CONSERVATION ASSESSMENT:

Ohio Lamprey
Ichthyomyzon bdellium

Photo from ODNR, Division of Natural Areas and Preserves

USDA Forest Service, Eastern Region
September 2005

Marsha G. Williams and Lance R. Williams
School of Natural Resources
The Ohio State University
2021 Coffey Road
Columbus, OH 43210
Email: williams.2365@osu.edu

TABLE OF CONTENTS

Executive Summary 3
Nomenclature and Taxonomy 3
Description of Species 4
Life History 5
- General Life Cycle 5
- Longevity 6
- Feeding and Food 6
- Reproductive Biology 6

Habitat 7
Distribution and Abundance 7
Population Biology and Viability 8
Potential Threats and Monitoring 9
Summary of Land Ownership and Existing Habitat Protection 9
- Alabama 10
- Georgia 10
- Illinois 11
- Indiana 11
- Kentucky 11
- New York 12
- North Carolina 13
- Ohio 13
- Pennsylvania 14
- Tennessee 15
- Virginia 15
- West Virginia 17

Summary of Existing Management Activities 17
Research and Monitoring 18
References 19
Appendix 1 22

EXECUTIVE SUMMARY

The Ohio lamprey *Ichthyomyzon bdellium* is a parasitic species found in the Ohio River basin including the Allegheny, Wabash, and Upper Tennessee drainages. Ohio lampreys spend approximately 4 years in the ammocoete stage in small streams before emerging as sexually immatures to parasitize other fish species in larger rivers. Sexually mature adult individuals return to natal streams to spawn in gravel/cobble riffles and die. The adult stage spans approximately 2 years for a total longevity of approximately 6 years. Ohio lampreys are uncommon to rare throughout their range. They have been documented historically in Alabama (suspect records), Georgia, Illinois (extirpated), Indiana, Kentucky, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia. The species if offered some protection in its range by the USDA Forest Service and National Park Service in Georgia (Chattahooche N.F. and Chickamauga-Chattanooga National Military Park), Kentucky (Daniel Boone N.F.), North Carolina (Pisgah N.F.), Ohio (Wayne N.F.), Pennsylvania (Alleghany N.F.), Tennessee (Cherokee N.F.), and Virginia (George Washington and Jefferson N.F.). In addition, the range of the Ohio lamprey in New York coincides with a network of protected lands including TNC and state wildlife management areas, forests, and preserves. The Ohio lamprey has declined across its range, probably related to habitat alteration through damming of large rivers and siltation of small streams, which are important reproductive and larval habitats. Recovery and protection of the species is limited because of its rarity in collections and lack of basic life-history and other population data. Future monitoring efforts should focus on understanding habitat use throughout the year at various life-cycle stages. What is clearly lacking is a range-wide assessment of the species, with a resampling of all historical collecting localities to document its current status. Habitat suitability modeling (HSI) also could be used to identify probable sites of occurrence that could be sampled as part of a regional monitoring effort. Unfortunately, we lack the basic life-history and population data to assess the status of the Ohio lamprey. Lack of these important data will impede any future monitoring or recovery efforts for the species.

NOMENCLATURE AND TAXONOMY

Phylum **Chordata**
Class **Cephalaspidomorphi**
Order **Petromyzontiformes**
Family **Petromyzontidae**
Scientific Name ***Ichthyomyzon bdellium*** (Jordan 1885)

The type specimen for the Ohio lamprey was collected from the Ohio River. (Kirtland, 1838, Trautman 1981). Kirtland first described the species as *Petromyzon argenteus*. Jordan (1885) changed the name to *Petromyzon bdellium* because the name *P. argenteus* Bloch 1795 already was in use with a European species (Smith 1985, FishBase 2005). In 1858, Girard revised taxonomy within this group and the species was placed into the genus *Ichthyomyzon* (FishBase 2005). The species was in obscurity until 1937 when

Hubbs and Trautman revised the genus and clarified the range and status of the Ohio lamprey.

The Greek translation for *Ichthyomyzon* means "fish, to suck" and bdellium means "leech" or "to suck" referring to feeding on blood (Smith 1985, Jenkins and Burkhead 1994). In southwesternVirginia, the Ohio lamprey is commonly called the "sand leech." *Ichthyomyzon* is the most primitive extant genus of lampreys (Smith 1985) and is thought to be a monophyletic group (Boschung and Mayden 2004). There are 6 species within the genus *Ichthyomyzon* in North America, all of which are confined to the eastern U.S. (Stauffer et al. 1995). Three parasitic species, of which the Ohio lamprey is one, are thought to have given rise to three, independently derived non-parasitic forms. The Ohio lamprey is thought to be the stem species of the non-parasitic mountain brook lamprey, *Ichthyomyzon greeleyi* (Boschung and Mayden 2004).

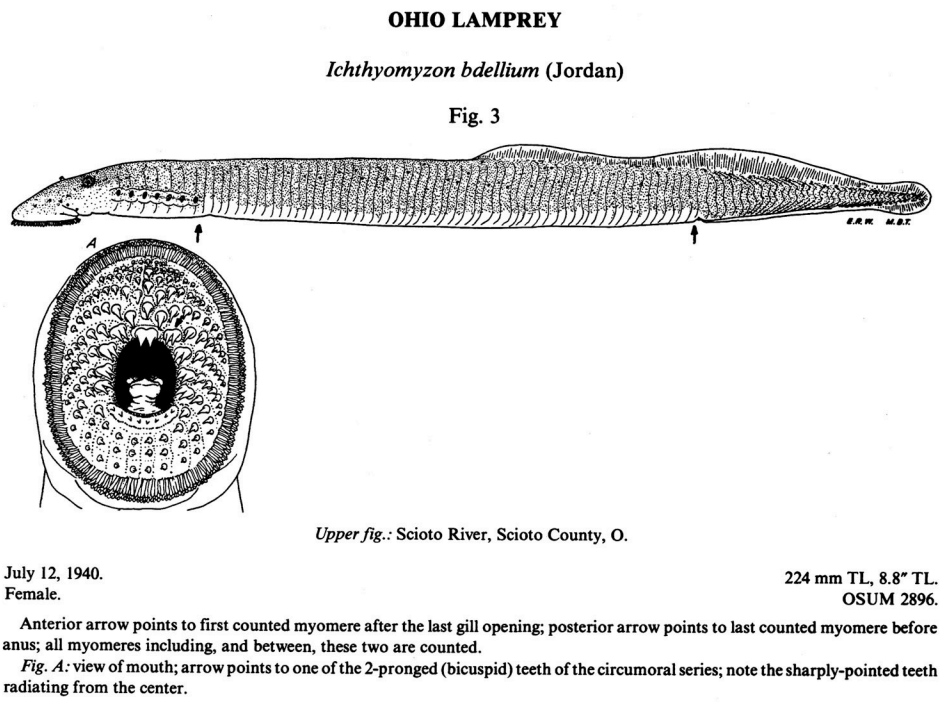
DESCRIPTION OF SPECIES

Lampreys are primitive fishes with cartilaginous skeletons and a notochord that is persistent throughout life. Lampreys and hagfishes form the most primitive extant branch of the vertebrates, represented by the superclass Agnatha or "jawless fishes." Agnatha first appear in the fossil record of the Late Paleozic Era 325 million years ago. In Pennsylvania, lampreys first appear in the fossil record 280 million years ago (Pennsylvania Fishes website).

Lampreys have eel-like bodies with muscle segmentation called myomeres. Seven pairs of external gill openings are present on the anterior sides of the body. One median nostril (naso-hypophyseal opening) is present and adults have small, rudimentary eyes. Lampreys lack paired fins, jaws, scales, and a complete vertebral column. Lampreys have a distinct, free-living larval stage called the ammocoete, which buries into stream sediments and filter feeds within the water column. Ammocoetes can live and feed up to seven years in some species (Helfman et al. 1997). Adult lampreys can be either parasitic or non-parasitic. Parasitic juveniles will migrate to larger streams or rivers to feed on host fishes until they reach sexual maturity (Mettee et al. 1996). Once sexually mature they will migrate upstream to spawn and then die. Non-parasitic species have similar behavior except for the migration to feed on host fishes (Jenkins and Burkhead 1994).

