# *Conservation Assessment*
# *for*
# *Lake sturgeon (Acipenser fulvescens)*

*Photo credit: Joshua Lallaman*

## *USDA Forest Service, Eastern Region*

September 2003


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*This document is undergoing peer review, comments welcome (delete if final)*

*This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service - Threatened and Endangered Species Program at 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.*

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## EXECUTIVE SUMMARY

*Acipenser fulvescens* (Lake sturgeon) are designated as a Regional Forester Sensitive Species in the Hoosier, Huron-Manistee, Hiawatha, Ottawa, Chequamegon/Nicolet, and Superior National Forests in the Eastern Region of the Forest Service. This species is not known to occur on any other National Forests in the country. The purpose of this document is to provide background information necessary to prepare a Conservation Strategy, which will include management actions to conserve the species.

Lake sturgeon are found throughout the Mississippi River, the Laurentian Great Lakes, and Hudson Bay drainages and are typically found in large rivers and lakes. Because lake sturgeon are characterized as long living, late maturing fish bouts, populations are highly susceptible to dissemination. Over-exploitation and habitat alterations have resulted in extremely low population size, estimated to be 1% of historical densities. In general, the lack of data regarding basic sturgeon biology and population estimates has hindered management decisions.

## NOMENCLATURE AND TAXONOMY

Scientific name: *Acipenser fulvescens* Rafinesque 1817
Common name: Lake sturgeon
Family: Acipenseridae

| Synonyms: | | |
|---|---|---|
| | *Acipenser rubicundus* | LeSueur 1818 |
| | *Acipenser rupertianus* Richardson | Richardson 1836 |
| | *Acipenser laevis* | Agassiz 1850 |
| | *Acipenser carbonarius* | Agassiz 1850 |
| | *Acipenser rhynchaeus* | Agassiz 1850 |
| | *Acipenser maculosus* LeSueur | Günther 1870 |
| | *Acipenser athracinus* | Duméril 1870 |
| | *Acipenser megalaspis* | Duméril 1870 |
| | *Acipenser lamarii* | Duméril 1870 |
| | *Acipenser atelaspis* | Duméril 1870 |
| | *Acipenser rosarium* | Duméril 1870 |
| | *Acipenser kirtlandi* | Duméril 1870 |
| | *Acipenser buffalo* | Duméril 1870 |
| | *Acipenser sturio* | Eigenmann 1895 |
| | *Acipenser fulvescens obtusirostris* | Roussow 1955 |
| | *Acipenser fulvescens acuitirostris* | Roussow 1955 |

Other common names:
Freshwater sturgeon
Great Lakes sturgeon
Ohio sturgeon
Rock sturgeon
Rock fish
Rubber nose
Black sturgeon
Dogface sturgeon
Stone sturgeon
Red sturgeon

Ruddy sturgeon
Common sturgeon
Shell back sturgeon
Bony sturgeon
Smoothback

Lake sturgeon have been recently grouped in the same subgenus with the Siberian sturgeon (*A. baeri*) and the shortnose sturgeon (*A. brevirostrum*) based on morphological and biogeographic similarities (Artyukhin 1995). After the Wisconsonian glaciation (approximately 10,000 years ago), lake sturgeon colonized the Hudson-James Bay drainages (from the Missourian refugia) and the Great Lakes and St. Lawrence River drainages (from the Mississippi River refugia) (Ferguson and Duckworth 1997).

## DESCRIPTION OF SPECIES

*Acipenser fulvescens* are long lived, late maturing, potamodromous fish with a large, torpedo shaped body covered with bony scutes (Figure 1) (Scott and Crossman 1973, Becker 1983). Lake sturgeon have a heterocercal tail, a large air bladder, and a single, large dorsal fin. The lake sturgeon's vertebrae are cartilaginous and lack a centrum, and the notochord extends into the tail (Scott and Crossman 1973). The snout is pointed with a ventral, protrusible mouth with four barbels. Young sturgeon are characterized by large, dark blotches while adults are uniform in color (Smith 1979). In addition, juveniles have a series of bony plates in five rows (Scott and Crossman 1973). Lake sturgeon are found in many large rivers and lakes in North America.

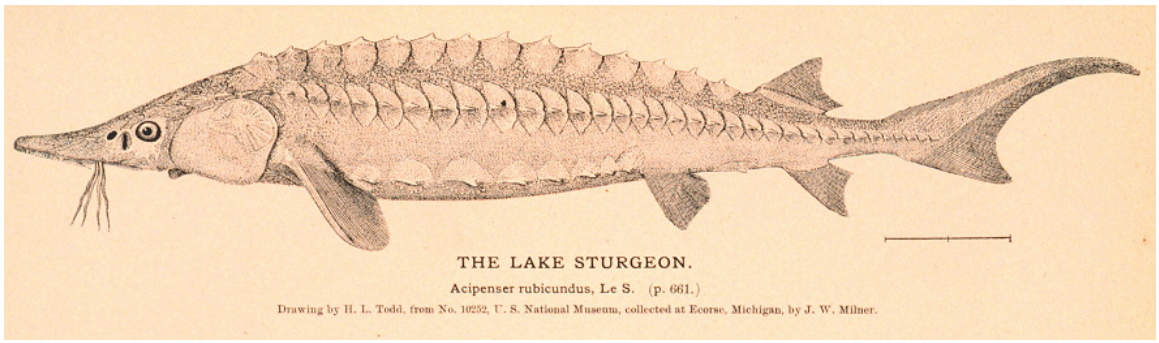

Figure 1. Drawing of the lake sturgeon from Goode (1884).

