Northern Riffleshell
(Epioblasma torulosa rangiana)

5-Year Review:
Summary and Evaluation

Fall 2008

U.S. Fish and Wildlife Service
Pennsylvania Field Office
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5-YEAR REVIEW

Species reviewed: Northern Riffleshell (*Epioblasma torulosa rangiana*)

1.0 GENERAL INFORMATION

1.1 Reviewers

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1.2 Methods Used to Complete the Review

The northern riffleshell 5-year review was conducted as an individual effort by the lead recovery biologist for the species. Biologists from the U.S. Fish and Wildlife Service (USFWS), State wildlife agencies, and State natural heritage programs were contacted for current information on occurrences, threats, and recovery activities in Indiana, Kentucky, Michigan, Ohio, Pennsylvania, and West Virginia. U.S. Geological Survey (USGS) biologists and academicians conducting research on the northern riffleshell were also contacted, as were USFWS fisheries biologists and others involved with captive holding of northern riffleshell. The current recovery plan was finalized in 1994 and is out of date; therefore, the information that was provided by the State and USFWS biologists, and included in Natural Heritage Program databases, reports, and other gray literature, are the principal basis for this status review.

1.3 Background

1.3.1 Federal Register Notice citation announcing initiation of this review:

71 FR 20178 (April 21, 2006): Notice of Endangered and Threatened Wildlife and Plants; Initiation of a 5-Year Review of Nine Listed Species: the Purple Bean (*Villosa perpurpurea*), Clubshell (*Pleurobema clava*), Northern Red-bellied Cooter (*Pseudemys rubriventris bangsi*), Roanoke Logperch (*Percina rex*), Swamp Pink (*Helonias bullata*), Northern Riffleshell (*Epioblasma torulosa rangiana*), Flat-spired Three-toothed Land Snail (*Triodopsis platysayoides*), Puritan Tiger Beetle (*Cicindela puritana*), and Dwarf Wedgemussel (*Alasmidonta heterodon*)

1.3.2 Listing history:

Federal Register notice:	58 FR 5638-5642
Date listed:	January 22, 1993
Entity listed:	Species
Classification:	Endangered, Entire Range; except where listed as Experimental Populations

1.3.3 Associated rulemakings: None

1.3.4 Review History: Since Federal listing of the northern riffleshell in 1993, no status review or 5-year review has been conducted for this species.

1.3.5 Species' Recovery Priority Number at start of 5-year review: 6 (indicating that the northern riffleshell is taxonomically categorized as a subspecies, has a high degree of threat, and low recovery potential)

1.3.6 Recovery plan:

Name of plan: Clubshell (*Pleurobema clava*) and Northern Riffleshell (*Epioblasma torulosa rangiana*) Recovery Plan
Date issued: September 21, 1994
Dates of previous revisions: None

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment Policy

2.1.1 Is the species under review a vertebrate? The subspecies is an invertebrate; therefore, the Distinct Population Segment (DPS) policy is not applicable to this listing.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes; however, see Section 2.2.3.

2.2.2 Adequacy of recovery criteria:

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat? No.

2.2.2.2 Are all of the five listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? No.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

1994 Recovery Plan Criteria

To ***reclassify*** the northern riffleshell as threatened from endangered, the following criterion must be met:

1. Viable populations must be documented in 10 separate drainages for this species. A viable population consists of sufficient numbers of reproducing individuals to maintain a stable or increasing population. These populations should include as many subpopulations as possible to maintain whatever fraction of the original genetic variability that remains.

   The following drainages are identified as necessary to achieve recovery: Tippecanoe River (Indiana), Detroit River (Michigan/Ontario – contingent on zebra mussel control), Fish Creek (Ohio), Green River (Kentucky), Big Darby Creek (Ohio), Elk River (West Virginia), French Creek (Pennsylvania), Allegheny River (Pennsylvania), and two additional as yet unidentified drainages.

   This criterion is partially met. Reproducing populations occur in 2 of the 10 listed waterways: the Allegheny River and its tributary French Creek, both in Pennsylvania. Apparently reproducing populations (*i.e.,* surveys found a range of sizes, including smaller individuals, that likely resulted from recent recruitment) also occur in two additional streams: East Branch Sydenham River and Ausable River, both in Ontario, Canada.

