Species Status Assessment

Common Name: Snuffbox **Date Updated:** 3/12/2025

Scientific Name: *Epioblasma triquetra* **Updated By:** A. Mahar & K. Crandall

Class: Bivalvia

Family: Unionidae

Species Synopsis *(a short paragraph which describes species taxonomy, distribution, recent trends, and habitat in New York):*

The status of *Epioblasma triquetra* in New York is unknown. It had been thought to be extirpated from the state and was last found prior to the 1950s in Lake Erie at Bay View, Buffalo Creek, and the Niagara River. One recently dead shell was found in 1999, and two weathered shells were found in 2017-2018 in a tributary to the Niagara River. It is possible that further surveys will find small populations in larger tributaries of Lake Ontario and the Niagara River, as well as in the Allegheny basin (Strayer & Jirka 1997). This species was removed from the New York Species of Greatest Conservation list in 2015 but reinstatement should be considered based on these recent findings.

E. *triquetra* is the most widespread species of the Epioblasma family (Williams et al 2008). This species is listed as state and federally endangered and is ranked by The Natural Heritage Program as historic in New York and as imperiled throughout its range.

I. Status

a. Current legal protected Status

i. **Federal:** Endangered **Candidate:** ______

ii. **New York:** Not Listed

b. Natural Heritage Program

i. **Global:** G2G3 – Imperiled / Vulnerable (NatureServe, 2023)

ii. **New York:** SH – Possibly Extirpated **Tracked by NYNHP?:** Yes

Other Ranks:

-New York 2025 SGCN status: Species of Greatest Conservation Need

-IUCN Red List: Endangered (2015)

-Northeast Regional SGCN: Yes (2023)

-Midwest Regional SGCN: Yes

-Committee on the Status of Endangered Wildlife in Canada (COSEWIC): Endangered (2011)

-American Fisheries Society Status: Threatened (1993)

-Species of Regional Northeast Conservation Concern (Therres 1999)

Status Discussion:

This North American species is declining throughout its widespread range and has become increasingly rare, with 83 streams with extant populations in 15 states/provinces, compared with a historical 211 streams across 19 states/provinces (USFWS, 2022). Distribution is greatly fragmented but remains relatively wide. Long-term viability of most populations is questionable, especially those in large rivers where zebra mussel populations are now established. The degree of decline has not been established (NatureServe 2013).

II. Abundance and Distribution Trends

Region	Present?	Abundance	Distribution	Time Frame	Listing status	SGCN?
North America	Yes	Declining	Declining			Yes
Northeastern US	Yes					Yes
New York	Unknown	Unknown	Unknown		SH	No
Connecticut	No	N/A	N/A			No
Massachusetts	No	N/A	N/A			No
New Jersey	No	N/A	N/A			No
Pennsylvania	Yes	Unknown	Unknown		Endangered, S2	Yes
Vermont	No	N/A	N/A			No
Ontario	Yes	Stable	Stable	2003-2013	Endangered, S1	(blank)
Quebec	No	N/A	N/A			(blank)

Column options
Present?: Yes; No; Unknown; No data; (blank) or Choose an Item
Abundance and Distribution: Declining; Increasing; Stable; Unknown; Extirpated; N/A; (blank) or Choose an item
SGCN?: Yes; No; Unknown; (blank) or Choose an item

Monitoring in New York *(specify any monitoring activities or regular surveys that are conducted in New York):*

As part of a State Wildlife Grant, NYSDEC Region 8 Fish and Wildlife staff conducted a native freshwater mussel baseline inventory of tributaries in central and western New York, 2009 to 2020.

