

*Conservation Assessment
for
the Spotted Darter (Etheostoma maculatum)*



Picture taken by Thomas P. Simon

USDA Forest Service, Eastern Region

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This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another provides information to serve as a Conservation Assessment for the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 626 East Wisconsin Avenue, Milwaukee, Wisconsin 53203.

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EXECUTIVE SUMMARY

The spotted darter *Etheostoma maculatum*, was first described by Jared Kirtland in 1896 (Hay 1896). The species has a disjunct geographic range occurring throughout the Ohio River Valley. About twelve known spotted darter populations occur in streams that flow through land under the ownership of the United States Department of Agriculture Forest Service. These sites fall within the Allegheny National Forest in northwestern Pennsylvania and the Hoosier National Forest in southern Indiana. The species occurs in moderate- to large-rivers and are associated with cobble/boulder substrates. Threats to the species' continued existence include habitat alterations such as siltation and the embeddedness of interstitial pores and the damming of flowing waters. The spotted darter is sensitive to changes in water quality. Another biological concern is the introduction of non-native predator species. The species receives some protection under the various State Endangered Species Protection Act and some habitat for the species is protected on USDA Forest Service lands. Management activities should include protection of habitat and restoration of impaired habitats, monitoring of the species' distribution and relative abundance, and further research to determine reproductive biology and early life history characteristics.

NOMENCLATURE AND TAXONOMY

Classification: Class Osteichthyes
Order Perciformes
Family Percidae

Scientific name: *Etheostoma maculatum*

Common name: Spotted darter

The spotted darter *Etheostoma maculatum* is a member of the darter subgenus *Nothonotus* (Zorach & Raney 1967; Zorach 1972; Etnier & Williams 1989). The *maculatum* clade was formerly a small monophyletic group of darters that occurred in moderate- to large- rivers, but has been recently revised. The *maculatum* species group includes *Etheostoma wapiti*, *E. vulneratum*, and *E. sanguifluum*. This group is the sister group to the remaining members of the *maculatum* species group. *Etheostoma vulneratum* and *E. sanguifluum* were considered subspecies of *E. maculatum*, which have been elevated to full species status from former subspecific recognition (Etnier & Starnes, 1993). Etnier & Williams (1989) using phylogenetic analysis found *E. vulneratum* to be more closely related to *E. wapiti* than to *E. maculatum*. Page (1985) elevated *E. sanguifluum* to species status. Subsequent phylogenetic analysis by Wood (1996), and Wood & Mayden (1993) using genetic allozymes confirmed these earlier hypotheses. The *Nothonotus* group includes three species that commonly are sympatric including *E. camurum*, *E. tippecanoe*, and *E. maculatum*.

Etheostoma maculatum was described by Kirtland (1841: 338-352) from specimens thought to have been collected from the Mahoning River, Ohio. Zorach (1972) considers

E. maculatum to be the sister species of the recently elevated *E. sanguifluum*, which was formerly described as a subspecies. All of the *Nothonotus* darters are small- to moderate-sized, laterally flattened inhabitants of swift riffles in medium to large streams and rivers. Lateral line is complete; head canals are complete; scale and fin ray counts high; gill membranes separate; six branchiostegal rays; dorsal saddles nine or more or not apparent and frenum well developed. Sexual dimorphism striking, eggs attached beneath rocks or buried in gravel. Most species with dark horizontal lines laterally. Twelve species belong to *Nothonotus* in the Ohio River drainage, and another three species occur outside the drainage (Zorach 1968, 1969, 1970, 1972; Zorach and Raney 1967; Etnier and Williams 1989).

DESCRIPTION OF SPECIES

The spotted darter include has a laterally compressed body, unequal jaws, short pectoral fins, an absent/weak suborbital bar, and a rounded posterior edge of the caudal fin (Zorach and Raney 1967). Spotted darters superficially resemble bluebreast darters (*E. camurum*), but the two can be distinguished by the latter having a black margin on its soft dorsal, caudal, and anal fins (Stauffer et al. 1995). Small spotted darters can resemble Tippecanoe darters (*E. tippecanoe*); however, the two can be distinguished by the latter having an incomplete lateral line (Stauffer et al. 1995). *Etheostoma maculatum* is fairly long-bodied relative to other darters, often exceeding 60 millimeters (mm) and even reaching 75 mm in standard length (SL) (Page 1983, Kuehne and Barbour 1983). The opercle and belly are scaled, the cheek is slightly scaled to unscaled, and the nape and breast are unscaled (Page 1983). Lateral line counts are usually 56 to 65 scales, and vertebrae number 37 to 39 (Kuehne and Barbour 1983).