To ***remove*** the northern riffleshell from the Federal list of threatened and endangered species, the following additional criteria must be met:

2. Each of the 10 populations in Criterion 1 must be large enough to survive a single, adverse ecological event. At this time, most populations are localized and susceptible to such impacts. Therefore, the extent of most populations must be increased, either naturally or through translocation.

3. The populations and their drainages in Criteria 1 and 2 must be permanently protected from all foreseeable and controllable threats, both natural and anthropogenic.

   The criteria have not been met and it is doubtful that they could be met. The specific condition of each of the required populations is described below in Section 2.3.1.2. Zebra mussel control in the Detroit River is unlikely. The reasons for the apparent continued decline of northern riffleshell in streams such as Green River, Tippecanoe River, Elk River, and Big Darby Creek are not clearly understood. These streams continue to support numerous other freshwater mussel species and confirmed or potential host fish. Until the particular threats influencing northern riffleshell populations are identified, Criterion 3 cannot be achieved.

   In addition to not being met, these recovery criteria are vague, in that: (1) Population viability is not defined, (2) the separation distance (between sub-populations) necessary to ameliorate catastrophic events is not identified, (3) population protection is not well defined, and (4) habitat protection is not well defined. Several recovery tasks are intended

to address habitat and population protection, but the needs of this species, including its environmental tolerances, are not well understood (See section 4.0).

2.3 Updated Information and Current Species Status

2.3.1 Biology and habitat:

The common name 'riffleshell' implies that riffle habitat often associated with the genus is required; however, the habitat requirement of the northern riffleshell may not be as narrowing constrained as the name implies. The northern riffleshell is also known to occur in relatively slow-flowing, more lentic, or deep run habitats. The species also occurred in Lake Erie, where wave action likely provided needed water flow. Northern riffleshells have also been found in the Allegheny River in run-of-the-river navigation pools 8 and 9 that are impounded to facilitate navigation and may only experience water flow during high river discharge periods. It is not clear if specimens living in more typical riffle/run areas can adapt to slower water should conditions change. Use of low-flow areas may also be limited in more turbid waters, where concomitant silt deposition may limit survival or successful reproduction.

No detailed life history studies of the northern riffleshell have been completed, but its life history probably follows that of closely related species, such as the tan riffleshell (*Epioblasma florentina walkeri*), which has been the subject of detailed study by Rogers *et al.* (2001).

2.3.1.1 New information on the species' biology and life history:

Rodgers *et al.* (2001) found that tan riffleshell males release sperm into the water in August and September, fertilizing eggs in females downstream. Like the larval stage of most freshwater mussels, northern riffleshell glochidia are obligate parasites on fish. Watters (1996) and O'Dee and Watters (2000) conducted host suitability studies that identified four fish species on which northern riffleshell glochidia develop into juveniles: banded darter *(Etheostoma zonale)*, bluebreast darter (*E. camurum*), brown trout (*Salmo trutta*), and banded sculpin (*Cottus carolinae*). McNichols *et al.* (2007) reported that Iowa darters *(Etheostoma exile)*, Johnny darters *(Etheostoma nigrum)*, and mottled sculpin *(Cottus bairdi)* also transformed northern riffleshell glochidia. These studies did not test all of the fish species that are native to the range of the northern riffleshell. Further, these fish species do not occur in all habitats that support northern riffleshells. Therefore, there are probably other, as yet unidentified, suitable fish host species for the northern riffleshell – most likely several species of *Etheostoma* and *Percina* (Zanatta and Murphy 2007).

Many freshwater mussel species utilize lures or exhibit behaviors to attract host fish. Rodgers *et al.* (2001) reported that tan riffleshell populations in Virginia are not visible on the substrate surface from November through January. Northern riffleshells also appear to undergo a seasonal vertical migration in the fall (Anderson 2000). Gravid females of the genus *Epioblasma* move to the substrate surface and gap widely, displaying a mantel "pad". Gravid northern riffleshells expose a brilliant white mantel margin to attract host fishes from May to October, although captive northern riffleshell females synchronously emerged from the substrate in early January 2006 (G.T. Watters, The Ohio State University, pers. comm. 2007). Jones (2004) reported that *Epioblasma* not only attract fish with the mantel display, but capture and hold those that come in contact with the mantel pads. Fish are temporarily trapped between the valves of the rapidly closing female while she expels glochidia onto the fish's gills and other tissues.