## LIFE HISTORY

### Reproduction

*A. fulvescens*, like other sturgeon, have delayed maturation. Males typically mature at 14-16 years while females mature at 24-26 years (Priegel and Wirth 1974). In addition, males spawn annually or biennially while females may spawn every 3-6 years (Priegel and Wirth 1977, Lyons and Kempinger 1992). Lake sturgeon spawn in rivers with a water depth of 1.5-3.5 meters and water current velocity ranging from 0 to greater than 10 $m \cdot s^{-1}$ (Scott and Crossman 1973, Bruch and Binkowski 2002, Smith 2003). Spawning

occurs over clean, rocky substrate with interstitial spaces (Auer 1996b, Bruch and Binkowski 2002), usually below rapids where the water is well oxygenated with upwelling flows (L. Aadland, MN DNR). When not in riverine habitats, lake sturgeon prefer to spawn along lake shorelines with relatively strong currents (> 0.15 $m \cdot s^{-1}$) and shallow water (Kempinger 1988). In lakes where suitable spawning habitat is not available, lake sturgeon will spawn over ledges or islands where wave action produces the level of oxygenation required for the eggs (Houston 1987).

Initiation of spawning is dependent on water temperature and can vary widely among years and systems. Spawning occurs when water temperatures reach 8.3-23.3 ºC but peaks at 10-14 ºC (Kempinger 1988). Slight decreases in water temperature (1.5-3.0 ºC) can result in cessation of spawning (Kempinger 1988). Spawning can occur within two different periods in the same year if water temperatures fluctuate, although the first period is more intensive (Kempinger 1988, LaHaye et al. 1992, Auer and Baker 2002). Water level and flow also appear to influence spawning (Auer and Baker 2002); hydroelectric facilities operating at near run-of-the-river flows have increased numbers of spawning sturgeon (Auer 1996b).

Males appear on spawning sites first (Harkness and Dymond 1961, Priegel and Wirth 1977, Folz and Meyers 1985, Lyons and Kempinger 1992) and cruise the area (Bruch and Binkowski 2002). Males exhibit porpoising behaviors, and spawning activity begins after females move to the site (Bruch and Binkowski 2002). Six to eight males will fertilize the eggs of one female (Kempinger 1988). Females release 50,000–700,000 eggs that are black in color, glutinous, adhesive, and approximately three mm in diameter (Priegel and Wirth 1971, Becker 1983). Eggs are scattered, drift downstream, and adhere to rocks or other objects in the water column and receive no parental care (Kempinger 1988). Larvae hatch approximately 18 days after spawning when eggs are 8-12 mm in size (Kempinger 1988, LaHaye et al. 1992). Hatching success is low (<1%) (Kempinger 1988). The larvae remain burrowed in the substrate until the yolk is absorbed and then drift downstream at night, although drifting larvae with partial yolk sacs have been observed (J. M. Holtgren, Little River Band of Ottawa Indians, personal communication) (Kempinger 1988). Common predators of lake sturgeon eggs are crayfish (*Orconectes* spp.), mudpuppies (*Necturus maculosus*), redhorse (*Moxostoma* spp.), common carp (*Cyprinus carpio*), and adult lake sturgeon (Kempinger 1988). Besides predation, egg mortality is also attributed to sediment deposition, water level fluctuations, and bacterial and fungal diseases (Kempinger 1988).

## Ecology

*Food*

Lake sturgeon are benthic feeders using barbels to sense potential food items (Scott and Crossman 1973). When prey are detected, the mouth is protruded, and food, along with associated sediment, is sucked into the mouth (Priegel and Wirth 1971). Diet composition varies among systems depending on prey availability (Magnin and Harper 1970, McKinley et al. 1993). Diets commonly include crayfish, mollusks, dipterans (especially chironomids), snails, ephemeropterans (including *Hexagenia* spp.),

trichopterans, neuropterans, fish eggs, nematodes, leeches, amphipods, decapods, zebra mussels, and, rarely, fish (Harkness 1923, Hay-Chmielewski 1987, Houston 1987, Choudhury et al. 1996, Kempinger 1996, Chiasson et al. 1997, Beamish et al. 1998, Jackson et al. 2002). Young-of-year sturgeon prey on small crustaceans, chironomid larvae, trichopterans and ephemeropterans (especially Baetidae) (Harkness and Dymond 1961, Kempinger 1996, Eddy and Underhill 1974, Choudbury et al. 1996). *Daphnia* sp. and *Leptadora* sp. were found in diets of adults during the summer in Lake Winnebago, Wisconsin (Choudhury et al. 1996). Feeding activity occurs throughout the year (Priegel and Wirth 1971) but ceases during spawning (Houston 1987).