Ichthyomyzon are smaller lampreys that possess a single dorsal fin that is continuous with the caudal fin; the junction may be denoted by a notch (Clay 1975, Stauffer et al. 1995). Adult Ohio lampreys are parasitic and can be distinguished from congeners based on number of myomeres (55-62) and tooth patterns in the oral disk (Boschung and Mayden 2004). Teeth are well developed with 3 to 5 teeth in the anterior row (usually 4) and transverse lingual lamina moderately to strongly bilobed and bearing 21 to 32 cusps (Figure 1). Morphologically, the adults are slate gray (darker above) with small spots located at each lateral sensory pore and a few spots on the rim of the oral disk, through the eye, over the gill openings, and a midlateral row converging with a dorsolateral row under the rear of the dorsal fin (Boschung and Mayden 2004). Sexually mature adults are

between 25.4 and 35.5 cm in length (Rice and Michael 2001). *Ichthyomyzon* ammocoetes look very similar and are difficult to distinguish morphologically (Jenkins and Burkhead 1994, Mettee et al. 1996). Ohio lamprey ammocoetes may be distinguishable based on their single dorsal fin and myomeres 55-62 (Cooper 1983). Ohio lampreys are morphologically uniform throughout the range and no subspecies have been proposed (Smith 1979).



OHIO LAMPREY

Ichthyomyzon bdellium (Jordan)

Fig. 3

Upper fig.: Scioto River, Scioto County, O.

July 12, 1940.
Female.

224 mm TL, 8.8″ TL.
OSUM 2896.

Anterior arrow points to first counted myomere after the last gill opening; posterior arrow points to last counted myomere before anus; all myomeres including, and between, these two are counted.

Fig. A: view of mouth; arrow points to one of the 2-pronged (bicuspid) teeth of the circumoral series; note the sharply-pointed teeth radiating from the center.

Figure 1. Illustration of the Ohio lamprey showing oral disk anatomical features (from Trautman 1981).

LIFE HISTORY

General Life Cycle

Among fishes, lampreys have a unique life cycle. Newly hatched, non-parasitic ammocoetes drift downstream of the natal nest and construct small, semicircular burrows in slow moving waters with substrates of sand, muck, and/or organic material. The larvae are blind and must filter feed microscopic particles and organisms from the current and detritus contained in the substrates (Jenkins and Burkhead 1994, Mettee et al. 1996, Boschung and Mayden 2004). Benthic ammocoetes will remain in the substrate for 4 years before metamorphosing into the parasitic form in the mid to late summer (Jenkins and Burkhead 1994, Boschung and Mayden 2004). In the fall (mid September to mid November), sexually immature adults that have newly metamorphosed will migrate downstream to larger bodies of water where host species occur and remain there feeding

on host fishes until they reach sexual maturity (Mettee et al. 1996, Boschung and Mayden 2004). Because the Ohio lamprey evolved with their native hosts its parasitic phase is not believed to have a detrimental impact on native fish populations (Jenkins and Burkhead 1994, Pennsylvania Fishes Website). Upon reaching sexual maturity in spring or early summer of the following year, adults will drop off the host fish and migrate upstream (possibly returning to their natal stream) for spawning and death immediately afterwards (Jenkins and Burkhead 1994).

Longevity

The Ohio lamprey typically completes its life cycle in 6 years (Boschung and Mayden 2004). Ammocoetes live for 4 years burrowed into the sediment before becoming adults. The adult portion of the life cycle typically lasts about 21-24 months and culminates with a spawning event and death immediately following (Etnier and Starnes 1993, Jenkins and Burkhead 1994). Sexually mature adults are usually 25.4 to 35.5 cm long (Rice and Michael 2001).

Feeding and Food

The trophic niche occupied by the Ohio lamprey changes throughout its life cycle ranging from herbivore/invertivore to piscivore and eventually to a non-feeding culmination. Non-parasitic larvae of the Ohio lamprey are thought to filter feed on detritus, plankton, bacteria, protozoans and other microscopic organisms found in the substrates in which they burrow (Smith 1979). Sexually immature juveniles who have developed parasitic mouthparts will emerge from the substrates and migrate downstream to larger rivers or streams where host species are more abundant (Mettee et al. 1996). The parasitic lamprey will feed on body fluids and tissues of host fishes which may include: paddlefish, carp, suckers, smallmouth buffalo, longnose gar, black bass, smallmouth bass, walleye, and trout (Pennsylvania Fishes website, Mettee et al. 1996). Ohio lampreys also have been documented feeding on smaller stream fishes such as madtoms, darters, and minnows (Smith 1985, Cochran and Jenkins 1994). Fish species with small, deciduous scales may be more susceptible to lamprey predation (Clay 1975). Feeding during the parasitic phase has its greatest activity from March to June probably related to cool water temperatures making prey easier to catch (Mettee et al. 1996). Juveniles will feed from host species until sexual maturity is reached (approximately 1 year) and spawning migration to upstream sites (thought to be natal sites) begins. Adults who have reached sexual maturity will not feed again (Jenkins and Burkhead 1994).

Reproductive Biology

The Ohio lamprey migrates upstream in late winter/early spring where nest building and egg laying will occur (Mettee et al. 1996). Spawning occurs once per year, in late April to May in the streams of the upper Tennessee River system (Jenkins and Burkhead 1994). In Ohio, spawning occurs on riffles (with gravel/cobble substrate with moderate to high flow) in May when water temperatures approximate 14°C (Barnes et al. 1993). The oviparous Ohio lamprey has anecdotally been noted as polygamous with several adults

often sharing the same nest (Cooper 1983, Jenkins and Burkhead 1994). Rice and Michael (2001) noted in their work in Ohio that only one nest was found in each riffle during the spawning season and if there were several nests, they occurred in complex series of riffles separated by runs and pools. Ohio lampreys are classified as benthic, coarse substrate spawners (pit builders; Dolloff et al. 2001). Nests are constructed in shallow areas with moderate to swift current in and above riffles (Jenkins and Burkhead 1994). Adults of both sexes may cooperate in constructing the nest (depression), which is excavated using the mouth and body movements to displace gravel (Jenkins and Burkhead 1994, Mettee et al. 1996). Dolloff et al. (2001) classified Ohio lampreys as nonguarder, brood hiders. Breeding behavior of the Ohio lamprey has not been described but it is assumed to be similar to other *Ichthyomyzon* (Smith 1985). Eggs and sperm are released during the spawning embrace. Spawning may last from several hours to several days (Mettee et.al. 1996). Fertilized eggs adhere to the substrates and are buried by movements of the adults (Cooper 1983, Jenkins and Burkhead 1994). Parasitic lampreys will generally lay more eggs (up to 20,000) than non-parasitic forms (500-3,000) (Pennsylvania Fishes website). Adults die shortly after spawning (Mettee et al. 1996).

In Pennsylvania, the mountain brook lamprey, *I. greeleyi*, has been observed sharing nests with the Ohio lamprey (Cooper 1983). The close proximity of spawning and nest sharing may result in hybridization between the two forms although no interspecific pairing or spawning has been reported (Cooper 1983).

HABITAT

The Ohio lamprey is a nonanadromous, freshwater species inhabiting warmwater habitats in the Ohio River basin, including the Allegheny, Wabash, and Upper Tennessee drainages (Lee et al. 1980). During its life cycle, the Ohio lamprey migrates between larval, juvenile, and adult habitats. Ammocoetes prefer slow areas with soft substrates and high detrital content, typically found in the backwaters and pools of smaller streams and rivers (Boschung and Mayden 2004). In the parasitic stage of the life cycle, sexually immature adults will migrate to medium to large river systems where host species occur (Mettee et al. 1996); in this life-stage the host essentially is the habitat for the Ohio lamprey. Some larvae may stay near spawning areas and may complete the life cycle without ever migrating downstream (Jenkins and Burkhead 1994). Sexually mature adults prefer runs and riffles of clean gravel/cobble in smaller streams and rivers for spawning (Trautman 1981, Boschung and Mayden 2004). No detailed study of microhabitat use of any life-stage has been published for the species.