The spotted darter is sexually dimorphic (Raney and Lachner 1939). Zorach and Raney (1967) presented identifying sexual characteristics of *E. maculatum*. Males have black-edged red spots on the body and a bluish-green breast that intensifies in color at spawning time. The caudal fin has a white edge on the posterior border that contrasts with the predominantly dusky color of the rest of the fin, including the black membranes. The basicaudal area is crossed by a pale bar that may be broken by four dark spots, none of which is as dark as the fin membranes. The first dorsal fin is uniformly dusky, except darker near the bases of the first and second membranes, and it has a narrow white border. The second dorsal fin is predominantly dusky, with membranes darker than rays, and a pale margin present. The anal fin is similar to the second dorsal, but the pale margin is more prominent. The pectoral fin is dusky, with rays darker than membranes. The pelvic fin is dusky with a whitish border on the outer half.

Females have dark spots on the sides of their bodies that, although larger, are more diffuse than the red spots of the males. The outer half of the caudal fin has dark spots on the rays and membranes. The basicaudal spots are present, but they are obscured by the generally dusky appearance of the caudal base. Females, in contrast to the males, never possess a white/pale border on the dorsal fins. The first dorsal fin is variably dusky, with discrete black spots occurring exclusively near the border, and a dark blotch on the lower half of the first membrane. The second dorsal fin has discrete round spots on the outer

two-thirds of the rays and membranes, while the basal third is irregularly dusky. The anal fin is the same as the second dorsal, except that the first two or three membranes are uniformly dusky. The pectoral fin has clear membranes, but the rays are dusky with scattered elongated blotches. The pelvic fin is dusky with a milky-white border on the lower and posterior edges.

LIFE HISTORY

The ecology and life history of species in the subgenus *Nothonotus* are poorly known. All of the *Nothonotus* inhabit moderate-sized streams of the Central Lowlands of the Ohio River drainage (Zorach & Raney, 1967; Page & Burr, 1991). The spotted darter, *Etheostoma maculatum* is widely distributed, but is limited to only a few high quality, isolated rivers and large streams. The species is restricted in distribution in Indiana and throughout most of its range in Ohio, Tennessee, Pennsylvania, New York, and Kentucky (Trautman 1981; Cooper 1983; Simon *et al.* 1987, 1992; Burr & Warren 1986; Smith 1985; Etnier & Starnes 1993). The known ecology of *E. maculatum* is based on studies in Pennsylvania.

AGE AND GROWTH

Etheostoma maculatum is a large darter, reaching lengths of 75 mm SL. Juveniles were slightly less than 30 mm SL by the end of the first summer (Simon *et al.*, 1987), young-of-the year in Ohio ranged between 30-43 mm in October (Trautman, 1981). In Pennsylvania, juveniles ranged between 21-28 mm in late August; and in October ranged between 22-28 mm (Raney and Lachner, 1939). Growth of *E. maculatum* showed that juveniles were slightly less than 30 mm SL by the end of the first summer (Simon & Wallus, 2005); young-of-the year in Ohio ranged between 30-43 mm in October (Cooper, 1983). In Pennsylvania, juveniles ranged between 21-28 mm in late August; and in October ranged between 22-28 mm.

REPRODUCTION

Etheostoma maculatum exhibits localized spawning, which occurs in quiet areas in streams with widths about 3.3 m at the head of the riffle, just before and after the water broke in its descent over the riffle. Eggs are attached beneath flat stones at depths of 0.2 – 0.6 m (Simon *et al.*, 1987).

Spawning occurs in May and early June throughout its range (Smith, 1985; Simon *et al.*, 1987), at temperatures of 17 C in French Creek, Pennsylvania (Simon *et al.*, 1987). Fecundity in *Etheostoma maculatum* is relatively high among darters.

A female 50 mm SL had 400 eggs; smaller females 40-45 mm SL contained a mean mature ova count of ca. 200 ova (Simon *et al.*, 1987). Ovarian eggs mature in batches of about 65 ova (Smith, 1985). Females (54-68 mm TL) collected in mid-April from Little River (Tennessee River drainage), Blount County, Tennessee, had mean ovaries that were 10.9% of the body weight, containing 178.3 total ova averaging 1.11 mm diameter (Table 1; Simon & Wallus 2005). No significant relationship was observed between increasing

TABLE 1. Fecundity data for *Etheostoma maculatum* from Little River, Blount County, Tennessee (Simon & Wallus 2005).