*Growth*

Lake sturgeon grow to extremely large sizes (Table 1). For example, an adult lake sturgeon was captured in 1903 in the Roseau River measuring 3.6 meters and weighing 204 kilograms (L. Aadland, MN Department of Natural Resources). Growth is characterized by rapid juvenile growth rates, but rates decline when adults become sexually mature (at approximately 20 years) (Harkness and Dymond 1961, Beamesderfer and Farr 1997). Growth varies among systems and years (Priegel and Wirth 1971, Jackson et al. 2002,) and has been attributed to a variety of abiotic and biotic factors. In general, size and growth rates decrease with latitude and water temperature (Fortin et al. 1996, Power and McKinley 1997) but increase in more alkaline and conductive waters (Fortin et al. 1996). No difference in growth rates has been demonstrated between riverine and lacustrine habitats (Power and McKinley 1997). Growth also varies with food availability (Houston 1987, Noakes et al. 1999). Males and females obtain similar sizes (Fortin et al. 1996).

Table 1. Mean lengths (cm) and weight (kg) of adult lake sturgeon captured in different systems.

| System | Length (cm) | Weight (kg) | Citation |
|---|---|---|---|
| | | *Michigan* | |
| Black Lake | 75–193 (range) | | Baker and Borgeson 1999 |
| | 132–193 (range) | 0.8 – 45.5 (range) | Hay-Chmielewski 1987 |
| Lake St. Clair | 118.2 | 12.5 | Thomas and Haas 2002 |
| | 121.3 | 17.2 | Thomas and Haas 1999 |
| Manistee River | 61-185 (range) | | Peterson et al. 2002 |
| St. Clair River | 123.4 | 14.8 | Thomas and Haas 2002 |
| Sturgeon River | 153.4 (female) | | Auer 1999 |
| | 134.5 (male) | | |
| | | *Wisconsin* | |
| Lake Winnebago | 138–143 (range) | 18 – 22 (range) | Folz and Meyers 1985 |

**Dispersal/Migration**

Movement patterns of lake sturgeon are not well defined (Sandilands 1987). Lake sturgeon undergo spawning migrations moving from lakes or large rivers to tributaries for spawning (Fortin et al. 1993, Rusak and Mosindy 1997, Auer 1999). It is believed that sturgeon imprint to their natal site (Boiko 1993) and return to these specific sites to

spawn (Lyons and Kempinger 1992). After spawning, the sturgeon return downstream (Auer 1996a), but little is known about post-spawn movement patterns (Scott and Crossman 1973). It appears that lake sturgeon may home to post-spawning and over-wintering sites (Auer 1996a, Knights et al. 2002), and annual migrations may be extensive (up to 280 km from spawning site, Sturgeon River, Lake Superior; Auer 1999). In fact, lake sturgeon may be capable of extremely long migrations (1,000-1,800 km) but are prevented by natural barriers and human alterations (Auer 1996a). Lake sturgeon may reside in the same system throughout the year (Fortin et al. 1993), and daily movements may be quite extensive (up to 6.8 km) (Hay-Chmielewski 1987).

### Obligate Associations

No obligate associations are known.

## HABITAT

### Range-wide

In general, lake sturgeon occupy benthic habitats in large freshwater rivers and lakes (Becker 1983).

### National Forests

Indiana

- In the Hoosier National Forest, adult and juvenile lake sturgeon have been found in the East Fork White River over the last eight years. Spawning activity is most likely occurring in the river (IN DNR 2002).

Michigan

- In the Hiawatha National Forest, the only known sturgeon population resides in Indian Lake. Prior to construction of dams on the Manistique River and Indian River downstream from Indian Lake, this population had access to Lake Michigan. Lake sturgeon were once found in the Sturgeon, Whitefish and Carp Rivers. Suitable spawning habitat still exists in these rivers, and there is potential to restore spawning runs through stocking efforts. (C. Bassett, Hiawatha NF, personal communication).
- In the Manistee National Forest, lake sturgeon are found in a 48 km reach from the mouth of the Manistee River to Tippy Dam (Peterson et al. 2002). Habitat assessments for all life stages are being conducted by Central Michigan University and the Little River Band of the Ottawa Indians.
- In the Ottawa National Forest, the Michigan Department of Natural Resources is stocking lake sturgeon fingerlings in the Ontonagon River in an effort to reestablish a self-sustaining population (J. Eddy, Ottawa NF, personal communication). Lake sturgeon sampling has targeted the West Branch and the Irish Springs of the Ontonagon River. The Ottawa NF has been active in the Federal Energy Regulatory Commission (FERC) relicensing of the hydroelectric dam on the Sturgeon River where a healthy sturgeon population resides (J. Edde, Ottawa NF, personal communication)

Minnesota

- Historically, lake sturgeon were abundant and broadly distributed throughout the Superior National Forest but are currently found in low numbers or extirpated (USDA FS 2003). In 1997, the U.S. Fish and Wildlife Service surveyed the Sturgeon and Shannon Rivers within or adjacent to the Superior National Forest. Adult sturgeon were captured within lower Sturgeon River. Suitable habitat appears to be available in the upper sections of the river, but access to the site is blocked by a log jam. Plans exist to reroute the river around the log jam to allow sturgeons access to the site.

Wisconsin

- Lake sturgeon are only found in the Chequamegon National Forest in the south fork of the Flambeau River and the west fork of the Chippewa River (S. Reinecke, Chequamegon-Nicolet NF, personal communication).

