolwater species), and several species of salmonids have been stocked in this system. Rainbow trout were stocked during the 1940s and 1950s, but returns from these plants were generally poor. Brook trout occasionally have been stocked in Imp Lake, but few brook trout were collected during subsequent surveys. Lake trout were also planted in Imp Lake on an irregular basis from 1936 to 1979. These fish survived well, and the presence of adult lake trout (some larger than 30 inches) added to the diversity of the fishery in Imp Lake. Limited stocking effort is necessary to maintain a modest lake trout fishery in this system, so periodic lake trout plants may be part of the future management strategy for Imp Lake. Splake have been the focus of fisheries management in Imp Lake since 1961. Although catch-per-unit-effort of splake was not exceptionally high during most surveys (typically around 2 fish/net night during fall gill net surveys), the size structure of the splake population has been impressive. Imp Lake has produced many splake larger than 20 inches, and the limited growth data available indicated that these fish were growing faster than the state average. Rainbow smelt were introduced into Imp Lake in 1942, and the presence of this forage species probably has contributed to the rapid growth observed for splake in this system.

Smallmouth bass, bluegill, pumpkinseed, and yellow perch also reside in Imp Lake. Steep drop-offs make it difficult to effectively sample these species during fisheries surveys. The panfish populations apparently are not large enough to attract much attention from anglers. Most of the smallmouth bass collected during surveys were sublegal, but fish up to 17 inches have been captured.

Little Duck Lake has also been managed as a two-story fishery. Bluegill, largemouth bass, and yellow perch make up the warmwater component of the fishery. Rainbow trout have been planted in Little Duck Lake for the last 60 years. Multiple fisheries surveys have indicated acceptable survival and growth of stocked rainbow trout in this system. In an attempt to convert some of the minnow biomass into trout biomass, splake (which are more piscivorous than rainbow trout) have been stocked in Little Duck Lake nearly every year since 1983. Only two legal-sized (≥12 inches) splake have been collected during the last three fisheries surveys on this lake, so the splake stocking program has been discontinued. Three adult walleyes were collected during the 2006 survey on Little Duck Lake. Walleye would place additional predation pressure on stocked trout, so the unauthorized introduction of this species is a major concern. If walleye begin reproducing in this lake (which is unlikely given the paucity of suitable spawning substrate), a chemical reclamation might be necessary to reestablish the trout fishery.

Walleye fry were stocked in Marion Lake from 1968 to 1972. During 1973 through 1989, the walleye population was maintained solely by natural reproduction. A survey conducted in 1990 indicated that walleye abundance was decreasing, and a supplemental walleye stocking program was initiated. Surprisingly, catch-per-unit-effort of walleye has actually declined since the supplemental stocking program was instituted. Although this lake has never been an excellent walleye producer, the walleye population is large enough to support a targeted fishery. Tiger muskellunge were also planted in Marion Lake in 1968, 1969, and 1979. Subsequent survey data indicate good survival from these stocking events, so this lake is a potential candidate for future muskellunge plants.

Marion Lake has earned a reputation for providing good bluegill fishing. Past survey data indicated that growth of this species was above state average, and individuals as large as 11 inches have been collected during sampling. Surveys have repeatedly shown that smallmouth bass were abundant in Marion Lake; however, these fish were slow growing and rarely attained legal size. At least three species of fish have been introduced into this lake (either by unauthorized stocking or entrance through Marion Creek): black crappie (1935), rock bass (1972), and northern pike (1992). Northern pike and black crappie have become only minor components of the fish community. The rock bass population expanded rapidly during the 1970s, and the 2005 survey indicated that rock bass had become the dominant fish species in Marion Lake.

Spring fingerling walleye were stocked in Tamarack Lake from 1984 to 1989. Since that time, natural reproduction has sustained a popular walleye fishery. Several rusty crayfish were found in this lake in 2001. The effects of this species introduction on the fish community in Tamarack Lake have yet to be determined. University of Notre Dame researchers and USFS are investigating the use of crayfish traps to control rusty crayfish abundance in lakes within the Ottawa National Forest (G. Lamberti, University of Notre Dame, personal communication).

Twelve lakes within the upper Middle Branch subwatershed are included in the Sylvania Wilderness Area: Crooked, Clark, Mountain, East Bear, West Bear, Corey, Germain, Helen, High, Katherine, Snap Jack, and Trapper lakes. Although some fish stocking occurred in the Sylvania Tract during the 1930s and 1960s, restrictive fishing regulations have been the foundation of modern fisheries management in this wilderness area since 1974. Sylvania lakes are only open to fishing from the last Saturday in April through October 31. High minimum size limits (20 inches for walleye, 30 inches for lake trout and northern pike) and low bag limits (1 fish total for walleye, lake trout, and northern pike, 10 fish for panfish species) provide further protection for Sylvania fish communities. Largemouth and smallmouth bass are the most popular species in the Sylvania Tract. The bass fishery is strictly catch-and-release. To reduce hooking mortality, only artificial lures with barbless hooks may be used within the Sylvania Wilderness Area. In addition, motors are not allowed on Sylvania lakes. This prohibition adds to the “wilderness experience” of visitors and makes it more challenging for anglers to access the remote regions of the Sylvania Tract.

Fisheries surveys and angler reports indicate that excellent fisheries still exist on Sylvania lakes. All evidence suggests that Sylvania's restrictive regulations have created some high quality fishing opportunities for anglers looking for a unique fishing experience.

Middle Branch—lower

The lower Middle Branch fishery is primarily dependent on migrations of potamodromous fishes from Lake Superior. Two coldwater tributaries to the lower Middle Branch also support trout fisheries. This subwatershed includes only two lakes larger than 10 acres, but some trout stocking has occurred in smaller ponds within the lower Middle Branch basin.

Lower Middle Branch Ontonagon River.–Logging roads and trails provide the only access to the lower Middle Branch. Due to the lack of vehicular access and correspondingly low fishing pressure, the fisheries management on the lower Middle Branch has been much less intensive than on the upper Middle Branch. Logistical considerations have limited nearly all fisheries surveys to within one mile of Agate Falls.

Although MDNR has not stocked fish in the lower Middle Branch, fish have moved into this stream reach from fish plants in the upper Middle Branch and the main stem Ontonagon River. Brown trout (stocked between Bond Falls and Agate Falls) have moved downstream into the lower Middle Branch and established a naturally reproducing population. Some brown trout reside in the lower Middle Branch year-round, but a large percentage of the brown trout are potamodromous. Thus, most of the brown trout fishing below Agate Falls occurs during fall spawning migrations. The wild steelhead population in the lower Middle Branch has been attracting anglers to Agate Falls for many years, and the main stem steelhead plants during 1988–2002 probably augmented the existing fishery. A few brook trout and coho salmon have also been collected during fisheries surveys below Agate Falls.

Tributaries.–Two tributaries to the lower Middle Branch, Trout Creek and the Baltimore River, support popular fisheries for brook trout and brown trout. With the exception of Trout Creek Pond (which is stocked with brook trout each year), the trout fisheries in these streams are supported entirely by natural reproduction. The Ontonagon Valley Conservation Club conducted a beaver removal project on the Baltimore River in 1991.

Lakes.–Bluegill, largemouth bass, and smallmouth bass were introduced into Erickson Lake during the 1930s and 1940s. The most recent survey (conducted in 1977) on Erickson Lake indicated that bluegill and largemouth bass were established in the lake, but no smallmouth bass were collected. The 1977 survey also indicated that the lake supported strong populations of northern pike and yellow perch. There is no public boat launch on Erickson Lake, but most of the lake is surrounded by the Ottawa National Forest.

Trout Creek Pond is a small impoundment that has been managed as a trout fishery for many years. Approximately 400 yearling brook trout are stocked in the pond each year. Trout Creek Pond receives heavy fishing pressure, so most fish are harvested soon after attaining legal size.

The MDNR stocked rainbow trout in Tanlund Lake from 1955 through 1996. As noted for Trout Creek Pond, the majority of the fish stocked in Tanlund Lake were harvested soon after reaching legal size. Survival of stocked rainbow trout declined substantially during the 1990s, and no trout were captured during the 1992 survey. The reasons for the abrupt change in trout survival were never identified.

Main Stem

The main stem Ontonagon River provides a wide array of fishing opportunities. Although some coolwater species inhabit the main stem throughout the year, the bulk of the fishing activity is directed toward potamodromous salmonids. The tributaries that flow into the main stem are warmwater streams that receive little (if any) fishing pressure. Lakes are essentially absent from this subwatershed.

Ontonagon River.–The Ontonagon River supports a diverse fishery that changes seasonally. Steelhead are the focus of most fishing activity during mid-April through mid-May. During late May–mid-September, anglers target walleye, northern pike, and smallmouth bass in the main stem. Potamodromous brown trout ascend the Ontonagon River from late August through October, initiating another pulse of angler activity. A few coho and Chinook salmon are also caught in the main stem, but abundance of these species is low relative to steelhead and brown trout.

The brown trout and salmon fisheries in the main stem are supported by natural reproduction and immigration of stocked fish from adjacent river systems. (Chinook salmon are stocked in the Big Iron River, 12 miles to the west, and brown trout are stocked in the Firesteel River, 7 miles to the east.) Yearling steelhead were stocked in the main stem until 2002. Fish stocked at this site (US-45 crossing) had to be dropped about 15 ft to the stream, and the logistics of safely releasing fish made this a less than ideal location. The annual steelhead plant was moved to the Jumbo and East Branch Ontonagon rivers in 2003 to minimize stocking stress and enhance returns of adult steelhead.

The walleye fishery near the mouth of the Ontonagon River is supported primarily by natural reproduction, but a periodic stocking program has been used to bolster the existing fishery. The United States Fish and Wildlife Service stocked lake trout in the main stem during 1982–94 as part of the Lake Superior lake trout rehabilitation effort. Some of these fish may have been caught in the lower main stem, but the lake trout stocking program primarily was used to supplement the Lake Superior fishery. Walleyes probably consumed some of the stocked lake trout; however, the extent of this predation was never quantified.

Habitat degradation and commercial overfishing led to the extirpation of lake sturgeon from the Ontonagon River during the early 1900s (see **History**). MDNR recently initiated a lake sturgeon stocking program to reestablish this native species in the Ontonagon River system. Approximately 33,000 fall fingerling lake sturgeon have been stocked in the main stem since 1998. Gametes were collected from spawning lake sturgeon in the Sturgeon River (Baraga County), and the fish were raised to fingerling size at the Wolf Lake State Fish Hatchery in southern Michigan.

Lake sturgeon return to their natal streams to spawn, and recent genetics studies have revealed that the few remaining lake sturgeon populations around Lake Superior are genetically distinct from each other. Because fish generally imprint at a young age, biologists became concerned that fish raised in traditional hatcheries and stocked as fall fingerlings might stray into other coastal streams and spawn with the native populations upon reaching sexual maturity. The influx of stocked fish into these historically isolated populations could “swamp” genes for local adaptations and reduce the fitness of remnant lake sturgeon populations.

Due to these genetic concerns, MDNR established a streamside rearing facility near the mouth of the Ontonagon River in 2007. Lake sturgeon gametes were collected from the Sturgeon River population as before, and the fish were raised to the fall fingerling stage in a rearing facility that uses water from the Ontonagon River. Approximately 750 lake sturgeon were stocked in the Ontonagon River from the streamside rearing facility in October 2007. The objective of this program is to allow the fish to imprint to the Ontonagon River, thus increasing the likelihood that they will return to the Ontonagon River to spawn. Because it often takes 15–20 years for male and 20–25 years for female lake sturgeon to reach sexual maturity, it will be many years before the results of these stocking efforts can be fully evaluated. Fillmore (2003) found numerous juvenile lake sturgeon in the lower main stem, so it appears that initial survival of stocked lake sturgeon has been acceptable.

