EASTERN SAND DARTER STATUS ASSESSMENT

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January 2004

NRRI Technical Report No. NRRI/TR-2003/40

DISCLAIMER

This document is a compilation of biological data and a description of past, present, and likely future threats to the eastern sand darter, *Ammocrypta pellucida* (Agassiz). It does not represent a decision by the U.S. Fish and Wildlife Service (Service) on whether this taxon should be designated as a candidate species for listing as threatened or endangered under the Federal Endangered Species Act. That decision will be made by the Service after reviewing this document; other relevant biological and threat data not included herein; and all relevant laws, regulations, and policies. The result of the decision will be posted on the Service's Region 3 Web site (refer to: http://midwest.fws.gov/eco_serv/endangrd/lists/concern.html). If designated as a candidate species, the taxon will subsequently be added to the Service's candidate species list that is periodically published in the Federal Register and posted on the World Wide Web (refer to: http://endangered.fws.gov/wildlife.html). Even if the taxon does not warrant candidate status it should benefit from the conservation recommendations that are contained in this document.

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SYSTEMATICS

Common Name(s): eastern sand darter

Scientific Name

Ammocrypta pellucida (Agassiz)

Taxonomy

The eastern sand darter was originally placed in the genus *Etheostoma* by Baird in Putnam (1863) but was assigned to *Pleurolepis pellucidus* by Agassiz in Putnam (1863). Jordan and Gilbert (1882) then placed the species in the genus *Ammocrypta* since *Pleurolepis* was occupied by a genus of fossil ganoid fish (Linder 1959). Bailey and Gosline (1955) treated *Ammocrypta* as closely related to *Percina*, and had it consisting of two subgenera - *Crystallaria*, containing only *A. asprella*, and *Ammocrypta*, containing the remaining six species, all much smaller than *A. asprella*. Studies by Page and Whitt (1973a, 1973b) suggested that genus *Ammocrypta* was more closely related to *Etheostoma* than to *Percina*. Simons (1991) provided evidence that the morphological characteristics common to *Ammocrypta* and *Crystallaria* are a result of convergence rather than homology. Simons (1991) also asserted that the genus *Ammocrypta* (inclusive of *C. asprella*) is polyphyletic and that its smaller species (subgenus *Ammocrypta*) are more closely related to the *Boleosoma* group of the genus *Etheostoma* than to *C. asprella*. Therefore, Simons (1991) recognized *Crystallaria* as a valid genus, and treated *Ammocrypta* as a subgenus of *Etheostoma*. This designation has been adopted by some (Page and Burr 1991, Simons 1992, Wiley 1992), although others have retained *Ammocrypta* as a distinct genus (Etnier and Starnes 1993, Jenkins and Burkhead 1994), giving *Crystallaria* subgeneric status. Cladistic analysis of *Ammocrypta* and *Crystallaria* early-life stages by Simon et al. (1992), however, supported the elevation of *Crystallaria* to generic status, retained the former subgenus *Ammocrypta* as a valid genus, and suggested that the close relationship Simons (1991) noted between *Ammocrypta* and subgenus *Ioa* of *Etheostoma* is based on convergence rather than phylogeny. Molecular analysis by Wood and Mayden (1997), Song et al. (1998), and Near et al. (2000) show support for a monophyletic genus *Ammocrypta* that is sister to the genus *Crystallaria* and remote from *Etheostoma* subgenera *Ioa* and *Bloeosoma*. While the elevation of *Crystallaria* to generic status has been well accepted, the synonymy of *Ammocrypta* with *Etheostoma* has been followed by few, and will not be embraced in the forthcoming American Fisheries Society List of Common and Scientific Names (Joseph Nelson, chairperson, Names Committee, North American Society of Ichthyologists and Herpetologists/American Fisheries Society, pers. comm. with co-author D. Etnier).

Williams (1975) described the confusion encountered with historical records thought to represent *A. pellucida* (e.g., Meek 1889, Evermann and Jenkins 1889, Woolman 1892, Fowler 1945) and concluded that they were more likely *A. clara* (western sand darter) or *A. vivax* (scaly sand darter). These closely related species have been considered subspecific to and/or synonymous with *A. pellucida* (Williams 1975). Linder (1959) distinguished *A. pelludica* from *A. clara* by the absence of the opercular (gill cover) spine, the greater number of scale rows, and a greater amount of pigmentation on the body, and treated the two as distinct species. Records of *A. pellucida* in the Mississippi River drainage north of the Ohio River confluence are referable to *A. clara* while records from the southern reaches of the Mississippi River drainage may represent either *A. clara* or *A. vivax* (Williams 1975). Distributional overlap between *A. pellucida* and *A. clara* occurs in the Wabash (Indiana and Illinois), Cumberland (Kentucky), and Green (Kentucky) river drainages (Williams 1975).

PHYSICAL DESCRIPTION AND CHARACTERISTICS

The eastern sand darter is a member of the Perch family (Percidae) which contains such common game species as walleye (*Stizostedion vitreum*), sauger (*Stizostedion canadense*), and yellow perch (*Perca flavescens*). The family Percidae is a group of freshwater fishes characterized by the presence of a dorsal fin separated into two parts, one spiny and the other soft (Kuehne and Barbour 1983). The darters differ from their percid relatives in being much smaller and having a more slender shape. Darters have a reduced or vestigial swim bladder which decreases buoyancy, allowing them to remain near the bottom with little effort (Kuehne and Barbour 1983).

Superficially, sand darters (genus *Ammocrypta*) resemble the crystal darter (*Crystallaria asprella*) (see Figure 1 in Appendix 1 - sketch by Samuel Eddy). However, they lack a premaxillary frenum and teeth on the palatine and prevomer. The two genera also differ in number of lateral-line scales and soft dorsal-fin rays (Stauffer et al. 1995). The eastern sand darter has an elongate body, generally about 50 millimeters (mm) standard length (SL) (Kuehne and Barbour 1983), and can reach a maximum of 70 mm SL (Page 1983). Williams (1975) described the eastern sand darter as the most elongate of the *Ammocrypta* species. The eastern sand darter lacks an opercular spine and has a single anal spine with 8 to 10 anal rays (Trautman 1981). The caudal fin is slightly emarginate and the lateral line is complete, with 65 to 84 scales (Trautman 1981).

There are six extant species comprising the genus *Ammocrypta*, all of which are characterized by elongated bodies and translucent flesh (Williams 1975). The specific epithet *pellucida* is derived from the Latin *pellucidus* meaning clear or transparent and refers to the eastern sand darter's transparent flesh (Williams 1975). Adults exhibit a faint yellow coloration on the dorsal surface of the head and body and a silvery hue on the ventral surface (Trautman 1981). Anywhere from 12 to 16 greenish blotches are located along the dorsum and sides, becoming rows of paired spots, one on either side along the base of the dorsal fins (Trautman 1981). These greenish spots are also found along the lateral line, becoming confluent posteriorly (Trautman 1981), and a faint yellow band may be present along the lateral line as well (Kuehne and Barbour 1983).

Scales on the upper half of the body may have darkly colored edges and the top of the head may have a dusky blotch (Kuehne and Barbour 1983). The ventral surface is almost entirely unscaled (Page 1983). The sides have four to seven rows of scales directly below the lateral line and one to four rows above it (Williams 1975). The upper cheek, opercle, and upper lip appear dusky as well, and a preorbital bar can be easily detected adjacent to the lip (Kuehne and Barbour 1983). The cheek and opercle vary from well to weakly scaled and the nape is partially scaled (Kuehne and Barbour 1983). The fin membranes are transparent but may have a yellowish tinge (Trautman 1981). Dark pigment is restricted to the margin of spines and rays (Williams 1975).

Spreitzer (1979) described a subtle sexual dimorphism appearing in the pelvic fins, anal fin, and genital papillae. Breeding males are similar in coloration to non-breeding adults although their bodies tend to be more yellowish (Kuehne and Barbour 1983). Juveniles exhibit less yellow coloration and more silver than adults (Trautman 1981). Protolarvae have a stomodeum and pectoral fins are present (Simon et al. 1992). Larvae hatch at 5.5 mm total length (TL). The head is not deflected over the yolk sac, the eyes are spherical and pigmented, and a single, midventral serpentine vitelline vein is present. Yolk absorption is complete at 7.4 mm TL (Simon et al. 1992).

BIOLOGY AND NATURAL HISTORY

Eastern sand darters are most commonly found inhabiting sandy raceways of streams and rivers at a depth of at least 60 centimeters (cm) with moderate current (Kuehne and Barbour 1983, Page 1983). However, Scott and Crossman (1973) reported a specimen collected in a trawl from Lake Erie at a depth of 14.6 meters (m). Trautman (1981) indicated that eastern sand darters are most abundant in sandy portions of medium to large sized streams where sediment deposition is minimal and the current gentle enough to avoid washing away the sandy substrate. Daniels (1993) found eastern sand darters on the depositional side of the Mettawee River channel, immediately downstream from a bend where the substrate was greater than 90 percent sand, water depth did not exceed 0.5 m, and velocity was less than 20 cm/second. Analysis indicated that the percent composition of sand substrate was the best predictor of eastern sand darter abundance (Daniels 1993).

Jordan and Copeland (1877) first described the burying behavior of the sand darter from aquarium observations. Their account is as follows:

> “...it put its nose... against the bottom, stood nearly straight on its head, and with a swift beating of it tail to the right and left was in less than five seconds completely buried... [with its] eyes and narrow forehead alone visible.”

The authors offer no explanation for this behavior. There are three alternative hypotheses explaining the burying behavior in the eastern sand darter, including: 1) prey ambush, 2) predator avoidance, and 3) energy conservation (Williams 1975). In a series of experiments investigating this burying behavior, Daniels (1989) found no evidence to support the hypothesis that this behavior increases prey capture rates or that it is useful for predator avoidance. The energy conservation hypothesis of Williams (1975) could not be rejected, although Daniels (1989) suggested that it may be incomplete since a negative rather than positive relationship between current velocity and burying was detected. Nonetheless, the conclusion reached by Daniels (1989) suggested that *A. pellucida* buries itself in sandy substrates to stabilize its immediate environment in response to changing current velocity and turbulence. By burying itself, the eastern sand darter is able to efficiently maintain its position on sand beds, thereby conserving energy (Daniels 1989).

Spawning generally occurs during June and July within the Ohio basin and two to three weeks later in the St. Lawrence populations (Kuehne and Barbour 1983). However, repeated surveys in Vermont’s Winooski River detected gravid females in early June, whereas no gravid females were present later that month (Facey 1998). Collette (1965) reported that breeding tubercles were detected on pelvic fin rays of Ohio and Indiana males collected in May, June, and August, although tubercles were generally absent or very small. These tubercles develop as small protuberances restricted to the basal half of the ventral surface of the segmented pelvic-fin rays, centered on the articulation between two segments (Collette 1965, Kuehne and Barbour 1983).