### Site Specific

Much of the site specific habitat research has been conducted in areas not found within national forests. Most of the studies have focused on substrate and water velocity associations. In Black Lake, Michigan, lake sturgeon are generally found in water depths of 6-13 m and move inshore in the winter (Hay-Chmielewski 1987). In the Mattagami and Groundhog Rivers, Ontario, Canada, sturgeon are positively correlated with the amount of clay present (Chiasson et al. 1997). In the Mississippi River, lake sturgeon occupy areas with a wide range of velocities (0-75 $cm \cdot s^{-1}$) and depths (<1-18.2 m) (Knights et al. 2002). In the Manistee River-Lake system, Huron-Manistee National Forest, on ongoing study is assessing habitat use by adults (spawning and non-spawning) and juvenile lake sturgeon.

## DISTRIBUTION AND ABUNDANCE.

### Range-wide Distribution

Lake sturgeon are found in the Mississippi River, the Laurentian Great Lakes, and Hudson Bay drainages (Houston 1987) (Figure 2).

### State and National Forest Distribution

See "Habitat-National Forests" and Appendix 1.

## RANGE WIDE STATUS

Lake sturgeon are globally ranked as vulnerable to extirpation or extinction. Lake sturgeon are federally listed as a management concern with a National Heritage Status Rank of N3N4 (apparently secure to vulnerable to extirpation or extinction). The United States Fish and Wildlife Service Great Lakes Basin Ecosystem Team (2000) has identified lake sturgeon restoration as a priority. In addition, The Nature Conservancy (2000) has designated lake sturgeon as a conservation target.

Locally, lake sturgeon are presumed to be extirpated (SX) in Alabama, North Carolina, North Dakota, and West Virginia and possibly extirpated (SH) in Georgia and Kansas. Arkansas, Indiana, Iowa, Kentucky, Missouri, Nebraska, Pennsylvania, Tennessee, and Vermont are listed as critically imperiled (S1). Illinois, Michigan, New York, and Ohio listed lake sturgeon as imperiled (S2) while Minnesota and Wisconsin listed lake sturgeon as vulnerable (S3). Lake sturgeon are state listed as endangered species in Indiana, Iowa, Kansas, Missouri, Pennsylvania, and Vermont. The fish are listed as a threatened species in Michigan (Latta 1998), and the Wisconsin Department of Natural Resources has listed lake sturgeon as a "watch" species.