Glochidia are discharged primarily in May and June and become encysted on a suitable host fish where they transform into juvenile mussels over a period of days to weeks. The transformed young then fall from the host fish and burrow into the substrate. Unlike filter-

feeding adults, juveniles are relatively mobile and appear to be pedial feeders, sifting food items from sediments with hair-like structures (cilia) arranged on their foot.

2.3.1.2 Abundance, population trends, demographic features, or demographic trends:

Riffleshells appear to have a relatively short life-span for a freshwater mussel. Sexual maturity can be reached in as little as three years, and most individuals probably live for only 7 to 15 years (Rodgers *et al.* 2001, Crabtree and Smith 2007). Like other mussels, the northern riffleshell probably experiences very low annual juvenile survival. The combination of short life span and low fecundity indicates that populations depend on a large annual cohort produced by a large population (Musick 1999). Species following this reproductive strategy are susceptible to loss of individuals from predation and stochastic events and are slow to recover from such losses (Rodgers *et al.* 2001). However, these species may be well suited to exploit dynamic micro-habitat shifts characteristic of free-flowing rivers.

With the exception of displaying females, northern riffleshell are cryptic, with an estimated 48 percent of a population occurring below the substrate surface (Smith et al 2001); therefore, qualitative population estimates must take into account undetected individuals. In addition, where northern riffleshell are found at low population densities, population estimates may have large margins of error due to undetected mussels. Sparsely distributed juveniles indicative of successful reproduction are likely even more difficult to detect.

Successful recruitment of northern riffleshell populations is often difficult to detect when densities are very low or surveys are single-day, catch-per-unit efforts. Few intensive, statistically valid surveys have been conducted on populations of this species outside of French Creek and the Allegheny River, and populations with densities near or below the detection rate may not be practically assessed with quantitative techniques. The difficulty in detecting northern riffleshells results in poorly defined information about the species' distribution and abundance, even within the streams where the species is known to occur.

All stream systems with known or fairly recent northern riffleshell populations are listed below (see also Appendix 1). The <u>underlined</u> streams and locations are listed in the recovery plan as areas where stable populations of northern riffleshell are necessary to achieve recovery:

Wabash River System

- No living or freshly dead shells of northern riffleshell have been found in the <u>Tippecanoe River in Indiana</u> since surveys during the 1970s. The Tippecanoe River was the last reported location for the species in Indiana, and the species may be extirpated from the state (B. Fisher, Indiana Department of Natural Resources, pers. comm. 2007).

St. Lawrence River System

- The <u>Detroit River population (Michigan and Ontario)</u> was thought to have been extirpated by heavy infestations of introduced zebra mussels (*Dreissena polymorpha*) in the 1990s. A freshly dead individual was found in the Detroit River in 2005, but 2006 surveys of the area failed to find additional living or freshly dead specimens; however, the species may persist in Lake St. Clair embayments and tributaries, away from the heaviest zebra mussel infestations (B. Hosler, USFWS, pers. comm. 2007).

- Northern riffleshells are present in small numbers in the Ausable River in Ontario (a Lake St. Clair tributary). However, while showing evidence of successful recruitment,

this small extant population is apparently declining (Prichard 2007, McGoldrick *et al.* 2007).

- The northern riffleshell population in East Branch Sydenham River in Ontario, Canada is reported to be extant at 17 sites (Metcalfe-Smith *et al.* 2003). However, this population may have declined by 90 percent in the past 30 years and is threatened by continued siltation (Pritchard 2007).

- No living or freshly dead shells of northern riffleshell have been found during recent surveys of the lower few miles of Fish Creek in Ohio, and the species may be extirpated (Brady *et al.* 2005) .

Green River System

- Freshly dead shells of northern riffleshell were reported in 1987 and 1989 from two sites in the Green River, Kentucky, both within the Mammoth Cave National Park (R. Evans, Kentucky Nature Preserves Commission, pers. comm. 2007). There are no more recent survey reports from this area, and the current status of northern riffleshell in the Green River is not known.