Trends Discussion *(insert map of North American/regional distribution and status):*

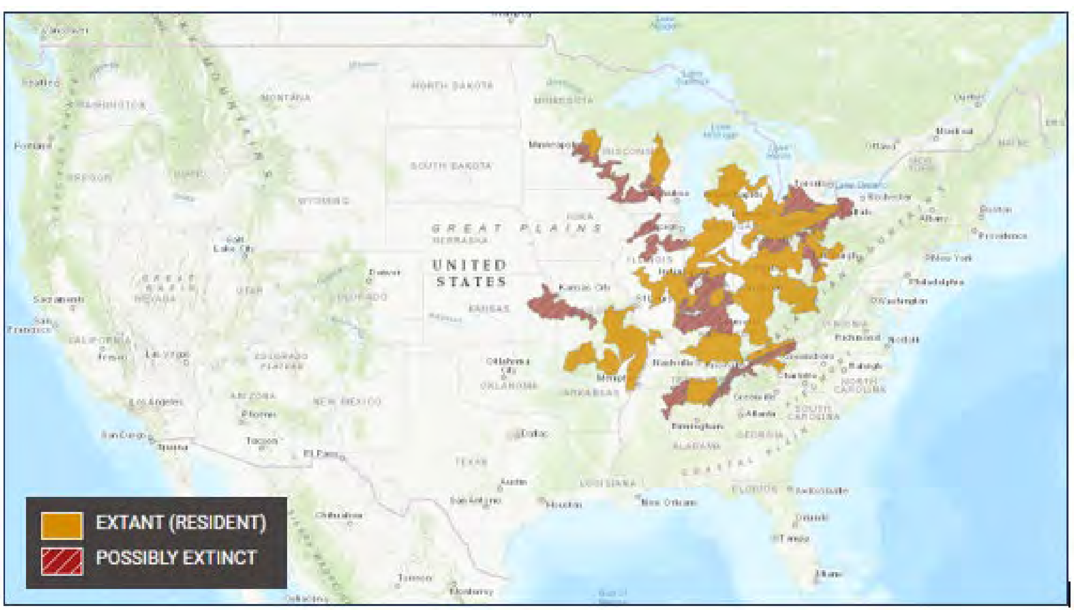

Figure 1. Snuffbox distribution (IUCN Redlist 2024)