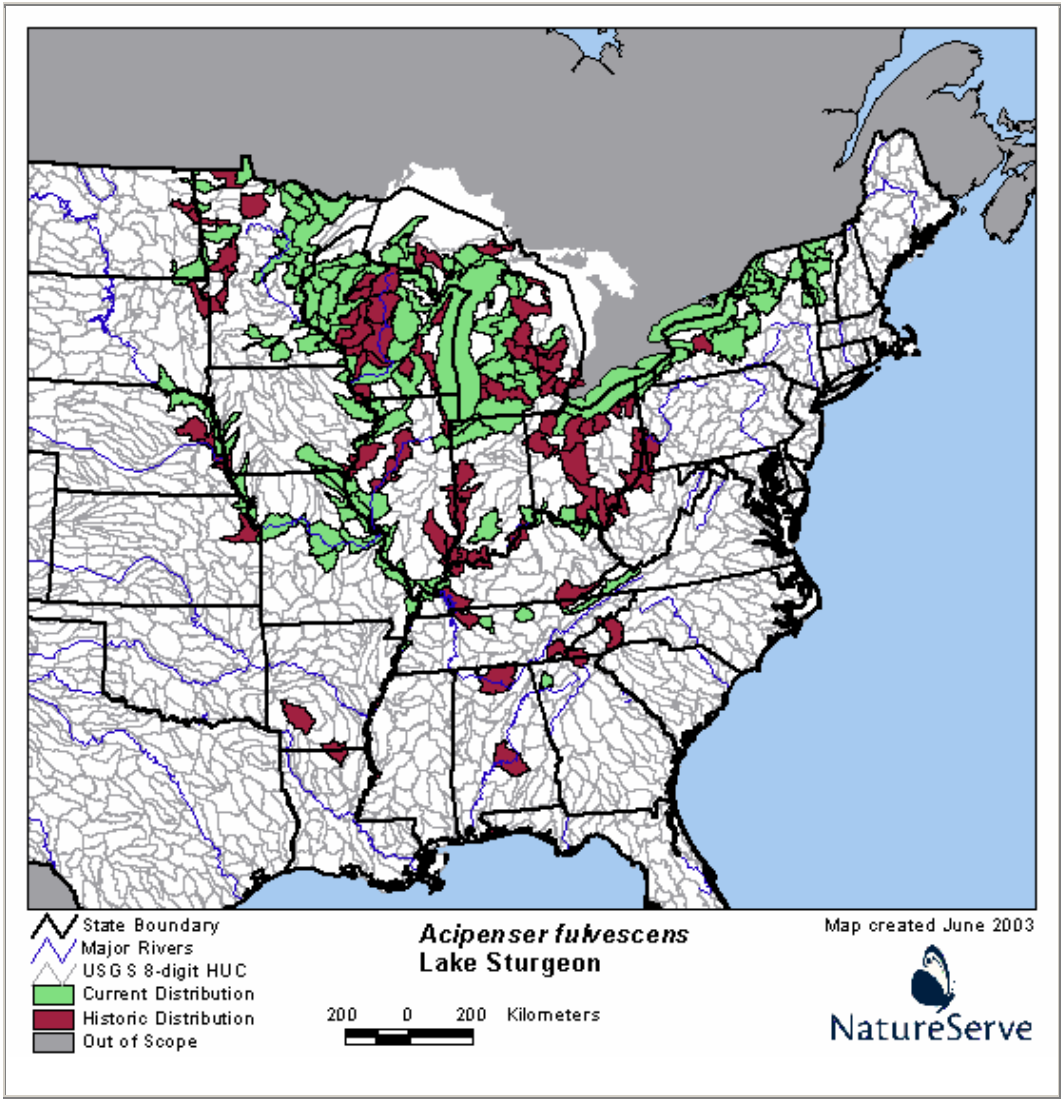


Figure 2. Historic and current distributions of lake sturgeon in the United States. Map from: www.natureserve.org.

## POPULATION BIOLOGY AND VIABILITY

Lake sturgeon abundances dramatically declined over the last two centuries. Historically, lake sturgeon were abundant throughout the Great Lakes including western Lake Erie,

Green Bay, southern Lake Michigan, and Chequamegon Bay (Bogue 2000). With the advent of commercial harvest of lake sturgeon in the mid 1800's, lake sturgeon production declined precipitously (Figure 3). Currently, populations are believed to be only 1% of their original size (Tody 1974).

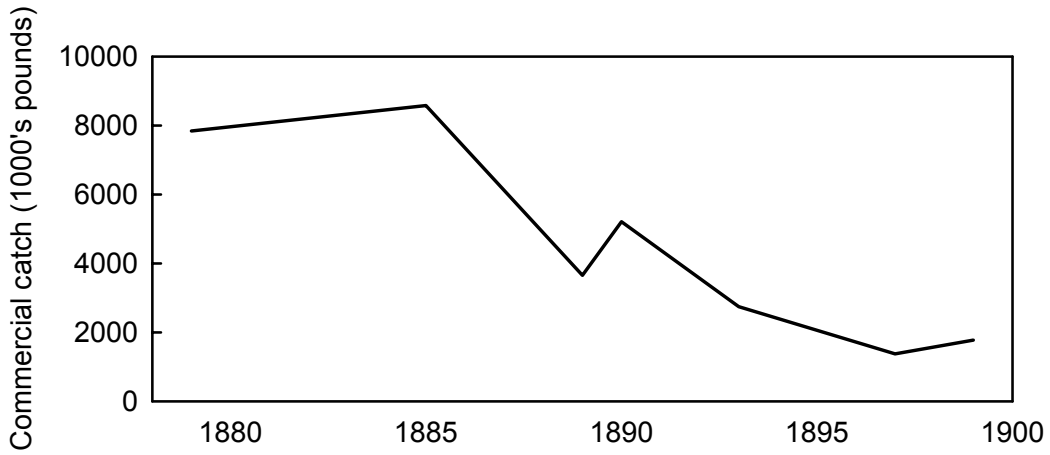


Figure 3. Commercial catch (thousands of pounds) of lake sturgeon from the Great Lakes, 1879-1899. Data from Bogue (2000).

Throughout the Great Lakes, lake sturgeon are known to have been extirpated from 44 sites (Holey et al. 2000). Lake sturgeon populations are currently known at 57 sites, while they are believed to be present at an additional three sites (Holey et al. 2000; Appendix 1). Of these sites, successful reproduction is known for only 20 populations, and spawning adult population estimates have been determined for seventeen sites (Appendix 1).

Population estimates have not been determined for many systems. Over 13,000 individuals were captured in Lake Winnebago, Wisconsin, between 1952-1984 (Lyons and Kempinger 1992). In Michigan, population estimates range from unknown to 3,200 individuals (Hay-Chmielewski and Whelan 1997); the Black Lake population declined from nearly 1,600 individuals in 1975 to less than 600 in 1999 (Baker and Borgeson 1999). In the Menominee River, bordering Wisconsin and Michigan, population estimates have ranged between approximately 900-3200 individuals (Thuemler 1997). Population estimates of all sturgeon (adults and juveniles) and spawning adults have been determined for Manistee River, Huron-Manistee National Forest (Table 2).

Male to female sex ratios are often reported as 1:1, but these ratios are often determined from sport or commercial catches, which may skew results (Dumont et al. 1987, Nowak and Jessop 1987, Fortin et al. 1993). High male to female sex ratios have been documented in other systems (5.7:1, Folz and Meyers 1985; 8.9:1, Lyons and Kempinger 1992; Sturgeon River and Lake Superior 1.25:1 – 4.1:1, Auer 1999) indicating the difference in spawning frequency between the sexes.