East Branch

Resident trout fisheries exist on the East Branch Ontonagon River and several of its tributaries. Potamodromous salmonids also contribute to the fishery in the lower East Branch. There are 34 lakes larger than 10 acres within this subwatershed, and several of these lakes provide popular coldwater or warmwater fisheries.

East Branch Ontonagon River.–Throughout most of its length, the East Branch is considered a high quality trout stream. The portion of the East Branch above M-28 is classified as a Type 1 trout stream. Resident brook trout and brown trout fisheries attract many anglers to this stream reach during the summer months. Below M-28, the East Branch is classified as a Type 3 trout stream. The portion of the East Branch between M-28 and Sparrow Rapids is a popular destination for anglers seeking steelhead, coho salmon, and potamodromous brown trout.

The brook trout and brown trout fisheries have been sustained by natural reproduction for over 40 years. Coho salmon were introduced into the East Branch in 1968. The species has become well-established, and modern salmon runs consist entirely of wild fish. Wild fish also make up a large percentage of the steelhead population, but alternating plants on the East Branch and the Jumbo River are used to supplement the wild steelhead fishery.

Since at least the 1950s, fisheries managers have been working to improve fish habitat in the East Branch Ontonagon River. For example, MDNR installed “sweeper logs” and half-log structures in the East Branch below Lower Dam during 1978–86, and USFS completed an intensive beaver removal project on this stream in 1992.

Tributaries.–The Jumbo River is the largest and most heavily fished tributary to the East Branch. Resident brook trout and brown trout inhabit the Jumbo River and both of its branches. Numerous juvenile steelhead have been found during fisheries surveys on this stream, and it appears that the Jumbo River is an important nursery area for the East Branch steelhead population.

Since the late 1990s, KBIC has been collecting brook trout from the upper Jumbo River (above Jumbo Falls) and its tributaries to use as broodstock in their hatchery operations. Previous hatchery strains of brook trout were developed from populations within the Lake Michigan watershed or outside the Great Lakes basin. Fisheries managers prefer to stock fish from locally adapted populations whenever possible, so development of a brook trout strain from the Lake Superior watershed was a high priority. The Jumbo River was chosen as a broodstock stream because it (1) had not been stocked with brook trout for many years, (2) contained a healthy, self-sustaining brook trout population, (3) was accessible for capturing sufficient numbers of brook trout, (4) contained a barrier (Jumbo Falls) which prevented mixing with other stocked streams, and (5) was located within the Lake Superior watershed (Mike Donofrio, WDNR, personal communication). To date, most of the Jumbo River strain fish have been stocked in streams within the KBIC Indian Reservation or in tributaries to the East Branch Ontonagon River. Some preliminary stocking evaluations have been completed, but a more thorough evaluation of the performance of these fish after stocking is needed before expansion of this program is deemed appropriate.

USFS has conducted extensive habitat work to enhance the fisheries in the Jumbo River and its tributaries. Recent habitat projects include beaver removal, sediment trap construction and maintenance, bank stabilization, and installation of gravel spawning riffles.

Additional trout fisheries exist on several other tributaries to the East Branch. Smith, Spargo, and Stony creeks enter the East Branch above the confluence with the Jumbo River. Brook trout dominate the fish communities in these streams, but a few brown trout are also taken by anglers. These trout populations are largely sustained by natural reproduction, but KBIC stocked Jumbo River strain brook trout in Spargo Creek during 2004–05. USFS completed beaver removal projects on Spargo and Stony Creeks in 1992.

Groundwater inflows decline in the northern portion of this subwatershed, and many of the tributaries that flow into the lower East Branch are marginal trout streams. The lower reaches of Onion Creek and Beaver Creek have wild brook trout populations that support modest fisheries.

Lakes.–Bob Lake has a long management history that extends back to the late 1930s. Bluegills and smallmouth bass were stocked in this lake as early as 1935. These introductions apparently were not successful, as neither species was collected in subsequent surveys. In 1959, the existing fish populations were eliminated with toxaphene, and brook trout stockings were initiated in 1960. Annual trout plants produced an acceptable fishery for a few years. Competing species quickly increased to nuisance levels, and the lake was chemically reclaimed with rotenone in 1967. A mixture of brook trout, rainbow trout, and brown trout were planted during the next decade. Once again, the trout plants produced a popular fishery for several years. By the late 1970s, yellow perch abundance had increased exponentially, and trout survival had declined. Another rotenone treatment was completed in 1979, followed by three years of brook trout stocking.

By 1982, yellow perch and bullheads had become so well established in Bob Lake that trout management no longer appeared feasible. A series of manual removals were conducted by MDNR and USFS during 1982–98 to reduce abundance of yellow perch and bullheads in this system. During these efforts, over 5,000 lb of yellow perch and 2,000 lb of bullheads were removed from Bob Lake. MDNR also initiated a walleye stocking program in 1984. Despite all these efforts, overabundance of yellow perch and bullheads continues to be a problem in Bob Lake. Walleye abundance has gradually increased since 1984, and it appears that the stocking program has created a modest walleye fishery on the lake.

Like many lakes in the area, Bob Lake is a softwater system with limited buffering capacity. The acidity of the water was identified as an additional hindrance to fishery management on Bob Lake. On two occasions (1984 and 1989), the lake was treated with lime to raise the pH closer to neutral. The pH increases after lime treatments were short-lived, and the liming program has been discontinued.

The MDNR has stocked rainbow trout in Lake On-three since the early 1960s. Most fisheries surveys during the last 40 years have shown acceptable survival and growth of stocked trout. Lake On-three has been a relatively low maintenance trout lake, and only one rotenone treatment (completed in 1976) has been necessary since the beginning of trout management on this system.

Crystal Lake was managed as a trout fishery from 1956 to 1996. During the early 1990s, the water level in this lake declined steadily, making it less suitable for trout survival. Largemouth bass and bluegill abundance increased during this period, and these species currently support a warmwater fishery in this small lake. Rainbow trout were also planted in Kunze Lake during the 1980s, but fisheries surveys indicated that low summer oxygen levels were severely limiting trout survival.

Lower Dam was constructed on the East Branch Ontonagon River in 1964 (see **Dams and Barriers**). MDNR was the original owner of this dam, but ownership was transferred to USFS in 1984. Brook trout were stocked in Lower Dam Lake from 1964 to 1970. Only one brook trout was collected during the 1970 survey, and approximately 99% of the biomass in the catch consisted of white sucker and northern pike. The pond was drawn down in 1973 and was not refilled until 1983. Brown trout were stocked for several years after the pond was refilled. Subsequent surveys indicated that adequate brook trout and (to a lesser extent) brown trout fisheries could be sustained entirely by natural reproduction in the stream reach above the dam. Overabundance of white sucker continued to be a concern for fisheries managers during the 1990s. Over 1,000 lb of suckers were manually removed from this impoundment by USFS during 1991–98. In the past Lower Dam Lake received heavy fishing pressure, due in part to the presence of the adjacent National Forest campground. The Lower Dam campground was converted to a “dispersed camping” site in 2005, and this change probably decreased fishing pressure on the impoundment. Lower Dam Lake is not a designated trout lake, so the minimum size limit for brook trout is 8 inches. The length-frequency distribution of brook trout collected during fisheries surveys suggests that trout ≥8 inches are common, but few fish attain lengths greater than 10 inches.

Stunting of bluegill has been a long-standing problem in Tepee Lake. A partial treatment with antimycin was conducted in 1976 to reduce bluegill abundance and improve the size structure of the population. This treatment yielded only temporary benefits, so subsequent management efforts were directed toward increasing predation pressure on the bluegill population. Walleye were stocked in Tepee Lake periodically from 1980 to 1995, and northern pike were transferred to this lake on multiple occasions. The walleye plants yielded poor returns, but northern pike made up 40% of the biomass during the 2003 survey on this system. The presence of several sublegal northern pike in the catch also suggests that natural reproduction may be sufficient to sustain this predator population. There was no evidence of stunting during the 2003 survey, as nearly 70% of the bluegill collected were of harvestable size (≥6 inches).

Cisco Branch

With the exception of Twomile Creek, the streams in this subwatershed receive little fishing pressure. Numerous lakes are connected to the Cisco Branch and its tributaries, and these lakes provide a wide variety of fishing opportunities.

Cisco Branch Ontonagon River.–The upper Cisco Branch is considered a warmwater stream. Some smallmouth bass and walleye inhabit the upper Cisco Branch, but these populations attract little attention from anglers. Although the lower portion of the Cisco Branch (below Kakabika Falls) is a designated trout stream, trout only occupy this stream on a seasonal basis. Juetten (1973) indicated that both brook trout and brown trout were found in the lower Cisco Branch, but no trout were found during the 2006 summer survey on this stream reach. Trout probably enter this stream from coldwater tributaries (e.g., Twomile Creek) during the spring and fall. Because of the seasonal nature of the fishery, difficult wading and boating conditions, and a virtual lack of road access, there is little fishing pressure on this stream.

Tributaries.–Twomile Creek is the only tributary in the subwatershed that receives any substantial use by anglers. There is a strong population of wild brook trout in this Type 1 trout stream. Brook trout in the 7–8 inch size classes are common in Twomile Creek, but it appears that most fish are harvested before they can attain lengths ≥10 inches.

The MDNR recently established a fisheries index station on Twomile Creek. The same stream reach was sampled for three years in a row (2004–06) as part of the MDNR Stream Status and Trends program. During this comprehensive sampling effort, information was collected on various habitat parameters (e.g., substrate, bank stability, riparian vegetation, and channel morphology) and the abundance, size structure, and growth of brook trout. MDNR will return to this stream in 2010–12 to repeat another three years of sampling. The information gained from these Status and Trends surveys will allow fisheries managers to track local and (in conjunction with similar surveys on other Michigan streams) regional changes in fisheries and habitat parameters through time.

USFS installed two sand traps on Twomile Creek in 2001, and an additional trap was installed by another party as part of a disciplinary action by MDEQ. USFS continues to maintain their traps to reduce the sand bedload in Twomile Creek. USFS has also installed several skyboom structures on this stream to increase the amount of cover available for brook trout and other fish species.

Lakes.–The Cisco Lake Chain is the most popular fishing destination within the Cisco Branch subwatershed. The chain consists of 14 interconnected lakes with a combined surface area of approximately 4,000 acres. Most of the lakes are located entirely within the State of Michigan, but three lakes (Big, West Bay, and Mamie) extend southward into Wisconsin. Past management activities in the Cisco Lake Chain generally have focused on improving the walleye fishery. Walleye were stocked in Cisco and Thousand Island lakes during the late 1930s and early 1940s. After a long hiatus, walleye stocking resumed in 1983. Lake trout, muskellunge, and tiger muskellunge have also been stocked in the Cisco Lake Chain. Stunting of northern pike has been a continual problem, and there is no minimum size limit for northern pike in this system. Big, West Bay, and Mamie lakes are governed by Michigan-Wisconsin boundary water regulations.

The MDNR conducted an intensive survey on the Cisco Lake Chain during 2002–03 as part of the LLSP (see Bond Falls Flowage discussion, earlier this section, for more information on the LLSP). The information provided in the following three paragraphs is from Hanchin et al. (2008).