DISTRIBUTION AND ABUNDANCE

The Ohio lamprey is found in North America in the U.S.A. Its range extends within the Ohio River Basin from southwest New York west to eastern Illinois and south to Tennessee and potentially into northern Alabama (Figure 2). The species is considered

uncommon to rare throughout most of its range, and abundances have been noted to fluctuate greatly (NatureServe Website).

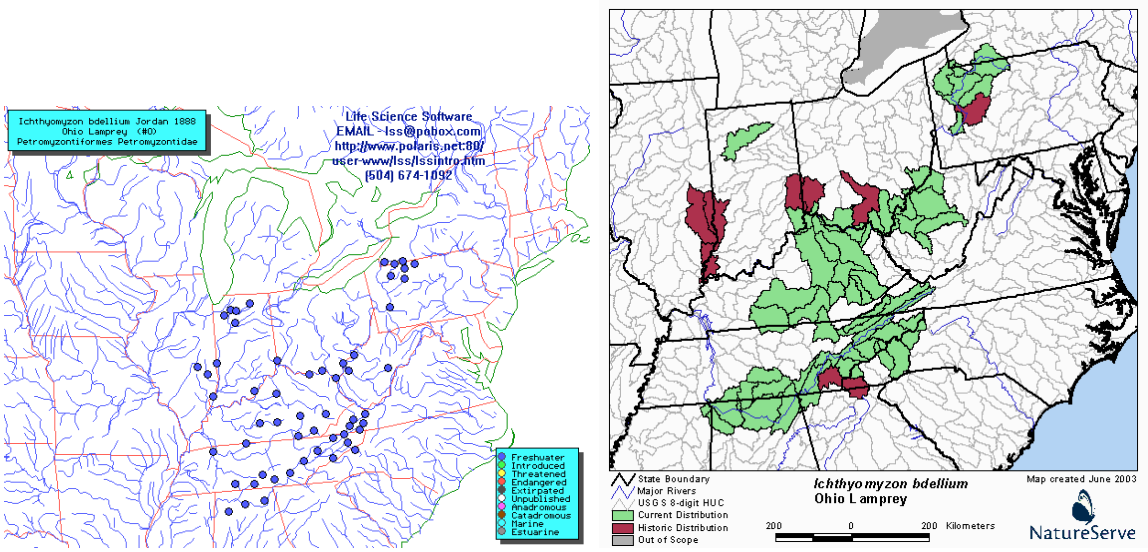


Figure 2. Range of Ohio lamprey in North America.

POPULATION BIOLOGY AND VIABILITY

The Ohio lamprey is vulnerable to many types of human disturbance. Pollution, siltation and hydrologic alteration that impact the quality and availability of spawning sites, the ability of ammocoetes to filter feed, and the migration of immatures to and from larger rivers for feeding are thought to be the most significant threats to the population (Pence 2004).

Population doubling time for this relatively long-lived species is 4.5 to 14 years. No formal modeling efforts such as Population Viability Analysis (Williams et al. 1999, Beissinger and McCullough 2002) have been attempted for this species. In fact, little life-history information other than anecdotal reports (e.g., Barnes et al. 1993, Rice and Michael 2001) has been reported for the species. Complex life-cycle combined with habitat specificity of different life-stages and k-selected life-history strategy make the species particularly susceptible to extinction (Meffe and Carroll 1997), particularly in areas of rapidly changing land-use (e.g., urbanization). The species has been extirpated from Illinois and is rare to uncommon throughout much of the rest of its range (Smith 1979, Boschung and Mayden 2004).

POTENTIAL THREATS AND MONITORING

Major threats to small streams and rivers include dams and other impoundments; water diversions; changes in landuse like agriculture, silviculture, mining, and urbanization; and alien species (Allan 1995). In Ohio, the species probably has been in decline since the early 1900s (Trautman 1981, Rice and Michael 2001), and many of the major threats outlined above have, not surprisingly, been hypothesized to negatively affect Ohio lampreys. Rice and Michael (2001) argued that the major cause of decline has been habitat destruction through dams on the Ohio River that prevent migration and cause increased sediment load and decreased habitat diversity. The degree to which these habitat alterations have directly or indirectly (through affecting host fish species) impacted the Ohio lamprey is largely unknown.

For spawning lampreys and ammocoetes that inhabit smaller streams, it is probably landuse changes (e.g., increased agriculture, construction activities, and eroding banks) and subsequent increasing silt loads that most limit its distribution and abundance (Rice and Michael 2001). The species requires clean gravel/cobble riffles for spawning (Trautman 1981, Boschung and Mayden 2004), and this type of habitat is threatened by landuse change. Because of its habitat specificity, some states have used the Ohio lamprey as an indicator of water and substrate quality (Jenkins and Burkhead 1994).

Long-term (and short-term) monitoring of the Ohio lamprey is difficult because the species tends to be uncommon and population sizes fluctuate (NatureServe website). Barnes et al. (1993) indicate that the best time to capture the species in Ohio is during the spawning period in May (which may be a one to two week period of time). In order to accurately monitor Ohio lampreys, collection efforts need to be carefully timed to the life-history of the organisms. For example, Nist (1968) in his study of the species in aquaria found that the ammocoetes emerged from the sediments at night. Night sampling in backwaters and shallows of streams known to contain the Ohio lamprey may be a useful tool in monitoring the population. Also, we need to better understand natural fluctuations in abundance and the cause of its relative rarity in collections (i.e., is it related to declining populations or is it just difficult to sample?).

SUMMARY OF LAND OWNERSHIP AND EXISTING HABITAT PROTECTION

Rangewide status G3G4

G3 = Either very rare and local throughout its range (21-100 occurrences or less than 10,000 individuals) or found locally in a restricted range or vulnerable to extinction from other factors.
G4 = Apparently secure globally (may be rare in parts of range).

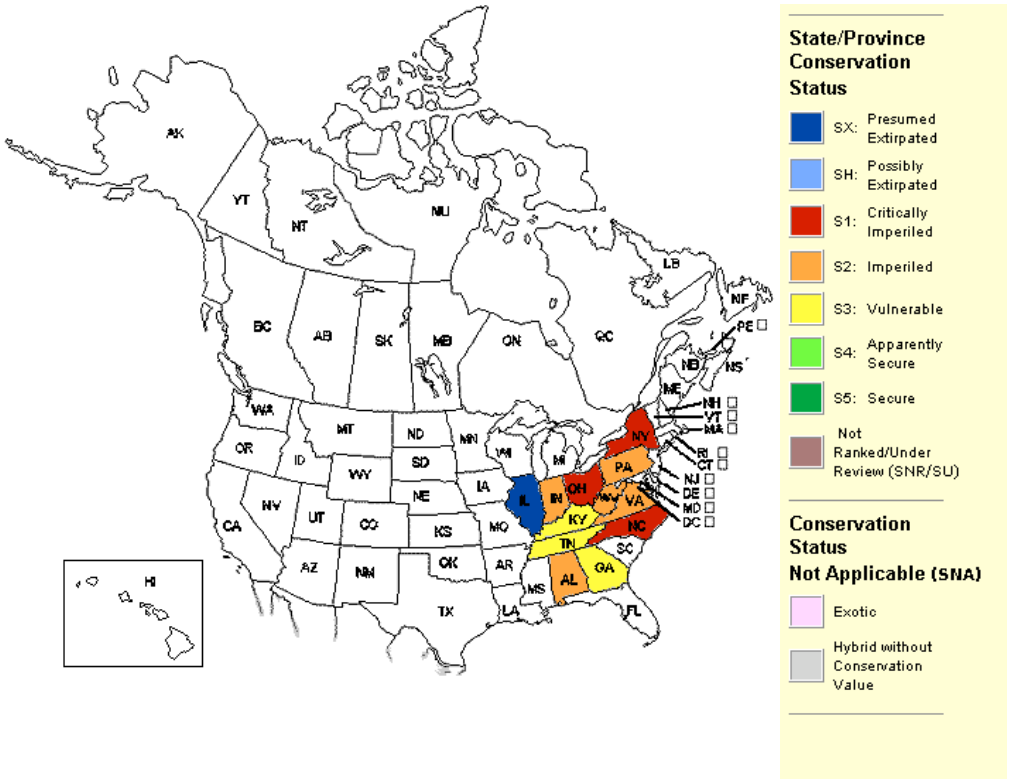


Figure 3. Status of the Ohio lamprey within its range in the eastern U.S. (NatureServe Website).