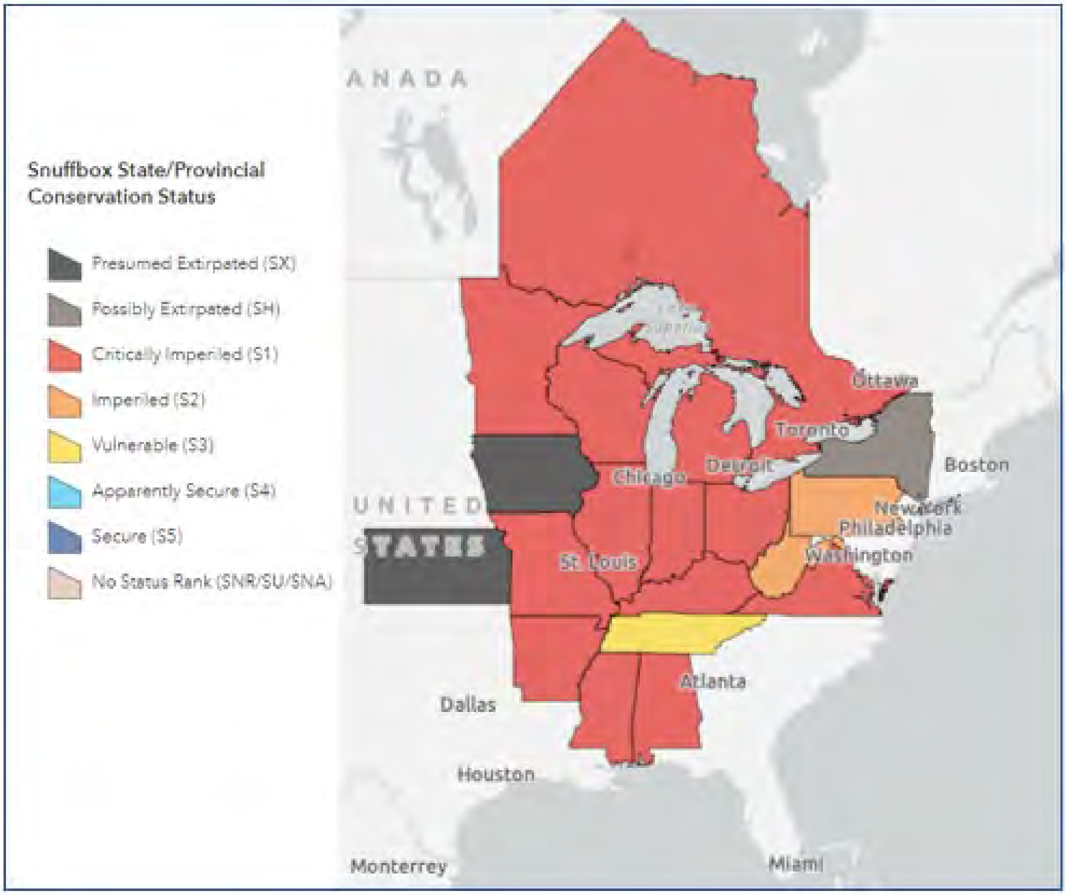

Figure 2. Snuffbox status (NatureServe 2024)