The pelvic fins of breeding males show a pronounced thickening of the epithelium on rays one to three extending into the margin of the inter-radial membrane posterior to it (Spreitzer 1979). Johnston (1989) reported that males collected during July from the Tippecanoe River in Fulton County, Indiana, displayed dark pigmentation on their pelvic fins while females exhibited distended abdomens. Aquarium observations were conducted to help elucidate the reproductive behavior of the eastern sand darter (Johnston 1989). Eggs were found buried in the sandy substrate. Fertilized eggs were described as “translucent, spherical, and slightly adhesive” and measured 1.4 mm in diameter (Johnston 1989). Prior to copulation, multiple males were observed pursuing a single female around the aquarium, often resting their pelvic fins and chin on the female’s back. Egg deposition occurred as one of the males mounted the female, the pair vibrating while burying their tails and caudal peduncles in the sand. The eggs were buried separately in the aquarium substrate over an area 160 square cm (Johnston 1989). Johnston (1989) suggested that females likely spawn multiple times during a single season and that egg survivorship is high in the well oxygenated substrates characteristic of eastern sand darter habitat. Spreitzer (1979) described ova differentiation occurring in December with the first mature ova being produced in May. Spreitzer (1979) analyzed monthly substrate composition and found evidence to suggest that the spawning season may be synchronized with low silt levels, further suggesting that high sediment loading may reduce hatching success.

Surveys conducted by Daniels (1993) in the Mettawee River in New York State in 1982 and 1984 indicated that eastern sand darter abundance was positively correlated with the abundance of bluntnose minnows (*Pimephales notatus*), fallfish (*Semotilus corporalis*), tessellated darters (*Etheostoma olmstedi*), rosyface shiners (*Notropis rubellus*), rock bass (*Ambloplites rupestris*), logperch (*Percina caprodes*), and channel darters (*Percina copelandi*). Daniels (1993) interpreted this relationship as an indication of the widespread distribution of these species rather than a specific association with the eastern sand darter. A negative correlation was detected between the eastern sand darter and cutlips minnow (*Exoglossum maxillingua*) (Daniels 1993). Spreitzer (1979) observed feeding congregations of eastern sand darters interacting in a non-antagonistic manner.

Forbes (1880) examined stomach contents of four eastern sand darters. Eighty-one percent of the diet consisted of chironomid (midge) larvae while twelve percent consisted of other dipterans. The remaining seven percent consisted of Ephemeroptera larvae. Turner (1921) examined three *A. pellucida* specimens and determined that midge larvae comprise the bulk of the darter’s diet. Spreitzer (1979) examined the alimentary tracts of 119 specimens. Chironomid larvae comprised 94 percent of the total diet. Further evidence suggested that *A. pellucida* preys selectively on chironomids from February to April, changing to oligochaetes during the spawning season in June (Spreitzer 1979).

RANGE

Historical Distribution

Historically, *Ammocrypta pellucida* is known to have occurred from southern Quebec and Ontario south to West Virginia, and from Illinois eastward to Vermont; see Figure 2 in Appendix 1. Linder (1959) described the distributional pattern of *A. pellucida* and *A. clara* as follows:

> "*Ammocrypta pellucida* is found east of the Mississippi River in the tributaries of this river in Illinois, in the Ohio River and its tributaries and in some of the tributaries of the Saint Lawrence River, Lake Huron, Lake St. Claire and Lake Erie. *Ammocrypta clara* is found primarily west of the Mississippi River... on both sides of this river in the upper regions (i.e., Minnesota and Wisconsin) but from northern Illinois southward it has been collected east of the Mississippi River only from southern Indiana."

However, Williams (1975) asserted that reports from the Ohio River in Illinois (e.g., Linder 1959, Smith 1965) were unsubstantiated. According to Kuehne and Barbour (1983) the eastern sand darter entered the Great Lakes system through the Maumee-Wabash connection during the late Pleistocene and later spread to the Erie, St. Claire, and Huron drainages. In 1890, a species of *Ammocrypta* was collected eight miles south of Cumberland Gap, Tennessee in the Powell River (Woolman 1892). The 1976 discovery of *A. clara* in the Powell River, near the 1890 collection locality, suggests that the Woolman (1892) record represented *A. clara* rather than *A. pellucida* (Starnes et al. 1977).

Historical records of the eastern sand darter exist for the Embarras, Little Wabash, Wabash (all pre 1901), and the Vermilion (1958) rivers - in **Illinois** (Smith 1968, and pers. comm. with Brooks M. Burr, Southern Illinois University and Mike Retzer, Illinois Natural History Survey); the Black (1942), Driftwood (1942), Eel (upper Wabash River drainage 1892 and lower West Fork White River drainage 1941), Flat Rock (1942), Ohio (pre 1900), Maumee (1893), Vernon Fork of the Muscatatuck (1941), Salamonie (1899), St. Joseph (1893), St. Mary's (1893), Tippecanoe (1886), Wabash (1887), West Fork White (1876), East Fork White (1886), White (1968), and Whitewater (1955) rivers and the Big (1941), Big Pine (1942), Big Walnut (1941), Black (1942), Coal (1941), Deer (1885), Fall (1942), Lewis (1942), Raccoon (1941), Sugar (middle Wabash River drainage 1943), and Wildcat (1887) creeks in **Indiana** (Kirsch 1895, Gerking 1945, Pearson and Krumholz 1984, Simon 1993, and pers. comm. with Brant Fisher, Indiana Department of Natural Resources); the Cumberland (1890), Green (1892, 1929), Little Barren (1892), and Rough (1892) rivers and Big Muddy Creek (1965) and Straight Creek (1892) in **Kentucky** (Woolman 1892, Burr and Warren 1986); the Little Raisin (1927) and St. Joseph (1922) rivers, Davis Creek (1938), Lake St. Clair (1942), and Big Gallagher (1955) and Strawberry (1949) lakes in **Michigan** (Yant 1977); the Little Salmon River (> 70 years ago), Cattaraugus and Cazenovia creeks (1893), and Lake Erie (>70 years ago) in **New York** (Smith 1985, McKeown 1986, and pers. comm. with Doug Carlson, New York State Department of Environmental Conservation); the Black River (1853), Lake Erie (1970), and Big Darby Creek (1925) in **Ohio** (Van Meter and Trautman 1970, Spreitzer 1979, Trautman 1981); the Monongahela (1886) and Youghiogheny (1869) rivers and French Creek (1938) in **Pennsylvania** (Cope 1869, Evermann and Bollman 1886, Cooper 1983); the Lamoille River (1934) in **Vermont** (Smith 1985, and pers. comm. with Mark Ferguson, Vermont Fish and Wildlife Department); the Ohio River (main channel), Middle Island and Twelvepole creeks, and the Monongahela, Little Kanawha, Lower Kanawha, and Mud rivers all of the Ohio River drainage (no specific dates) in **West Virginia** (Stauffer et al. 1995, and pers. comm. with Dan Cincotta, West Virginia Department of Natural Resources). The earliest documented records from Lake Erie come from Ontario in 1953, even though there are non-specific references for New York in 1927 and Ohio prior to 1900 (D. Carlson, pers. comm.).

Historical records describing the eastern sand darter's Canadian distribution are described by Holm and Mandrak (1996). In Ontario, the species was collected in 1953 near Pelee Island in Lake Erie. Additional specimens were collected from the eastern and western basins of Lake Erie in 1957. Prior to 1970, *A. pellucida* was collected from the Ausable (1920), Sydenham (1927), and Thames (1923) rivers and Big (1923), Big Otter (1923), and Catfish (1922) creeks. In Québec, occurrence records prior to 1970 exist for Lac des Deux-Montagnes near Montréal (1941), Saint-Laurent near Sorel (unknown date), and in the following tributaries of Saint-Laurent: Rivière Châteauguay (1941), Rivière L'Assomption (1969), Rivière Yamaska (1967), Rivière Saint-François (1944), Rivière Yamachiche (1944), and Rivière Gentilly (1941).

Current Distribution

The following information on recent eastern sand darter occurrence in the United States was used to generate a distribution map based on USGS Hydrologic Units (Figure 3 in Appendix 1). Each of these units is identified by a unique hydrological unit code (HUC); see http://water.usgs.gov/GIS/huc.html. The shaded areas indicate hydrologic units containing waters in which recent (post 1970) occurrences of the eastern sand darter have been documented.

Illinois - A 1976 survey of a thirteen mile reach of the Wabash River extending downstream from Darwin, Clark County, produced only two eastern sand darters (D. Etnier, co-author, pers. comm.). There are no recent records from the lower Wabash River or the Little Wabash River despite considerable sampling effort. Brooks M. Burr (pers. comm.) reported that recent sampling has confirmed the continued presence of the eastern sand darter in the Middle Fork of the Vermilion River and the Embarras River in Illinois. Information contained in Smith (1979) also supports a current distribution of the eastern sand darter that is restricted to the middle portion of the Embarras River and the Middle Fork of the Vermilion River. Mike Retzer (pers. comm.) further substantiated current presence in the Embarras and Vermilion river systems, and absence from the Wabash and Little Wabash rivers.

Indiana - According to Brant Fisher (pers. comm.), ongoing surveys efforts initiated in 2001 show that eastern sand darters currently inhabit the following Indiana rivers: Big Blue River in Johnson County; Driftwood River in Bartholomew County; Muscatatuck River in Jackson, Jefferson, Jennings, Scott, and Washington counties; Eel River (upper Wabash River drainage) in Cass, Miami, and Wabash counties; Eel River (lower West Fork White River drainage) in Clay, Greene, Putnam, and Owen counties; Flatrock River in Bartholomew and Shelby counties; Maumee River in Allen County; Vernon Fork of the Muscatatuck River in Jackson and Jennings counties; St. Joseph River in Allen County; St. Mary's River in Adams and Allen counties; Tippecanoe River in Fulton, Kosciusko, Marshall, Pulaski, Starke, and White counties; East Fork White River in Bartholomew, Daviess, Dubois, Jackson, Lawrence, Martin, Pike, and Washington counties; West Fork White River in Greene County; West Fork Whitewater River in Franklin County; Vermillion River in Vermillion County; Wabash River in Carroll, Fountain, Parke, Vermillion, Vigo, and Warren counties; Whitewater River in Dearborn, and Franklin counties. In addition, extant populations inhabit the following creeks: Big Creek in Jefferson

County; Big Raccoon Creek in Parke County; Big Walnut Creek in Putnam County; Clifty Creek in Bartholomew County; Coal Creek in Fountain and Parke counties; Deer Creek (upper Eel River drainage, West Fork White River drainage) in Putnam County; Deer Creek (upper Wabash River drainage) in Carroll County; Lewis Creek in Shelby County; Mill Creek in Putnam County; Plummer Creek in Greene County; Richland Creek in Greene County; Salt Creek in Franklin County; Sand Creek in Bartholomew, Decatur, Jackson, and Jennings counties; Sugar Creek (upper East Fork White River drainage) in Johnson County; Sugar Creek (middle Wabash River drainage) in Montgomery, and Parke counties; Wildcat Creek in Carroll and Tippecanoe counties.

Kentucky - Ron Cicerello (Kentucky State Nature Preserves Commission, pers. comm.) recently reported on the distribution and status of five darters in the Green River, including the eastern sand darter. *Ammocrypta pellucida* has not been collected in the Green River since 1965, but could be present in the lower Green River where the last basin record was collected in 1929 (Cicerello 2003). Recent collections of *A. pellucida* have been made from the Rolling Fork of the Salt River, Kentucky River (mainstem and tributaries), Licking River (mainstem), Little Sandy River, and Blaine Fork of the Big Sandy River (R. Cicerello, pers. comm.).