Table 2. Population estimates (range) of total lake sturgeon and spawning adults in Manistee River, Michigan, in 1999-2003.

| | Population estimates (range) | | |
|---|---|---|---|
| Year | Total sturgeon | Spawning adults | Citation |
| 1999 | 106 (54-227) | 48 (18-175) | Peterson et al. 2002 |
| 2000 | 57 (35-111) | 24 (12-51) | Peterson et al. 2002 |
| 2001 | 46 (34-65) | 23 (16-35) | Lallaman 2003 |
| 2002 | | 36 (21-68) | Lallaman 2003 |

The unique genetic (lake sturgeon are tetraploidy) and life history characteristics (late maturation and long periods of time between spawning bouts) make assessment of population viability difficult (Great Lake Fishery Trust 1999). The Lake Superior Sturgeon Committee has defined a self-sustaining population as a group of fish that spawn in a common tributary although each individual fish does not spawn each year (Auer et al. 2003). Given conditions in the Sturgeon River, Michigan, the characteristics of a self-sustaining population include a minimum of 1500 mature adults, an equal sex ration, a broad range of year classes, evidence of successful reproduction, and recruitment to juvenile stages (Auer et al. 2003). Because populations vary among systems, these are not necessarily requirements for each spawning population. In addition, evolutionary significant or management units cannot be determined until the extent of genetic variation within and among populations is not known.

## POTENTIAL THREATS

### Present or Threatened Risks to Habitat

Most of the remaining lake sturgeon populations in the United States are restricted in movement resulting from construction of dams (the exceptions being Sturgeon River, Michigan, and the Bad River, Wisconsin) (Auer 1996a). Lake sturgeon are blocked from spawning sites or prevented from even entering a system (Priegel and Wirth 1971, Houston 1987, Payne 1987, Auer 1996a). The construction of dams also increases siltation, which could potentially affect egg survival. In addition, hydroelectric facility operations may alter water temperature and flow regime affecting spawning habitat (Auer 1996b, Auer and Baker 2002).

### Over utilization

Because sturgeon are long lived, late maturing, and sporadic spawners, they are especially susceptible to overharvest. In the mid-1800's, commercial fishing operations for lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis*) viewed lake sturgeon as a nuisance species. The sturgeon's bony scutes tore nets, and, as a result, the fish were often destroyed (Tody 1974). By the 1880's, the value of the sturgeon for meat and roe and the production of isinglass resulted in increased harvest (Tody 1974). Overharvest by commercial fishing operations is one of the major contributing factors in the demise of the lake sturgeon (Brousseau 1987, Hart 1987, Houston 1987). In 1977, all commercial fishing for lake sturgeon in United States waters was discontinued (Hay-Chmielewski and Whelan 1997).

### Disease or Predation

Lake sturgeon are susceptible to parasitism by a number of different organisms. Evidence of sea lamprey (*Petromyzon marinus*) and silver lamprey (*Ichthyomyzon unicuspis*) attacks have been documented (Scott and Crossman 1973, Thomas and Hass 2002). Lake sturgeon are also parasitized by trematodes, acanthocephala, nematodes, cestodes, *Argulus* sp., and coelenterates (Harkness and Dymond 1961, Choudhury and Dick 1993, Choudhury et al. 1996). Helminth parasites are closely correlated with the lake sturgeon's diet (Choudhury and Dick 1993). In addition, gonadal anomalies have been documented by Roussow (1960 as cited by Harkness and Dymond 1961). Lake sturgeon eggs are susceptible to predation by crayfish, mudpuppies, and fish (Kempinger 1988). Rusty crayfish (*Orconectes rusticus*), an invasive species and opportunistic feeder, are a potential predator of larval lake sturgeon (J. Edde, Ottawa NF, personal communication). Lake sturgeon are most likely not susceptible to predation due to the protection provided by bony scutes of the juvenile and the size of the adults (Scott and Crossman 1973). No evidence exists of predation on larval and juvenile sturgeon by other fish species to date (Harkness and Dymond 1961), although predation on drifting larvae may occur when non-native salmonids are introduced (Auer and Baker 2002, Auer et al. 2003, J. M. Holtgren, Little River Band of Ottawa Indians, personal communication).

### Inadequacy of Existing Regulatory Mechanisms

Recreational harvest regulations of lake sturgeon have been inadequate (Hart 1987, Houston 1987). Size limits and harvest regulations have not resulted in increased abundances (Priegel and Wirth 1971, Baker and Borgeson 1999). Illegal harvesting of lake sturgeon (especially spawning adults) most likely contributes to population declines (Baker 1980, Dumont et al. 1987) but effects are difficult to estimate.

### Other Natural or Human Factors

Natural mortality rates of lake sturgeon are considered low or negligible (Priegel and Wirth 1971, Houston 1987), although no studies have directly addressed natural mortality. Toxic effluents have been cited as the source of sturgeon mortality in the St. Lawrence River (Dumont et al. 1987), and the effluents indirectly affect sturgeon by negatively impacting forage availability (Hart 1987). In addition, sturgeon are vulnerable to low oxygen conditions (Harkness and Dymond 1961). Larval lake sturgeon may be susceptible to mortality due to boat propellers (Killgore et al. 2001). Larval and early juvenile lake sturgeon appear to be sensitive to the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) (Johnson et al. 1999), and application should not occur when larval lake sturgeon are present in the system.

## SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION

Lake sturgeon are found within or bordering several national forests (Appendix 1). Because dissemination of lake sturgeon is partially the result of habitat degradation,

protection through land acquisition alone is not sufficient. Removal of barriers, suitable spawning habitat, and protection of watersheds are all needed to ensure restoration.

## SUMMARY OF EXISTING MANAGEMENT ACTIVITIES

Lake sturgeon are designated as a Regional Forester Sensitive Species in the Hoosier, Huron-Manistee, Hiawatha, Ottawa, Chequamegon/Nicolet, and Superior National Forests in the Eastern Region of the Forest Service. Because there is little known about the extirpated and remnant populations, research has focused on assessing the status of these populations.