Scioto River System

- During a survey of the lower 20 miles of Big Darby Creek, Ohio, a young (approximately 8-year-old) female northern riffleshell was found on June 16, 2000, in the upstream reach in Pickaway County (A. Zimmerman, USFWS, pers. comm. 2007). No other living or freshly dead shells of northern riffleshell have been found during recent surveys of Big Darby Creek, and the species may now be extirpated (G.T.Watters, pers. comm. 2007).

Kanawha River System

- Two livingspecimens were found in 1993 at one site in the Elk River in West Virginia. The species has not been found in surveys since that time,(J. Clayton, WVDepartment of Natural Resources, pers. comm. 2008).

Allegheny River System

- In the Allegheny River in Pennsylvania, northern riffleshells have been documented to occur in abundance at several locations, but the species' distribution is discontinuous (*i.e.*, localized to areas of suitable habitat). The condition of these populations ranges from those exhibiting successful reproduction to those with apparently depressed vigor and a predominance of older adults (USGS 2004). The most upstream location that northern riffleshells have been found alive in recent years is near the City of Warren, Pennsylvania (EnviroScience 2002). The Allegheny River in Warren is strongly influenced by hypolimentic releases from Kinzua Dam, and this population appears to be dependent on warmer, more nutrient-rich water coming from Conewango Creek, which confluences with the Allegheny River immediately upstream of the habitat supporting this species.

  Northern riffleshells appear to become a frequent member of the Allegheny River mussel community about 9 miles below Warren, with peak densities documented near the Forest and Venango County line. At that location, northern riffleshells are the dominant mussel species, with a mean density of 7.57 individuals/m^2 and an estimated

population of 169,622 individuals in a 100-meter-wide cross-section of the Allegheny River (USGS 2002).

Sampling at the West Hickory bridge site in 1999 revealed a mean density of $0.5/m^2$ (USGS 2004). Approximately 42,758 and 42,650 northern riffleshell were estimated to occur in 100-meter-wide river sections located 200 and 300 meters downstream of the existing bridge (USGS 2000). Compared to the West Hickory site, northern riffleshells have been found to be more abundant both upstream and downstream, with a mean density of $1.8/m^2$ at five sites quantitatively sampled between Tidioute and Tionesta. Northern riffleshell populations are known from scattered locations in the middle Allegheny River (*e.g.*, near the towns of Kennerdell, Foxburg, Oil City, Parker, East Brady, and downstream to river mile 58), where population densities are generally less than $0.1/m^2$. The total population of northern riffleshell in the Allegheny River may exceed 6,500,000 individuals (Villella 2007).

- The northern riffleshell population is discontinuously distributed in approximately 60 miles of lower French Creek in Pennsylvania, from its confluence with the Allegheny River at Franklin, upstream to the vicinity of the State Route 6 bridge at Mill Village. Within this reach, northern riffleshells range from relatively common, to rare or absent at sites that have otherwise diverse mussel communities. For example, of 31 sites investigated along the length of French Creek in 2003, northern riffleshells were documented to occur at 9 of the lower 21 sites, where population estimates in 2004 ranged from 23 to over 10,000 individuals (Smith and Crabtree 2005). These 9 sites supported mussel assemblages containing between 6 and 19 species, although they were often separated by sites that appeared to be equally diverse (up to 15 species) but did not include northern riffleshells (Smith and Crabtree 2005).

- Northern riffleshells have also been found in Conewango Creek in Warren County (an Allegheny River tributary), as well as in the lower reaches of two French Creek tributaries, Muddy Creek (Crawford County) and LeBoeuf Creek (Erie County). Due to the proximity of these populations to French Creek and the Allegheny River, they may represent extensions of the larger mainstem population rather than self-sustaining sub-populations.

In summary, northern riffleshells appear to be restricted to four successfully recruiting populations in the Ohio and St. Lawrence River Basins, specifically the East Branch Sydenham River, Allegheny River, French Creek, and Ausable River populations. The Elk River population is probably extant, but recruitment has not been documented recently. Since the species was listed as endangered, populations in Fish Creek, Detroit River, Green River, Big Darby Creek, and Tippecanoe River have undergone severe declines and recent surveys failed to locate living specimens. Although additional surveys are ongoing, northern riffleshells may have been extirpated from these systems.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation:

There are several freshwater mussels that have been described as subspecies, morphs, forms, or ecophenotypes within the *Epioblasma torulosa* complex *(e.g., cincinnatiensis, gubernaculum, rangiana, sampsoni, torulosa)*. Most of the locations from which these taxa originated no longer support *Epioblasma torulosa,* making the true relationships difficult or impossible to discern. Of the three *E. torulosa* subspecies currently recognized, the other two, the tubercled blossom (*E. torulosa torulosa*) and green blossom (*E. torulosa gubernaculum*), have not been seen alive, or freshly dead, in recent decades, and may be extinct.