Michigan - In 1977, six locations in Livingston County, two from lower Davis Creek and four from the Huron River, yielded between one and ten specimens per site (Yant 1977). Kevin Gardiner (Michigan Department of Natural Resources, pers. comm.) reported that other 1977 records were supportive of these occurrences in the Huron River. Surveys conducted in 1978 failed to locate eastern sand darters in the Raisin River, leading Smith et al. (1981) to conclude that the species may have been extirpated from the system. Schultz et al. (1982) failed to detect the species in the St. Joseph River (Maumee River drainage), and reported the existence of only one suitable sand-bottomed habitat. Other sections of the Maumee River drainage, including Bean and Ten Mile creeks, were searched without success (Schultz et al. 1982). Occurrences were recently (1985) recorded for the Pine River (K. Gardiner, pers. comm.). Specimens were detected in Lake St. Clair in 1994 (Latta 1994), although surveys the following year detected none (Latta 1996). Latta (1994) noted a 1993 specimen collection from the Belle River in St. Clair County, although subsequent surveys in 1995 failed to detect the eastern sand darter in that area. Latta (1996) also reported the 1996 collection of two specimens from the historic collection site in Davis Creek; however, no specimens were found in the upstream portion of Davis Creek or the mainstem of the Huron River. Ten specimens were collected from the Black River in Sanilac County in 1994 (Latta 1994).

New York - Smith (1985) described the discovery of breeding populations in the Mettawee River in 1979 and the collection of a single specimen in 1980 from the Little Salmon River. Doug Carlson (pers. comm.) indicated additional collections in both of these waters in 2001. Recent collections (1983 and 1984) were reported for the Poultney River, a border water with Vermont (D. Carlson, pers. comm.). Eastern sand darters were also detected in the Poultney River from 1987 to 1991 (Bouton 1991 summarized in Facey 1995; see Vermont summary for additional Poultney River information). The earliest collections in two additional rivers were 1997 and 1998 for the St. Regis/Deer and Grasse rivers, respectively. Doug Carlson (pers. comm.) also reported recent collections (with trawl and seine) in Lake Erie near Athol Springs (1991), Sturgeon Point (1994), and Evangola State Park (1995).

Ohio - Trautman (1981) described a single collection in 1977 from the Ohio River in Gallia County, Ohio. Information from the Ohio Department of Natural Resources (Daniel Rice, retired - Ohio Department of Natural Resources, pers. comm.) showed 1994 - 95 occurrences of the eastern sand darter in Coshocton County (Doughty Creek, Killbuck Creek, Mohican River), Knox County (Mohican River), and Licking and Muskingum Counties (Wakatomika Creek), as well as 1998 occurrences in Washington County (Little Muskingum River). Randy Sanders (Ohio Department of Natural Resources pers. comm.) provided recent occurrence records for *A. pellucida* in creeks and rivers (no counties specified) including Bear Creek (1995), Federal Creek (1984 - 90), Hocking River (1990), Kokosing River (1987), Licking River (1994), Mahoning River (1980 - 94), Muskingum River (1983 - 88), Paint Creek (1985), Salt Creek (1984 - 92), Salt Run (1983), Symmes Creek (1990), and the Walhonding River (1983 - 87). An Ohio Department of Natural Resources' listing (D. Rice, pers. comm.) of counties (no creeks or rivers specified) with recent eastern sand darter records includes: Ashtabula (1986), Athens (1990), Gallia (1992), Lake (1989), Morgan (1988), Muskingum (1994), Ottawa (1978), Ross (1988), Scioto (1983), Trumbull (1980), Vinton (1983), Williams (1992), and Wood (1972).

Pennsylvania - Rob Criswell (Pennsylvania Game Commission, pers. comm.) reported that the eastern sand darter exists in French Creek near the Erie-Crawford County line, and downstream of Meadville in Crawford County. Approximately 10.8 kilometers (km) of Muddy Creek, a tributary to French Creek in northern Crawford County situated within the Erie National Wildlife Refuge, is inhabited by the eastern sand darter (R. Criswell, pers. comm.). Records also exist from Lake Erie in 1996 and 1997. Although early eastern sand darter collections were made from the Monongahela River, Cooper (1983) indicated that this darter has been recently found only in French Creek and Lake Erie.

Vermont - Collection efforts on the Lamoille (1985, 1989, 1993, and 1994), the Poultney (2001), which flows along the border with New York (see New York summary for additional Poultney River records), the Missisquoi (1985, 1993, 1994, and 1998), and the Winooski (1985, 1993 through 1995, 1998, and 2002) documented recent occurrences of the eastern sand darter in these rivers (Facey 1995, Facey 1998, Facey and O'Brien 2003, O'Brien and Facey 2003, M. Ferguson, pers. comm., and Doug Facey, St. Michael's College, pers. comm.).

West Virginia - According to Stauffer et al. (1995), the distribution of the eastern sand darter in West Virginia is patchy with significant numbers found only in Middle Island Creek and the Little Kanawha River. Dan Cincotta (pers. comm.) reported that the species remains very common in the Elk (lower Kanawha) and the Little Kanawha rivers.

United States Distribution Summary - The preceding compilation of recent occurrences, by individual state, can be summarized by saying that the eastern sand darter's current distribution encompasses: one water of the Allegheny River Drainage, one water of the Big Sandy River Drainage, two waters of the Great Miami River Drainage, one water of the Kanawha River Drainage, two waters of the Kentucky/Licking River Drainage, one water of the Lower Illinois River Drainage, one water of the Lower Ohio/Salt River Drainage, two waters of the Middle Ohio River Drainage, five waters of the Muskingum River Drainage, sixteen waters of the Patoka/White River Drainage, five waters of the Rivière Richeliew Drainage, two waters of the Scioto River Drainage, one water of the Southwestern Lake Huron Drainage, one water of the Southeastern Lake Michigan Drainage, four waters of the St. Clair/Detroit Drainage, three waters of the St. Lawrence Drainage, three waters of the Upper Ohio River/Beaver Drainage, four waters of the Upper Ohio River/Little Kanawha River Drainage, nine waters of the Wabash River Drainage, and three waters of the Western Lake Erie Drainage.

Canadian Distribution - Holm and Mandrak (1996) and Erling Holm (Royal Ontario Museum, pers. comm.) indicated that since 1970, eastern sand darters have been collected at new locations in Lake Erie near Rondeau Bay (1975) and Long Point Bay (1996), Lake St. Clair (1983, 1984, 1985), and the Grand River (2001). Various locations in the Thames River supported eastern sand darter populations as recently as 1998 (E. Holm, pers. comm.). Collections have been made in the Sydenham River as recently as 1999 (E. Holm, pers. comm.). Two records exist for Rivière Chateauguay in 1975 and 1976. One record for Rivière Trout (1976), two for Rivière Richeliew (1970, 1974), one for Rivière Yamachiche (1972), two for Rivière Gentilly (1982), one for Rivière aux Orignaux (1982), one for Rivière du Chêne (1982), and two for Rivière Becancour (1989) exist as well.

POPULATION ESTIMATES AND TRENDS

There is general agreement among fisheries biologists that the eastern sand darter abundance is steadily declining (Kuehne and Barbour 1983). For example, data from surveys conducted in Ohio from 1925 through 1950 displayed a continuous decrease in abundance (Trautman 1957). Subsequently, between 1955 and 1980, the eastern sand darter was rarely collected from inland localities in Ohio and, when found, the specimens were in locations that had historically supported large populations (Trautman 1981). Daniels (1993) and Facey (1998) summarize evidence of abundance declines and reduced collection success in the introductory texts of their respective publications.

Illinois

Embarras River. Smith (1968, 1979) suggested that the eastern sand darter was once common in the Embarras River of Illinois, but had been extirpated. However, Mike Retzer (pers. comm.) believes that the Embarras River population is self-sustaining and Brooks Burr (pers. comm.) reported that sampling within the last ten years yielded eastern sand darters from four or five sites on this river. Trent Thomas (Illinois Department of Natural Resources, pers. comm.) reported that of 28 sites sampled in 2001, only three eastern sand darters were collected from two sites in Jasper County. These sites were considerably south of the historical, upstream limit of its distribution in the basin. In 2002, specimens were collected from Kickapoo Creek in Coles County, where a total fish kill had occurred for nine miles in 2001 (T. Thomas, pers. comm.). According to Trent Thomas (pers. comm.), the eastern sand darter expanded its range into this “vacated” area within a year after the event. Subsequent sampling has yielded additional specimens from this location. A single specimen was collected from Riley Creek, also in Coles County, representing a one-time collection in this creek.

Little Wabash River. Smith (1979) stated that the Little Wabash River of Illinois once supported populations of the eastern sand darter described as “general in occurrence.” The disappearance of eastern sand darters from the Little Wabash River is thought to have occurred in the 1980s (M. Retzer, pers. comm.). The absence of the eastern sand darter from the Little Wabash River is corroborated by Brooks Burr (pers. comm.), who suggested that concerted sampling needs to be directed at finding *A. pellucida* in this river.

Wabash River. All eastern sand darter occurrences in the Wabash River are from the portion of the river upstream of where the Wabash River forms the boundary between Indiana and Illinois. At one time, the eastern sand darter was "general in occurrence" in the Wabash River of Illinois (Smith 1979). It appears to have declined or disappeared from this river (M. Retzer, pers. comm.). Despite considerable sampling of the mainstem by other investigators, no records exist for the Illinois side of this river (B. Burr, pers. comm.). It should be noted here that David Etnier (co-author, pers. comm.) knows of *A. pellucida* collection circa 1980, and that information obtained for Indiana (B. Fisher, pers. comm.) indicated its recent presence in this river (see Indiana summary below).

Vermilion River. Mike Retzer (pers. comm.) believes that the Vermilion River population is self-sustaining. Brooks Burr (pers. comm.) reported that sampling the Middle Fork of this river, within the last ten years, yielded eastern sand darters.

<u>Indiana</u>

A recent state-wide survey of Indiana was initiated in 2001 and was scheduled to continue through 2003. Brant Fisher (pers. comm.) provided qualitative information from this recent survey (table below) to illustrate the absence of eastern sand darters from the following historical, collection locations.

Table 1. Historical locations in Indiana where eastern sand darters have not been recently collected.

Waterbody	Location	County	Collector
Ohio River[1]	at Falls of the Ohio	Clark	R.E. Call
Fall Creek[2]	near Indianapolis	Marion	S.D. Gerking
Black Creek[2]	Sanborn	Knox	S.D. Gerking
West Fork White River[3]	Indianapolis Gosport Freedom couple locations	Marion Owen Owen Daviess	Jordan and Copeland Eigenmann S.D. Gerking S.D. Gerking
Salamonie River[4]	Mt. Etna Monument City	Huntington unknown	T. Large Williamson, Hubbs
Eel River tribs[5]	several locations	Wabash, Miami, Cass	Kirsch
Big Pine Creek[6]	N.W. Attica	Warren	S.D. Gerking
Black River[7]	E Garrett	Posey	S.D. Gerking
Wabash River[8]	unknown Lafayette N.W. Garrett Mackey's Ferry New Harmony	Wabash Tippecanoe Gibson Posey Posey	Banta and Haseman S.D. Gerking S.D. Gerking Evermann, H.R. Becker Evermann

[1]Ohio River record is from pre-impoundment conditions (pre 1900). The river has not been recently surveyed for the eastern sand darter.
[2]Eastern sand darters were last seen in 1942 despite extensive survey efforts.
[3]Collections have been made in Greene County, which is located between Owen and Daviess counties. Owen and Daviess counties have not been surveyed recently to determine status.
[4]Last collected in 1930. The Salamonie has been impounded and recent sampling has not been conducted.
[5]This is a pre-1900 collection. Common in mainstem Eel but tributary sampling has not been conducted.
[6]Last collected in 1942 despite extensive survey efforts. Collections were made at the confluence with the Wabash River, however.
[7]Last collected in 1942. The Black River has not been sampled for eastern sand darters in recent years.
[8]The Middle Wabash is still inhabited. However, Illinois surveys indicate that the eastern sand darter has declined or disappeared from most of the river (see *Wabash River* summary above).