Alabama

State Status: S2

In a recent study by Kuhajda and his colleagues (Boschung and Mayden 2004), specimens of Ohio lamprey reported from Alabama were shown to be specimens of the Chestnut lamprey, *I. castaneus*. Because the Ohio lamprey occurs in the Tennessee River drainage near Alabama, it is possible that the species may have occurred at one time or might still occur, thus far unnoticed, in Alabama. In Alabama, the Tennessee River makes a U-shaped bend across the northern part of the state. The entire length of the river in Alabama has been impounded to form numerous lakes; therefore, like several other species in this section of the Tennessee drainage, the Ohio lamprey may have been extirpated because of habitat modification, siltation, and hydrologic alterations (Mettee et al. 1996). The closest confirmed population to Alabama is in South Chickamauga Creek, east of Chattanooga, Tennessee (Boschung and Mayden 2004).

Georgia

State Status: S1S2, Rare

The Georgia Natural Heritage Program database indicates two recent collections of the Ohio lamprey along the outskirts of the Chattahooche National Forest in Catoosa Co. (USGS Quad. Ringgold). The collections were taken from East Chickamauga and Little Chickamauga creeks by The Tennessee Valley Authority (Appendix 1).

A recent collection from the Chickamauga - Chattanooga National Military Park was taken on May 24, 2005 (Teresa Leibfreid, National Park Service, Inventory and Monitoring Coordinator, pers. comm.). This National Park is located in Catoosa, Walker and Dade County, GA and in Chattanooga County, TN. It is unknown by the authors whether their record is officially from Georgia or Tennessee. No other records could be found for this state and the species is not part of the Chattahooche-Oconee National Forest Management Plans.

Illinois

State Status: SX (extirpated)

The species is believed extirpated from Illinois with no collections or sightings since 1918. Historic specimens were collected from the Wabash River and the Embarrass River of southeastern Illinois. In more recent collections of the Wabash valley in Illinois and Indiana only *I. castaneus* was found indicating that the chestnut lamprey has replaced the Ohio lamprey in these systems (Smith 1979).

Indiana

State Status: S2, WL

The Ohio lamprey is currently on the Watch List (WL) for the state of Indiana. The species is listed as rare in Pulaski, Cass, Vigo, Fulton, Wayne, and Kosciusko counties (Indiana Department of Natural Resources website). The most recent collections found were by Page et al. from 1985 and 1987 from the Tippacanoe River of the Wabash River Drainage (Appendix 1), and also from the White River basin near Indianapolis by the USGS (http://pubs.usgs.gov/wri/wri034331/). Historic counties where the species has been collected include: Floyd, Lawrence, Pulaski, Kosciusko, Fulton, Marshall, and Owen (Appendix 1). Prior to the 1950s the Ohio lamprey was collected in the Whitewater River of southeastern Indiana (Harrington 1999).

Kentucky

State Status: S3S4

In Kentucky, populations of the Ohio lamprey have been documented on the Daniel Boone National Forest. Within the Daniel Boone National Forest, the Ohio lamprey is native to the following hydrologic units: Licking River, Middle Fork Kentucky River, South Fork Kentucky River, Rockcastle River, Cumberland River-Buck Creek, and Big

South Fork River. It also may occur in the Kentucky-Red River hydrologic unit although it has never been verified there (Dolloff et al. 2001). This species is listed as a Conservation Species (CS), Selection Criteria 3 (locally rare) for the Daniel Boone National Forest. Records from this forest indicate that it was recently taken from Rock Creek, Buck Creek, Russell Creek, and the Licking River.

Clay (1975) indicated that the Ohio lamprey is widely distributed in Kentucky. Museum collections from the University of Louisville contain specimens from Lake Cumberland, Kentucky River, Middle Fork at Buckhorn Reservoir, Licking River, and the Ohio River at Louisville (Clay 1975). Other published collection localities include: Licking River at Farmer's and Triplett Creek near mouth, Green River near Munfordville and Greensburg, and Tygarts Creek near Carter Caves (Clay 1975, Branson et al. 1981). Tygarts Creek was one of Kentucky's highest quality streams in the 1970s (Branson et al. 1981) with several sections that are encompassed in state or federally protected lands (e.g. Daniel Boone National Forest). Burr and Warren (1986) indicated that the species is "sporadic and uncommon" in the upper Green, Cumberland, Kentucky, Licking and Ohio rivers. Recent records from the Kentucky Natural Heritage Program have been reported from the Cumberland, Salt and Green Rivers (R. Cicerello, Kentucky State Nature Preserves Commission, pers. comm. 2005). The Kentucky Department of Fish and Wildlife Resources lists the species from the following USGS quads within the state: Barthell, Bobtown, Cane Valley, Claysville, Columbia, Dunmor, Farmers, Hibernia, Hickory Flat, Hillsboro, Holland, Howe Valley, Moorefield, and Oneida North (Kentucky Department of Fish and Wildlife website). The National Park Service has a record of the Ohio lamprey from Big South Fork National River & Recreation Area (Cumberland River). This park unit is affiliated with the Appalachian Highlands Network (Mike Williams, Data Manager, Heartland I&M Network and Prairie Cluster Prototype Monitoring Program, pers. comm.). Historical museum records exist from Estill, Franklin, Green, Laurel, Lewis, Magoffin, Pendelton, Pulaski, Rockcastle, Rowan, Bath, and Clay counties (Appendix 1).

In addition, recent collections for Kentucky were found from the Licking River in Pendleton Co., Horse Lick Creek (Lower Cumberland River) in Rockcastle Co., in Hazel Patch Creek (Lower Cumberland River) in Laurel Co., in the Kentucky River in Estill Co., and in the Kentucky River at RM 257.6 and 260.8 (Jeff Thomas, ORSANCO biologist, pers. comm., see Appendix 1).

New York

State Status: S1, SU (unprotected)

The Ohio lamprey is found in the Allegheny River of western Pennsylvania and New York. In New York it occurs in the very southwestern tip of the state in Chautaqua, Cattaraugus, and Allegany Counties. Many state, federal and private reserves are found in these counties: The Nature Conservancy's French Creek Preserve, Allegheny National Park, and numerous New York State Wildlife Management Areas, State Forests and Preserves (69 in 3 counties). The New York Aquatic Gap Analysis Program obtained

records for its species/habitat predictive modeling from the New York Department of Environmental Conservation fisheries database. This database had the following occurrence localities: Conewango Creek, Allegheny River (Olean Creek and Dodge Creek), Great Valley Creek, Mill Creek, and French Creek. Recent work by Bain and Meixler (Cornell University, 1998, pers. comm.) indicates that the species may be doing relatively well in New York.

North Carolina

State Status: S1, SR (significantly rare)

The Ohio lamprey has been collected from Spring Creek in the French Broad Drainage in Madison County (Rohde et al. 1998, North Carolina Natural Heritage Program website). Spring Creek and its tributaries drain most of western Madison County before emptying into the French Broad River at Hot Springs and are within the boundaries of the Pisgah National Forest (North Carolina Division of Water Quality Website). The species is considered critically imperiled in North Carolina because of its extreme rarity and its vulnerability to extirpation. The state designation for this species also may be related to collections of this species occurring at the edge or periphery of its range. The number of extant population in North Carolina are thought to be between 1 and 5. Two museum records from the Alabama Museum of Natural History were found from the Little Tennessee River in Jackson and Macon counties from May and July 1980 (Appendix 1). Another historical record exists from the Tuckaseegee River (collected by Gutsell 1930, Appendix 1). These records may be suspect as the first documented occurrence of this species in the state was published by Rohdes et al. (1998) from Madison Co. In addition, these collections are not reported in the North Carolina Natural Heritage database. If these records are verified as Ohio lamprey specimens, the collecting localities are within the boundaries of the Pisgah and Nantahala National Forests.