## PAST AND CURRENT CONSERVATION ACTIVITIES

Conservation activities have historically focused on regulatory harvest of the lake sturgeon. In United States waters, commercial harvest of lake sturgeon was halted in 1977 (Hay-Chmielewski and Whelan 1997). Canadian provinces regulate commercial and recreational fishing seasons, size limits, catch limits, and capture methods although these regulations vary among provinces and years (Houston 1987). Where systems are tightly regulated, mortality results from illegal harvest and mortality related to injuries sustained during legal recreational harvest (Baker and Borgeson 1999). Lake sturgeon restoration activities have been initiated across the Great Lakes region. Lake sturgeon have been reintroduced to several systems including Oneida Lake, New York (Jackson et al. 2002), and the St. Louis River, western Lake Superior (Schram et al. 1999). The success of such introductions is yet to be determined since it be several decades until the adult sturgeon spawn.

## RESEARCH AND MONITORING

### Existing Surveys, Monitoring, and Research

Various surveys have documented the presence of lake sturgeon in national forests. In the Chippewa River, Chequamegon National Forest, the USDA Forest Service, the US Fish and Wildlife Service, Wisconsin Department of Natural Resources and the Lac Courte Orielles Conservation Department are currently monitoring lake sturgeon movement within the East Fork of the Chippewa River and upstream of the Chippewa Flowage Dam. Results will be available at the end of 2003.

The US Fish and Wildlife Service (Ashland FRO) surveyed the Sturgeon and Shannon Rivers, Minnesota, adjacent to the Superior National Forest, in 1997-1998. Sturgeon were captured in the lower Sturgeon River.

In the Manistee River, Huron-Manistee National Forest, Central Michigan University personnel are examining movement and habitat use of lake sturgeon adults in an ongoing study. In addition, spawning activity, egg deposition, larval densities are also being monitored by the Little River Band of Ottawa Indians.

### Survey Protocol

A variety of methods are employed to survey and monitor lake sturgeon populations. Electrofishing, seining, fyke nets, and dip nets are commonly used to capture adult lake

fish (Thuemler 1985, Kempinger 1996). Gill nets are also used to capture adult lake sturgeon with more success during night sets (Lyons and Kempinger 1992, Baker and Borgeson, Chiasson 1999). In deep rivers with strong current, setlines baited with round gobies (*Neogobius melanostomus*) are successful (Thomas and Haas 1999). Mark recapture studies are used for population estimation, and monel clips and floy tags appear to have the best retention (Auer 1996b). Lake sturgeon movements are monitored with radio telemetry and ultrasonic telemetry (Thuemler 1985, Hay-Chmielewski 1987). The pectoral fin spine is used for aging (Thuemler 1985, Wilson 1987, Rossiter 1995). Lake sturgeon larvae are sampled with drift nets (Kempinger 1988) and SCUBA diving for counting spawning lake sturgeon (Kempinger 1988).

Reintroduction of sturgeon into historical sites seems to be a viable option. Propagation of lake sturgeon was initiated in the late 1800's and early 1900's (Harkness and Dymond 1961). Lake sturgeon have been stocked in the Menominee River since 1982 (Thuemler 1985), the St. Louis River since 1983 (Schram et al. 1999), and Oneida Lake since 1995 (Jackson et al. 2002). Before stocking a system, however, the site must be evaluated to ensure that the proper habitat and water quality are suitable for lake sturgeon. Caution should be taken when introducing lake sturgeon in regards to genetic consequences of the broodstock and other populations.

**Research Priorities**

The United States Fish and Wildlife Service's Great Lakes Basin Ecosystem Team (USFWS 2000), the Great Lakes Fishery Commission (Auer 2003), Michigan Department of Natural Resources (Hay-Chmielewski and Whelan 1997), and the Wisconsin Department of Natural Resources (2000) have prioritized lake sturgeon management objectives. In addition, a newly formed Lake Michigan Lake Sturgeon Task Group is addressing similar issues in the Lake Michigan basin. In general, these research objectives can be broken into the broad categories of population assessment, habitat, passage, propagation, regulation, and ecological interactions. Recovery and rehabilitation efforts need to be evaluated on an individual basis to ensure proper management.

First, current (including remnant) populations must be identified, assessed, and protected. The definition of a healthy or rehabilitated sturgeon population must be delineated and include density, age structure, and habitat use guidelines. In addition, the goal of the Michigan Department of Natural Resources is to conserve and rehabilitate self-sustaining populations to a level that will permit delisting as a threatened species under the Michigan Endangered Species Act. Measures should be taken to conserve or rehabilitate self-sustaining lake sturgeon populations. Where populations have been extirpated, the potential for re-establishment should be investigated. Development of a rapid survey assessment would aid in population assessments; these metrics should include measures of exploitation, effort, age, size, and sex. Minimum viable population size must be empirically established.