Despite the apparent absence of the eastern sand darter from these historic locations, its distribution in Indiana is thought to be as good or better than it has been in the past (B. Fisher, pers. comm.). In fact, several new locations of eastern sand darter occurrence were determined from the recent sampling efforts, including the Big Blue River, Vermillion River, Clifty Creek, Sand Creek, Richland Creek and Plummer Creek (B. Fisher, pers. comm.). However, this perceived increase in distribution may also be the result of using more specific sampling methods and targeting specific habitats when sampling (B. Fisher, pers. comm.).

<u>*Kentucky*</u>

Green River. Cicerello (2003) made reference to recent observations within the Kentucky State Nature Preserves Commission's database that indicate *A. pellucida* to be relatively common and widely distributed throughout its historic range, except for within the Green River. Woolman (1892) collected 75 specimens from two sites on the Green River. One specimen was collected at Mammoth Cave in 1929, with additional collections from Mammoth Cave National Park and the Mud River confluence with the Green River described by Burr and Warren (1986) and Cicerello (2003). Cicerello (2003) noted that the most recent collection of the eastern sand darter from impounded sections of the Green River occurred in 1965, and that it had not been observed in the Green River since that year, despite extensive sampling efforts. However, Cicerello (2003) remains optimistic that *A. pellucida* may persist at the 1929 Mammoth Cave collection site and in the lower Green River. Recent collections (60+) from Rolling Fork of Salt River, Kentucky River (mainstem and tributaries), Licking River (mainstem), Little Sandy River, and Blaine Fork of the Big Sandy River system indicate that this darter is easy to find in appropriate habitat, with observations of > 5 individuals and the presence of more than one age class at many collection sites (R. Ciccerello, pers. comm.).

<u>*Michigan*</u>

Black River. Ten specimens were collected from the Black River of Michigan in 1994 (Latta 1994), effectively expanding the known distribution of *A. pellucida* in this river by 40 miles to the north. Although this observation indicates a range expansion of the eastern sand darter in the Black River, the status of the population in this river and many of those within Michigan drainages is considered "uncertain" (K. Gardiner, pers. comm.).

Huron River. Kevin Gardiner (pers. comm.) stated that this is the only river of the Michigan drainages in which the eastern sand darter population is not experiencing population declines from historical levels.

Lake St. Clair. Although specimens have been collected in Lake St. Clair since 1994, Kevin Gardiner (pers. comm.) reported that insufficient information exists to speculate on population status in this lake.

<u>*Ohio*</u>

The results of surveys for stream fishes in Ohio waters from 1979 through 1995 were provided by Randy Sanders (pers. comm.). These data showed that the sampling of 43 sites (15 streams) yielded 248 eastern sand darters. Ted Cavender (Ohio State University, pers. comm.) reported that this species is not in trouble in the Ohio River basin, and also indicated that extant populations exist in the Scioto and Muskingum river drainages. White (1987) also reported *A. pellucida* to be widespread in the Ohio River drainage. Although noting that the eastern sand darter was not abundant at any given locality, White (1987) stated that the species is far more common than its status would imply. Daniel Rice (pers. comm.) described the discovery of an eastern sand darter population in the Little Muskingum River in 1999, and reported 1994 collections of 17, 10, and 25 specimens from Killbuck, Doughty, and Wakatomika creeks, respectively. He also reported 1995 collections of two specimens from the Mohican River.

In contrast to the above summary of recent information, Trautman (1981) described a 50 percent decline of successful, pre 1930 eastern sand darter collection sites within a mile-long stretch of Big Darby Creek sampled from 1930 to 1945. In 1972, Trautman revisited localities in Lake Erie for which museum records of *A. pellucida* exist, but was unable to collect any additional specimens (Spreitzer 1979).

<u>*Pennsylvania*</u>
French Creek. Surveying efforts were completed from 1991 to 1993 on approximately 104 km of French Creek to determine the status of the eastern sand darter in this Pennsylvania stream. Rob Criswell (pers. comm.) reported a maximum collection of 34 *A. pellucida* specimens from 510 square meters of ideal habitat during this survey. The results indicated that a stable population exists in the vicinity of the Erie-Crawford County line with a second, more vulnerable, population located downstream of Meadville in Crawford County (R. Criswell, pers. comm.).

Monongahela River. The eastern sand darter inhabited the Monongahela River prior to 1900, and was previously described as “common everywhere in suitable places” (Evermann and Bollman 1886). It is now thought to be extirpated from the Monongahela River (R. Criswell, pers. comm.).

Muddy Creek. Based on a 1998 survey, eastern sand darters are known to occupy a 10.8 km section of Muddy Creek (R. Criswell, pers. comm.). Their abundance in this Pennsylvania creek was described as low, but well distributed, with four specimens at one survey location and no more than two at any other location (R. Criswell, pers. comm.).

Youghiogheny River. The eastern sand darter inhabited the Youghiogheny River prior to 1900 (Cope 1869), but is now thought to be extirpated (R. Criswell, pers. comm.).

Lake Erie. Rob Criswell (pers. comm.) noted the collection of 15 to 20 eastern sand darters (via trawl) at depths of 12 to 15 meters, circa 1996-1997.

In summary, the information available is insufficient to make a determination regarding eastern sand darter population changes or trends in Pennsylvania waterways that are currently occupied by *A. pellucida* (R. Criswell, pers. comm.). However, based on records from the Monongahela River drainage, it is evident that the eastern sand darter was once well established in the state. Considering the widespread pollution in that region reported long ago by Ortmann (1909), it is likely that additional populations within the Ohio River system were extirpated prior to their documentation. According the Rob Criswell (pers. comm.), it appears as though the eastern sand darter’s range has been reduced by more than fifty percent in Pennsylvania’s inland waters.

<u>*West Virginia*</u>
Dan Cincotta (pers. comm.) noted that the Elk and Little Kanawha rivers, and Middle Island Creek harbor excellent breeding populations of the eastern sand darter in West Virginia. Conversely, he reported that specimens from the Ohio, Mud, main-channel Kanawha, and its Coal River tributaries are sparse; therefore, eastern sand darter status in these West Virginia waters is not presently known.

<u>*Lake Champlain Area* (*New York and Vermont*)</u>
*Cattaraugus and Cazenovia creek*s. Eastern sand darters were present in these New York creeks in 1893 (Smith 1985). None were detected in Cattaraugus Creek during surveys in 1928 or 1985 (McKeown 1986). Information provided by Doug Carlson (pers. comm.) indicated that these population have both been extirpated.

Grasse River. Information regarding this recently (1998) discovered New York population was provided by Doug Carlson (pers. comm.), who indicated that the species was abundant in three of 30 sites sampled (exact numbers were not provided). In 2000 and 2003, sampling near Massena, New York produced over 30 specimens from one location (D. Carlson, pers. comm.).

Little Salmon and Salmon rivers. Eastern sand darters were first discovered in New York's Little Salmon River at Fort Covington during surveys conducted in 1930 (D. Carlson, pers. comm.). Smith (1985) described a 1980 collection of a single specimen of *A. pellucida* at Fort Covington as confirmation of continued presence at this site. Information provided by D. Carlson (pers. comm.) indicated that the Salmon River population has been found to extend up the Little Salmon River eight miles and, in 1998, the known range of the population was extended two miles upstream of the original Fort Covington collection site. Several repeated collections from 1987 to 1991 produced 113 individuals (D. Carlson, pers. comm.).

Mettawee River. Daniels (1993) described the survey results of Greeley (1930), which did not detect the eastern sand darter in New York's Mettawee River in 1929. Smith (1985) described the first discovery of a breeding population of eastern sand darters in this river in 1979. Subsequent surveys in 1982 and 1984 conducted by Daniels (1993) yielded 276 eastern sand darters with an average of five fish per seine haul, thus indicating the presence of a viable population. Whether the species was overlooked in 1929 or colonized the Mettawee River after the survey was conducted is uncertain (Daniels 1993). Sampling efforts in 1995 indicated that the eastern sand darter maintained populations in three of sixteen sites where they were detected during the early 1980s (Robert Daniels, New York State Museum, pers. comm.). Furthermore, additional collections from three previously sampled areas were made in 2001, which led Doug Carlson (pers. comm.) to conclude that these populations were not declining.

St. Regis/Deer River. Populations in these New York waters were readily sampled between 1997 and 2003 and one seine haul yielded 130 adult specimens (D. Carlson, pers. comm.).

Poultney River. Eastern sand darters were first discovered in this New York - Vermont border river in 1983 (D. Carlson, pers. comm.). This population was considered to be the most abundant of those studied from 1987 to 1991, relative to those in the Mettawee, St. Regis/Deer, and Grasse rivers of New York (D. Carlson, pers. comm.). Mark Ferguson (pers. comm.) reported that 12 eastern sand darters were captured in 1983 and five in 1984. Thirty-four sites were sampled in the fall, between 1987 and 1991, with the numbers of *A. pellucida* collected ranging from 143 to 282 per year (Bouton 1991). The mean yearly catch rates associated with these recent efforts fluctuated from about 11 to 27 per 1000 square feet, and even greater variations in catch rate (0 to 133 per 1000 square feet) were noted for individual collection sites. Facey (1995) also noted the high degree of year-to-year fluctuation in eastern sand darter density in the Poultney River, with differences as great as five to ten fold. While conducting an investigation of habitat characteristics preferred by *A. pellucida*, researchers collected 42 specimens from this river in 2001 (Facey and O'Brien 2003, and O'Brien and Facey 2003). Their data indicated a very nonrandom distribution of eastern sand darters as only 19 of 99 plots yielded specimens.

Lamoille River. There are few data available in Vermont records to indicate historical abundances; e.g., accounts describing the two 1934 specimens did not indicate how many total individuals were collected (M. Ferguson, pers. comm.). A 1989 collection at one site yielded 96 eastern sand darters (M. Ferguson, pers. comm.). The results of surveys conducted in 1993 and

1994 led Facey (1998) to conclude that the Lamoille River supports a viable population of eastern sand darters.

Winooski River. While conducting an investigation of habitat characteristics preferred by *A. pellucida*, researchers collected 112 specimens from this Vermont river in 2002 (O'Brien and Facey 2003). Only twelve of fifty-six plots yielded eastern sand darters, and seventy-four of the specimens came from one, three-by-ten-meter plot. As found for the Poultney River, these data indicate a nonrandom distribution of eastern sand darters in the Winooski River (D. Facey, pers. comm.). Facey (1995) concluded that the Winooski River population is viable, although historical information was not available to determine whether or not the population has experienced significant changes over the years.