The population estimates generated from the LLSP survey were 10.1 adult walleyes/acre and 3.7 adult northern pike/acre. The northern pike estimate was within the range expected for lakes with strong pike fisheries. The adult walleye population estimate for the Cisco Lake Chain was higher than all previous estimates obtained from lakes in the LLSP (average = 3.1 fish/acre). The annual harvest estimates for walleye and northern pike in the Cisco Lake Chain were 18% and 23%, respectively.

During the LLSP creel survey, the main species harvested (from most to least) were yellow perch, bluegill, black crappie, walleye, northern pike, rock bass, pumpkinseed, smallmouth bass, and largemouth bass. An estimated 304 muskellunge were caught and released during the 2002 open water fishing season. Eight Master Angler muskellunge entries have come from the Cisco Lake Chain since 1980, suggesting that growth of muskellunge in this system is at or above the state average.

Tag returns of adult walleye and northern pike provided considerable information on the movement patterns of these species within the Cisco Chain. Although fish frequently moved between lakes within the chain, the walleye and pike populations could be divided into relatively distinct north and south populations. When a dividing line was drawn through the narrows between Lindsley and Morley lakes, the tag return data indicated that only a small percentage of fish tagged in the north and south halves of the chain were subsequently recaptured in the opposite half. Differences in growth rate were also observed for walleyes in the two halves of the chain. The mean growth indices for the north and south walleye populations were -0.6 and -3.2, respectively. Walleye population density was much higher in the southern lakes, so the slow growth observed for the southern population may have been related to forage availability. No significant differences in growth were observed for the northern pike populations in the two halves of the Cisco Lake Chain. The mean growth index for the entire northern pike population was -4.0. This slow growth prevents most pike from reaching the statewide minimum size of 24 inches, so the existing no minimum size limit regulation on the chain appears to be appropriate.

Beatons Lake also receives substantial fishing pressure. This lake is managed to provide a two-story fishery. During the last 15 years, rainbow trout, splake, and walleye have been stocked in Beatons Lake. Rainbow trout generally have been the main species of interest, and rainbow trout larger than 20 inches are not uncommon in this system. Returns from the annual splake plants have been less impressive. During the 2004 survey, only 12 splake were captured compared to 81 rainbow trout. The 2004 survey also indicated that the forage base (e.g., bluegill and yellow perch) was depleted. To facilitate recovery of the panfish populations in Beatons Lake, the splake and walleye stocking programs have been temporarily discontinued.

Cornelia Lake is a small (14 acre) lake that has been stocked with brook trout since 1964. These plants have produced a popular fishery, and the length-frequency data from fisheries surveys suggests that most fish are harvested soon after reaching legal size. The existing Type A trout regulations (which prohibit the use of minnows as bait) apparently have been successful in preventing the introduction of undesirable species into Cornelia Lake, as no rotenone treatments have been necessary since 1977 (Table C.2).

Langford Lake supports a diverse fishery for largemouth bass, smallmouth bass, northern pike, and panfish. MDNR fisheries surveys on this lake indicate that natural reproduction sustained a strong walleye population during the 1950s to early 1980s. Black crappies became established in Langford Lake during the early 1980s. Although this species may have entered the lake from Langford Creek, unauthorized stocking activity is a more probable explanation for the appearance of black crappie in this system. Surveys conducted during the late 1980s and early 1990s suggested that natural recruitment of walleye had declined dramatically. Adult black crappie prey on small minnows and other fishes (e.g., young-of-year walleye), and predation by black crappies was identified as the most likely cause for the decline in juvenile walleye abundance. A spring fingerling walleye stocking program was instituted in 1990 in an attempt to restore the walleye fishery in Langford Lake. Although walleye have been stocked for several years, the population in this lake still has not recovered.

Several lakes in the Cisco Branch subwatershed are located within the Sylvania Wilderness Area and are governed by special regulations (see Sylvania regulations discussion for the upper Middle Branch subwatershed). Whitefish Lake is the most notable lake in this category. This lake supports productive fisheries for smallmouth bass and walleye. No whitefish (family Salmonidae – subfamily Coregoninae) have ever been collected during MDNR fisheries surveys on Whitefish Lake.

Tenderfoot Lake is a Michigan-Wisconsin boundary water. The Michigan portion of Tenderfoot Lake falls within the University of Notre Dame Environmental Research Center, and the only public access to the lake is from the Wisconsin side. Because of the access situation, most fisheries management activities on this lake have been completed by WDNR. Walleye, muskellunge, largemouth bass, and smallmouth bass were stocked in Tenderfoot Lake by WDNR during 1935–53. Since that time, the fish populations in this lake have been sustained solely by natural reproduction.

Eighteen of the lakes in this subwatershed are located entirely within the State of Wisconsin and fall under the jurisdiction of WDNR. Several of these lakes (e.g., Forest and Palmer lakes) support popular fisheries for coolwater and warmwater fish species.

South Branch

Fishing activity on the South Branch is limited compared to other branches of the Ontonagon River system, but wild trout fisheries exist on a few tributaries to this stream. Lakes are scarce in this subwatershed.

South Branch Ontonagon River.–Although the upper end of this river is classified as Type 1 trout water, the South Branch is primarily a coolwater stream (Figure 43). There is little fishing pressure on the South Branch, but local anglers report catching smallmouth bass, walleye, muskellunge, bluegill, yellow perch, and northern pike in this stream near the town of Ewen.

Tributaries.–Sucker Creek and its tributaries (e.g., Bluff Creek) are the only designated trout streams that flow into the South Branch. These streams support wild populations of brook trout and brown trout. The Ottawa National Forest surrounds large reaches of these tributaries, and several stream crossings provide easy access for anglers.

The flow regimes in Bluff and Sucker creeks are strongly influenced by operation of the Bond Falls diversion (see **Dams and Barriers**). In 1995, a biological survey conducted by MDEQ indicated that dam operations at the Bond Falls diversion were adversely affecting fish populations in Bluff Creek (Taft 1995). In 2003, FERC issued a new license for the Bond Falls Hydroelectric Project which established ramping rate restrictions and specified minimum and maximum water releases into the Bond Falls Canal (Appendix A). MDEQ conducted another survey in 2004 to evaluate the effects of the new flow restrictions on the fish communities in Bluff Creek. Both the number of fish collected and the number of species collected were higher in 2004 than in 1995, so Taft (2005) concluded that the new operating regulations had "substantially improved the quality and density of the Bluff Creek fish community."

Lakes.–Sucker Lake is the largest lake in the South Branch subwatershed. This nutrient-rich lake has a mean depth of 9 ft, and winterkills have been common in this system. The fish community in Sucker Lake is dominated by species that are tolerant of low winter oxygen levels (e.g., yellow perch, white sucker, and brown bullhead). During the 1970s, USFS evaluated the feasibility of constructing a dam at the outlet of Sucker Lake (Crumrine 1974). Crumrine (1974) concluded that damming the outlet to create an additional 10 ft head was hydrologically possible, but he predicted that winterkill (though less frequent) would still be a problem during winters with heavy snowfall.

Bluegill and smallmouth bass were introduced into County Line Lake during 1936–43. These introductions apparently were successful, as the lake still supports productive fisheries for both species. A variety of salmonid species were stocked in County Line Lake from 1960 to 1980. These fish plants produced only modest returns, so the stocking program was discontinued.

Two small (<10 acre) impoundments in this subwatershed have been stocked to provide additional trout fishing opportunities. Brook trout and brown trout have been planted in Paulding Pond since 1958. Although this impoundment is only 7 acres in size, fisheries surveys have repeatedly documented acceptable growth and carryover of stocked trout in this system. Robbins Pond is an even smaller impoundment that was stocked with trout (primarily brown trout) for nearly 40 years. Annual trout plants historically supported popular fisheries in this pond. The impoundment gradually filled in with sediment, and aquatic plant growth increased the biological oxygen demand and interfered with fishing and boating activity. Habitat conditions eventually became unsuitable for trout survival, and the trout stocking program in Robbins Pond was discontinued in 1996.

West Branch

West Branch Ontonagon River.–Coolwater game fish (smallmouth bass, walleye, and northern pike) are fairly abundant in the West Branch above the Victoria Reservoir, but there is little fishing pressure on this stream reach (Juetten 1973). A major factor limiting fishing pressure on this stream is the paucity of access sites. There are only three access sites on the West Branch: M-28 (near Bergland), Norwich Road, and Victoria Dam.

Special fishing regulations have been implemented on the West Branch to protect spawning lake sturgeon. The portion of the West Branch between Victoria Dam and the confluence with the Victoria hydroelectric facility tail race is closed to fishing from 01 April through 10 June. In addition, the new FERC license specifies minimum water releases into this portion of the river during the spring to ensure adequate flow conditions for lake sturgeon reproduction (see **Dams and Barriers**). Although lake sturgeon are thought to be extirpated from the Ontonagon River system, these regulations should protect any fish that might remain and will aid restoration efforts as stocked fish begin returning to the river. The lake sturgeon stocking program in the main stem Ontonagon River was initiated in 1998, so adult fish are not expected to enter the West Branch until at least 2013 (see **Biological Communities**).

Downstream from the Victoria tail race, the West Branch is classified as a Type 3 trout stream (no closed season for salmonids). This portion of the West Branch supports seasonal fisheries for walleye and steelhead.

Tributaries.–Most of the tributaries that flow into the West Branch are considered coolwater streams. Cascade Creek is a designated trout stream, and the wild brook trout population in this creek provides some fishing opportunities. Although road access is limited, the surrounding federal lands allow walk-in access to much of the stream.

A few coldwater tributaries flow into Lake Gogebic. Wild brook trout populations inhabit these tributaries, but fishing pressure is low due to the small size of the streams.

Lakes.–Lake Gogebic has been one of the most intensely studied waters within the Ontonagon River watershed. Fisheries management activities on this lake date back to the 19th century. Eschmeyer (1941) provided this description of early fisheries management on Lake Gogebic.

> Smallmouth bass, largemouth bass, bluegills, and sunfish comprised the principal game fishes [sic] previous to 1900. In the late 1890s, northern pike were introduced and subsequently became the dominant game fish [sic] species of the lake, until about 1920, when the walleyed pike, which had been introduced in 1913 as fry, became of first importance in the lake. With its relative, the yellow perch, this species has continued in this position since that time, with the northern pike dwindling in numbers and the centrarchid species becoming increasingly scarce.

Additional research suggests that walleyes may have been introduced into Lake Gogebic before 1913.

> On May 3, 1985, the Baraga office of the Michigan Department of Natural Resources received word from Florence Daniels of Bergland, that her grandfather, Adolph Martin Borseth, was hired by G. A. Bergland to plant walleyes in Lake Gogebic in 1904. The fish, which came in by train, were planted from a rowboat into Bergland Bay just east of the Bergland dock. According to Bob Haas, Biologist, Mt. Clemens (personal communication), archive records indicate 300,000 fry were planted in 1904, their source unknown, but Haas suggests they came from the hatchery in Sault Ste. Marie, Michigan. [From Norcross 1986.]

The walleye fishery still brings thousands of people to Lake Gogebic every year, and many local businesses depend heavily on walleye anglers for their livelihood. The rocky shoreline of Lake Gogebic provides excellent spawning habitat for walleye, and natural reproduction essentially has sustained the population for at least 90 years. From 1971 to 1988, MDNR collected gametes from Lake Gogebic walleye and used these gametes to produce fry and fingerlings for stocking in other waters. In an attempt to offset any effect these gamete collections might have had on the donor population, some fry were planted back into Lake Gogebic during this time period.