Ohio

State Status: S1, Endangered

In Ohio, this species occurs within the boundaries of the Wayne National Forest. This species is state endangered in Ohio and is listed as a Regional Forester Sensitive Species for the Wayne National Forest (Wu 2003). The species has been found in Monroe and Washington Counties (ODNR 2003).

Historically the Ohio lamprey has been collected in the Ohio River as far upstream as Lawrence Co. and from the lower Scioto River (Trautman 1981). Parasitic phase individuals have been reported from the Ohio River as far upstream as Captina Creek in Belmont County and in the lower portions of the Muskingum, Leading, Ohio Brush, Little and Great Miami rivers (Trautman 1981). Historic specimens have been collected from the Ohio River near Marietta in Washington Co. and from Salt Creek in Vinton Co. near the Hocking Co. line (Trautman 1981). The distribution of this species in Ohio indicates that Ohio is at the edge or periphery of the species native range (Barnes et al.

1993). Historic records from Ohio have been collected from the following counties: Hamilton, Adams, Brown, Scioto, Lawrence, Gallia, Washington, Vinton, and Monroe (Barnes et al. 1993, see also Appendix 1). In Ohio, the species is thought to be in decline (Trautman 1981, Rice and Michael 2001). It has been noted that in Ohio this species spawns in the 1st or 2nd week of May. Rice and Michael (2001) found spawning Ohio lampreys on May 8 and 9 at a water temperature of 65° F. It is thought that the species has been eliminated or endangered in Ohio as a result of siltation, pollution, and the construction of dams along the Ohio River and its tributaries (hydrologic alteration), which provides impediments to spawning migrations and barriers to immatures looking for host species (Rice and Michael 2001).

A breeding population exists in the Little Muskingum River on the Wayne National Forest in SE Ohio. This is the only documented breeding population in Ohio (Barnes et al. 1993). Recent Ohio lamprey records for Ohio include: Rice and Michael (2001) collected 43 Ohio lampreys at eight different sites during a 1999 survey of the Little Muskingum River (Table 1); Ohio EPA has collected Ohio lamprey from the Middle Fork of Salt Creek, the Little Muskingum River, and from the Ohio River (Wu 2003); the Ohio River Valley Sanitation Commission (ORSANCO) has collected the Ohio lamprey from the Ohio River at RM 89.3, 161.7, and 339.4 (Jeff Thomas, ORSANCO biologist, pers. comm., see Appendix 1).

Table 1: Ohio lamprey collection sites from the Little Muskingum River in May 2000 (from Rice and Michael 2001).

Location	Date	RM	Total #
At mouth of Eightmile Creek	5/8/2000	5.9	4
Lane Farm Canoe Access	5/8/2000	7.7	2
Just South of Bear Run Bridge	5/8/2000	11.6	3
Hune Bridge Canoe Access	5/8/2000	21	15
Haught Run Canoe Access	5/8/2000	23.8	9
Downstream of Wingett Run	5/8/2000	25.5	1
Downstream of Sackett Run	5/9/2000	26.5	6
At mouth of Wilson Run	5/9/2000	32.4	3

Pennsylvania

State Status: S2, Candidate Sp.

The Ohio lamprey is a candidate species for endangered/threatened status in the state. It is native to the Alleghany and Ohio River watersheds (Cooper 1983). The species has been documented from Allegheny, Crawford, Erie, Potter, Forest, Armstrong, Jefferson, McKean, Mercer, Warren, and Venango counties (NatureServe website, Cooper 1983, Wu 2003, see also Appendix 1). Spawning has been reported from late spring to early summer (Cooper 1983). This species inhabits clean, moderate to large streams of the

Upper Alleghany River System. Approximately 11% of the potential habitat for this species in Pennsylvania is in stewardship lands of the Alleghany National Forest based on PA GAP analysis data (Pence 2004). The majority of occurrences of this species in PA are from the Allegheny National Forest lands. The forest plan for the ANF is projected to minimize threats to this species (Pence 2004).

Tennessee

State Status: S3

The Ohio lamprey occurs within the boundaries of the Cherokee National Forest in the Paint Creek tributary of the French Broad River. This species has also been documented in the larger rivers that flow through the Cherokee National Forest such as the Hiwassee, French Broad, Pigeon, Nolichucky, and Watauga (Jim Herring, Fisheries Biologist, Cherokee National Forest, pers. comm.). The species is widespread in the Cumberland and Tennessee River drainages and is relatively common in the rivers of east Tennessee (Etnier and Starnes 1993). In May and June of 2000, a survey of the Nolichucky River by the Tennessee Valley Authority found the Ohio lamprey in Hamblen/Cocke Co. (USGS Quad. Springvale) and in Greene Co. (USGS Quad. Cedar Creek; Tennessee Valley Authority Website). In this same report, the Ohio lamprey in the Nolichucky River below Enka Dam was estimated to be common from boat electoshocking survey data. A recent record for the Clinch River was found in the Alabama Museum of Natural History with a site locality of Frost Ford in Hancock Co. (Appendix 1). Historic records exist from the following counties: Bedford, Bradley, Claiborne, Hancock, Meigs, Monroe, Morgan, Perry, and Wayne (Appendix 1).

Virginia

State Status: S2, Biological Indicator

In Virginia, the Ohio lamprey has been documented on the Wythe Ranger District, George Washington-Jefferson National Forest. There are no other documented occurrences on federal or state lands (Virginia Fish and Wildlife Information Service 2005). Virginia lists the Ohio lamprey as a Tier III species (Virginia Department of Game and Inland Fisheries http://www.dgif.state.va.us/wildlife/cwcs/tiers.html). Tier III indicates a high conservation need because extinction or extirpation is possible. The designation also means that management action is needed to stabilize or increase populations.

The Tennessee River drainage has the most diverse ichthyofauna in North America (Etnier and Starnes 1993). In Virginia, the Ohio lamprey is currently found in the upland Holston and Clinch-Powell systems of the Tennessee River and may have historically occurred in the upper Big Sandy drainage of the Ohio River, which is ecologically similar to the Clinch River (Jenkins and Burkhead 1994). The Ohio lamprey has been found in the warm waters of the North Fork of the Holston River above Saltville where the naturally saline waters of this region enter the North Fork. It is unknown if this natural

salinity has provided a barrier to the Ohio lamprey as it has to the distribution of some other upper river fauna or if the commercial production of salt (since the 1760s) and the presence of a chemical plant where dissolved solids and mercury contamination polluted the stream up to the early 1970s, when the plant was closed, has caused the lamprey to be extirpated from the river reach below Saltville (Jenkins and Burkhead 1994). The Holston River was ranked as one of the most polluted rivers in the U.S. in the 1970s. Since that time it has been in a state of recovery. Despite improvements in this system, the Ohio lamprey has not reappeared below Saltville (Jenkins and Burkhead 1994).

The Clinch-Powell systems arise in the coal bearing Appalachian Plateau where over half of the coal in Virginia is produced. The accumulation of silt from strip mining and coal fines from coal washing operations impacted these systems prior to the late 1960s when these inputs were curtailed. The sediment load of coal and silt was heaviest in the Powell River headwaters (Jenkins and Burkhead 1994). These systems now resemble other montane Virginia drainages with little remaining evidence of these past inputs (Jenkins and Burkhead 1994). The Ohio lamprey has been found in the Clinch River above Carbo downstream to Copper Creek, the lowest tributary of the Clinch River in VA. Parasitic phase specimens have been documented from the lower 10 rkm of Copper Creek and sexually mature specimens have been collected as far up as 4.5 rkm (Jenkins and Burkhead 1994). Copper Creek contains many localized, relict, or threatened species, including the Ohio lamprey and its non-parasitc derivative, the mountain brook lamprey, *I. greeleyi*. In 1967, the Clinch River, including Copper Creek, experienced a total fish kill from a chemical spill. Before this fish kill it is unknown what the exact distribution of many species was however it is thought that many species have since recovered and few have been extirpated. The Ohio lamprey has seemingly recovered after the spill but it is unknown to what extent. In the Powell River the Ohio lamprey occurs up to the North Fork mouth (Jenkins and Burkhead 1994). Because of past sediment loads it is possible that this species has been extirpated from some portions of the Powell River (Jenkins and Burkhead 1994).