TL	Ovary weight (mg)	Ripening oocytes (LA)	Number of Ova		Egg diameters (mm)
			Mature oocytes (EM,MA &LM)	Ripe eggs (MR&RE)	
49	221	84	37	22	2.00
50	197	174	41	31	1.66
54	360	226	72	39	2.00
55	377	127	44	41	2.20
55	74.6	228	43	0	--
55	76.4	180	78	0	--
57	277	221	70	58	1.66
63	144	188	146	0	--
63	187	208	32	45	1.53
70	257	258	81	53	1.53

female size with increasing number of mature ova in the ovaries ($F = 6.150$, $p = 0.056$); nor with total ova ($F = 1.527$, $p = 0.252$).

Territories are established at minimum distances of 3.6 m, a single male occupies the large flat rocks. Eggs are deposited on the underside of flat stones 75-225 mm in diameter. Egg masses are square in shape, with the eggs in 4 or 5 layers and 5-10 layers opposite. Eggs are guarded exclusively by the males (Simon, unpublished data). Reproduction occurs in the early morning when a female enters the opening of the nest stone.

Courting consisted mainly of a male making a lateral display followed by tail wagging, which leads the female into the cavity. A head-to-tail position is maintained while the male nudges and nipping of the caudal fin. Males and females were sexually mature at age II at lengths greater than 48 mm SL; some young 32 mm SL females were mature at age I (Simon, unpublished data). The spawning act includes males establishing and encouraging the female to invert. Spawning occurs over an extended period of time, in short 5-10 s of vibrating bursts. A total of 3-5 eggs are laid during any single spawning event. The eggs may be layered and tend to be concentrated in the furthest portion of the cavity (Simon, unpublished data). Parental care was provided by the male (Simon, unpublished data).

Examination of the ovaries showed that ovoid latent ova ranged from 0.5-0.71 mm, early maturing small spherical light yellow colored ova ranged from 1.0-1.5 mm, and large mature ova ranged from 1.53-2.2 mm (T.P. Simon, unpublished data). Mature ova are demersal, adhesive, and spherical; possessing a single oil globule, a narrow perivitelline space, and an unsculptured chorion (Simon et al., 1987). Eggs averaged 2.0 mm in diameter (Simon et al. 1987).

Eggs cultured in laboratory aquaria at 22-24 C hatched after 175 hrs (Simon et al., 1987). Eggs are deposited on the underside of flat stones in squarish clusters at the head or end of the riffles. Simon et al. (1987) described the development of early life stages. Hatching occurred by violent motions within the egg. Yolk sac larvae settle on the bottom and remained lying on their side. Occasional erratic movements were produced by rigorous jerking of the bodies and it appeared to require considerable effort to reach the surface. Larvae are demersal, remaining in close association with the substrate usually on the edges of the head of the riffle within interstitial spaces. No distinction is evident between the habitat of young juveniles and adults.

DIET

The majority of spotted darter's diet is aquatic insects, including Dipterans, caddisflies, stoneflies, mayflies, and beetles (Kuehne & Barbour 1983; Page 1983; Etnier & Starnes 1993; Simon & Wallus 2005). Raney and Lachner (1939) reported that insect larvae made up 95% of the diet. Based on 25 specimens taken by Raney and Lachner (1939) in June, the bulk of the food items consisted of larval Diptera (mostly chironomids) and Trichoptera (caddisflies); while larval stoneflies (Plecoptera), mayflies (Ephemeroptera) and beetles (Coleoptera) occurred frequently enough to be considered important, along with adult water mites (Hydracarina).

HABITAT

Etheostoma maculatum usually inhabits the riffles of large streams where it is found over coarse gravel and rubble (Trautman 1981; Kuehne & Barbour 1983; Burr & Warren 1986). It is taken during all months of the year, and moves only slightly to deeper parts of the same riffle during the winter months (Simon et al. 1987; Simon & Wallus 2005).

DISTRIBUTION AND ABUNDANCE

The spotted darter is wide ranging in the Ohio River basin, occurring in only a few Indiana streams (Figure 1). The species occurs at a few sites in tributaries of the Allegheny River in northwest Pennsylvania (Cooper 1983), and formerly recorded in the Mahoning River, Muskingum, and Scioto Rivers, Ohio (Trautman 1981). The species occurs in the upper Wabash River, East Fork White River, and Blue River, Indiana (Gerking 1945; T.P. Simon & B.E. Fisher unpublished data). Specimens recorded from the Licking River, Kentucky (Burr & Warren 1986), and lower Kanawha River, West Virginia (Stauffer et al. 1995), has not been matched with recent collections.