Slow growth of Lake Gogebic walleye has been a major concern for anglers and fisheries managers. Forage fish introductions during the 1980s and 1990s yielded no noticeable improvement in walleye growth, and few individuals of the stocked forage species have been collected during subsequent surveys.

To compensate for the slow growth of Lake Gogebic walleye, the minimum size limit on this lake remained at 13 inches even after the statewide limit was raised to 15 inches in 1976. Population modeling conducted during the 1990s suggested that a 15-inch minimum size limit would increase the total pounds of harvestable fish in the lake and produce a better overall fishery (Miller 1997). As a result of this modeling effort, the minimum size limit for walleye was increased to 15 inches in 1996.

During 2005–06, MDNR completed a comprehensive survey on Lake Gogebic as part of the LLSP. Analysis of the data from this survey will allow fisheries managers to evaluate the effects of the 15-inch minimum size limit on the walleye fishery in Lake Gogebic.

Though walleye are the featured species in Lake Gogebic, two other species are worthy of mention. Smallmouth bass (originally the premier species in the lake) continue to provide a popular summer fishery in this system. Lake Gogebic is also famous for its trophy yellow perch fishery. Twelve-inch yellow perch are common in this lake, and a few 14-inch individuals were found during the LLSP survey.

Habitat manipulations in Lake Gogebic primarily have consisted of water level control (see **Dams and Barriers**) and installation of fish cover structures. Since 1948, MDNR and various other organizations have installed hundreds of fish cover structures in this system. Though the effects of such structures on fish populations are difficult to quantify, the structures are very popular with local anglers.

Victoria Reservoir is one of the better panfish waters in Ontonagon County. A 2002 fisheries survey of this impoundment found strong populations of black crappie and yellow perch. Northern pike and smallmouth bass are also common in this reservoir, but few legal-sized fish of either species were found during the 2002 survey. Walleye fry were stocked in Victoria Reservoir during 1971–72. These fish apparently survived well, and natural reproduction was sufficient to sustain a modest walleye fishery for nearly 30 years. A fisheries survey conducted in 2000 suggested that several year class failures had depleted the walleye population, and supplemental walleye plants were made during 2000–02. The walleye plants have been temporarily discontinued, and additional monitoring will be conducted to determine if further walleye plants are needed.

Recreational Use

The large tracts of publicly owned land in the Ontonagon River watershed provide a wide variety of recreation opportunities (Figure 45). Popular outdoor activities within the basin include fishing, boating, water skiing and tubing, canoeing, kayaking, hunting, trapping, berry and mushroom picking, camping, swimming, off-road vehicle (ORV) trail riding, snowmobiling, snowshoeing, cross-country skiing, hiking, bike riding, bird and wildlife watching, and waterfall viewing.

Boating is a major recreational activity on lakes within the watershed (Table 27). Motor boating and water skiing generally occur on larger lakes, while canoeing and kayaking are popular pastimes on smaller lakes and ponds. Rental boats are available at several resorts along the shorelines of Lake Gogebic and the Cisco Chain.

Motors are prohibited on most lakes within the Sylvania Wilderness Area. Canoeing and hiking are the only modes of transportation in this roadless wilderness, and many visitors use canoes to access remote lakes within the Sylvania Wilderness Area.

Steep gradients and rock-strewn rapids make many of the streams in the Ontonagon River system unsuitable for leisurely canoeing. Juetten (1973) provided this description of canoeing on the West Branch.

> The stream is said to be canoeable from Norwich Road down to Victoria Dam, however, during periods of low water, protruding rocks and boulders make canoeing difficult. One local canoe enthusiast commented that the most enjoyable part of his trip was taking his canoe out at Victoria Dam. Canoeing from Lake Gogebic downstream to Norwich Road is not recommended. [From Juetten 1973.]

A few stream reaches within the basin are frequented by canoeists. The upper Middle Branch, South Branch, and the main stem are popular canoeing destinations (Dennis and Date 2005). These streams still can be challenging to float in a canoe, and portages may be required around rapids and small waterfalls. A canoe livery in Watersmeet provides rental crafts for use on the upper Middle Branch and Sylvania Wilderness Area lakes.

The turbulent waters of the Ontonagon River system attract visitors looking for a challenging whitewater experience. No guided trips are available, but many whitewater enthusiasts bring their own canoes and kayaks to descend the steeper stream reaches within the watershed. It is difficult to quantify the importance of this activity to the local economy, but anecdotal information suggests that whitewater paddling has been increasing in popularity. A local canoe enthusiast provided this description of the whitewater opportunities on the West and Cisco branches.

> I believe the West Branch contains some of the best intermediate whitewater recreational opportunities in the Ontonagon River watershed. Although there are only short periods of adequate water levels, usually in early spring and late fall, the USGS gauge near Bergland provides "real time" water level data [http://waterdata.usgs.gov/mi/nwis/rt]. Since 1975 I have regularly canoed the West Branch from the Bergland Dam to Lake Victoria with water levels ranging from 200-800 cfs. At 200 cfs, the stretch from Bergland Dam to about a mile upstream from its confluence with Cascade Creek is Class II and Class I from Cascade Creek to the Norwich Bridge. The uppermost segment (just below the dam) is Class III at higher water levels (600-800 cfs).
>
> The segment from Norwich Bridge to Lake Victoria begins with flat water for the first two miles and ends with a two-mile paddle across Lake Victoria. However, there is spectacular scenery, camping opportunities and long intermittent stretches of Class II rapids (Class II/III at higher water levels) in between [sic]. Each of these segments can be easily paddled within four-five hours.
>
> The Cisco [Branch], from its confluence with Tenderfoot Creek to [Forest Hwy] 6930 has even shorter periods of adequate water volume for paddling. However, when conditions are right it has a longer continuous stretch of Class II/III whitewater than the East Branch. Most of the stretch beginning shortly upstream of an old USFS gravel pit on [Forest Hwy] 527 (Section 23 T46N R41W) is continuous Class II with Wolverine Falls Class III. Wolverine Falls approaches Class IV at higher water levels. [From A. Warren, personal communication]

Canoeing or kayaking on the West and Cisco branches is not recommended for novice paddlers. Flows in the West and Cisco branches can change rapidly due to dam operations (see **Hydrology**). In addition, maps may not accurately depict the locations of rapids and waterfalls, so paddlers should exercise caution when running a stream reach for the first time.

The public lands within the watershed provide a myriad of hunting and trapping opportunities. Waterfowl hunting is a common activity on the lakes and streams within the basin. Riparian corridors are also prime trapping locations for beaver, muskrat, and otter. Deer, bear, and upland bird hunting are popular activities on the forested lands within the Ontonagon River watershed.

An extensive network of trails exists for snowmobiling, hiking, biking, cross-country skiing, and horseback riding. Hundreds of miles of snowmobile trails cross the Ontonagon River watershed, and snowmobiling has become an important source of revenue for many area businesses. Many other trails function as hiking (or biking) trails during the summer and cross-country ski trails during the winter. Over 30 miles of such trails exist within the Sylvania Wilderness Area, and several shorter trails are located near campgrounds and waterfalls. The North Country National Scenic Trail crosses the northern portion of the watershed (from Bob Lake to Cascade Creek). When completed, this hiking trail will connect the Lewis and Clark Trail in North Dakota to the Appalachian Trail in Vermont.

Off-road vehicles are a popular method of transportation in the Upper Peninsula. Although the only state designated ORV trail in the Ontonagon River basin is the Iron River-Marenisco Route (which runs through the southern portion of the watershed near Watersmeet), Michigan state forest lands are open to ORVs unless posted otherwise. The Ottawa National Forest historically had a similar policy, but increasing ORV traffic in recent years has prompted USFS to revise this policy. As of May 2006, cross-country use of ORVs is prohibited in the Ottawa National Forest. Under the new regulations, ORVs still are allowed on designated roads and trails within the forest.

There are 13 public campgrounds and several private campgrounds in the Ontonagon River watershed (Table 15). Dispersed camping is also practiced on state and federal lands throughout the basin.

> Camping is permitted anywhere on State Forest property as long as it is not posted “No Camping,” and is one mile or more from a designated State Forest Campground. Campers must follow all state land rules and must also post a registration card at the campsite. On National Forest lands, no permit is needed to primitive camp for up to [16] days, no closer than 50 ft from a lake or stream and not less than 100 ft from a road. [From Madison and Lockwood 2004.]

Dispersed camping is not permitted in the Sylvania Wilderness Area. Permits to camp at designated campsites within the Sylvania Wilderness Area can be obtained from the Wilderness Entrance Station or the Watersmeet Visitor Center.

The numerous waterfalls in the Ontonagon River watershed attract thousands of tourists each year. Marked trails lead to many of these falls. Two waterfalls within the basin, Bond Falls and Agate Falls, are designated as State Scenic Sites.

Fishing is one of the most popular outdoor activities in the watershed. For many years, MDNR has used angler creel surveys to monitor fishing activity on Michigan lakes and streams. During 1928–64, conservation officers recorded catch and effort data for several streams within the watershed (Table D.1). These “General Creel Census” surveys were qualitative in nature, and it was not possible to estimate total annual harvest or effort from this data. More comprehensive creel surveys have been conducted on some of the heavily fished waters within the basin. These surveys were designed to evaluate total fishing effort (i.e., through regular angler or boat counts) and annual harvest (i.e., through angler interviews) of one or more game fish species.

The available creel data for each subwatershed are summarized in the following sections. The catch-per-hour (CPH) estimates for game fish reported below were calculated by dividing the total estimated harvest of the subject species by the total estimated fishing effort (regardless of targeted species) during the study period.

Middle Branch—upper

General Creel Census data indicated that brook trout was the premier game fish species in the upper Middle Branch from the late 1920s through the early 1960s. Conservation officers checked 4,191 brook trout during this period, compared to 233 brown trout and 648 rainbow trout. Brook trout was also the most abundant species harvested on upper Middle Branch tributaries during the General Creel Census.

Wagner et al. (1994) used an intensive creel survey to estimate the relative contributions of stocked and wild brook trout to the upper Middle Branch fishery. The mean annual effort during the pre-stocking period (1988–89) was 1,760 angler hours. The mean estimated harvest was 539 brook trout, yielding a CPH of 0.306. During the stocking period (1990–92), the mean annual effort was 1,488 angler hours. The mean estimated brook trout harvest was 959 fish, resulting in a CPH of 0.645. Hatchery fish made up 41% of the total annual harvest during 1990–92 (see **Fishery Management**).

Walleye was the most abundant fish species harvested during the 2003 LLSP creel survey on the Bond Falls Flowage (Hanchin, in press). Walleye CPH was 0.0453 during this survey. By comparison, the mean walleye CPH for all LLSP open water creel surveys conducted during 2001–05 was 0.0403 (Hanchin, in press). Additional fish species harvested, in order of decreasing abundance, were rock bass, yellow perch, smallmouth bass, black crappie, northern pike, bluegill, largemouth bass, muskellunge, green sunfish, and pumpkinseed. Piscivorous game fish composed 49% of the total harvest (by number). The high relative abundance of predators in the creel corroborates the catch data from the 2003 fisheries surveys which suggested that the forage base was depleted in this reservoir.

Another creel survey was conducted on Duck Lake during the 1993 open water fishing season. Species harvested (from most to least abundant) were bluegill, black crappie, pumpkinseed, rock bass, yellow perch, walleye, northern pike, and smallmouth bass. Panfish composed 97% of the total harvest during this period. Catch-per-hour values for bluegill and black crappie were 0.31 and 0.28, respectively. Although walleye made up only a small percentage of the total harvest, a substantial number of anglers targeted this species. Fourteen percent of the anglers surveyed indicated that they were fishing for walleye.