David Zanatta (Royal Ontario Museum) and associates have been investigating the genetic structure of the northern riffleshell with a focus on determining the genetic relatedness of three of the remaining four reproducing populations. The data indicate that populations in the Allegheny River, French Creek, and the East Branch Sydenham River may have a relatively recent common ancestry (Zanatta and Murphy 2007). The post-glacial Allegheny River system is thought to have been a tributary to the St. Lawrence River system prior to being captured by the Ohio River system. This may explain the apparently close genetic relationship between northern riffleshells in the upper Ohio River and East Branch Sydenham River, despite being separated by a continental drainage divide.

Due to extreme rarity, no genetic samples could be obtained from populations further downstream in the Ohio River system. If extant, these populations may differ genetically from the three reproducing populations remaining to the north. The expression of genetic differences between northern populations centered on Lake Erie and those few remaining in the lower Ohio River may be found in the apparently more resilient nature of the northern populations.

2.3.1.4 Taxonomic classification or changes in nomenclature:

The name "*biloba*" may be a senior synonym for "*rangiana*" (Parmalee and Bogan 1998) and is sometimes used for this taxon.

2.3.1.5 Spatial distribution, trends in spatial distribution, or historic range:

The northern riffleshell is now sparsely distributed within a highly restricted range, although population numbers can be high in localized areas. Of 54 streams once known to be occupied by this species, only 4 show evidence of recruitment: two in the Allegheny River system (Allegheny River and French Creek, Pennsylvania), one in the East Branch Sydenham River, and one in the Ausable River (Ontario, Canada).

Populations in several rivers, including the Tippecanoe River, Detroit River, Fish Creek, Green River, Big Darby Creek, and Elk River, have undergone severe declines and may be near extirpation. A significant range contraction would occur with the loss of the northern riffleshell from these rivers, eliminating Indiana, Ohio, Michigan, Kentucky, and West Virginia from the species' range.

2.3.1.6 Habitat or ecosystem conditions:

The remaining recruiting northern riffleshell populations occur in medium to large rivers. In several streams, including the Green River, Big Darby Creek, Detroit River, and Elk River, extant northern riffleshell populations appear highly limited (a single stream reach, and a small number of individuals). Because northern riffleshells appear to be relatively short-lived – surviving only seven to 15 years (Rodgers *et al.* 2001, Crabtree and Smith 2007) – the presence of scattered live individuals suggests that recent successful recruitment has occurred. However, unknown limiting factors (*e.g.*, altered hydrology, siltation, or inherent demographic requirements of this species) may prevent a population increase.

Northern riffleshells, as the common name suggests, are typically associated with sections of river with higher water velocities. While this habitat description applies to some locations, the subspecies also occurred within the Lake Erie/Lake St. Clair system in deep, more slow-flowing water. Since 1999, populations have also been documented in deep, slow runs (down to 20 feet) in the Allegheny River, in both the free-flowing and impounded navigation channel, where limited flow and silt deposition are evident during low river discharge periods.

2.3.2 Five-factor analysis:

The listing rule and the 1994 recovery plan identified four primary factors responsible for the decline of northern riffleshell populations: siltation, impoundment, instream sand and gravel mining, and pollutants (USFWS 1994).

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

Ongoing threats to the northern riffleshell include water quality degradation from point and non-point sources, particularly in tributaries that have limited capability to dilute and assimilate sewage, agricultural runoff, and other pollutants. In addition, the species is affected by hydrologic and water quality alterations resulting from the operation of impoundments such as Union City Reservoir on French Creek and Kinzua Dam on the Allegheny River. The presence of impoundments may have ameliorated the effects of downstream siltation on northern riffleshell, but these structures also control river discharges (and the many environmental parameters influenced by discharge), which may profoundly affect the ability of these populations to occupy or successfully reproduce in downstream habitats.