Etheostoma maculatum is sporadic and uncommon throughout its range. It occurs in the upper Green and Barren River, Kentucky; recently discovered in North Fork Kentucky River (Burr & Warren 1986). In New York, the species occurs only in French Creek (Smith 1985); limited to Big Darby and Deer Creeks, Scioto basin, Ohio (Trautman 1981). In the upper Wabash River drainage, *Etheostoma maculatum* was collected from

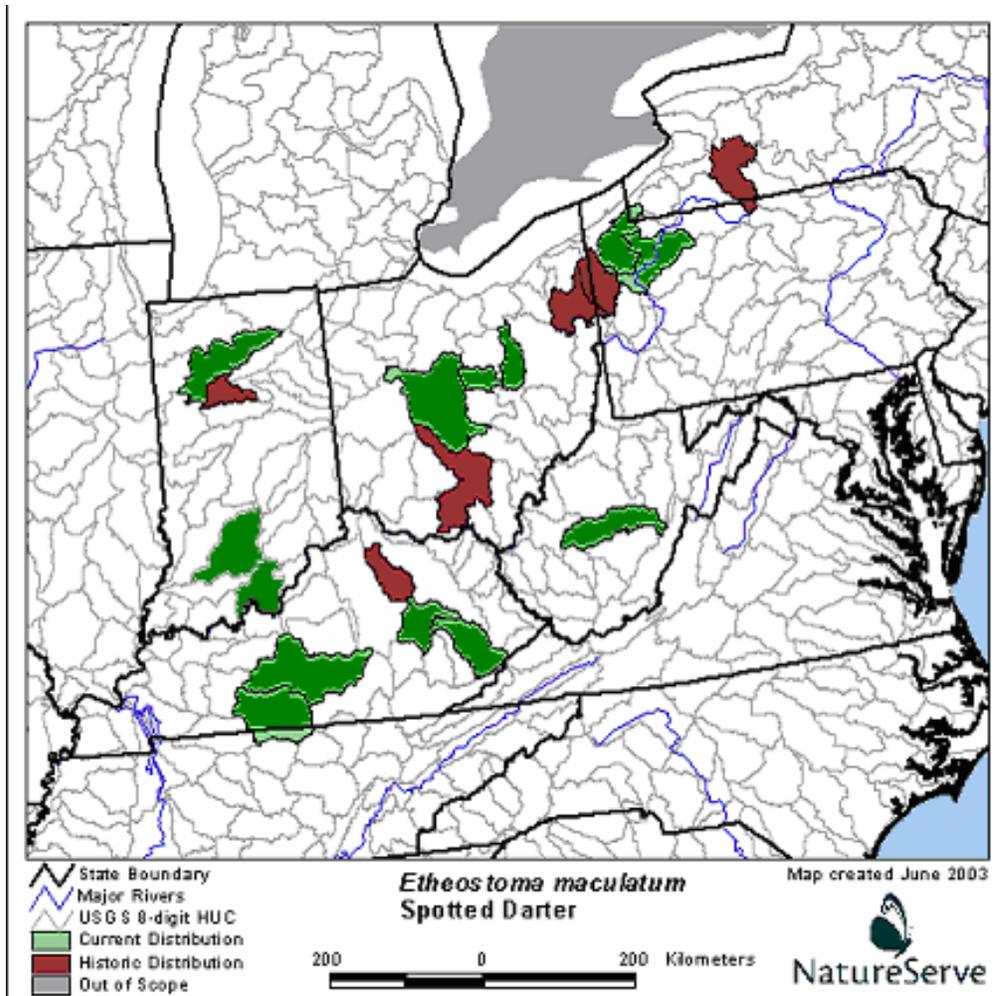


Figure 1. Distribution of *Etheostoma maculatum* and heritage status ranks by state, downloaded from NatureServe, Sept. 30, 2003 including original information from Indiana.

the middle Tippecanoe River (Raney & Lachner 1939; Carney et al. 1993), lower White River basin (Gerking 1945), and from the Blue River in Crawford, Washington, and Harrison Counties (Baker et al. 1985). In Pennsylvania, the species is a typical darter of the Shenango and Allegheny Rivers and French Creek (Cooper 1983).