The North Fork of the Holston, and the Clinch-Powell system are unique in that they have large shoals of loose, small to medium gravel, unlike other rivers in Virginia. In addition, they are upland rivers with frequent runs and riffles (Jenkins and Burkhead 1994), ideal habitat for the Ohio lamprey. Below Virginia, the Tennessee Valley Authority has impounded much of the Tennessee River and extirpated many species. In Virginia, there are no major impoundments in these rivers (Jenkins and Burkhead 1994).

In Virginia, the Ohio lamprey has been documented in the following 5 counties: Bland, Russell, Scott, Smyth, and Wise (Appendix 1). The Virginia Natural Heritage Program has older records for the Ohio lamprey from Smyth and Russell Counties: Laurel Creek in 1981 (North Fork Holston River), Thompson Creek in 1970 (Clinch River), and Little Stoney Creek in 1964 (Clinch River) (Virginia Natural Heritage Program Website). Recent collections of the species from the mouth of Copper Creek (Clinch River, Scott Co.) and from the North Fork Holston River (Smyth County) were found in the Alabama Museum of Natural History (Appendix 1).

West Virginia

State Status: S2

In West Virginia, the Ohio lamprey has historically been recorded from the mainstem of the Ohio River, the mouth of Fish Creek, Little Kanawha River, Kanawha River, and Elk River (Stauffer et al. 1995). The Ohio lamprey was collected in 2002 from the Kanawha River (RM 60.1 and 91.4) by an Ohio River Valley Sanitation Commission (ORSANCO) crew (Jeff Thomas, ORSANCO biologist, pers. comm. and see Appendix 1). The Ohio lamprey has been documented to occur in Braxton, Clay, Tyler, Doddridge, Kanawha, Marshall, Ohio, and Wood counties of West Virginia (NatureServe website, Wu 2003, see also Appendix 1).

SUMMARY OF EXISTING MANAGEMENT ACTIVITIES

Within national forests and other federal or state entities, the Ohio lamprey is offered protection in Georgia, Kentucky, New York, Ohio, Pennsylvania, Tennessee, and Virginia. In Georgia, the species is found on the outskirts of the Chattahooche National Forest and within the Chickamauga-Chattanooga National Military Park. In Kentucky, the Ohio lamprey is found in the Daniel Boone National Forest where it is listed as a Conservation Species (CS). In New York, the species likely is protected within numerous state, federal and private preserves and wildlife management areas. In North Carolina the Ohio lamprey has been collected within the boundaries of the Pisgah National Forest. In Ohio, it occurs within the Wayne National Forest and is a Regional Forester Sensitive Species. In Pennsylvania, the majority of occurrences are within the boundaries of the Alleghany National Forest. In Tennessee, the Ohio lamprey occurs within the boundaries of the Cherokee National Forest. In Virginia, the species occurs within the George Washington-Jefferson National Forest (Wythe Ranger District). All of the National Forests in which the species occurs have a Land and Resource Management Plan that contains direction and guidance that promotes the protection and restoration of riparian areas and stream systems. The Forest Plans provide direction and guidance that minimizes the potential for sedimentation of aquatic systems from earth disturbing activities, and they call for revegetation of disturbed lands, improvement of aquatic organism passage at stream road crossings, and reclamation of abandoned mine lands. Some states provide direct protection, and, in many cases, state regulations provide indirect conservation measures. For example, the Ohio Division of Mineral Resources Management enforces state regulations on oil and gas well development, which aids in protection from brine spills into streams (which may be important in the Wayne and Allegheny N.F., and other areas with extensive mining).

It is worth noting that, in all cases, private lands occur within N.F. boundaries, and activities on these lands may or may not be beneficial to the Ohio lamprey and its habitat. Some adverse effects on private lands are offset by the fact that direct manipulation or modification of streams generally is regulated by the U.S. Army Corps of Engineers and

state regulation agencies (e.g., Ohio EPA). The Natural Resources Conservation Service and county soil and water districts offer educational Best Management Practices (BMP) training to private landowners, as well as programs to promote healthy riparian areas and aquatic systems (e.g., Conservation Reserve Program, Wetland Reserve Program). The Forest Service and state forestry agencies also have landowner assistance programs to promote woodland stewardship on private lands.

It should be noted that Aquatic GAP analysis modeling (see http://www.gap.uidaho.edu/projects/Aquatic/default.htm) is ongoing in NY, PA, TN, GA, and OH. Information from species/habitat modeling may provide useful information for developing a regional monitoring plan for the species.

RESEARCH AND MONITORING

The Ohio lamprey is considered in most states to be a good indicator of water and substrate quality in the ammocoete (filter feeding) stage of the life cycle because they are more sensitive to turbidity (silt) and pollutants than later in the life cycle (Jenkins and Burkhead 1994). The species probably has declined because of habitat degradation. The Ohio lamprey is difficult to identify and collect making the task of monitoring populations very difficult. The species is elusive, living most of its life in the substrates and attached to fishes in larger rivers; therefore, the status and health of the populations in most of the states within its native range are uncertain. In addition, larval Ohio lampreys may be more susceptible to capture at night (Nist 1968), and monitoring programs rarely incorporate this type of sampling. The likelihood that they may be tied to their natal streams may provide a means to assess the health of the population through mark/recapture studies. Also, the very specific and narrow window of the spawning season documented in many parts of its range may provide a means to collect and census specimens that have completed the life cycle.

Conservation needs include protection of spawning habitats for the species and removal or prevention of impediments (e.g. dams) that might prevent spawning migrations and immatures from finding suitable host species to complete the life cycle (Trautman 1981, Rice and Michael 2001). Reforestation of disturbed areas may also improve water quality of spawning areas (Wu 2003). Management activities by the Wayne National Forest likely do not threaten persistence of the Ohio lamprey; in fact, exceptional warmwater habitat designation (sensu Ohio EPA) and presence of the species in the Little Muskingum River is evidence of the protection offered by the forest.

Future monitoring and research should focus on understanding Ohio lamprey use of specific habitats throughout the year at various life-cycle stages. What is clearly lacking is a range-wide assessment of the species, sampling historical collecting localities to document its current status. Habitat suitability modeling (HSI) also could be used to identify probable sites of occurrence to sample as part of a regional monitoring effort. Unfortunately, we lack the basic life-history and population data to assess the status of

the Ohio lamprey. Lack of these important data will impede any future monitoring or recovery efforts for the species.

REFERENCES

Allan, J.D. 1995. Stream Ecology: Structure and function of running waters. Chapman and Hall, London.

Barnes, M.D., D.L. Rice and G.J. Phinney. 1993. Ohio lamprey, *Ichthyomyzon bdellium* (Petromyzontidae), in Ohio: A review and recent records. The Ohio Journal of Science 93: 42-43.

Beissinger, S.R. and D.R. McCullough, Eds. 2002. Population Viability Analysis. University of Chicago Press: Chicago, IL.

Branson, B.A., D.L. Batch, and S. Rice. 1981. Collections of Fishes from the Little Sandy River and Tygarts Creek Drainages, Kentucky. Transactions of the Kentucky Academy of Science 42:98-100.

Burr, B.M. and M.L. Warren, Jr. 1986. A Distributional Atlas of Kentucky Fishes. Kentucky Nature Preserves Commission, Scientific and Technical Series Number 4.

Clay, W.M. 1975. The Fishes of Kentucky. Kentucky Department of Fish and Wildlife Resources, Frankfort, KY.

Cochran, P.A., and R.E. Jenkins. 1994. Small fishes as hosts for parasitic lampreys. Copeia 1994:499-504.

Cooper, E.L. 1983. Fishes of Pennsylvania and the Northeastern United States. The Pennsylvania State University Press, University Park.

Dolloff, C.A., K.N. Leftwich, M. Hudy, M.L. Warren, W. Haag, V. Bishop, J. Walker, L. McDougal, G. Chalfant, G. Chen, and J. Kershner. 2001. As assessment and strategy for conservation of aquatic resources on the Daniel Boone National Forest, Interim Report. Center for Aquatic Technology Transfer, Virginia Polytechnic Institute and State University, Blacksburg.