Middle Branch—lower

Rainbow trout (steelhead) was the most abundant species harvested in the lower Middle Branch during the General Creel Census, followed by brook trout and brown trout. The lower Middle Branch supports a seasonal fishery, with most angling effort occurring during the spring steelhead migration.

General Creel Census data indicated that brook trout was the primary species caught in lower Middle Branch tributaries, although brown trout made up a substantial portion of the catch in the Baltimore River. Surprisingly, few rainbow trout were harvested from any of the tributaries to the lower Middle Branch.

Main Stem

Coolwater fish species (i.e., walleye and northern pike) dominated the catch during the General Creel Census surveys on the main stem. During the last 20 years, several intensive creel surveys have been conducted at the mouth of the Ontonagon River as part of the Great Lakes Creel Program. Many of the anglers interviewed at this port were fishing in Lake Superior rather than the main stem. The major game fish species recorded during these surveys were lake trout, walleye, coho salmon, Chinook salmon, brown trout, and steelhead.

East Branch

General Creel Census data indicated that anglers were catching brook trout, brown trout, and rainbow trout in the East Branch and its tributaries. Although rainbow trout composed a substantial percentage of the East Branch harvest in some years, brook trout clearly was the dominant species in the East Branch and associated tributaries.

USFS conducted a creel survey on Lower Dam Lake in 1983. Estimated fishing effort for June–September was 952 angler hours. The CPH for trout (brook trout and brown trout combined) was 0.46.

Cisco Branch

Limited creel census information is available for the Cisco Branch and associated tributaries. Although brook trout were harvested in this stream during 1941 and 1962, recent electrofishing surveys and anecdotal reports suggest that the Cisco Branch is a marginal trout stream that receives little fishing pressure.

General Creel Census data were collected on Cisco and Thousand Island lakes during 1928–64. For Cisco Lake, species harvested (most to least abundant) were yellow perch, bluegill, walleye, northern pike, pumpkinseed, largemouth bass, smallmouth bass, rock bass, black crappie, muskellunge, and lake trout. The CPH values were 0.13 for walleye and 0.62 for all species. On Thousand Island Lake, species harvested were yellow perch, bluegill, walleye, northern pike, pumpkinseed, smallmouth bass, rock bass, largemouth bass, black crappie, lake trout, and muskellunge. Catch-per-hour was 0.08 for walleye and 0.60 for all fish species.

Another creel study was conducted on Cisco and Thousand Island lakes in 1978. As in previous surveys, yellow perch was the most abundant species in the creel for both lakes. The CPH estimates for all species combined were 0.87 for Cisco Lake and 0.56 for Thousand Island Lake. Walleye CPH was relatively low in both lakes during 1978: 0.02 in Cisco Lake and 0.03 in Thousand Island Lake. The apparent decline in walleye catch rates may have been due to survey design. Conservation officers probably patrolled the Cisco Chain more frequently in May (around the opening of walleye season) when walleye catch rates were higher, which would have biased the General Creel Census data. The 1978 creel survey was conducted from mid-May through August, so it encompassed the late summer period when walleye harvest is typically lower.

The most recent creel data for the Cisco Chain were collected during the 2002–03 large lake survey (Hanchin et al. 2008; Table D.3). This creel survey encompassed the entire Cisco Chain, so it was not directly comparable to the previous surveys on Cisco and Thousand Island Lakes. During the open water season (May–October), the main species harvested were yellow perch, bluegill, black crappie, walleye, northern pike, rock bass, smallmouth bass, and largemouth bass. The CPH estimates were 0.02 for walleye and 0.66 for all species. Creel data were also collected during the winter ice fishery. Species harvested during the winter included yellow perch, bluegill, northern pike, walleye, pumpkinseed, rock bass, and black crappie. Winter CPH estimates were 0.02 for walleye and 0.81 for all fish species.

South Branch

Little creel census information is available for the South Branch. General Creel Census data indicated that brook trout fisheries existed on some South Branch tributaries, including Bluff Creek, Scott and Howe Creek, and Sucker Creek. Anglers were also catching brown trout and rainbow trout in Bluff and Sucker Creeks during 1945–64.

West Branch

General Creel Census data were collected on the West Branch during 1937–59. Walleye dominated the catch in this stream, followed by northern pike, yellow perch, and smallmouth bass. Walleye and northern pike were also important components of the fishery in the Slate River. During the General Creel Census, brook trout fisheries existed on several Lake Gogebic tributaries, including Marshall Creek, Pelton Creek, Trout Brook, and the Slate River. Cascade Creek is the only direct tributary to the West Branch that supports a targeted trout fishery. Over 900 brook trout were harvested during the General Creel Census on Cascade Creek.

Several creel surveys have been conducted on Lake Gogebic during the last 70 years. Walleye and yellow perch consistently have composed over 80% of the harvest on this lake. During the 2005 open water fishing season, CPH estimates for walleye and yellow perch were 0.0479 and 0.0891, respectively (Z. Su, MDNR Fisheries Division, unpublished; Table D.4). Smallmouth bass (CPH = 0.0114) are also an important part of the fishery, but the 2005 creel data indicated that about 85% of the smallmouth bass caught were subsequently released. Lake Gogebic is one of the most heavily fished lakes in the western Upper Peninsula, and over 100,000 angler hours were expended on this system during the 2005 open water season.

Citizen Involvement

Various citizen groups have been involved in watershed planning and aquatic habitat improvement projects within the Ontonagon River basin. Natural resource agencies (e.g., MDNR, MDEQ, USFS, USFWS, KBIC, or United States Department of Agriculture – Natural Resources Conservation Service) collaborate with these groups and provide technical and (in some instances) financial assistance.

Sport fishing clubs have worked on numerous habitat improvement projects during the last 70 years. These groups have assisted with beaver removals, installation of fish cover structures and spawning riffles, and construction of a walleye rearing pond. The Ontonagon Valley Sportsmen’s Club, the Copper Country Chapter of Trout Unlimited, the Ottawa Sportsmen’s Club, and the Upper Peninsula Sport Fishing Association are active clubs that regularly interact with MDNR regarding fisheries issues.

Various lake associations have also participated in fisheries projects. These associations have assisted with fisheries surveys, manual removals, installation of fish cover structures, and public education regarding aquatic invasive species. Some lake associations have paid private hatcheries to stock fish in their respective lakes. These fish plants were conducted after receiving the required fish stocking permits from MDNR.

Several nongovernmental organizations provided comments during the relicensing period for the five hydroelectric-related dams in the watershed. Trout Unlimited, Michigan United Conservation Clubs, Anglers of Au Sable, Great Lakes Council, Inc., Federation of Fly Fishers, Inc., American Rivers and American Whitewater Affiliation, the Cisco Chain Riparian Owners Association, the Lake Gogebic Improvement Association, North Shore Concerned Citizens Group of Lake Gogebic, the Upper Peninsula Sport Fishing Association, and the Upper Peninsula Sportsmen’s Alliance all participated in the FERC relicensing process. The Upper Peninsula Public Access Coalition and other nongovernmental organizations have also provided comments to FERC regarding UPPCo’s shoreline management plan for the Bond Falls Flowage.

LVD maintains a small walleye hatchery along the shore of Lac Vieux Desert (Wisconsin River watershed). LVD is working to expand their walleye rearing capabilities, and it is likely that many of the walleye produced at this facility would be stocked within the Ontonagon River watershed. As mentioned in previous sections, KBIC has their own fish hatchery, and they have stocked Jumbo River strain brook trout in several East Branch tributaries. Keweenaw Bay Indian Community is also in the process of developing a walleye rearing pond. MDNR will continue to work with LVD, KBIC, and USFS to ensure that the various organizations are not employing competing stocking strategies on the same water body.

Basinwide watershed councils have been established for many Michigan watersheds, but no equivalent council exists for the Ontonagon River basin. Watershed councils provide a means for the various government and nongovernmental organizations to exchange information, set common goals for DNR management, and prioritize proposed projects. Because watershed councils involve multiple entities, they also have the financial and labor resources to complete projects that are too large for individual organizations to address.

MANAGEMENT OPTIONS

The Ontonagon River watershed is a valuable resource that supports a diverse array of recreational opportunities. Although the Ontonagon River is healthy relative to most other streams in Michigan, human activities over the last two centuries have altered many of the physical and biological characteristics of the watershed. The management options presented below are intended to address the most significant known problems within the basin and establish priorities for further investigations.

Management options follow the recommendations of Dewberry (1992), who outlined measures necessary to protect the health of riverine ecosystems. Dewberry (1992) stressed protection and rehabilitation of headwater streams, riparian areas, and floodplains. Streams need to be reconnected to their floodplains where possible. A river system must be viewed as a whole, because system-level processes strongly influence aquatic habitat and fish community composition.

Options identified herein are consistent with the MDNR, Fisheries Division mission 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 current and future generations. In particular, 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 understanding of fish, fishing, and fishery management.

The following options reflect five approaches to watershed management: (1) protection of existing resources, (2) identification of issues requiring further investigation, (3) restoration of degraded resources, (4) enhancement of natural resources above and beyond their original condition (e.g., boat launch construction or management of single species trout lakes), and (5) public education regarding watershed function and management. Many management options listed below are already being put into practice, while other options will be implemented within the next five years. Remaining options (e.g., dam removal) will be implemented as opportunities arise. These options were developed to guide watershed activities and are applicable for citizen groups and other resource agencies with interest in the Ontonagon River basin.

Geology and Hydrology

Streams in the southern portion of the Ontonagon River watershed (e.g., the upper Middle Branch) have stable flows due to an abundance of coarse textured glacial till and highly permeable soils. Large deposits of lacustrine clay and silt in the northern half of the basin prevent infiltration and produce flashier stream flows in the main stem and lower Middle Branch. Operations at the Bond Falls diversion and other dams have substantially altered the flow regimes in large portions of the Ontonagon River system. Human development within the watershed is relatively sparse, and an important goal of future management is to preserve the hydrologic function of existing pristine areas.

Option: Protect the natural hydrologic regime of streams by preserving existing wetlands, floodplains, and upland areas that provide recharge to the water table.

Option: Work with MDEQ, FMFM, land managers, local authorities, timber companies, and private citizens to protect natural flow regimes by incorporating best management practices (e.g., riparian buffer strips, infiltration basins, seeding and mulching, etc.) throughout the watershed.

Option: Protect and restore groundwater recharge by restricting addition of impervious surfaces and requiring that all development-related runoff be captured by infiltration basins.

Option: Protect natural lake outlets by opposing construction of new lake-level control structures.

Option: Restore the natural hydrologic regimes of lakes and lake outlets by removing lake-level control structures when possible.

Option: Restore natural hydrologic regimes by removing dams when possible and requiring existing dams to operate in a manner that mimics natural flow regimes.

Option: Reestablish flow gauges at former East Branch and South Branch gauge sites, and explore the possibility of establishing additional gauge stations (e.g., upper East Branch near Kenton and lower Cisco Branch near Twomile Creek) within the watershed.

Option: Protect groundwater and stream flows by supporting laws that require major water withdrawals to be registered with MDEQ. Water withdrawal operations should indicate the volume and timing of proposed withdrawals and demonstrate that these withdrawals will not diminish the biological and recreational values of affected streams.