STATUS

The status of the spotted darter is declining over its range. In Indiana, the species has expanded its range and is stable or increasing in the Blue River and East Fork White River. Mayasich et al. (2004) compiled recent occurrences of the spotted darter, by individual state and drainage. They indicated that the spotted darter distribution includes, two waters of the Allegheny River drainage, eight waters of the Green River drainage, a single water of the Kanawha River drainage, six waters of the Ohio River drainage, and two waters of the Wabash River drainage. The following is summarized from Mayasich et al. (2004):

Kanawha River drainage. In the Kanawha River the spotted darter has been collected at only two locations in West Virginia. Both records are from West Virginia Department of Natural Resource collection efforts on the Elk River of the lower Kanawha River basin (Stauffer et al. 1995; D. Cincotta, personal communication, 2005). The first record came from the main-channel Elk River in 1976 immediately above Sutton Lake reservoir, while the second was from a 1991 survey made from a mid-river location which was below the reservoir (D. Cincotta personal communication). The mid-river location has been checked regularly over the last ten years, and the spotted darter continues to be present there; however, it has never been retaken at the 1976 collection site despite several attempts in the 1990s (D. Cincotta, personal communication, 2005).

Allegheny River drainage. The spotted darter still occurs in the Pennsylvania portions of French Creek (Cooper 1983; Rob Criswell, Pennsylvania Game Commission, personal communication, 2005). Although considered to be uncommon to rare in the middle Allegheny between Franklin, Pennsylvania and Kinzua Dam, spotted darters are still present in this river system (R. Criswell, pers. comm., 2005.). The spotted darter also inhabits a 14 mile section of New York's French Creek (Smith 1985, and Doug A. Carlson, New York State Department of Environmental Conservation, personal communication, 2005). The sampling of West Branch French Creek (Chautauqua County) in 1992, produced the first record of the spotted darter in the New York portion of that stream (D.A. Carlson, pers. comm., 2005).

Mahoning River drainage. According to Trautman (1981), the section of the Mahoning river where Kirtland collected his early specimens is almost devoid of fish life due to pollution and degraded water quality. According to Rob Criswell (pers. comm., 2005), there are no definitive records for occurrences of the spotted darter in the Pennsylvania portion of the Mahoning river; only unverified information indicating a historical (circa 1890) presence in the Mahoning, which meets with the Shenango to form the Beaver River. He stated that the spotted darter is evidently extirpated from the Shenango/Mahoning River.

Shenango River drainage. The current distribution of *E. maculatum* does not include the Shenango River system in Pennsylvania (R. Criswell, pers. comm., 2005).

Ohio River System. The spotted darter was collected in the Walhonding River below the Mohawk Dam in 1999 (Dan Rice (retired), Ohio Department of Natural Resources, personal communication, 2000) revealed that, for the first time since the 1960s. A record from 1985 found spotted darter when sampling the Kokosing River, which joins with the Mohican to form the Walhonding River (Sanders et al., unpublished data). The State of Ohio records of spotted darter occurrences include occurrences from 1983 to 1987. Trautman (1981) associated the occurrence of the spotted darter in the Olentangy River with a wide range of years, 1950 to 1980, and he noted that its occurrence was unexpected because the typically more numerous variegate darter had not been collected from that river. Recent occurrences of *E. maculatum* in Big Darby Creek, from 1979 through 1992, and in 1997, are supported by Ohio Department of Natural Resource

records (Sanders et al., unpublished data). This population may be expanding its range upstream into Franklin County, to just beyond the confluence with Little Darby Creek (Mayasich et al. 2004). The Big Darby Creek population may also be expanding its range downstream to reoccupy a historical Scioto River locality. Big Darby Creek differs from other upper Scioto River tributaries, such as the Olentangy River, Big Walnut, and Deer creeks, in having better water quality. The spotted darter's current distribution does not include Deer or Big Walnut creeks. The spotted darter occurs in the Blue River and south Fork Blue River, tributaries of the Ohio River in Crawford, Harrison, and Washington counties. The species has been collected regularly from 1976-2000.

Green River drainage. The spotted darter is likely extirpated from all Kentucky waters except those of the Green River. Collections in the 1980s documented the presence of the spotted darter in the mainstem Green River, and in the Little Barren River, a tributary (Cicerello 2003). More recently, spotted darters were collected at 20 sites over about 94 river-miles of the mainstem of the Green River (Cicerello 2003). Spotted darters were found, post-1990, in four tributaries to this 94-mile stretch of the Green River mainstem; e.g., in the Little Barren River (Green County), in Russell and Big Pitman creeks (Green County), and as a first record for Meadow Creek in Green County (Cicerello 2003). As recently as 2002, adults were collected and young of the year were observed in the mainstem of the Green River (Cicerello 2003). Cicerello (2003) concluded that the spotted darter was relatively common and evenly distributed in the Green River system; however, he noted that it has not been collected from the Green River downstream of Mammoth Cave National Park, despite the presence of suitable habitat. *Etheostoma maculatum* was also recently collected in Warren County, Kentucky within the Barren River basin; e.g., in 1990 from the Barren River itself (below Lock and Dam No. 1) and in 2001 from its tributaries, the Gasper River and West Fork Drakes Creek (Cicerello 2003). Cicerello (2003) concluded that the spotted darter inhabits a fraction of its historical range in the Barren River basin, as it is currently restricted to the tributaries (West Fork Drakes Creek and lower Gasper River) and the contiguous Barren River, upstream to Lock and Dam No. 1.