Given the loss of eastern sand darter populations at the Cattaraugus and Cazenovia creek historical locations, their continued presence in Lake Erie and the Salmon/Little Salmon River, and their recent discoveries in the St. Regis/Deer, Grasse, Mettawee, and Poultney rivers, Doug Carlson (pers. comm.) concluded that, in general, populations are increasing in New York state.

Mark Ferguson (pers. comm.) reported that survey results of the Missisquoi, Lamoille and Winooski rivers, in 1993 and 1994, also had considerable fluctuations in the numbers and distributions of eastern sand darters collected. He cited work by Facey (1998) when he speculated on the reasons for collection data variance; specifically, swings in levels of reproduction and recruitment, and instability of habitat conditions including those that affect sampling efficiency. Although the very recent collections of *A. pellucida* in the Poultney and Winooski rivers are encouraging, no clear population trends are apparent in Vermont's waters (M. Ferguson, pers. comm.). There is some speculation that the eastern sand darter is expanding its range in Vermont and New York, and certain locations in Canada, from water quality improvements resulting from decreased sedimentation and pollution (D. Facey, pers. comm.). In addition, the northern extent of eastern sand darter distribution may have once been too cold (or winters too long) for large populations to persist at high density. Recent warming trends that prevent Lake Champlain from freezing, for example, may allow the species to become more abundant in the northern portions of its range (D. Facey, pers. comm.).

<u>Canada</u>

Holm and Mandrak (1996) and Erling Holm (pers. comm.) described the population status of the eastern sand darter in Canada as follows:

Ausable River. A single specimen was collected from this Lake Huron tributary in 1928. Sampling in 1936, 1974, and 1982 failed to detect the eastern sand darter. This has led Holm and Mandrak (1996) to conclude that the species is no longer present in the Ausable River.

Grand River. One specimen was collected from the Grand River in 1987 with an additional 47 collected in 1991. These occurrences represent new localities for the eastern sand darter in Ontario. More recent efforts have collected one eastern sand darter in 1997 and three individuals in each of the years 1998, 1999, and 2001 (E. Holm, pers. comm.).

Rivière aux Orignaux. A single 1982 collection of an unspecified number of specimens exists for this locality. Records do not indicate recent collection attempts.

Rivère Chateauguay. An unspecified number of specimens were collected in 1975 and 1976. There are no records of more recent collections from this location. However, it is unclear whether more recent collection efforts failed to detect the eastern sand darter or if collection efforts were even made after 1976.

Rivière du Chêne. A single 1982 record exists for this body of water. Records do not indicate recent collection attempts at this locality.

Rivière Gentilly. Two 1982 records exist for this body of water, although abundance data are unspecified. No recent occurrences have been documented.

Rivère Richelieu. Records exist for collections made from various locations in Rivère Richelieu in 1970 and 1974. However, the number of specimens collected is unspecified.

Rivière Yamachiche. Two locations in the Rivière Yamachiche produced an unspecified number of eastern sand darters in 1972. More recent records do not exist.

Sydenham River. The first eastern sand darter specimen was collected from the Sydenham River in 1927. In 1929 an additional three specimens were collected. Collections were made in 1983, although the number of specimens collected was unspecified. Thirty specimens were collected in 1989, four in 1991 (near the mouth of Fansher Creek) with an additional eight specimens collected just south of Croton. More recently, a single specimen was collected in 1996, three in 1997, and one in 1999 (E. Holm, pers. comm.).

Thames River. Forty-eight specimens were collected from this Lake St. Clair tributary in 1923. While efforts to collect the species in 1941 failed, surveys conducted in 1958 recorded the species near the Moravian Indian Reservation. During the 1970s, the eastern sand darter was collected from sites in the same vicinity. Resampling of historical occurrence locations in the Thames River during 1989 and 1991 found the species at "most" of these sites. More recently, one specimen was collected in 1997 and two in 1998 (E. Holm, pers. comm.). Holm and Mandrak (1996) suggest that, because the number of specimens collected in 1923 is roughly equivalent to the total number of collections since, the species has experienced a population decline in the Thames River.

SUMMARY OF THREATS

The information available in the published literature concerning threats to eastern sand darter populations lacks sufficient detail to formulate and test hypotheses on the responses of these populations to potential threats. In a multi-species assessment of threats, Deacon et al. (1979) found that of 251 fish taxa surveyed, 98 percent (%) were threatened by habitat modification, 37% by natural or artificial factors, 16% by range restriction, 3% by overexploitation, and 2% by disease. As a result, generalized responses of fish populations to these threats are discussed within the context of eastern sand darter susceptibility. Personal communications with several natural resource and conservation specialists established a current list of purported threats to eastern sand darters (Table 2). The most commonly cited threat to eastern sand darter persistence is the destruction and degradation of habitat as a result of impoundment, channelization, dredging activities, and siltation.

Table 2. Potential threats to eastern sand darter populations in various states.

State	Habitat Impacts	Overutilization	Disease or Predation	Other Factors
Illinois	siltation, impoundment, channelization, water pollution (from oil fields)	not a potential threat	unknown	unknown
Indiana	currently a low potential threat	unknown	unknown	unknown
Kentucky	siltation, impoundment, coal mining, highway construction	unknown	unknown	poor riparian zone management
Michigan	siltation, water quality (agricultural runoff, erosion)	not a potential threat	not a potential threat	unknown
New York	siltation, impoundment, channelization, water quality	unknown	unknown	sea lamprey control (chemical)
Ohio	sedimentation, channelization, suburban development (culverts), pollution	unknown	unknown	unknown
Pennsylvania	siltation, development	not a potential threat	not a potential threat	exotic species
Vermont	sedimentation, erosion (stream banks), development (storm water)	not a potential threat	not a potential threat	sea lamprey control measures and chemical, manure, and other catastrophic spills
West Virginia	sedimentation and drainage (mining, forestry, petroleum operations), residential development	unknown	unknown	agricultural non-point pollution

Information supplied by B. Burr - Southern Illinois University; M. Retzer - Illinois Natural History Survey; B. Fisher - Indiana Department of Natural Resources; R. Cicerello - Kentucky State Nature Preserves Commission; K. Gardiner - Michigan Department of Natural Resources; D. Carlson - New York State Department of Environmental Conservation; R. Sanders - Ohio Department of Natural Resources; R. Criswell - Pennsylvania Game Commission; M. Ferguson - Vermont Fish and Wildlife Department; D. Cincotta - West Virginia Department of Natural Resources.

A. Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range.

According to Warren et al. (2000), the most significant threat to fishes in the southern United States, including the eastern sand darter, is landscape degradation and habitat alteration resulting in the reduction and fragmentation of suitable habitat. In a survey of 251 North American fishes, Deacon et al. (1979) found that 98 percent were threatened by habitat modification. An estimated 28 percent of southern freshwater fishes are considered extinct, endangered, threatened, or vulnerable with the number of imperiled species increasing 125 percent over the past 20 years (Warren et al. 2000). Due to their geographically restricted distribution, these fishes are highly susceptible to extirpation from localized habitat degradation through water impoundment, siltation, and stream flow modification (Warren et al. 2000). It is likely that these large-scale declines in species richness reflect the degradation of southern watersheds under the stress of the growing human population in the region. Deacon et al. (1979) suggested that protection of suitable habitat and restoration of degraded habitat could slow population declines, though they admitted that little has been done to address the loss of habitat and more effort is needed. Warren et al. (2000) specifically noted that the eastern sand darter is a vulnerable species which may become imperiled by seemingly minor habitat disturbance, and should therefore receive careful monitoring to assess population status and provide protection for population persistence. However, Ron Cicerello (pers. comm.) believes that due to the relatively large number of recent records from the Kentucky, Licking, and Little Sandy rivers (all coal-field streams) eastern sand darter populations may be quite resilient to massive habitat destruction and degradation pressures. Similarly, Brant Fisher (pers. comm.) reported that despite the perception that the distribution of the eastern sand darter has been decreasing because of increased siltation, recent surveying of Indiana waters shows that there is always a section of suitable habitat available at every site sampled. Still, the purported connection between habitat degradation and population declines cannot be ignored. For example, Trautman (1981) reported:

> "...before 1930 I found 1-10 sandy areas, containing sand darters, in every pool in a mile-long stretch of Big Darby Creek in Pickaway County [Ohio]. Between 1930-45 many of these areas became silt-smothered and after 1945 only 8 sandy areas remained in the mile stretch of stream, of which only 4 areas contained sand darters."

He also speculated that similar decreases in eastern sand darter distribution were linked to the concomitant decline in suitable habitat in the Scioto and Maumee river drainages.

Siltation

The physical properties of silt are significantly different than those of sand (Brady 1974). Daniels (1993) clearly demonstrated that the one physical parameter overwhelmingly associated with the distribution of *A. pellucida* was the presence of sand. Very recent research conducted in Vermont strongly indicates that the eastern sand darter is quite selective in its preference for fine-to-medium grained sand as habitat (Facey and O'Brien 2003, O'Brien and Facey 2003). Smith (1968) and Kuehne and Barbour (1983) specifically mention siltation as a major threat to eastern sand darter populations, reducing its numbers and likely resulting in the extirpation from much of its historical range. It has long been recognized that siltation alters aquatic habitats by reducing light penetration, changing heat radiation, covering the stream bottom, and retaining organic material and other debris (Ellis 1936). This translates into the disruption of reproductive behavior and alteration of food resources utilized by stream-fish communities (Ellis 1936). The spawning season for the eastern sand darter may be synchronized with low silt levels and it is thought that high sediment loading may reduce hatching success (Spreitzer 1979). Investigating the effects of siltation on fish communities in Missouri streams, Berkman and Rabeni (1987) found that as siltation increased, the distinction among riffle, run, and pool communities decreased, and that the feeding guilds most impacted by siltation were those dependent on the substratum. Bhowmik and Adams (1989) provided an example of how sediment deposition has altered aquatic habitat in the Upper Mississippi River system where the construction of locks and dams has resulted in a successional shift from open water to habitats dominated by submergent and emergent vegetation. This successional process is not likely to favor species such as the eastern sand darter which rely on extensive, clean sand and gravel raceways for population persistence (Page 1983).

Spreitzer (1979) suggested that the mechanism by which eastern sand darters are removed from silt-laden stretches is through the avoidance of areas with heavy siltation, which may inhibit its burying behavior as interstitial silt accumulation complicates respiration. The benefits of energy conservation and adequate substrate conditions for egg deposition are compromised as silt covers the stream beds and habitat is lost. Waters (1995) extensively discussed the sources and influences of sediment deposition on cold and warm-water fish habitats and concluded that the two most deleterious effects were the filling of interstitial spaces of riffles and reductions in overall water depth. A recent report by Powell (1999) concluded that although a single factor like crop-land density influences many key water quality and fish habitat variables, fish community composition is primarily influenced by the cumulative effects of sedimentation.