III. New York Rarity *(provide map, numbers, and percent of state occupied)*

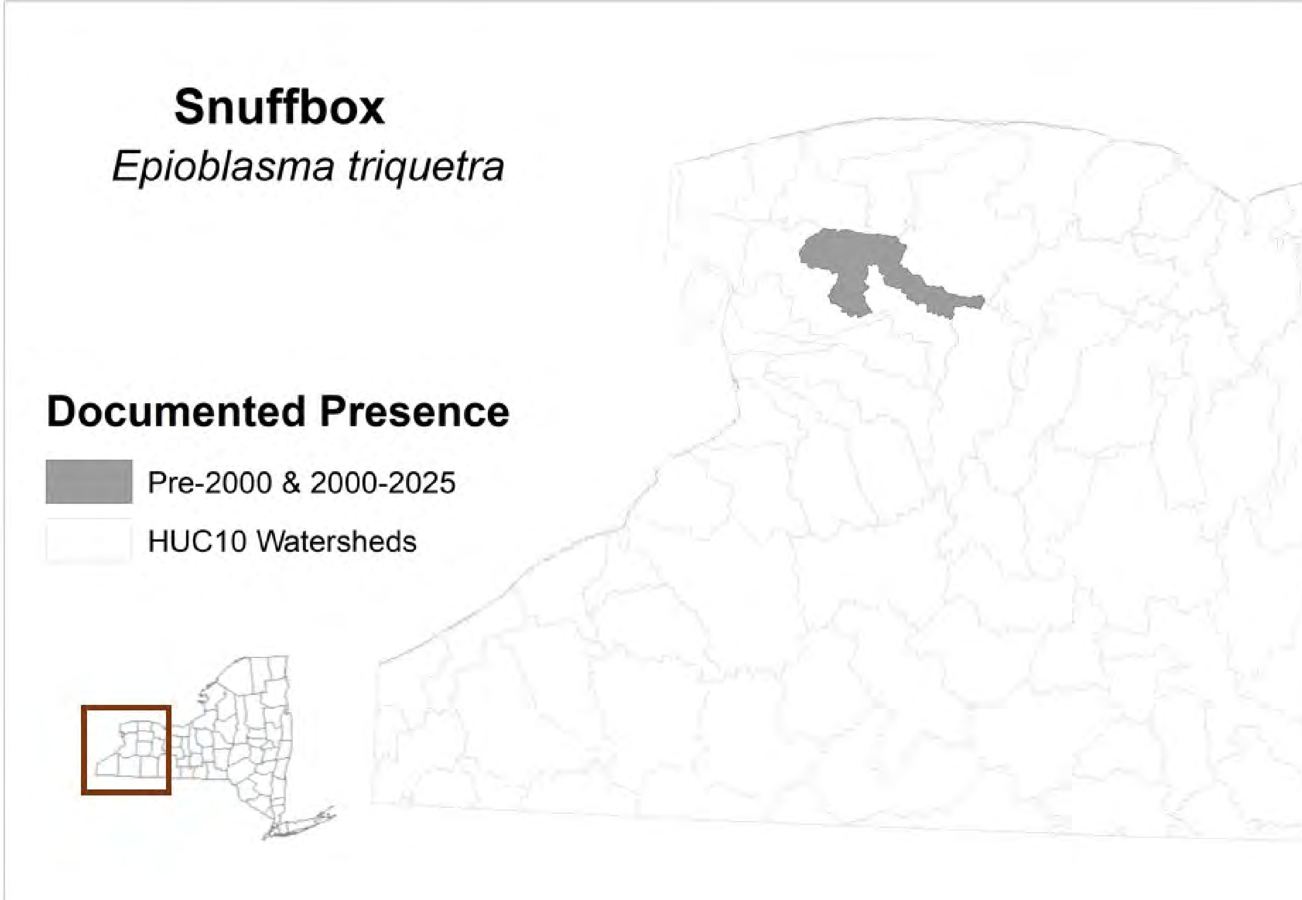

Figure 3. Records of snuffbox in New York (NYSDEC 2022)

Years	# of Distinct Waterbodies	% of State
Total	1	0.1%

Table 1. Records of snuffbox in New York.

Details of historic and current occurrence:

New York *E. triquetra* has been collected from Lake Erie at Bay View, Buffalo Creek, and the Niagara River. All of these collections were made prior to 1950 (Strayer & Jirka 1997).

Shells of this species were found in 1999 and 2017-2018 in tributary to the Niagara River, indicating that an extant population may still exist in New York. The shells were found in 2 of New York's 1802 HUC 12 watersheds (0.1%). There are no recent live occurrences of this species in New York (Strayer & Jirka 1997, The Nature Conservancy 2009, Harman and Lord 2010, White et al. 2011, Mahar and Landry 2013, NY Natural Heritage Program 2013, NatureServe 2013). Strayer and Jirka (1997) recommend searching for this species in the Niagara River and the larger tributaries of Lake Ontario and the Niagara River. It should also be sought in the Allegheny basin, as it has been found in Pennsylvania only a few kilometers south of the New York border.

New York's Contribution to Species North American Range:

Percent of North American Range in NY	Classification of NY Range	Distance to core population, if not in NY
1-25%	Peripheral	350 miles

Column options
Percent of North American Range in NY: 100% (endemic); 76-99%; 51-75%; 26-50%; 1-25%; 0%; Choose an item
Classification of NY Range: Core; Peripheral; Disjunct; (blank) or Choose an item

IV. Primary Habitat or Community Type *(from NY crosswalk of NE Aquatic, Marine, or Terrestrial Habitat Classification Systems):*

a. **Size/Waterbody Type:** Medium River

b. **Geology:** Moderately Buffered

c. **Temperature:** Warm

d. **Gradient:** Low Gradient

Habitat or Community Type Trend in New York

Habitat Specialist?	Indicator Species?	Habitat/ Community Trend	Time frame of Decline/Increase
Yes	Yes	Unknown	Unknown

Column options
Habitat Specialist and Indicator Species: Yes; No; Unknown; (blank) or Choose an item
Habitat/Community Trend: Declining; Stable; Increasing; Unknown; (blank) or Choose an item

Habitat Discussion:

E. triquetra is typically a medium to high water quality species (Watters et al. 2009). It is chiefly found in medium-sized to large rivers in shallow riffles (depths of 2 inches to 2 feet) with clear, swift-flowing water and firm coarse sand and gravel substrates (Metcalfe-Smith et al. 2005, Cummings and Mayers 1992, McMurray et al. 2012, Parmalee and Borgan 1998, Watters et al. 2009, Spoo 2008). However, there is some evidence that it occurs most frequently in clear, hydrologically stable, low-gradient streams (Strayer & Jirka 1997). It has also been found in some lakes (i.e., Lake Erie) (Strayer & Jirka 1997) and impoundments, but this is probably not a preferred habitat (Watters et al. 2009). This species typically buries itself deeply in the substrate (Strayer and Jirka 1997, McMurray et al. 2012, Watters et al. 2009, Metcalfe-Smith et al. 2005, Williams et al. 2008), a characteristic that makes it harder to detect than other Unionid species.