Soils and Land Use

Compared to other Michigan watersheds, the Ontonagon River watershed is sparsely populated. Forest continues to be the dominant land cover type, and wetland loss has been relatively minor. The sandy soils in the southern portion of the Ontonagon River watershed are highly susceptible to erosion when vegetation is removed by timber harvesting, agricultural activities, roadway development, or other earth-disturbing activities. The fine-textured soils in the northern half of the watershed are less subject to erosion, but bank slumping is a major concern in hilly areas. Improperly constructed stream crossings can fragment fish populations and contribute excess sediment to streams. A thorough stream crossing inventory has not been completed for the Ontonagon River watershed.

Option: Protect and maintain forested buffers along lake shores and river corridors.

Option: Protect remaining stream margin habitats, including floodplains and wetlands, by encouraging vegetation buffer strips in zoning regulations.

Option: Work with MDEQ to protect streams from excessive sedimentation by supporting the use of best management practices in commercial timber harvest operations.

Option: Protect undeveloped private riparian lands by bringing lands under public ownership or through economic incentives such as tax credits, deed restrictions, conservation easements, or other means.

Option: Prevent excessive sedimentation from agricultural lands by supporting best management practices and agricultural zoning plans.

Option: In conjunction with local sport fishing groups and other organizations, survey road-stream crossings to identify problem areas and implement best management practices at these crossings.

Option: Conduct aerial surveys to identify nonpermitted stream crossings within the watershed.

Option: Replace or improve culverts or road-stream crossings that are undersized, perched, or misaligned.

Option: Encourage the use of bridges at road-stream crossings and discourage the use of culverts.

Option: Protect streams from excessive sedimentation by reviewing stream crossing proposals to ensure that adequate erosion control measures (e.g., diversions and revegetation) are implemented.

Option: Reduce sediment from roadways by encouraging education of workers involved in road construction and maintenance regarding the use of best management practices.

Option: Protect streams from degradation by promoting bore and jacking or directional drilling methods of pipeline stream crossings as an alternative to open ditching.

Option: Use soft-armoring techniques to restore stream banks that are eroding as a result of human activities.

Option: Continue to evaluate proposed shoreline development activities around the Bond Falls Flowage and Victoria Reservoir and provide comments to FERC regarding the potential biological and recreational impacts of such activities.

Channel Morphology

Relative to other river systems in Michigan, the Ontonagon River and its tributaries are high gradient streams. Channel morphology within the watershed has been shaped primarily by natural processes, but human activities (e.g., construction of dams and road crossings) have altered channel morphology on some stream reaches. Due to the location of the major dams, little high gradient habitat has been lost as a result of dam construction.

Option: Protect diverse stream channel habitats by preventing removal of large woody structure from stream channels and educating riparian landowners on the value of large woody structure to fish and other aquatic species.

Option: Protect and restore riparian forests by educating riparian residents on how riparian forests influence water quality, stream temperatures, trophic conditions, channel morphology, bank erosion and stability, and aquatic, terrestrial, and avian communities.

Option: Survey coldwater streams to identify where beaver activity is adversely affecting riparian habitats or stream channel morphology.

Option: Work with FMFM, USFS, timber companies, and private landowners to reduce growth of aspen (the primary food for beavers) along coldwater streams.

Option: Restore channel diversity by controlling unnatural sediment contributions and by removing artificially introduced streambed sediment.

Option: Protect channel morphology by using bridges or bottomless arch structures at stream crossings.

Option: Protect riparian greenbelts through adoption and enforcement of zoning standards.

Option: Maintain natural channel morphology by opposing channelization of streams within the watershed.

Option: Protect natural channel movement by encouraging and requiring the use of soft armor methods of bank stabilization (e.g., vegetative plantings or whole tree revetments rather than rock riprap) through permitting processes and cooperative planning.

Option: Increase channel diversity by adding woody structure or habitat improvement structures in stream reaches where habitat diversity is low due to past or present land management activities (e.g., residential development or removal of old-growth forests).

Dams and Barriers

There are 17 registered dams and an unknown number of smaller dams within the Ontonagon River watershed. These dams may negatively affect aquatic resources by impeding potamodromous fish migrations, fragmenting resident fish populations, blocking downstream movement of large woody structure and detritus, disrupting the sediment balance above and below impoundments, altering flow regimes and channel morphology, and elevating stream water temperatures. Dams do provide some recreational and economic benefits, so both the positive and negative effects of dams need to be considered when making decisions regarding the operation and removal of existing dams.

Option: Protect fish habitat and river functionality by actively opposing construction of new dams and within-stream-channel storm water detention basins.

Option: Examine dams owned by MDNR and USFS to determine their usefulness or potential for removal.

Option: Work with private and corporate dam owners to remove dams that are no longer used for their original purpose.

Option: Protect the public trust by encouraging dam owners to make appropriate financial provisions for future dam removal and supporting legislation that requires dam owners to establish such funds.

Option: Work with dam owners to rehabilitate stream and wetland habitats at lake outlets by removing dams, modifying dams to fixed-crest structures, or modifying operations of existing dams.

Option: Educate resource managers and citizens on the effects of lake-level control structures and the ecological benefits of allowing lakes to function naturally.

Option: When feasible, work with dam owners to provide upstream and downstream fish passage at existing dams.

Option: Continue to require minimum water releases from Bond Falls Dam (Middle Branch Ontonagon River) and Victoria Dam (West Branch Ontonagon River).

Option: For Bergland Dam, work with UPPCo, FERC, local residents, and other interested parties to establish minimum water releases and lake level requirements that benefit the West Branch aquatic communities without negatively affecting recreational opportunities on Lake Gogebic.

Option: Protect fish from entrainment and injury by requiring screened turbine intakes at the Victoria hydroelectric facility.

Option: Survey and develop an inventory of other barriers to fish passage, such as culverts, and explore options for correcting each problem.

Water Quality

Water quality is excellent throughout most of the watershed. Sedimentation (e.g., at stream crossings) is the primary water quality concern within the basin. Thermal pollution is an additional concern for stream reaches below impoundments.

Option: Enhance public stewardship of the watershed by supporting educational programs that provide interested constituents and local organizations with information regarding best management practices and the effects of land use practices on water quality.

Option: Survey stream temperature conditions throughout the watershed to assess the potential of these waters to support populations of different fish species.

Option: Rehabilitate coldwater valley segments by promoting harvest of beaver in areas where beaver dams are blocking fish migration and elevating stream temperatures to levels unsuitable for trout production. Beaver harvest generally will be conducted during the regulated fur harvest season. When this is not feasible, Fisheries Division will work with Wildlife Division (and other divisions as necessary) to secure permits for harvest outside of the normal trapping season.

Option: Evaluate effects of existing human-made dams on downstream temperature regimes.

Option: Measure late winter oxygen profiles in current and potential trout lakes to determine if dissolved oxygen levels are adequate for trout survival.

Option: Conduct limnological surveys on lakes within the watershed to establish current data on pH, alkalinity, dissolved oxygen, and water clarity.

Option: Work with MDEQ to evaluate effects of NPDES permitted discharges on receiving waters.

Special Jurisdictions

The State of Michigan exercises jurisdiction over most of the Ontonagon River watershed through MDNR and MDEQ. The Wisconsin portion of the watershed is under the jurisdiction of WDNR. Much of the watershed is included in the Ottawa National Forest, so USFS heavily influences land management practices within the basin. FERC oversees operations at the five dams associated with the Victoria hydroelectric facility, and the United States Army Corps of Engineers addresses issues pertaining to navigability. The United States Fish and Wildlife Service, coordinating with the Great Lakes Fishery Commission, controls sea lamprey abundance in Lake Superior tributaries (see **Biological Communities**). Various units of local government also have jurisdiction over portions of the watershed. The activities of these governmental organizations can affect the aquatic habitat and biological communities in the Ontonagon River system.

Option: Protect the river system by supporting cooperative planning and decision making that involves all units of government and interested citizens.

Option: Support continued protection of stream reaches designated under the federal Wild and Scenic Rivers Act.

Option: Identify remaining high quality stream reaches for inclusion in the Michigan Natural Rivers program.

Option: Protect the health of wetlands, streams, and lakes through enforcement of the Natural Resources and Environmental Protection Act of 1994 (Public Act 451; Parts 31, 91, 301, and 303).

Option: Work with the United States Army Corp of Engineers on dredging and channel maintenance issues to minimize effects on stream habitat and aquatic communities.

Option: Continue collaborative habitat restoration efforts involving MDNR, Fisheries Division; MDNR, Forest, Mineral, and Fire Management Division; USFS; USFWS; and other interested parties.

Biological Communities

The biological communities in the Ontonagon River watershed have changed dramatically during the last two centuries. Logging during the late 1800s accelerated erosion of stream banks and increased sediment inflows to the river system. Dams have affected fish communities by fragmenting fish populations, altering flow regimes and water temperatures, and interfering with the downstream transport of large woody structure, detritus, and sediment. Commercial fishing depleted populations of several fish species, and overexploitation was a major factor leading to the extirpation of lake sturgeon in the Ontonagon River. Exotic species introductions (both intentional and unintentional) have further altered the species composition of biological communities within the basin.

Option: Review fish stocking permit applications and require documentation of fish health testing for all private and public stockings to prevent introduction of pathogens and undesirable species into public waters.

Option: Disinfect all sampling gear (including boat, motor, and trailer) between surveys to reduce the risk of transferring aquatic invasive species or pathogens to new waters.

Option: Educate the public regarding aquatic invasive species by maintaining informative signage at boat launch sites and continuing discussions with sport fishing groups, lake associations, and other interested groups.

Option: Work with the United States Fish and Wildlife Service Sea Lamprey Control Unit to monitor sea lamprey abundance and distribution within the watershed, and implement control measures as necessary.

Option: Work with local lake associations and other organizations to suppress or eliminate Eurasian water-milfoil infestations.

Option: Conduct surveys to evaluate the survival, movement, and growth of lake sturgeon stocked in the main stem.

Option: Conduct surveys to evaluate the fish communities in river valley segments and lakes without recent survey data.

Option: Conduct surveys to determine the abundance and distribution of native mussels in the Ontonagon River system.

Option: Work with MDEQ to continue monitoring the aquatic macroinvertebrate communities in the Ontonagon River watershed.

Option: Consider potential effects on amphibians and reptiles (e.g., wood turtles) when developing new boat launches and other recreational facilities. Adjust designs as necessary to protect critical habitats for these organisms.

Option: Record observations of amphibians and reptiles during MDNR fish community surveys.

Option: Collaborate with various universities to determine the effects of habitat manipulations on fish and macroinvertebrate communities.

Option: Monitor the distribution of aquatic invasive species and pathogens within the Ontonagon River watershed and maintain a database of the results.

Fishery Management

The various branches and tributaries of the Ontonagon River present a diverse array of fishing opportunities. Brook trout is the principal game fish species in the southern portion of the watershed, while potamodromous brown trout, steelhead, and coho salmon provide seasonal fisheries in the stream reaches with Great Lakes access. Although stocking is a part of the management strategy for this system, the salmonid populations primarily are sustained by natural reproduction. Popular fisheries for coolwater and warmwater species also exist on many lakes.

Option: Continue fish stocking programs in various parts of the watershed to maintain well-balanced fish communities and diverse angling opportunities.

Option: Protect self-sustaining trout stocks by discouraging stocking on top of these populations.

Option: When fish are to be stocked in the Ontonagon River watershed, require that stocked fish be certified as disease-free.

Option: Develop an educational pamphlet to inform angler clubs, lake associations, and other interested parties of Fisheries Division's concerns regarding fish stocking.