Etnier, D.A. and W.C. Starnes. 1993. The Fishes of Tennessee. The University of Tennessee Press, Knoxville.

FishBase website. http://www.fishbase.org/. Accessible September 2005.

Harrinton, S. 1999. Occurrence and Distribution of Fish Species in the Great and Little Miami River Basins, Ohio and Indiana, Pre-1900 to 1998. US Department of the Interior, US Geological Survey Water-Resources Investigations Report 99-4198.

Helfman, G.S., B.B. Collette, and D.E. Facey. 1997. The diversity of fishes. Blackwell Science, Inc. Malden, Massachusetts.

Hubbs, C.L. and M.B. Trautman. 1937. A revision of the lamprey genus *Ichthyomyzon*. Misc. Publ. Mus. Zool. Univ. Mich. 35:1-109.

Indiana Department of Natural Resources Website. http://www.in.gov/dnr/. Accessible September 2005.

Jenkins, R.E. and N.M. Burkhead. 1994. Freshwater Fishes of Virginia. American Fisheries Society, Bethseda, Maryland.

Kentucky Department of Fish and Wildlife Resources Website. http://www.kdfwr.state.ky.us/. Accessible September 2005.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History.

Meffe, G.K. and C.R. Carroll. 1997. Principles of conservation biology, 2nd edition. Sinauer Associates, Inc., Sunderland, Massachusetts.

Mettee, M.F., P.E. O'Neil, and J.M. Pierson. 1996. Fishes of Alabama and the Mobile Basin. Oxmoore House, Inc., Birmingham, Alabama.

NatureServe Website. http://NatureServe.org. Accessible September 2005.

Nist, J.F. 1968. Growth and behavior of ammocoetes of the Ohio lamprey, *Ichthyomyzon bdellium*, (Jordon). Thesis, The Pennsylvania State University, University Park.

North Carolina Division of Water Quality Website. http://h2o.enr.state.nc.us/basinwide/ Accessible September 2005

North Carolina Natural Heritage Program website. http://www.ncnhp.org/. Accessible September 2005.

Pence, B. 2004. RFSS Risk Evaluation for the Ohio lamprey, *Ichthyomyzon bdellium* on Allegheny National Forest. R9-FS-2672-1 (1/2000).

Pennsylvania Fishes Website. http://sites.state.pa.us/PA_Exec/Fish_Boat/pafish/fishhtms/chapindx.htm. Pennsylvania Fish and Boat Commission. Accessible September 2005.

Rice, D.L. and M.M. Michael. 2001. The fish fauna and distribution of the Little Muskingum River watershed and selected Ohio River tributaries in the Marietta Purchase Unit of the Wayne National Forest. USDA Forest Service: Wayne National Forest.

Rohde, F.C., M.L. Moser, and R.G. Arndt. 1998. Distribution and status of selected fishes in North Carolina, with a new state record. Brimleyana 25:43-68.

Smith, P.W. 1979. The Fishes of Illinois. University of Illinois Press, Urbana.

Smith, C.L. 1985. The inland fishes of New York State. New York Department of Environmental Conservation, Albany.

Stauffer, J.R. Jr., J.M. Boltz, and L.R. White. 1995. The Fishes of West Virginia. Academy of Natural Sciences of Pennsylvania.

Tennessee Valley Authority: Nolichucky Reservoir Flood Remediation Website. Appendix B. http://www.tva.gov/environment/reports/nolichucky/. Accessible September 2005.

Virginia Fish and Wildlife Information Service. 2005. BOVA booklet for the Ohio lamprey (010356). Commonwealth of Virginia, Department of Game and Inland Fisheries.

Virginia Natural Heritage Program Website. http://www.dcr.virginia.gov/dnh/nhrinfo.htm Accessible September 2005.

Williams, L.R., A.A. Echelle, C.S. Toepfer, M.G. Williams, and W.L. Fisher. 1999. Simulation modeling of population viability for the leopard darter, Percidae: *Percina pantherina*. Southwestern Naturalist 44:470-477.

Wu, J. 2003. Species viability evaluation – Ichthyomyzon bdellium. USDA Forest Service Report, Wayne National Forest, Ohio.

APPENDIX 1

Museum/Agency/dbase Name*	Catalog #	Date	Year	County	State
ANSP	EDC-CC	21-Jan	1991		Tennessee
ANSP	EDC-KISK	15-Jun	1992		Pennsylvania
ANSP	Z22056	31-Aug	?		Pennsylvania
CU	940	27-Dec	1875	Floyd	Indiana
CU	1310	Jul	1875	Peoria	Illinois
CU	11800	8-May	1947	Meigs	Tennessee
CU	21986	28-Jun	1950	Forest	Pennsylvania
CU	23421	Apr	1953	Braxton	West Virginia
CU	32296	8-Oct	1953	Braxton	West Virginia
CU	43631	17-Sep	1958	Warren	Pennsylvania
CU	48646	9-Jun	1965	Pulaski	Kentucky
CU	52110	14-Jun	1967	Scott	Virginia
CU	52340	13-Jun	1967	Scott	Virginia
CU	62646	17-Jun	1967	Scott	Virginia
CU	62671	17-Jun	1967	Scott	Virginia
CU	64469	19-Mar	1973	Wayne	Tennessee
CU	64472	19-Mar	1973	Wayne	Tennessee
CU	64837	29-Apr	1959	Armstrong	Pennsylvania
CU	64838	6-Jun	1962	Allegheny	Pennsylvania
CU	64839	26-Aug	1966	Warren	Pennsylvania
CU	64839	26-Aug	1966	Warren	Pennsylvania
CU	64985	25-Oct	1980	Cattaraugus	New York
CU	65689	18-Jun	1980	Chautauqua	New York
CU	66510	19-Mar	1966	Cattaraugus	New York
CU	67998	2-Oct	1982	Cattaraugus	New York
CU	70624	5-Oct	1982	Kanawha	West Virginia
CU	78013	14-Apr	1977	Tyler	West Virginia
CU	79140	9-Aug	1973	Clay	West Virginia
Daniel Boone NF	DOW02008004	4-May	1989		Kentucky
Daniel Boone NF	DOW02012014	26-May	1998		Kentucky
Daniel Boone NF	DOW03030007	21-May	1998		Kentucky
Daniel Boone NF	DOW05028002	5-May	1982		Kentucky
Daniel Boone NF	DOW05028003	6-May	1982		Kentucky
Fishbase	AMNH 225369		1976		
Fishbase	AMNH 42285		1979		
Fishbase	AMNH 55773				
Fishbase	AMNH 56019		1984		Tennessee
Fishbase	AMNH 65661		1970		
Fishbase	AMNH 66030		1970		
Fishbase	AMNH 66530		1971		
Fishbase	BMNH 1883.12.14.258		1883		Illinois
Fishbase	BMNH 1983.8.19.5-6		1983	Braxton	West Virginia
Fishbase	CAS 208628			Pulaski	Indiana
Fishbase	AMNH 42053		1979		
Fishbase	CAS 208629			Pulaski	Indiana