A variety of instream activities continue to threaten northern riffleshell populations, including sand and gravel dredging, gravel bar removal, bridge construction, and pipeline construction. Protecting these populations from the direct physical disturbance of such activities depends on accurately identifying the location of the populations, which is difficult with a cryptic species such as the northern riffleshell. The indirect effects of altering the streambed configuration following instream disturbance can result in long-lasting alteration of streamflow patterns that may cause head-cutting and channel reconfiguration, thereby eliminating previously suitable habitat some distance from the disturbance.

Coal, oil, and natural gas resources are present in some of the watersheds known to support northern riffleshell, including the Allegheny and Elk Rivers. Exploration and extraction of these resources can result in increased siltation, a changed hydrograph, and altered water quality, even at a distance from the mine or well field. Northern riffleshell habitat in larger streams can be further threatened by the cumulative effects of multiple mines and well fields.

Land-based development near streams of occurrence, including residential development and agriculture, often results in loss of riparian habitat, increased stormwater runoff due to increased impervious surfaces, increased sedimentation due to loss of streamside vegetation, and subsequent degradation of streambanks. *Epioblasma*, including northern riffleshell, appear to be exceptionally sensitive to the increased siltation and associated turbidity caused by changing land use (Peacock *et al.* 2005).

Development has also increased the number of sewage treatment plants in drainages that support northern riffleshell and increased the amount of sewage discharged from existing plants. Mounting evidence indicates that freshwater mussels are more sensitive to several components of treated sewage effluent (*e.g.,* ammonia, chlorine, and copper) than are the typical organisms used to establish water quality criteria protective of aquatic life (*e.g.,* Newton, 2003). Small streams, such as LeBoeuf Creek, are particularly vulnerable to sewage effluent which can comprise a significant portion of the total stream flow.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Northern riffleshell is not a commercially valuable species. Nonetheless, the small number of remaining populations increases their vulnerability to over-zealous scientific collecting or

educational programs, and may increase their value for illegal trade by shell collectors.

2.3.2.3 Disease or predation:

Due to the relatively small size of northern riffleshell, several animals prey on this mussel, including muskrats, raccoons, otters, molluscivous fish, and some invertebrates. Such predation could locally reduce populations of northern riffleshell. This effect may be negligible in larger populations such as those in the Allegheny River, but it could represent a significant threat to small, isolated northern riffleshell populations located elsewhere.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

Coal, oil, and gas resources are present in a number of the basins where the northern riffleshell occurs, and extraction of these resources has increased dramatically in recent years, particularly in Pennsylvania and West Virginia. Although oil and gas extraction generally occurs away from the river, extensive road networks are required to construct and maintain wells. These road networks frequently cross or occur near tributaries, contributing sediment to the receiving waterway. In addition, the construction and operation of wells may result in the discharge of brine. Point source discharges are typically regulated; however, non-point inputs such as silt and other contaminants may not be sufficiently regulated, particularly those originating some distance from a waterway. In 2006, more than 3,700 permits were issued for oil and gas wells by the Pennsylvania Department of Environmental Protection, which also issued 98 citations for permit violations at 54 wells (Hopey 2007).

Regulated point sources may adversely affect the northern riffleshell. Freshwater mussels appear to exhibit more sensitivity to some pollutants than do the organisms typically used in toxicity testing. As a result, some of the water quality criteria established by the U.S. Environmental Protection Agency (EPA) to protect aquatic life may not be protective of mussels. For example, Augspurger *et al.* (2003) found that the current EPA numeric criteria for ammonia may not protect mussels. Consequently, even those sewage treatment plants that comply with their ammonia effluent limits at all times may still be discharging water that is toxic to unionids. Few substances have been tested for their toxicity to mussels, and none at all on northern riffleshell, so "safe" concentrations for this species are not yet known. In addition, states such as Pennsylvania allow mixing zones, or zones in which numeric water quality criteria can be exceeded.

Agriculture, and suburban and urban land uses continue to expand in many watersheds within the current range of the northern riffleshell. These land use changes alter runoff patterns and flow in this species habitat, and the consequences of such changes to these remaining populations are not known. Few regulatory mechanisms exist to address land use changes that may indirectly affect stream habitat far from the source of disturbance.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

As stated above, large populations appear to be necessary for the long-term conservation of this species. Below an as-yet-undetermined population density, mortality exceeds reproductive potential and the population may crash (Rodgers *et al.* 2001).