Second, characterization of lake sturgeon critical life stages and associated habitat requirements (including spawning tributaries, minimum flow requirements, water level

fluctuations, and fish passages) are needed. Habitat assessments and enhancements should be conducted in historic and present spawning sites. In addition, movement patterns of adults and juvenile lake sturgeon should be examined, and variability in habitat use among size classes, systems, and years must be determined for both riverine and lacustrine habitats. Spawning stream protection and restoration can be promoted through conservation practices such as instream sand trapping, introduction of spawning gravel and cobble, riparian area protection and management, and lowered levels of non-point source pollution (e.g., sediment). Furthermore, the minimum flow requirements of lake sturgeon and the impacts of water level fluctuations on reproduction must be expanded; a return to the natural flow regime during the spawning period is critical. Where possible, the removal of dams is recommended. Construction of new dams or road crossings should not impact flow in sturgeon rivers. Riparian zone effects on lake sturgeon habitat should be examined. Buffer zones (following the guidelines listed in Water Quality Management Practices on Forest Land (1994)) should be required for lake sturgeon streams and tributaries, and woody debris in rivers should be allowed to be processed naturally, and sedimentation on spawning habitats must be prevented.

Third, genetic variation within and among stocks needs to be defined, which is critical to the rehabilitation of lake sturgeon. These data will help determine management units and effective population sizes; the consequences of other threats (e.g., low population numbers, habitat destruction) must be put in the context of genetics.

Fourth, the potential for passageways to be constructed around physical barriers should also be examined. Techniques for passage on streams which historically supported spawning populations but are now blocked by hydroelectric facilities need to be built. Hydroelectric facilities should be required to install protective devices to ensure safe passage, and dam spillways should be made to be "sturgeon" friendly. The effects of entrainment during downstream passage and methods to pass sturgeon around low-head dams while blocking sea lamprey should also be developed.

Fifth, appropriate stocking strategies to rehabilitate lake sturgeon populations must be determined. Continued research to identify appropriate genetic markers and techniques to identify the most suitable stocking sources are required. Strategies should focus on rehabilitations where lake sturgeon have been extirpated in historically significant streams. Similar strains from within the same basins should be used for stocking and transfers unless extirpated in the basin of interest. The genetic variability in hatchery reared fish used for rehabilitation or reintroduction reflect stocks from local basins. In addition, pond culture methods should be developed, and alternative food sources to decrease cost of rearing lake sturgeon should be examined. Modeling techniques including annual survival of all life stages to determine stocking rates and appropriate sizes and number need to be calculated. Because sturgeon reintroductions have yet to be proven "successful", appropriate stocking rates have not been determined.

Sixth, regulations regarding lake sturgeon harvest should be re-examined. Incidental catch and harvest rates from commercial and recreational fisheries need to be assessed and continually monitored. Agencies that permit commercial harvest of lake sturgeon

should be encouraged to reduce harvest quotas in sensitive areas. Law enforcement should be encouraged to support existing regulations and give sturgeon protection high priority, and strong enforcement of sturgeon regulations at all times. Additional research is needed to determine safe harvest. Public outreach programs should also be encouraged and proactive public involvement in sturgeon management; public support for sturgeon rehabilitation will dramatically aid progress.

Finally, abiotic and biotic factors that potentially affect sturgeon growth and survival should be studied further. Impacts of toxic substances on growth, reproduction, and survival should be determined, and potential for lake sturgeon exposure to, accumulation of, or transport of toxic chemicals above barriers. Interspecific interactions such as predation and competition should also be examined. Sea lamprey treatments should avoid lake sturgeon migration.

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**APPENDIX**

Appendix 1. Sites within the Great Lakes and St. Lawrence basins with historical and current population status. Data from Holey et al. 2000.

| State | Basin/Drainage | Site | Population status | Forest | Comments |
|---|---|---|---|---|---|
| Indiana | | E. Fork White River | Small[1] | Hoosier NF | [1]Adult and juveniles sited |
| Michigan | Lake Michigan | Indian Lake | Small[2] | Hiawatha NF | |
| | | Carp River | Extirpated[3] | Hiawatha NF | [2]Suitable spawning habitat |
| | | Sturgeon River | Extirpated[3] | Hiawatha NF | [2]Suitable spawning habitat |
| | | Whitefish River | Extirpated[3] | Hiawatha NF | [2]Suitable spawning habitat |
| | | Manistee River | Small[3] | Huron-Manistee NF | |
| | | Manistique River | Small[3] | Lake Superior State Forest | |
| | | Menominee River* | Small[3] | Escanaba River SF | |
| | Lake Superior | Ontonagon River* | Reintroduced[3] | Ottawa NF | [4]Priority for stocking<br>[4]All wetland habitat lost, regulated water flows, dredging in the lower river |
| | | Sturgeon River | Small[3] | Copper Country State Forest | [4]Stressors include dams, sediment loads, lake control structures |
| | | Tahquamenon River* | Extirpated[3] | Superior State Forest, MI | [4]Sedimentation, past logging practices, little spawning habitat available |
| Minnesota | Lake Superior | Sturgeon River | Small[3] | Superior NF | [5]Suitable spawning habitat |
| | | Shannon River | | Superior NF | [5]Suitable spawning habitat |
| Wisconsin | | S. Fork Flambeau River | | Chequamegon NF | |
| | | W. Fork Chippewa River | | Chequamegon NF | |

*Candidate river for genetic analsysi (Great Lakes Fishery Trust 1999)

[1]IN DNR 2002; [2]J. Edde, Ottawa NF, personal communication; [3]Holey et al. 2000; [4]Auer et al. 2003; [5]USDA FS 2003

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