Museum/Agency/dbase Name*	Catalog #	Date	Year	County	State
Fishbase	CAS 208630			Owen?	Indiana
Fishbase	CAS 208631			Pulaski	
Fishbase	CAS 218769			Lawrence	Indiana
Fishbase	KU 11658		1966	Clay	
Fishbase	MNHN a-5190				Kentucky
Fishbase	MOVI 30976-30979		1944	Lawrence	Indiana
Fishbase	USNM 00007419				Kentucky
Fishbase	USNM 00017761				Illinois
Fishbase	USNM 00022679				
Fishbase	USNM 00030733				Kentucky
Fishbase	USNM 00035384				Tennessee
Fishbase	USNM 00064914			Marshall	Indiana
Fishbase	USNM 00066882				Indiana
Fishbase	USNM 00092527		1930		North Carolina
Fishbase	USNM 00162481				Virginia
Fishbase	USNM 00210680		1965	Warren	Pennsylvania
Fishbase	USNM 00210684		1965	Warren	Pennsylvania
Fishbase	USNM 00230900		1978	Wayne	Tennessee
Fishbase	USNM 00232548		1962	Monroe	Tennessee
Fishbase	USNM 00247233		1957	Doddridge	West Virginia
Fishbase	USNM 00247234		1970	Scott	Virginia
Fishbase	USNM 00247701		1981	Bedford	Tennessee
Fishbase	USNM 00353418		1998		
Fishbase	USNM 00355799		1998		
GA Natural Heritage Program		11-Apr	1995	Catoosa	Georgia
GA Natural Heritage Program		19-Apr	2000	Catoosa	Georgia
Indiana Fish Dbase--OSUM	55163	May	1951	Kosciusko	Indiana
INHS	INHS 27137	28-Apr	1979	Braxton	West Virginia
INHS	INHS 27156	6-May	1979	Scott	Virginia
INHS	INHS 37863	12-May	1996	Clay	West Virginia
INHS	INHS 41689	23-Jul	1997	Green	Kentucky
INHS	INHS 63534	20-Sep	1987	Fulton	Indiana
INHS	INHS 68798	15-Jul	1985	Pulaski	Indiana
INHS	INHS 74310	12-Jun	1975	Scott	Virginia
INHS	INHS 82538	15-Mar	1976	Bradley	Tennessee
INHS	INHS 89073	1-Oct	2000	Pendleton	Kentucky
INHS	INHS 89170	13-Jan	2001	Claiborne	Tennessee
MOSU	MOSU 1619	1-Jun	2000	Pendleton	Kentucky
MOSU	MOSU 1725	10-May	2001	Rowan/Bath	Kentucky
MOSU	MOSU 1770	7-Sep	2001	Rowan/Bath	Kentucky
MOSU	MOSU 1941	16-May	2002	Pulaski	Kentucky
MOSU	MOSU 2149		1976	Franklin	Kentucky
MOSU	uncatalogued	Apr	1981	Rowan	Kentucky
MOSU	uncatalogued	Apr	1971	Lewis	Kentucky
NMC	CMNFI 1982-0122.1	14-May	1977	Crawford	Pennsylvania
NMC	CMNFI 1982-0123.1	14-May	1977	Erie	Pennsylvania
NMC	CMNFI 1982-0130.1	14-May	1977	Erie	Pennsylvania

Museum/Agency/dbase Name*	Catalog #	Date	Year	County	State
NMC	CMNFI 1982-0142.1	14-May	1977	Erie	Pennsylvania
NMC	CMNFI 1986-0862.1	26-May	1977	Potter	Pennsylvania
NMC	CMNFI 1986-0864.1	19-Jun	1973	Warren	Pennsylvania
NMC	CMNFI 1986-0865.1	9-Aug	1960	Warren	Pennsylvania
NMC	CMNFI 1996-0024.1	17-May	1946	Perry	Tennessee
NY DEC		20-Sep	2001		New York
NY DEC		21-Jun	2001		New York
NY DEC		21-Jun	2001		New York
NY DEC		17-Jun	1992		New York
NY DEC		17-Jun	1992		New York
NY DEC		30-Jun	1992		New York
NY DEC		11-Aug	1992		New York
NY DEC		27-Jul	1999		New York
NY DEC		26-Oct	1999		New York
Ohio Aquatic GAP			1997		Ohio
Ohio Aquatic GAP			1983		Ohio
ORSANCO Records		27-Aug	1957		Pennsylvania
ORSANCO Records		28-Oct	2002		West Virginia
ORSANCO Records		28-Oct	2002		West Virginia
ORSANCO Records		29-Oct	2002		West Virginia
ORSANCO Records		27-Oct	2003		Kentucky
ORSANCO Records		27-Oct	2003		Kentucky
ORSANCO Records		27-Oct	2003		Kentucky
ORSANCO Records		27-Oct	2003		Kentucky
ORSANCO Records		10-Sep	1996		Ohio
ORSANCO Records		11-Sep	1980		Ohio
ORSANCO Records		27-May	1957		Ohio
ORSANCO Records		1-Oct	1987		
OSUM	1473		1929		
OSUM	2896	12-Jul	1940	Scioto	Ohio
OSUM	2969	28-Apr	1940	Scioto	Ohio
OSUM	11652	29-Apr	1931	Adams	Ohio
OSUM	14177	28-Feb	1965	Washington	Ohio
OSUM	23681	11-May	1970		West Virginia
OSUM	33959	8-May	1970		West Virginia
OSUM	35813		1932	Brown	Ohio
OSUM	37258	3-Nov	1974		Pennsylvania
OSUM	43412	22-Apr	1978		Kentucky
OSUM	46183	12-May	1980		Tennessee
OSUM	48954	19-Mar	1979		Tennessee
OSUM	52438	18-May	1980		Virginia
OSUM	52468	13-May	1980		Tennessee
OSUM	55163	May	1951		Indiana
OSUM	55166	12-May	1983	Monroe	Ohio
OSUM	55167	7-Jan	1983		Ohio
OSUM	56287	23-Jun	1981		Virginia
OSUM	56515	20-Jun	1983		Virginia

Museum/Agency/dbase Name*	Catalog #	Date	Year	County	State
OSUM	58976	16-Jun	1977		Tennessee
OSUM	76276	7-Oct	1991		Ohio
OSUM	83917	20-May	1992		Ohio
OSUM	83927	19-May	1992		Ohio
OSUM	94427	8-May	2000		Ohio
OSUM	94550	8-May	2000		Ohio
OSUM		20-Nov	2002	Washington	Ohio
Rhode et al. 1998 (Brimleyana)		14-May	1994	Madison	North Carolina
Rhode et al. 1998 (Brimleyana)		22-Apr	1995	Madison	North Carolina
Rhode et al. 1998 (Brimleyana)		14-May	1995	Greene	North Carolina
UAIC	5993.01	1-Jul	1980	Jackson	North Carolina
UAIC	5998.01	1-May	1980	Macon	North Carolina
UAIC	6322.01	23-Jul	1980	Monroe	Tennessee
UAIC	10340.01	23-Jun	1991	Cattaraugus	New York
UAIC	12433.01	25-Mar	2000	Hancock	Tennessee
UAIC	12459.01	11-May	2000	Estill	Kentucky
UAIC	12460.01	10-May	2000	Rockcastle	Kentucky
UAIC	13454.01	3-Jul	2001	Scott	Virginia
UAIC	13455.01	3-Jul	2001	Smyth	Virginia
UAIC	13475.01	15-Sep	2001	Laurel	Kentucky
UAIC	13640.01	6-Jun	2002	Morgan	Tennessee
UF	43518	27-Apr	1968	Magoffin	Kentucky
UF	93731	12-Aug	1993	Hancock	Tennessee
UF	93792	10-Aug	1993	Lee	Tennessee
UF	93922	11-Aug	1993	Hancock	Tennessee
UF	94020	12-Aug	1993	Hancock	Tennessee
UF	97962	16-Aug	1994	Claiborne	Tennessee
Questionable Records					
CU	943				Wisconsin
ANSP	JH08-MR	21-Jan	1991		Missouri
ANSP	Z85450	15-Jun	1992		Michigan

*Museum/Agency/dbase Acronyms:

AMNH American Museum of Natural History, New York
ANSP Academy of Natural Sciences, Philadelphia
BMNH British Museum of Natural History
CAS California Academy of Sciences, San Francisco
CU Cornell University Ichthyology Collection
INHS Illinois Natural History Survey
KU University of Kansas, Museum of Natural History, Lawrence, Kansas
MOSU Morehead State University Museum (KY)
MOVI Museu Ocenografico do Vale do Italia
MNHN Muséum National d'Histoire Naturelle, Paris
NMC Canadian Museum of Nature, Ichthyology Collection

NY DEC	New York Department of Environmental Conservation, Fisheries Database
OSUM	Ohio State University Museum of Zoology, Division of Fishes
UAIC	University of Alabama Ichthyological Collection
UF	Florida Museum of Natural History, University of Florida
USNM	National Museum of Natural History--Smithsonian, Washington D.C.

Further information about the above records may be obtained by contacting the authors or by contacting Becky Ewing, Forest Biologist, Wayne National Forest, Nelsonville, Ohio.