Zebra mussels have continued to spread in North American waterways since their accidental introduction in the 1980s. Large zebra mussel populations in Lake St. Clair, the Detroit River, and Lake Erie appear to have eliminated most native mussels from the areas colonized, including northern riffleshell, although the species may persist in refugia where habitat is less suitable for zebra mussels. In much of the remaining range of the northern riffleshell, zebra

mussels have not developed large populations outside of lakes and impoundments. The effect of large zebra mussel populations developing in headwater impoundments and lakes, upstream of northern riffleshell populations, is not known but could influence food availability or result in periodic zebra mussel population spikes downstream. Northern riffleshells occur in lower Allegheny River navigation pools 8 and 9, and perhaps further downstream. These navigation impoundments may provide suitable zebra mussel habitat, which may threaten northern riffleshells in these areas.

2.4 Synthesis

Three apparently large and recruiting populations occur in Allegheny River, French Creek, and East Branch Sydenham River. A fourth, smaller population in Ausable River has also recently (2006) been shown to be recruiting. Each of these populations is susceptible to both natural stochastic events, such as floods, and anthropogenic threats, such as toxic spills. Although northern riffleshells have been documented in one additional Allegheny River tributary (besides French Creek), and two French Creek tributaries, the species occurs in the lower reaches of these streams, and these occurrences may not be self-sustaining if the mainstem population is damaged.

In contrast to the recruiting populations, five northern riffleshell populations have declined since the species was listed as endangered in 1994, and some of these may be extirpated. Extirpated or nearly extirpated populations include the following: the Detroit River, following zebra mussel infestation; the Green River, possibly due to point and non-point inputs, and hydrologic controls on flow and temperature from Green River Reservoir; Big Darby Creek, as a result of urban and agricultural runoff; Fish Creek, following a 1993 diesel fuel spill; and the Tippecanoe River, where no living or freshly dead northern riffleshell have been observed since the 1970s. A few individual specimens have been reported from the Elk River in West Virginia; however, no evidence of recent successful reproduction has been reported from this stream. Although specific events are cited as causing the apparent loss of several northern riffleshell populations, these events likely worked in concert with other events that cumulatively reduced overall population levels to the extent that a single event could result in extirpation.

In many cases, diverse freshwater mussel populations persist where northern riffleshells have not. Like other *Epioblasma,* this species may be more sensitive to environmental perturbations than other mussel species. This could be because life history traits make recovery from a disturbance less likely than with other mussels, or because this species is more sensitive to silt and contaminants.

The large populations of northern riffleshell in Pennsylvania provide a potential source of animals to implement recovery actions described in the recovery plan. However, translocation and population augmentation will only work to the extent that historic habitat is now suitable. Because the reasons for the original decline of northern riffleshell have often not been identified, transferred animals may also not survive.

The northern riffleshell should continue to remain listed as *endangered* because the species has continued to decline, threats have not been ameliorated, and the criterion for downlisting to threatened has not been met. Declining populations and loss of habitat in the Ohio River basin are not compensated for by the locally abundant but geographically limited populations in Pennsylvania and Ontario. Numerous threats persist for the remaining northern riffleshell populations, including invasive species, habitat alteration, land-use changes, and point and non-point source pollution. The life history and environmental sensitivity of the subspecies are poorly known, increasing the threat that previously unidentified activities could cause a precipitous decline of one or more of the remaining reproducing populations. These unknowns also make it unlikely that the subspecies can be downlisted in the near future. In sum, our current understanding of the northern riffleshell's status leads us to conclude that this species continues to face a probability of extinction throughout its range, thereby meeting the definition of endangered under the Endangered Species Act.

3.0 RESULTS

3.1 Recommended Classification: Endangered; no change is needed.

Rationale: See section 2.4 above.