Upper Cumberland and Licking River Systems. No data supports recognition of the spotted darters presence in these river systems.

Wabash River System. Simon collected spotted darters from a riffle downstream of Winamac in 1985. This record was published by Carney et al. (1993) representing a single location in Pulaski County. Brant Fisher in 1997 discovered a previously unknown population of *E. maculatum* in the East Fork White River.

The following is the list of states and the protection afforded the spotted darter. In Indiana, the species has been recommended that it be a species of special concern.

In New York, the spotted darter is considered threatened. This designation indicates that the spotted darter is likely to become imperiled in the foreseeable future and therefore makes it illegal to take, import, transport, possess or sell the species in New York

In Ohio, the spotted darter is endangered based on its disappearance from three central Ohio streams (e.g., the lower Olentangy River, lower Big Walnut Creek, and lower Deer Creek), remaining only in parts of Big Darby Creek. Funds for conservation efforts have been allocated to restore the species.

In Pennsylvania, *E. maculatum* is listed as threatened, which provides legal protection preventing the catching, taking, killing, possessing, importing to or exporting from the Commonwealth, selling, offering for sale, or purchasing, of and individual, alive or dead, or any part thereof, without a special permit from the Executive Director of the Commission.

In West Virginia, there are no state-established endangered species laws to protect and manage state or federal species of concern.

POTENTIAL THREATS

Three primary threats may impact the continued existence of *Etheostoma maculatum*. Habitat alteration, water quality, and the introduction of non-native predator species threaten the stability of populations in the Allegheny and Hoosier National Forests. There are no known diseases that could adversely affect the spotted darter nor is there a high likelihood that overutilization for commercial, recreational, scientific, or educational purposes could impact current populations.

HABITAT ALTERATION

Habitat alteration including the increase in habitat destruction and impacts in water quality could potentially affect the spotted darter. Kuehne and Barbour (1983) indicated that darters were sensitive to water quality changes and found that they were among the most sensitive species to turbidity, siltation, and embeddedness. Blocked aquatic passages from lowhead dams would prevent migration of spotted darters and also reduces desired riffles habitat into undesired deep pool habitats. Sedimentation increase behind lowhead dams causes bedload embeddedness in needed cobble and boulder substrate habitats.

The spotted darter occurs in moderate- to large rivers with coarse substrates such as gravel, cobble, and boulder habitats and is extremely sensitive to siltation, which results from watershed disturbance. The spotted darter is among the first darter species to disappear when siltation levels increase (T.P. Simon, unpublished data). The species utilizes interstitial pore spaces for reproduction around large cobble and boulders and seeks refuge from predators beneath rocks. As embeddedness increases from siltation, pore spaces would be unavailable if covered by high silt levels. Poor agricultural techniques, removal of riparian buffer strips along stream margins, and tributary channelization represent the greatest source of increased silt loads in rivers containing *E. maculatum*. Efforts to remove riffle, run, and pool habitats through activities aimed at improving watershed drainage (i.e., channelization) and the removal of bottom substrates by instream cobble and gravel mining could adversely affect the species. The species

requires cobble and boulder substrates for refuge. Removal of such habitat components would significantly increase predation rates.

Stream impoundment is another habitat alteration that represents a threat to the spotted darter. The species occurs exclusively in fast flowing rivers, but may occasionally be found in slower flowing pools of streams. Faster flowing riffle habitats are always found in adjoining stream reaches. Conversion of stream reaches from lotic habitat to lentic conditions through stream impoundment would make that habitat uninhabitable. In addition to a fundamental change in habitat structure, stream impoundment could alter suitable habitat by increasing benthic silt loads and providing more desirable habitat for predators. Predator species that could consume adult darters might include the blackbasses (*Micropterus* spp.), temperate basses (*Morone* spp.), and pikes (*Esox* spp.). Predators on juvenile and larval individuals could include sculpins (*Cottus* spp), various opportunistic minnow and sunfish species (i.e., *Semotilus atromaculatus*, *Lepomis* spp., and *Pomoxis* spp.). If impoundments are large enough for recreational fishing, the construction of reservoirs on streams containing the spotted darter would also substantially increase the risk for non-native predator introductions, such as black basses, temperate basses, and pike species.