Impoundment

Artificial impoundments drown riffles and reduce flow, thereby increasing the amount of siltation, which causes changes in substrate composition (see previous section). After the construction of dams on the North Fork of the Vermilion River and the middle Embarras River in Illinois, loss of riffle habitat and silt deposition resulted in the disappearance of the greenside darter, northern hog sucker, brindled madtom, blackside darter, and the fantail darter (Smith 1968). According to Etnier and Starnes (1993), impoundments at Lake Cumberland, Cordell Hull, and Dale Hollow reservoirs in Tennessee have caused the apparent extirpation of the closely related crystal darter (*Crystallaria asprella*) by altering big-river habitat in the region. Impoundments also fragment stream habitat, blocking immigration and emigration between populations and preventing recolonization from source populations. Permanent refugia and transitory habitats providing hydraulic connectivity and dispersal routes can be rendered inaccessible by impoundments (Minckley 1995). As a result, recolonization is unable to counter local extinctions caused by demographic or environmental stochasticity. Small, isolated populations are more susceptible to environmental perturbation and demographic stochasticity, both of which may lead to local extinction (Lande 1988). Warren et al. (2000) point out that range restriction in southern fishes, including the eastern sand darter, emphasizes the significant threat of range fragmentation and isolation to their persistence. Despite maintaining isolated populations and inhibiting dispersal, Simon (1993) believes that a large dam on the St. Joseph River in Indiana has benefitted the eastern sand darter by removing a considerable portion of the silt load, a major threat to population persistence. It should also be noted that not all impoundments are the direct result of anthropogenic factors. As Rob Criswell (pers. comm.) pointed out, beavers have had an influence on eastern sand darters in Pennsylvania's Muddy Creek. For example, during one round of spring sampling, suitable habitat was available and the darter was collected. However, after beaver activity, later sampling revealed that sand deposits had been smothered in silt (R. Criswell, pers. comm.).

Stream flow modification

Etnier (1972) studied fish community assemblage changes in Middle Creek, a tributary to the East Fork of the Little Pigeon River in Sevier County, Tennessee, after a flood control project widened and straightened the channel. Some species declined or disappeared from the stream after rechannelization while others maintained stable population levels from an influx of upstream migrants (Etnier 1972). Overall dominance shifted in the fish community. Changes were attributed to substrate instability and decreased variation in the habitat structure, which led to a decline in invertebrate fauna (Etnier 1972). The recent research conducted in Vermont draws attention to the potential linkage among stream-flow change, stream substrate composition and *A. pellucida* habitat preference (Facey and O'Brien 2003, O'Brien and Facey 2003).

Water quality
Percid species are sensitive to anthropogenic disturbance (Leonard and Orth 1986) as most are restricted to clear, fast-flowing water with clean substrate (Page 1983). Specific association with clean gravel and sand substrates make the eastern sand darter especially sensitive to changes in a stream's chemical and physical characteristics. Maitland (1995) cites water pollution as "the single most significant factor in causing major declines in the populations of many fish species." The fact that freshwater fish populations are geographically confined to discrete freshwater systems with significant water movement and therefore vulnerable to the effects of pollution, argues the importance of multiple populations to ensure overall persistence (Maitland 1995). Pollutants can cause direct mortality to sensitive species and, at sublethal levels, can increase susceptibility to other threats (Maitland 1995). The issue of water pollution is closely linked to habitat alteration and land use practices within the watershed. Major sources of aquatic pollutants include domestic wastes, agricultural runoff, and industrial chemicals. Reash and Berra (1987) conducted a comparison between clean-water and polluted streams in Ohio. Polluted streams contained a simplified fish community as evidenced by the absence of pollution intolerant species, including the fantail darter (*Etheostoma flabellare*). Polluted sites generally supported habitat and diet generalists that were able to tolerate degraded environments, while species with more specific preferences were absent (Reash and Berra 1987). There is evidence from Florida suggesting that water quality improvements during the 1960s to mid 1980s coincided with the recovery of fish assemblages to stable levels, although questions remain as to whether or not improved water quality has maintained healthy fish populations (Walsh et al. 2003).

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes.

Although the eastern sand darter has no commercial value, live specimens may be collected for the aquarium trade (Walsh et al. 2003). Deacon et al. (1979) asserted that despite elaborate regulations to protect fish populations from over-harvesting, little has been done to address habitat loss. These authors also suggested that collection for scientific purposes should not be restricted since it provides managers with crucial information for habitat and species management actions. Commercial bait dealers could potentially alter suitable habitats and/or directly impact individuals, unintentionally, if their collection activities occur in areas where eastern sand darters are present (M. Ferguson, pers. comm.).

C. Disease and Predation.

Some natural predation by piscivorus fish and wildlife likely occurs (Trautman 1981, and Daniels 1989). Exotic species could pose an immediate threat to *A.pellucida* in Lake Erie (R. Criswell, pers. comm.). Newly introduced species may act as predator and/or competitor of native fish species. Spreitzer (1979) found the digenetic trematode (*Uvulifer ambloplitis*) encysted on the entire body of a darter specimen and determined that the eastern sand darter may act as an intermediate host; e.g., infected by cercariae, which are shed by the ramshorn snail (*Helisoma* sp.), with the life cycle completed when the darter is consumed by the belted kingfisher (*Megaceryle alcyon*). Furthermore, 80 percent of *A. pellucida* specimens examined were infected by the proteocephalan cestode (*Proteocephalus ambloplitis*) which creates cysts in the coelom attached to the liver lobes, gallbladder, ovaries, and coelomic surfaces of the esophagus, caeca, stomach, and intestine (Spreitzer 1979). Eleven of 119 specimens examined contained the camallanid nematode (*Camallanus oxycephalus*) embedded in the rugae of the intestine, and spread by copepods infected with nematode larvae (Spreitzer 1979). The parasitic copepod *Lernaea cyprinacea*, or anchor worm, was discovered in 6 of 119 specimens. However, despite these parasite burdens, parasitized specimens did not appear physically impaired in any way (Spreitzer 1979).

D. The Inadequacy of Existing Regulatory Mechanisms.

Contaminated sediment guidelines
The U.S. Environmental Protection Agency (EPA) has prepared technical guidance to address the exposure of sediment-dwelling organisms to contaminants that tend to partition into aquatic sediments (U.S. EPA 2000 a, b, c, d). The eastern sand darter's unusual behavior of burrowing into sediments coupled with its tendency to feed on sediment-dwelling benthic organisms, potentially doubles its probability of exposure to sediment-borne contaminants; e.g., the burrowing activity establishes a direct exposure route and the ingestion of sediment-dwelling organisms establishes an indirect exposure route. A more recent EPA document on contaminated sediment acknowledges that the equilibrium partitioning sediment guidelines do not protect against synergistic or antagonistic effects of contaminants or bioaccumulative effects to benthos, and that they are not protective of wildlife health endpoints (U.S. EPA 2002-draft).

Other legislation
Legal protection afforded freshwater fishes is generally applied within the context of fish as an exploitable resource (Maitland 1995). Maitland (1995) described the 'no net habitat loss' policy of the Canadian Department of Fisheries and Oceans, which requires developers to ensure that habitat loss will not result from the proposed action and if so, alter the proposal accordingly or provide for remediation. The Clean Water Act of 1964 includes similar provisions for protecting the United States' water resources, although enforcement is often criticized as a significant problem for fish conservation (D. Cincotta, pers. comm.).

E. Other Natural or Manmade Factors Affecting its Continued Existence.

Genetic variation
White (1987) conducted a study to assess the genetic variation and population structure of the eastern sand darter in Federal Creek and Hocking River in Athens County, Ohio. The results indicated that local population differentiation was consistent with local distribution patterns and small population sizes, suggesting a population structure consisting of small populations separated by unsuitable habitat (White 1987). White (1987) believed that the sampled populations displayed sufficient genetic differentiation and that gene flow had occurred. In the future, however, these small, and increasingly isolated eastern sand darter populations may begin to suffer from decreasing within-population diversity as inbreeding among close relatives, which can lead to problems such as reduced fertility and fitness, increases in likelihood (Noss and Cooperrider 1994). Similarly, the random loss of adaptive genes through genetic drift may function to limit the ability of eastern sand darters to respond to changes in their environment (Noss and Cooperrider 1994). Small population sizes and inhibited gene flow between populations may increase the likelihood of local extinction (Gilpin and Soulé 1986).

Lamprey control
Chemical control of sea lampreys in the Poultney River was considered a threat to eastern sand darter populations. Bioassays were conducted to better understand the effects of TFM on the eastern sand darters (D. Carlson, pers. comm.). Reduced application rates of the lampricide TFM were subsequently recommended and used (M. Ferguson, pers. comm. and Plosila et al. 1986).

CURRENT PROTECTIVE STATUS

The level of effort dedicated to documenting eastern sand darter occurrence and monitoring population status is generally minimal throughout its range, and variable on a state-by-state basis. Each state has therefore established a specific level of protection (or lack thereof) for the eastern sand darter, as deemed necessary. The following table lists the eastern sand darter's protective status and National Heritage ranking by state, as well as its global, Canadian, and U.S. federal protective status designation.

Table 3. The eastern sand darter's protective status at the global, federal, and state level.

Governmental Level	Protective Status	Heritage Status Rank
Global	none	G3
Canada	threatened	N3
Federal (U.S.)	none	N3
Illinois	threatened	S1
Indiana	special concern	S2
Kentucky	none	S4S5
Michigan	threatened	S1S2
New York	threatened	S2
Ohio	species of concern	S3
Pennsylvania	endangered	S1
Vermont	threatened	S1
West Virginia	none	S2S3

G3 = vulnerable globally; N3 = nationally vulnerable; S1 = critically imperiled; S1S2 = critically imperiled to imperiled; S2 = imperiled; S2S3 = imperiled to vulnerable; S3 = vulnerable; S4S5 = apparently secure to secure. Information obtained from NatureServe Explorer 2002; B. Burr - Southern Illinois University; G. Kruse - Illiniois Department of Natural Resources; J. Kath - Illinois Department of Natural Resources; B. Fisher - Indiana Department of Natural Resources; R. Cicerello - Kentucky State Nature Preserves Commission; K. Gardiner - Michigan Department of Natural Resources; D. Carlson - New York State Department of Environmental Conservation; T. Cavender - Ohio State University; R. Sanders - Ohio Department of Natural Resources; R. Criswell - Pennsylvania Game Commission; M. Ferguson - Vermont Fish and Wildlife Department; D. Cincotta - West Virginia Department of Natural Resources.

Glen Kruse of the Illinois Department of Natural Resources (pers. comm.) reported that the eastern sand darter was listed as endangered in 1994 and then was reclassified to threatened in

1999. Brooks Burr (pers. comm.) had speculated that the status of the eastern sand darter in Illinois could be changed to “endangered” in the near future. However, the 2004-2009 Illinois Endangered and Threatened Species List was proposed with the status of the eastern sand darter remaining “threatened” (Joseph Kath, Illinois Department of Natural Resources, pers. comm.). According to B. Fisher (pers. comm.) the eastern sand darter is currently on Indiana’s list of special concern species. As a species of special concern in Indiana, the eastern sand darter receives no special protection; only state endangered species receive protection. There is no regulatory authority in Kentucky to list or protect species that are not listed by the U.S. Fish and Wildlife Service (R. Cicerello, pers. comm.). Similarly, the eastern sand darter is not afforded protection by the state of West Virginia (D. Cincotta, pers. comm.).

Under authority of Part 365, Endangered Species Protection, of the Natural Resources and Environmental Protection Act (P.A. 451 of 1994), the Michigan Department of Natural Resources lists the eastern sand darter as a "threatened species.” The definition of threatened species means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. This listing prevents a person from taking, possessing, transporting, importing, exporting, processing, selling or offering to sell eastern sand darters in Michigan (K. Gardiner, pers. comm.).