3.2 Recommended Recovery Priority Number: 6; no change recommended.

Rationale: A Recovery Priority Number of 6 indicates that the northern riffleshell is taxonomically categorized as a subspecies, has a high degree of threat, and low recovery potential. Despite an apparently healthy population in the Allegheny River system and East Branch Sydenham River, the listing as endangered appears to be appropriate because the criterion to downlist the species has not been achieved. An endangered classification is also appropriate, since, due to a variety of causes, there has been a decline, or complete loss, of more than half of the populations believed to be extant at the time of listing.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Recommendation: Revise recovery plan.

The northern riffleshell recovery plan is more than 10 years old, and a significant amount of information has since become available regarding threats to the essential recovery streams identified in the plan. A revised plan will assist local and State entities in planning watershed and ecosystem actions to recover habitat needed for eventual relocation efforts.

Recommendations for specific recovery actions:

The following recovery actions should be made a priority over the next 5 years:

1) Complete surveys of the Green River, Elk River, and Big Darby Creek to determine if northern riffleshell are still extant in these streams.

2) Identify and map activities or practices within each ecosystem that may affect the northern riffleshell and its host fish at known sites, and at potential augmentation/reintroduction sites.

3) Determine sensitivity of each life stage for major contaminants likely to be found in sewage, and runoff from urban and agricultural areas at known sites, and at potential augmentation and reintroduction sites.

4) If extant populations are found in Ohio River tributaries, undertake additional genetic studies to determine their relationship to Allegheny/Great Lakes populations and those remaining elsewhere in the Ohio River basin.

5) Captive holding of northern riffleshell may provide additional options for the species' recovery and re-establishment into historic habitat. Captive husbandry methods should be developed and an assessment of historic habitat completed to identify sites where northern riffleshell augmentation and re-establishment can be achieved.

6) Propagation and augmentation projects are advancing in Illinois, Ohio and Indiana. Kentucky and West Virginia have expressed interested in developing similar programs in the near future. These activities should be coordinated between the three Fish and Wildlife Service regions, and six states (including Pennsylvania which has the source population) to maximize the chance of success and reduce any adverse affects on existing populations.

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of Northern Riffleshell (*Epioblasma torulosa rangiana*)

Current classification: Endangered

Recommendation resulting from the 5-Year review: Retain endangered classification.

Review conducted by: Robert Anderson, Pennsylvania Field Office, State College, Pennsylvania

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 8-15-07

REGIONAL OFFICE APPROVAL

Regional Director, Region Five, Fish and Wildlife Service

Approve _____ Date 9/1/07

Cooperating Regional Director, Fish and Wildlife Service

X Concur ____ Do Not Concur

Approve _____ Date 12/10/07.

Cooperating Regional Director, Fish and Wildlife Service

X Concur ____ Do Not Concur

Signature _____ Date 11/27/07

acting Assistant Regional Director
Ecological Services

Appendix 1.

Northern riffleshell populations are presently known to occur (or possibly extant) in the following streams.

Basin	Population	Stream	Approximate Range	Status[1]
St. Lawrence River system	Lake St. Clair	East Branch Sydenham River	Lower and middle reaches, 17 sites	Recruitment documented; declining
	Lake Huron	Ausable River	Upper and middle reaches	Recruitment documented; declining
	Maumee River	Fish Creek	Last reported in early 1990's, 2-mile reach	Status unknown; possibly extirpated
	Detroit River	Detroit River	A freshly dead shells found in 2005	Status unknown; possibly extirpated
Ohio River	Green River	Green River	One to two freshly dead shells found in 1987 and 1989 at two sites	Status unknown; possibly extirpated
	Scioto River	Big Darby Creek	Last reported in early 1990's;	Status unknown; possibly extirpated; Augmentation project
	Allegheny River	Allegheny River	scattered over 66 miles – Warren, Forest, Venango, Clarion, Armstrong Counties	Successful recruitment at multiple sites; stable
		Conewango Creek	Near the confluence with the Allegheny River	A few live individuals found in 2005; no recruitment documented; status unknown
	French Creek	French Creek	Scattered over 60 miles -- Venango & Crawford Co.	Successful recruitment at multiple sites; stable
		LeBoeuf Creek	3-mile reach	Recruitment documented; stable
		Muddy Creek	1 site near the confluence with the French Creek	Peripheral to French Creek; status unknown
	Kanawha River	Elk River	Two freshly dead shells found in 2003 at one site	Status unknown; possibly extirpated
TOTALS	9 populations	12 streams	4 populations in 5 streams recruiting	