NON-NATIVE INTRODUCTIONS

In North America, there are several examples of the effects of non-indigenous species introductions causing impacts to native benthic fish species. Non-native species that are introduced for sport fishing, such as brown trout (*Salmo trutta*) would have negative impacts on spotted darter. However, most examples have found that alien species caused the rapid displacement of native benthic species. For example, the introduction of the round goby, *Neogobius melanostomus*, in the Great Lakes has caused greater than 50% reduction in the number of native populations of native darter and sculpin species, with some populations in the nearshore of Lake Erie being entirely eliminated (R.F Thoma, personal communication). The round goby has invaded the Illinois River drainage and is moving downstream into the Mississippi River. If the round goby invades the Mississippi River most moderate- to large river darters will be vulnerable. Stocking of non-indigenous predator fish species may have a similar effect causing the reduction in native benthic species. Although the evidence for such impacts are not documented, non-indigenous predator species such as Pacific salmon are known as keystone predators and are able to rapidly disrupt the fish assemblage of streams tributary to the Great Lakes (Simon and Stewart 1999). Non-native fishes can also carry pathogens harmful to native species.

Non-native fishes displace native species through competition, predation, and reproductive interference. In North America, the most common pathway for the introduction of non-native fishes has been through the transport in ship ballast, release after being used as fishing bait, or intentionally stocked as recreational fishery. Other pathways documented in North America and abroad include legal and illegal stocking, aquaculture escape, and aquarium and pond trade escape.

LAND OWNERSHIP AND EXISTING HABITAT PROTECTION

Simon and Fisher (unpublished data) found 12 known spotted darter populations occurring in the Blue River drainage. Many of these populations include reaches that flow through land under the ownership of the United States Department of Agriculture Forest Service. Potential sites within the Allegheny National Forest in northwestern Pennsylvania and the Hoosier National Forest in southern Indiana. Pence (2004) hypothesized that populations of the species most likely occur in parts of the following streams flowing through the Allegheny National Forest property; the Allegheny River provides the most ideal habitat, but Tionesta Creek and possibly the Clarion River would also provide this habitat. These streams have the size, substrate, and water temperatures necessary for the species. The remainder of streams on the Allegheny National Forest are too small and are cold-water streams. Populations of the spotted darter are rare in the Allegheny River so the exact number of stream miles with suitable spotted darter habitat occurring on Allegheny National Forest Service property is unknown.

Within the Hoosier National Forest, the species is known only to occur in the Blue River (Crawford, Washington counties) and the East Fork of the White River downstream of Williams dam. The exact number of stream miles with suitable spotted darter habitat that occurs on Forest Service property is unknown. The Nature Conservancy also maintains an office and land holdings on the Blue River. The remaining public land holdings include properties maintained by the State of Indiana including State Forests, natural areas, and state parks. Other than these major state and federal land holdings, the remainder of the spotted darter's range is under private ownership.

Within the Allegheny National Forest, habitat for the spotted darter receives protection under the Amended Land and Resource Management Plan (USDA FS, 1986). Under that Plan, the Forest Service is directed to “protect and/or manage habitat to ensure the continued existence” of the spotted darter. The plan requires the protection of all pool/riffle complexes in streams known to contain the species from activities that may result in habitat degradation.

The spotted darter is currently listed as a Regional Forester's Sensitive Species (RFSS), in the Hoosier National Forest as a result of the 2000 update of the Regional Forester Sensitive Species List. The 1991 Forest Plan Amendment takes riparian corridors out of the suitable timber base, but trees can be removed according to Forest Plan guidance for certain management activities. The 1991 Forest Plan Amendment does not allow mechanical removal of substrates from stream channels, but the Draft Forest Plan in review does allow removal for specific situations. In addition critical habitat is given some protection under the Land and Resource Management Plan (USDA FS, 1991). Under this Plan, riparian strips 50 – 100 feet wide that border streams are to be protected and managed to enhance water quality and within-stream habitats. The Plan also exempts commercial timber harvest within riparian strips and the instream mechanical removal of sand, gravel, or other minerals within management zones.