Option: Whenever possible, use fish marked with oxytetracycline (OTC) for walleye stocking to facilitate evaluation of the relative contributions of hatchery and wild walleye to the fisheries of interest.

Option: Maintain and enhance the streamside rearing facility for lake sturgeon on the main stem. Collaborate with other resource agencies and universities to monitor the survival, growth, and movements of stocked lake sturgeon.

Option: Continue to survey fish communities and habitats within the basin. Prioritization should be given to waters that are currently stocked (e.g., Duck Lake), support intensive fisheries (e.g., the upper Middle Branch), or have not been surveyed in many years.

Option: Conduct electrofishing and creel surveys to evaluate the effects of Type 6 trout regulations on the brook trout fishery in Duck Creek.

Option: Conduct netting and creel surveys to evaluate the effects of special fishing regulations on the fisheries within the Sylvania Wilderness Area.

Option: Continue to work with WDNR to develop boundary water fishing regulations that are biologically sound and simple for anglers to understand.

Option: Continue to consult with LVD, KBIC, and Great Lakes Indian Fish and Wildlife Commission to develop methodology for setting biologically-sound spearing quotas for harvesting walleyes in the 1842 Treaty-ceded inland territory of Michigan. Continue to work with LVD, KBIC, and Great Lakes Indian Fish and Wildlife Commission to set spearing quotas and help enforce such quotas.

Option: Collect water temperature data for streams within the basin and change trout stream designations or stocking strategies if warranted.

Option: Work with FMFM, USFS, timber companies, and private landowners to discourage growth of aspen near designated trout streams.

Option: Work with MDNR, Wildlife Division, USFS, and other organizations to identify streams where more aggressive beaver control should be instituted to protect trout habitat.

Option: Identify river reaches in need of habitat improvement (e.g., erosion control or fish cover installation) and work with interested partners to restore or enhance fish habitat in these streams.

Option: Work with the United States Fish and Wildlife Service to ensure that appropriate measures are taken to control sea lamprey abundance within the watershed.

Option: Conduct manual removals of panfish or rough fish (e.g., suckers or bullheads) as necessary to restore the predator-prey balance in lakes within the watershed.

Option: Conduct rotenone treatments as necessary to eliminate competing species in managed trout lakes.

Recreational Use

A myriad of recreational opportunities exist throughout the watershed due to the abundance of public-owned land. The public has legal access to much of the watershed, but the paucity of roads complicates access to some stream reaches. Steep gradients and abundant rapids further limit canoeing and kayaking opportunities on many streams. Fishing and boating are common activities on lakes within the basin, and over 40 boat launches provide public access to these water bodies. Roadless areas (e.g., the Sylvania Wilderness Area) provide unique recreational opportunities for persons desiring a true wilderness experience.

Option: Maintain or improve existing parks and public boat launch facilities.

Option: Secure and develop additional access sites on waters where public access is lacking, while still maintaining a good array of roadless and remote fishing opportunities.

Option: Support funding for handicapped-accessible fishing piers, walkways, and other facilities to enhance recreational opportunities within the watershed.

Option: Improve public access at or below hydropower-related impoundments through the FERC relicensing process.

Option: Use best management practices at primitive access sites to reduce erosion and sedimentation.

Option: Protect recreational use of small tributaries by supporting the establishment of a “recreational” definition of legal navigability.

Option: Work with responsible parties to reduce effects of ORV usage on streams and wetlands.

Citizen Involvement

Citizen involvement is a necessary component for effective management of the Ontonagon River watershed. Collaboration between resource agencies, universities, user groups, and interested citizens increases the knowledge and resource base available for watershed projects and enhances public acceptance and understanding of watershed management activities.

Option: Educate citizens and local governments regarding significant management issues by providing information through various media outlets, sport groups, civic leaders, and public meetings.

Option: Protect and rehabilitate the watershed by educating river users and riparian property owners on watershed management principles.

Option: Support and provide technical assistance to groups seeking funding for stream protection and restoration projects.

Option: Support the establishment of a watershed council to facilitate communication between different user groups within the basin.

Option: Survey other watersheds in the state to identify watershed councils that could assist with the formation of an Ontonagon River Watershed Council.

GLOSSARY

alfisols – well-developed, fertile soils that typically are associated with deciduous forests

alkalinity – capacity of water to neutralize an acid; for aquatic situations, alkalinity is generally determined by the concentrations of carbonate (CO_3^{-2}), bicarbonate (HCO_3^-), and hydroxide (OH^-) and is expressed in mg/L of calcium carbonate ($CaCO_3$) equivalent

alluvium – clay, silt, sand, gravel, or similar detrital material deposited by running water

angler hour – one hour of fishing by one angler

anthropogenic – of, relating to, or resulting from the influence of humans on nature

antimycin – chemical compound historically used to eliminate or reduce fish populations in lakes, streams, or ponds; this chemical is also used as an antibiotic

assemblage – collection of species living within a defined region or stream segment

avian – of or pertaining to birds

base flow – discharge amount that is equaled or exceeded 90% of the time and essentially equals the groundwater discharge to a stream; equivalent to 90% exceedence flow

basin – an area of the earth's surface that drains toward a receiving body of water (such as a stream or lake) at a lower elevation; synonymous with watershed

biological oxygen demand – measure of the consumption of oxygen in an ecosystem within a fixed period of time

biomass – total weight of fish collected in sampling gear

biota – animal and plant life

broodstock – group of sexually mature individuals of a cultured species that is kept separate for breeding purposes

buffer strip – vegetated land adjacent to a stream or lake that is not altered during timber harvest or construction activities

bulkhead – retaining wall along the edge of a lake or stream

capillary action – the action that causes a liquid (e.g., water) to move through a porous solid (e.g., soil) due to attractive forces between the two substances; a process that can move groundwater from wet areas of soil to dry areas

catchment – the area of the earth's surface that drains to a particular location on a stream

centrarchid – sunfishes of the family Centrarchidae; examples include largemouth and smallmouth bass, bluegill, pumpkinseed, and black crappie

cfs – cubic feet per second

channelization – conversion of a stream into a ditch; channelized streams are narrower, deeper, and straighter than natural channels; channelization may be done for navigation or to improve drainage for agricultural purposes

coldwater fish species – fish that generally achieve their maximum growth potential at water temperatures below 65°F; examples include brook trout, rainbow trout, brown trout, and slimy sculpin

community – an interacting group of organisms of multiple species

confluence – the joining or convergence of two streams

coniferous – cone-bearing, typically evergreen, trees

coolwater fish species – fish that generally achieve their maximum growth potential at water temperatures between 65°F and 75°F; examples include walleye, yellow perch, northern pike, muskellunge, and smallmouth bass

CPH – catch per angler hour; number of fish harvested by 1 angler in 1 hour

creel survey – fisheries assessment method that typically involves angler interviews, boat or angler counts, and collection of biological information about angler-caught fish

CWA – Federal Clean Water Act of 1977

deciduous – vegetation that sheds its foliage annually

detritus – nonliving particulate organic material (e.g., small pieces of wood or leaves)

discharge – volume of water flowing past an arbitrary line through a stream during a specified time period; usually expressed in cubic feet per second (cfs)

diversion – earthen or stone dike used to direct water flow away from an area that is susceptible to erosion

ecosystem – functional unit consisting of a biological community and the nonliving factors of its environment

electrofishing – method of sampling that uses electrical currents to stun or attract fish

entrain – to pass through the turbines of a hydroelectric dam

EPA – Environmental Protection Agency

EPT – organisms in the following families: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies); commonly used as water quality indicators

erosion – the process of moving soil particles by wind or water

evapotranspiration – loss of water from the soil and the plants growing on the soil to the atmosphere

exceedence flow – discharge amount that is exceeded by a stream for a given percentage of time; for example, for 90% of the year the stream's discharge is greater than its 90% exceedence flow value

extinct – completely and globally eliminated

extirpated – an extirpated species is no longer present in a specific region, but (in contrast with an extinct species) may persist elsewhere on earth

fall fingerling – fish that is in the fall of its first year of life

FERC – Federal Energy Regulatory Commission

flashy – streams characterized by rapid and substantial fluctuations in stream flow

flood flow – discharge amount that is equaled or exceeded 10% of the time; equivalent to 10% exceedence flow

floodplain – flat valley floor adjacent to a stream that is subject to periodic inundation

flow regime – term used to describe the pattern of stream discharge over periods ranging from days to years; discharge of streams with stable flow regimes does not fluctuate quickly or substantially through time, whereas streams with unstable flow regimes are referred to as "flashy" (see definition above)

game fish – species that commonly are targeted by anglers

gamete – mature sexual reproductive cell, as a sperm or egg, capable of participating in fertilization

General Creel Census – refers to direct contact angler creel data collected by MDNR conservation officers from 1928 through 1964; this was a qualitative survey that provided general information on catch rates for various fish species, but cannot be used to estimate total annual harvest or effort

GLIFWC – Great Lakes Indian Fish and Wildlife Commission

gradient – rate of descent of a stream from an upstream location to a downstream location

gravitational acceleration – downward acceleration due to the force of gravity; generally approximated as 9.8 m/s^2

growth index – difference between the average length-at-age for fish in a given population and the statewide average length; positive growth indices indicate fish are growing faster than the state average, and negative indices indicate fish are growing slower than the state average

head – the difference in stream elevation above and below a dam

headwaters – the upper end of a stream, near its source

herbivory – consumption of plants

hydrograph – graph of the water level or discharge of a stream as a function of time

hydrology – science pertaining to the distribution and circulation of water on and below the earth's surface and in the atmosphere

impervious – not permitting penetration or passage

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

imprint – create a lasting impression of the physical and chemical properties of a stream; such an impression allows migratory fish to return to their native (or stocked) streams to spawn

infiltration – downward movement of water through gaps between soil particles

infiltration basin – excavated basin with a porous (e.g., sandy) bottom that intercepts water flow and prevents transport of sediment to a stream; often used in conjunction with one or more diversions

KBIC – Keweenaw Bay Indian Community

kinetic energy – energy associated with motion (e.g., water movement)

lacustrine – pertaining to lakes

LLSP – Large Lakes Survey Program

LVD – Lac Vieux Desert Band of Chippewa Indians

macroinvertebrate – animal without a backbone that is visible to the naked eye; aquatic examples include insects, crayfish, worms, snails, sponges, and mussels

main stem – primary branch of a river

MDEQ – Michigan Department of Environmental Quality

MDNR – Michigan Department of Natural Resources

mean – arithmetic average obtained by adding together all of the values and dividing the sum by the number of values

meander belt – the zone within which a stream routinely shifts its course by eroding one bank and depositing sediment on the opposite bank

median – a value in an ordered set of values below and above which there is an equal number of values

mesic – characterized by, relating to, or requiring a moderate amount of moisture