In New York State, the eastern sand darter was listed as endangered in 1983, based on localized extinctions in Cazenovia and Cattaraugus creeks in the early 1900s (D. Carlson, pers. comm.). Reevaluation in 1993 maintained the endangered status despite the discovery of two new populations in eastern Lake Erie, and the Mettawee, and Poultney rivers. Four additional populations have been discovered in the Salmon, Grasse, St. Regis, and Deer Rivers (D. Carlson, pers. comm.). Based on these additions and the fact that no populations have been lost since the two mentioned, the state reduced the status from endangered to threatened in 1998. The presence of six disjunct populations of *A. pellucida* in New York state has resulted in a recommendation to down-list the species to “special concern” (D. Carlson, pers. comm.). There has yet to be any action taken on the recommendation.

The eastern sand darter is listed as a species of concern in Ohio. The definition for this designation is as follows (R. Sanders, pers. comm.).:

> SPECIES OF CONCERN - A species or subspecies which might become threatened in Ohio under continued or increased stress. Also, a species or subspecies for which there is some concern but for which information is insufficient to permit an adequate status evaluation. This category may contain species designated as a furbearer or game species but whose statewide population is dependent on the quality and/or quantity of habitat and is not adversely impacted by regulated harvest.

In Pennsylvania, *A. pellucida* is listed as “endangered.” Rob Criswell (pers. comm.) shared the following relevant details from the Commonwealth of Pennsylvania Fish & Boat Code Act 1980-175 Title 30 Pennsylvania Consolidated Statutes Chapter 1, Section 102. Definitions:

> "Endangered species." All species and subspecies of fish which:
> (1) have been declared by the Secretary of the United States Department of the Interior to be threatened with extinction and appear on the Endangered Species List or the Native Endangered Species List published in the Federal Register; or

> (2) have been declared by the executive director to be threatened with extinction and appear on the Pennsylvania Endangered Species List published in the Pennsylvania Bulletin.
>
> Legal protection is, therefore, afforded according to Commonwealth of Pennsylvania Fishing and Boating Regulations Title 58 Pennsylvania Code, Chapter 75. Endangered Species Section 75.1. Endangered species. - 2305(b). This protection prevents the catching, taking, killing, possessing, importing to or exporting from this Commonwealth, selling, offering for sale, or purchasing, of any individual, alive or dead, or any part thereof, without a special permit from the Executive Director of the Commission.

The eastern sand darter is listed as threatened under the Vermont Endangered Species Act. This designation affords it with legal protection, with fines imposed for violations which are a criminal offense (M. Ferguson, pers. comm.).

The Committee on the Status of Endangered Wildlife in Canada lists the eastern sand darter as "threatened" as of 1994 (COSEWIC website). This designation was reexamined and confirmed in November 2000. Under the Species At Risk Act (SARA) of 2002, a recovery strategy for the species must be prepared. In addition,

> "any projects requiring an environmental assessment under federal law that are likely to affect a listed species or its critical habitat need to identify the adverse effects, and, if the project goes forward, steps must be taken to avoid or lessen those effects and to monitor them."

Beginning in June 2004, Canadian law will make it a punishable offense to "kill, harm, harass, or take" endangered or threatened species in addition to their collection, sale, and/or possession (COSEWIC website).

SUMMARY OF LAND OWNERSHIP

There is no comprehensive database or publication containing specific occurrence records that are thoroughly cross-referenced with site-specific ownership documentation for the entire geographic distribution of the eastern sand darter. In general, most streams are managed as state and/or federal navigable waters. However, land ownership within each watershed is variable and land use decisions on property within a watershed will likely have impacts on fish populations within individual streams. For example, Warren et al. (2000) reported that 11 percent of the 212 million acres of forested watersheds, which support the most ecologically significant streams and rivers in the southern United States, are publicly owned. What follows is a description of the available information concerning land ownership surrounding the waters where the eastern sand darter is know to occur.

In Illinois, landowners own the substrate in streams that run across their property but not the water flowing in the stream (B. Burr, pers. comm.). The majority of stream segments with extant populations are privately owned (M. Retzer, pers. comm.). One population along a segment of the Embarras River and several segments of the Middle Fork of the Vermilion River are protected, with the latter designated as a National Scenic Riverway (M. Retzer, pers. comm.).

Several state properties are located along areas of eastern sand darter distribution in Indiana (B. Fisher, pers. comm.): Tippecanoe River State Park (Tippecanoe River-Pulaski County), Shades State Park (Sugar Creek-Montgomery/Parke counties), Turkey Run State Park (Parke County), Atterbury Fish & Wildlife Area (Sugar Creek-Johnson County), Williams Dam fishing area (East Fork White River-Lawrence County), Hindonstan Falls fishing area and Martin State Forest (East Fork White River-Martin County). Federal properties include the Hoosier National Forest (East Fork White River-Martin and Lawrence counties) and Muscatatuck National Wildlife Refuge (Vernon Fork Muscatatuck River-Jennings County).

Kentucky populations inhabiting the middle and south fork of the Red River (Kentucky River tributary) are located within the proclamation boundaries of Daniel Boone National Forest; however, numerous private holdings exist in the forest (R. Cicerello, pers. comm.).

The Island Lake Recreation Area in Michigan affords some protection to eastern sand darters inhabiting the Huron River. According to Kevin Gardiner (pers. comm.), this section of the Huron River is a part of the Michigan Natural Rivers Program, and is managed by the Michigan Department of Natural Resources Parks and Recreation Division to maintain natural stream dynamics. In addition, some of the river and surrounding riparian zone is enrolled in the Michigan Natural Areas Registry which guides management towards maintaining natural stream dynamics and minimizing threats such as runoff and erosion (K. Gardiner, pers. comm.).

Land ownership adjacent to eastern sand darter habitat in New York is summarized as "streams and lakes surrounded by private landowners" (D. Carlson, pers comm.). One of the sand darter locations, in the Deer River (a tributary of the St. Regis River), is bordered by a state forest on one side and private property on the other side (D. Carlson, pers comm.). Similarly, land adjacent to West Virginia waters with eastern sand darter populations is, predominantly, in private ownership (D. Cincotta and B. Douglas, U.S. Fish and Wildlife Service, pers. comm.).

Barnes (1979) reported on surveys conducted in the Wayne National Forest in Ohio. Although sufficient habitat was present in Symmes Creek, Pine Creek, and the Hocking River below Athens, eastern sand darters were only found in Federal Creek. Recent (late 1990s) surveys supported the presence of *A. pellucida* within the Wayne National Forest’s Little Muskingum River (D. Rice, pers. comm., and Wayne National Forest website).

Except for a section of Muddy Creek, within the Erie National Wildlife Refuge, the vast majority of the eastern sand darter’s range is associated with private land holdings in Pennsylvania (R. Criswell, pers. comm.). Several of the access points to French Creek are owned by government entities such as the U.S. Army Corps. of Engineers, the Pennsylvania Fish and Boat Commission, and the Pennsylvania Department of Transportation (http://frenchcreek.allegheny.edu/canoeguide.html).

M. Ferguson (pers. comm.) reported that there are numerous landowners along the Vermont waters inhabited by *A. pellucida*. He reported that there is a federal wildlife refuge on the lower Missisquoi River and a state wildlife refuge on the Winooski River. He noted, however, that these protected lands were not adjacent to the river stretches occupied by the eastern sand darter. There is a state wildlilfe management area on the Lamoille River, adjacent to eastern darter habitat (M. Ferguson, pers. comm.). Doug Facey (pers. comm.) reported that The Nature

Conservancy owns land along the Vermont side of the Poultney River, adjacent to a mile-long section of river currently supporting eastern sand darters.

BENEFICIAL CONSERVATION ACTIVITIES

Information from Indiana (B. Fisher, pers. comm.), Ohio (R. Sanders, pers. comm.), and West Virginia (D. Cincotta, pers. comm.) indicated that there were no beneficial conservation activities occurring that were relevant to the eastern sand darter in these states. Although water quality improvements to Cattaraugus Creek in New York state made it a candidate for additional recovery work, this restoration project was not pursued further (D. Carlson, pers. comm.).

The state of Illinois has moved to stop the construction of reservoirs on the Middle Fork of the Vermilion River and the middle stretch of the Embarras River (B. Burr, pers. comm.). These projects would have inundated eastern sand darter habitat and most likely extirpated the populations inhabiting these rivers. In addition, the Illinois Department of Natural Resources and The Nature Conservancy have been working with the Farm Bureau and local farmers to ensure that topsoil does not end up in nearby streams (B. Burr, pers. comm.). The establishment of the Embarras River Land and Water Reserve in 2003, along the mainstem of the Embarras River in Coles County, will likely protect suitable habitat and allow for the continued existence of the eastern sand darter in this portion of the river (T. Thomas, pers. comm.).

Ron Cicerello (pers. comm.) reported that a watershed-based conservation efforts in Kentucky, aimed at protecting riparian areas and endangered species habitat, have been initiated for sections of the Licking River below Cave Run Dam. Partners include the Kentucky Division of Water, The Nature Conservancy, Kentucky Fish and Wildlife, Kentucky Nature Preserves Commission, and the U.S. Fish and Wildlife Service.

The only instance of relevant habitat protection in Michigan applies to a portion of the Island Lake Recreation Area, along the Huron River, in Livingston County (K. Gardiner, pers. comm.). This stretch of the Huron River is a part of the Michigan Natural Rivers Program, and is managed to maintain natural stream dynamics. A large portion of the river and adjacent riparian zones is enrolled in the Michigan Natural Areas Registry. This is basically an agreement between the Michigan Department of Natural Resources and The Nature Conservancy that seeks to manage this stretch of the Huron River, so as to maintain natural stream dynamics and minimize threats such as erosion and runoff. In combination, these efforts are likely to ensure that this important stretch of habitat is maintained for the future (K. Gardiner, pers. comm.).

In Pennsylvania, there are no conservation activities that have directly targeted *A. pellucida*. However, streambank fencing and stabilization efforts are underway in the French Creek watershed. These efforts may benefit the eastern sand darter by reducing erosion and siltation (R. Criswell, pers. comm.).

In Vermont, past activities directed at conservation of *A. pellucida* have included land acquisition and conservation, a statewide assessment of populations, multi-year surveys on the Winooski and Poultney rivers, studies of microhabitat use, and toxicity testing related to sea lamprey control (M. Ferguson, pers. comm.). Recent efforts have also included population management planning on the Poultney River and the development of a recovery plan, which is in progress. The activity that has likely provided the greatest direct benefit to the species is land acquisition and conservation, primarily by The Nature Conservancy (M. Ferguson, pers. comm.).

MANAGEMENT ACTION AND RESEARCH NEEDS

A. Taxonomic, Ecological, and Distributional Status

Confusion over the taxonomic designations used for the eastern sand darter described by Williams (1975) warrants an ongoing discussion as to the relationships between closely related species as well as conspecific populations across the eastern sand darter's geographic distribution. Biologists are still uncertain about the ecology of the species and its response to human alteration of stream habitat (see THREATS section) as well as its distribution (see RANGE section). These deficiencies call for conducting more research on the eastern sand darter with the resulting information and data aiding future management efforts.