PAST AND CURRENT MANAGEMENT AND CONSERVATION ACTIVITIES

Other than the habitat protection measures listed under **LAND OWNERSHIP AND EXISTING HABITAT PROTECTION**, there are few other known conservation activities directed towards the spotted darter. Almost every state that has had reported spotted darter occurrences has listed the species under some formal protection. Only the State of Indiana and West Virginia do not list the species. Endangered listing under the various state Endangered Species Protection Acts (ESPA) prohibits the possession, taking, transportation, sale, offer for sale, or disposal of any listed animal without a permit. These protective measures apply to both private and governmental parties and are only afforded to those populations that have Endangered listing of the species. Populations within the State of Indiana and West Virginia do not receive similar protection.

MANAGEMENT AND RESEARCH PRIORITIES

Management

Protection of existing moderate- to large-river riffle habitats for the spotted darter must be a management priority. Without clean, coarse substrates in flowing habitats, the species will not persist. In addition, decreased water quality from siltation, acid mine drainage, and toxic substance runoff may adversely affect the species. One of the greatest needs is to identify core population areas, and determine existing and potential threats. By seeking conservation agreements with landowners throughout the watershed these threats can be minimized, and possibly negated.

Management activities within the watersheds known to contain the spotted darter must minimize or eliminate:

- 1) the instream removal or destruction of cobble/ slab boulder substrates,
- 2) the input of runoff from agricultural and industrial activities,
- 3) the impoundment of flowing streams, and
- 4) increase in siltation and loss of interstitial pore spaces.

Another prudent management decision would be to restore and improve instream habitat. Although many of the stream miles within the spotted darter range have been impaired for spotted darter inhabitation; however, the relative abundance of spotted darter could be increased by the increase in flow, removal of lowhead dams, such as those in the Allegheny National Forest, and improvement of large cobble and boulders in stream channels. Disturbed reaches that did not possess cobble or large boulder habitats do not contain spotted darter; however, when flow modifications are increased through diversion procedures employing the Bernouli principal, especially at the head of riffles, natural scouring could occur thus restoring natural flow patterns and the stream's ability to process its sediment load and could remove fine sediment buildup around large rock particles. Typically, these large cobble rocks are generally found within a narrow band around riffles. By increasing the number of rubble piles within large river habitats,

migration corridors could be created that would provide migration routes between populations. However, little is known about the needed distances between cobble rock habitats to encourage migration routes and movement.

A prudent management activity would also be to discourage the stocking of predator species, such as brown trout, black basses, temperate basses, and pike species such as muskellunge in areas where spotted darters are known to occur.

Research

The current life-history and population data for the spotted darter and the improved status of Indiana populations in the Blue River provides a chance to increase information on this species that would assist in management. To accurately assess the status of *E. maculatum*, the following issues need to be addressed:

- 1) further analysis on the possible historical range in Indiana, specifically address the discrepancy in the reported range in the Tippecanoe and upper Wabash Rivers,
- 2) compile trend data, especially for Indiana,
- 3) clarify the range reduction issue in the Allegheny River, Mahoning River, and French Creek populations in Ohio, Pennsylvania, and New York, and
- 4) document past and existing threats to populations.
- 5) migration distances and known aquatic passage barriers to the species
- 6) sedimentation/embeddedness thresholds

Identical sampling methodology needs to be established including determining sampling intensity (i.e., each site should be visited more often) and frequency so that trends in species population levels can be established.

Additional, reproductive biology should be studied with the objective of determining clutch size, longevity, and early life history. In addition, a study of the species relative abundance should be conducted to assist in estimating total population size and determining crucial changes that would be occurring and whether more sensitive life-history stages exist for the spotted darter, especially whether any bottle-necks in recruitment exist.

A Species Data Collection Form prepared for the USDA Forest Service by Brent Pence, Allegheny National Forest in 2004, suggested that the potential for the spotted darter to occur in two other tributaries in the Allegheny National Forest exists. Further intensive sampling of Tionesta Creek and possibly the Clarion River should be conducted to determine whether additional populations of the spotted darter occur.

Finally, it is necessary that distribution and status monitoring be conducted. Two types of monitoring activities should be continued including, 1) the sampling of historical localities to determine if local populations are persisting and what, if any, threats are

pressuring those populations, and 2) determine the distribution of previously unknown populations in Allegheny and Hoosier National Forests.

By conducting field collection of historical sites two benefits could be derived. First, these collections provide an early warning of impairments that would decrease spotted darter populations and it provides an opportunity to monitor the relative abundance and stability of known populations. Finally, field surveys should be conducted in under-sampled streams in the Allegheny and Hoosier National Forests to determine if previously unknown populations of the spotted darter exist.

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