MIRIS – Michigan Resource Inventory System

moraine – a mass of rocks, gravel, sand, clay, and other material carried and deposited directly by a glacier

morphology – pertaining to form or structure of a river or organism

net night – one overnight set of one net; used to describe sampling effort for fyke net or gill net surveys

nongame – refers to fish species that rarely are targeted by anglers

NPDES – National Pollution Discharge Elimination System

organic – of, relating to, or derived from living organisms

ORV – off-road vehicle

OTC – oxytetracycline; antibiotic that produces a mark on the bony structures of a fish once it is submersed in the chemical, thus allowing for differentiation between stocked and wild fish

outwash – glacial deposits that have been sorted by flowing water; outwash deposits typically consist of coarse substrates such as sand or gravel

panfish – small game fish species in the families Centrarchidae and Percidae; for the Ontonagon River watershed, this term applies to bluegill, pumpkinseed, black crappie, rock bass, and yellow perch

parent material – substance from which soil is formed; examples include glacial till and lacustrine clay and silt

percolate – to pass a liquid through small spaces or a porous substance

permeability – the ability of a substance to allow the passage of fluids; sands and gravels have high permeability for water, because it readily moves through them

piscivorous – fish-eating

planktonic – floating or drifting in a body of water

point source discharge – pollution to a water course that is attributable to a single, well-defined source (e.g., outfall of a wastewater treatment plant)

potamodromous – fish that migrate from freshwater lakes into freshwater rivers to spawn; in the context of this report, it refers to fish that migrate into the Ontonagon River from Lake Superior

proximal – close or immediate

raptor – carnivorous bird that feeds primarily on meat taken by hunting or on carrion

regeneration – renewal or restoration of a forest

revetment – facing for protecting an embankment

riparian – adjacent to, or living on, the bank of a river or other body of water; also refers to the owner of stream or lakefront property

riprap – layer of stones or chunks of concrete used to prevent erosion of stream banks, hillsides, or stream crossings

riverine – of or pertaining to a river; refers to organisms that reside in a stream or river

rotenone – substance used to eliminate or reduce fish populations in lakes, streams, or ponds; naturally occurring compound found in the roots of several species of tropical trees

rough fish – fish species that most anglers consider undesirable (e.g., bullheads and suckers)

runoff – precipitation that flows over the earth's surface into lakes or streams; usually referred to as surface runoff

sand trap – an artificial pool that typically is created and maintained with a backhoe; because the current velocity subsides as water enters the pool, suspended sand particles fall to the bottom of the stream and can be removed when the sand trap is "emptied"

sedimentation – deposition of silt, sand, or gravel within a stream bed or floodplain

silvicultural – pertaining to the development or management of forests

sinuosity – refers to the bending or meandering pattern of the stream channel; often expressed in ratio form as the distance between two points on the stream measured along the channel divided by the straight line distance between the two points (meandering streams have higher sinuosity ratios than straight streams)

skyboom – fish cover structure that is designed to simulate an undercut bank

softwater – water that has a limited capacity for neutralizing acids (i.e., low alkalinity)

specific power – rate at which potential energy is supplied to a stream channel bed and banks; primarily a function of discharge and slope

spodosols – acidic, infertile soils that typically are associated with coniferous forests

spring fingerling – fish that is in the spring or summer of its first year of life

standardized discharge – discharge divided by the median discharge for a particular location on a stream

strain – a group of organisms of the same species, having distinctive characteristics but not usually considered a separate subspecies

substrate – materials lying beneath the waters of a lake or stream

surficial – referring to something on or at the surface

tail race – flume or channel leading away from a mill or turbine

taxonomic – relating to the orderly classification of organisms; examples of taxa include species and families

TFM – 3-trifluoromethyl-4-nitrophenol; substance used to kill sea lampreys in Great Lakes tributaries

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

topographic relief – differences in elevation of the earth's surface; high relief areas have steep slopes, while low relief areas have more gradual slopes

toxaphene – organic insecticide historically used to eliminate or reduce fish populations in lakes, streams, or ponds; use of this environmentally persistent organochlorine was banned in 1990 in the United States because of health and environmental concerns

trophic – of, or relating to, the nutritional habits and food relationships between the organisms in a biological community

turbidity – measure of suspended particles in the water column; turbid waters have large amounts of suspended particles and low water clarity

Type 1 trout stream – stream governed by standard trout stream fishing regulations (see Table C.1)

Type 2 trout stream – stream with the same open season and possession limits as standard (Type 1) trout streams, but with higher minimum size limits (see Table C.1)

Type 3 trout stream – stream that is open to fishing all year with no special gear restrictions; minimum size limits for brook trout, brown trout, rainbow trout, and splake are higher than for standard (Type 1) streams (see Table C.1)

Type 6 trout stream – stream in which only artificial lures or flies may be used for fishing; possession limits and minimum size limits also differ from standard (Type 1) streams (see Table C.1)

UPPCo – Upper Peninsula Power Company

USFS – United States Forest Service

USFWS – United States Fish and Wildlife Service

valley segment – a portion of a stream classified as a distinct ecological unit based on catchment size, hydrology, water chemistry, water temperature, valley character, channel character, and fish assemblages; a valley segment may be comprised of one or more stream reaches and may be 1 to 25 miles (or so) in length

wadeable – a stream that is shallow enough to be traversed by someone wearing chest waders

warmwater fish species – fish that generally achieve their maximum growth potential at water temperatures above 75°F; examples include largemouth bass, bluegill, pumpkinseed, and black crappie

watershed – an area of the earth's surface that drains toward a receiving body of water (such as a stream or lake) at a lower elevation

water yield – stream discharge divided by the area of the contributing watershed; usually expressed in cfs/mi^2

WDNR – Wisconsin Department of Natural Resources

weir – fence or enclosure set in a stream to facilitate sampling or harvesting of fish

wild – fish that have never been in a hatchery

wing deflector – structure that redirects water currents; used to minimize bank erosion, create pools, and provide desirable scouring and sorting of channel materials

yearling – fish that is in its second year of life, which is defined to start on January 1

young-of-year – fish that is in its first year of life, which is defined to end on December 31

PUBLIC COMMENT AND RESPONSE

A draft of this assessment was made available on the MDNR web site in March 2008. Statewide MDNR press releases were also issued, describing how citizens could access the draft, advertising the public meeting in Ontonagon, and stating how to send comments to the authors.

A public meeting was held on April 28, 2008 at the Ontonagon Village Hall. Twenty-five people attended and their comments were incorporated into this river assessment. Public comments were received until June 15, 2008. All comments received were considered, and similar comments were combined to avoid unnecessary duplication. Suggested changes were incorporated into the final document.

Comment: Several individuals commented that this river assessment was highly informative and thought-provoking.

Response: Thank you!

Comment: "In several places (pages xvii, 27, 33, and 41) you refer to Victoria Falls (which is now submerged behind the backwaters of Victoria Dam) as a natural fish barrier. I am not sure that this contention is supported by historical fact, given that certain coldwater species which almost certainly must have come originally out of Lake Superior (lake herring in Crooked Lake, and lake herring as well as burbot in Lake Gogebic) are occasionally caught by anglers to this day. If you have a reference for your contention, or if you can otherwise explain the existence of these coldwater species in these water bodies, please provide same."

Response: These coldwater species probably colonized Crooked Lake, Lake Gogebic, and other parts of the Ontonagon River watershed from the Mississippi refugium as the glaciers retreated from this area (Bailey and Smith 1981; Coon 1999). Given the impressive vertical drop (124.7 ft drop in 0.05 miles) at Victoria Falls, it is very unlikely that there has been any upstream movement of fish over Victoria Falls during the last few millennia.

Comment: "On page 36 under United States Army Corps of Engineers you define the lower Ontonagon River channel 'from the mouth to the M-64 bridge' as being regularly dredged. You actually mean the old M-64 swing bridge that has since been removed, not the new M-64 bridge above the railroad crossing."

Response: You are correct. This section of the river assessment has been reworded for clarification.

Comment: "On page 37 under 'Navigable Waters' you include the 0.76 miles of the lower river from the mouth to the first railroad bridge upstream as being within the list of navigable waters maintained by the Corps of Engineers. Now, do you mean the *list* that is maintained by the Corps, or the *navigable waters* that are maintained by the Corps? The distinction is important, since the Village of Ontonagon is currently embroiled in a running debate with the Corps about getting the channel dredged above the old M-64 swing bridge location."

Response: The United States Army Corps of Engineers, Detroit District, possesses navigational jurisdiction over United States waters up to the ordinary high water mark for

Lake Superior (603.1 ft above sea level). The railroad bridge 0.76 miles above the Ontonagon River mouth is the upstream limit of the Corps' jurisdiction. The text in the Navigable Waters section has been reworded for clarification.

Comment: "On page 40, you point out that Ontonagon County is the only county in the watershed that does not have a drain commissioner. This brings up a question that I have always entertained regarding Trout Creek: why, when the creek is clear as it leaves the pond in Trout Creek village, is it permanently dingy by the time it gets to the Gardner Road bridge only a couple miles downstream? If next spring I hike the length of [Trout Creek] and discover that an illegal drain is causing this condition, to whom and how should I report it?"

Response: We have also noticed this rapid decrease in water clarity below the Trout Creek Dam. This phenomenon probably is due to natural causes. The upper portion of Trout Creek flows through sandy soils and end moraines of coarse-textured glacial till. Thus, the upper reaches of Trout Creek are relatively clear. Trout Creek Pond also acts as a sediment trap, so the water leaving the impoundment is "sediment-starved" and unnaturally clear.

As the water leaves the impoundment, it flows through extensive deposits of lacustrine clay and silt (vastly different from the sandy soils a few miles upstream). To restore equilibrium, the "sediment-starved" water rapidly picks up sediment (in this instance clay and silt) as it flows downstream. In addition, Dover Creek (which flows through silt/clay dominated soils for most of its length) merges with Trout Creek a short distance upstream of Gardner Road. We suspect that Dover Creek contributes a substantial amount of sediment to Trout Creek.

If you hike this stream and find an illegal drain or any other environmental violations, please contact the MDEQ office in Crystal Falls at (906) 875-2071.

Comment: "On page 59 under 'Ontonagon River' you specify that Chinook salmon are planted in the Big Iron River. Please be advised that the same special interest group that is working on the Big Iron River is currently planning an imprinting attempt on Chinook [salmon] this spring in the Ontonagon Marina proper."

Response: This imprinting (pen-rearing) effort did not occur in 2008. MDNR has had discussions with sport fishing groups regarding this issue for many years. Piscivorous fish (e.g., walleye) that could consume stocked salmon are abundant in the lower Ontonagon River. This is not a good stocking location, so MDNR does not support pen-rearing of salmon in the lower Ontonagon River. The existing stocking site in the Big Iron River has a much lower abundance of fish predators.

Comment: "On pages 72-73 and pages 82-83 under 'Citizen Involvement', you are strangely silent on UPPAC and its efforts regarding UPPCo and Naterra Land's development attempts at Bond Falls Flowage, which, if successful, will likely change and/or undo everything which this river assessment has attempted to accomplish. You cannot ethically avoid at least mentioning the current P-1864 development controversy somewhere in this river assessment."

Response: To address this issue, additional language was added to the Soils and Land Use, Citizen Involvement, and Management Options sections.

Comment: "A popular book, *Canoeing Michigan Rivers* by Jerry Dennis and Craig Date offers excellent descriptions of the Ontonagon's East, South, and Main branches access points, paddling times, and required skill levels. This valuable resource book should be mentioned in the assessment."

> Response: This book is referenced in the **Recreational Use** section of the assessment.

Comment: One local citizen provided considerable information regarding whitewater paddling opportunities on the West and Cisco branches.

> Response: This information has been incorporated into the **Recreational Use** section of the assessment. Thank you!

Comment: "Under Management Options – Geology and Hydrology, page 75, the draft mentions reestablishing flow gauges at the former East Branch and South Branch gauge sites and to explore the possibility of establishing additional gauge sites. I support this option and recommend if a new gauge can be established on the lower Cisco [Branch], it should be located on the [Forest Hwy] 6930 bridge crossing where it would provide valuable information to paddlers and fishermen (as would the reestablishment of the East and South branch gauges)."

> Response: We agree with this recommendation. The Forest Hwy 6930 bridge would be an excellent location for a gauging station.