B. Habitat Protection and Restoration

Habitat protection and restoration will allow for the long-term success of conservation efforts aimed at freshwater fishes (Maitland 1995). Reinstating spawning areas and ensuring the maintenance of clean sand and gravel raceways for eastern sand darter populations is likely to allow for population persistence, if conducted in concert with pollution control and abatement programs within the species' range. For example, a sandbar constructed in 1988 in a cut-off of the Tenn-Tom Waterway has yielded 17 specimens of the crystal darter (*Crystallaria asprella*), whose habitats requirements are similar to those of the eastern sand darter (Kuhajda 2000). This suggests that the sandbar may provide suitable habitat to support a small population (Kuhajda 2000). Tactics for restoring habitat, such as tax incentives to control sedimentation, have been suggested (B. Burr, pers. comm.). However, management priorities should be given to high quality habitat areas currently supporting eastern sand darter populations rather than heavily impacted areas, since the cost of restoring degraded habitats is high. Walsh et al. (2003) stressed the need for surveys aimed at identifying suitable habitat as potential sources for translocation efforts (see below).

C. Translocation

Translocation should be considered before a species becomes critically imperiled (Poly 2003). Williams et al. (1988) provided criteria for the planning of fish translocations. It is essential that transplantation occur within the species' native range since ecological interactions within its natural distribution are likely to have fewer negative consequences than would introduction to a novel environment (Williams et al. 1988, Minckley 1995). Transplant sites should be afforded some degree of protection from habitat degradation (Williams et al. 1988), contain sufficient natural resources to support self-sustaining populations, and be large enough to sustain the range of natural variability needed to maintain local and regional diversity (Moyle and Sado 1991). Maitland (1995) emphasized that translocation should pose no threat to the parent stock from which propagules are selected, and that consideration be given to the genetic composition of the introduced stock, so as to maintain genetic variation within and between populations. Other considerations include recognizing the potential for introduction of disease or parasites (Williams et al. 1988) and hybridization with closely related species (Williams et al. 1988, Minckley 1995). Post-introduction monitoring should be implemented to determine survival, recruitment, and population persistence (Williams et al. 1988). Research on the bloodfin darter (*Etheostoma sanguifluum*) and the boulder darter (*E. wapiti*) by Rakes et al. (1999), emphasized the benefits of understanding the relationships among captive breeding, reproductive behavior, and the restoration of extirpated populations. Unfortunately, Doug Carlson (pers. comm.)

indicated that a research effort to develop propagation techniques for the eastern sand darter by Pennsylvania State University for New York State ceased as of 1995.

Ron Cicerello (pers. comm.) suggested that the eastern sand darter should be reintroduced to the Green River in Kentucky. Precedent for the translocation of imperiled darter species has been set by efforts to reestablish populations of the snail darter (*Percina tanasi*) (Hickman and Fitz 1978), duskytail darter (*Etheostoma percnurum*) and fringed darter (*Etheostoma crossopterum*) (Poly 2003) populations. Poly (2003) stressed that the number of individuals released should be substantial, consist of multiple age classes, and that individuals be released into suitable habitat. Other factors to consider include sex ratio of inoculum, fecundity, and potential interactions with species in the new locale (Poly 2003). Fringed darters displayed normal breeding activity after translocation and both juveniles and adults were present in following years along with an increase in the number of nests discovered in subsequent years (Poly 2003). Efforts to move individuals at the beginning of their natural breeding season seem most effective for increasing the chances of locating a mate in the new habitat prior to dispersal (e.g., Poly 2003). Similar steps could be taken to evaluate the potential for eastern sand darter translocation if deemed necessary. However, Poly (2003) suggested that a closely related species be used as a surrogate for initial investigation into the efficacy of translocation for imperiled species.

D. Monitoring

Many resource managers (pers. comms.) recommended that comprehensive survey efforts be employed to clarify eastern sand darter distribution and abundance, as well as identify potentially suitable habitat. With this information, managers could better identify specific threats to populations and develop management strategies to mitigate those threats. However, based on the amount and nature of the information obtained from the literature, and communications with resource managers, it appears that routine sampling and population monitoring is often neglected. This is indeed unfortunate, because population monitoring efforts are essential to providing baseline information and trend data. Historic occurrence sites should also be monitored to establish and/or verify trend information (B. Burr, pers. comm.). Monitoring efforts should also be designed to discover new locations of eastern sand darter occurrence, in order to document sub-population movement and habitat change (NatureServe Explorer 2002). Monitoring efforts should be standardized across geographic and political boundaries to facilitate comparisons in both space and time (Maitland 1995). All management actions should include adequate monitoring to evaluate the success of plans and programs implemented, and guide future management efforts to protect imperiled species.

One challenge associated with conducting the surveys necessary to monitor eastern sand darters is assuring consistency in sampling methods (D. Facey, pers. comm.). For example, sampling is generally more effective in shallower locations where seines can be dug into the substrate. Variation in site characteristics, such as water depth and current velocity, complicate the analysis of survey data since differentiation between “absence” and an “inability to effectively sample” the habitat is difficult in some situations. Schmidt (1995) addressed the effectiveness of sampling techniques for the crystal darter (*Crystallaria asprella*). Many of the concerns raised in Schmidt (1995) pertain to eastern sand darters sampling efforts. The year-to-year variability in eastern sand darter abundance underscores the importance of implementing long-term studies, with consistent and repeated sampling of established locations, to gain a better understanding of this species’ population dynamics.

E. Watershed Management

Efforts should be made to address watershed-scale stressors to eastern sand darter populations and/or habitat in order to address multiple stressors that may or may not originate in close proximity to extant populations (see THREATS section), and build consensus among stakeholders from a diverse assemblage of interest groups within a watershed. For example, a large portion of the Huron River and adjacent riparian zones is enrolled in the Michigan Natural Areas Registry. This is an agreement between the Michigan Department of Natural Resources and The Nature Conservancy that seeks to manage a portion of the Huron River, so as to maintain natural stream dynamics and minimize threats such as erosion and runoff. In combination, these efforts are likely to ensure that this important stretch of habitat is maintained for the future (K. Gardiner, pers. comm.). State agencies should continue to work with landowners to minimize threats from soil erosion and stream sedimentation. For example, in Illinois the Department of Natural Resources and The Nature Conservancy have been working with the Farm Bureau and local farmers to ensure that topsoil does not end up in nearby streams (B. Burr, pers. comm.).

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APPENDIX 1

Figures 1, 2, and 3.

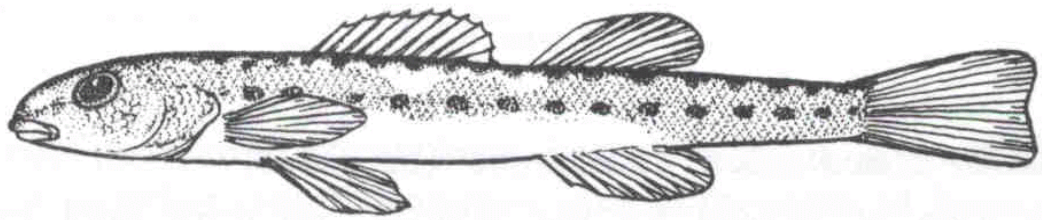

Figure 1. Eastern Sand Darter (*Ammocrypta pellucida*). Sketch by Samuel Eddy.

Figure 2. Historical eastern sand darter distribution, generalized by state and province. Adapted from NatureServe Explorer 2002.

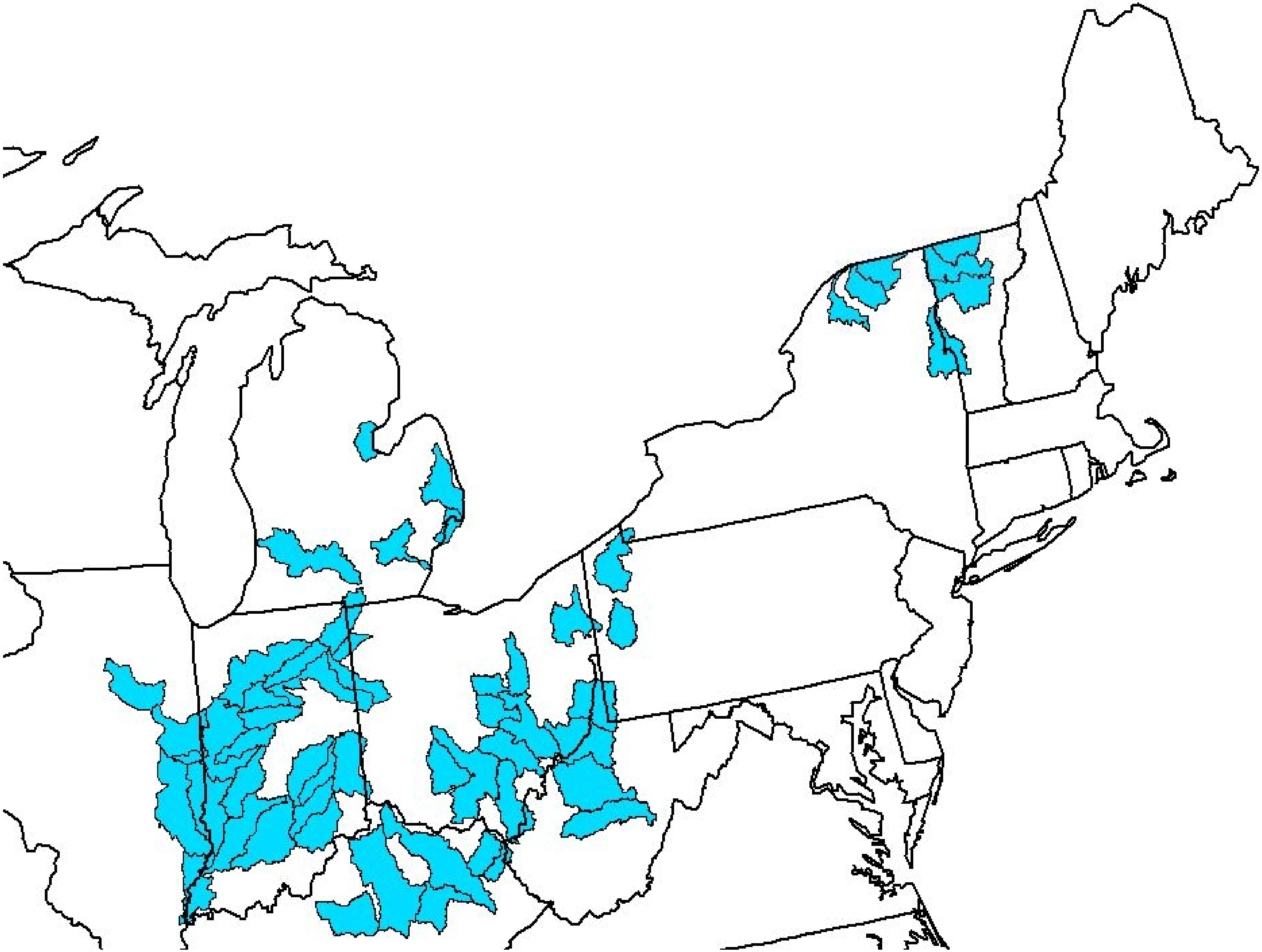

Figure 3. Current distribution of the eastern sand darter. Shaded areas indicate USGS Hydrologic Units containing rivers, streams, and/or creeks with post-1970 occurrence records.