V. Species Demographic, and Life History:

Breeder in NY?	Non-breeder in NY?	Migratory Only?	Summer Resident?	Winter Resident?	Anadromous/ Catadromous?
Unknown	No	No	Unknown	Unknown	(blank)

Column options
First 5 fields: Yes; No; Unknown; (blank) or Choose an item
Anadromous/Catadromous: Anadromous; Catadromous; (blank) or Choose an item

Species Demographics and Life History Discussion *(include information about species life span, reproductive longevity, reproductive capacity, age to maturity, and ability to disperse and colonize):*

Upstream males release sperm into the water. Females downstream take up the sperm with incoming water. Fertilization success may be related to population density, with a threshold density required for any reproductive success to occur. Eggs are fertilized within the female. Like nearly all North American mussels, this species must parasitize an often-specific vertebrate host to complete its life cycle. It is suspected that some mussel populations are not recruiting because their hosts no longer occur with them. Once released by the female, glochidia must acquire a suitable host or die, usually within 24-48 hours. After attaching to a suitable host, glochidia encyst, usually at the fish's gills or fins and receive food and dispersal. Once the glochidia metamorphose into juveniles, they drop from the host. If they land in suitable substrate, they will burrow into the substrate, where they may remain for several years (Watters et al. 2009). *E. triquetra*, in particular, has a rather drastic approach to parasitizing its host fish. The female specimens entrap the snout of the host fish in the shell. It then releases the glochidia directly through the gills of the host fish (Barnhart et al. 1998). This type of behavior limits this species' host fish selection to only those that can survive the encounter long enough for the glochidia to develop (Zanatta 2009).

In the adult form, freshwater mussels are basically sessile; movement is limited to a few meters of the lake or river bottom. The only time that significant dispersal can take place is during the parasitic phase. Infected host fishes can transport the larval unionids into new habitats and can replenish depleted populations with new individuals. Dispersal is particularly important for genetic exchange between populations. Dispersal is likely to be a slow process for mussels which use resident fishes with limited home ranges as their hosts (COSEWIC as cited in NaturesServe 2013).

This species is bradytictic, with eggs present in early September, glochidia forming in mid-September, and glochidia overwintering on the female until the following April or May. Individuals older than 15 years are rare (Watters et al. 2009). *E. triquetra* glochidia have been reported to transform on black sculpin (*Cottus baileyi*), mottled sculpin (*Cottus bairdi*), banded sculpin, (*Cottus carolinae*), Ozark sculpin (*Cottus hypselarus*), blackspotted topminnow (*Fundulus olivaceous*), logperch (*Percina caprodes*), blackside darter (*Percina maculata*), and Roanoke darter (*Percina roanoka*) (Watters et al. 2008).

VI. Threats *(from NY 2015 SWAP or newly described):*

Dams
Dams affect both upstream and downstream mussel populations by disrupting natural river flow patterns, scouring river bottoms, changing water temperatures, and eliminating habitat. Adapted to living in flowing water, the snuffbox cannot survive in the lakes or slow water created by dams. Snuffbox mussels depend on host fish to move upstream. Because dams block fish passage, they also prevent mussels from moving upstream, isolating downstream mussels from upstream populations. This fragmentation leads to small, unstable populations that easily die out.

Pollution
Adult mussels, because they are sedentary (meaning that they tend to stay in one place), are easily harmed by toxins and poor water quality caused by pollution. Pollution may come from specific, identifiable sources such as accidental spills, factory discharges, sewage treatment plants and solid waste disposal sites or from diffuse sources like runoff from cultivated fields, pastures, cattle feedlots, poultry farms, mines, construction sites, private wastewater discharges, and roads. Contaminants may directly kill mussels, but they may also reduce water quality, affect

the ability of surviving mussels to have young, or result in lower numbers or disappearance of host fish.

Sedimentation
Although sedimentation is a natural process, poor land use practices, dredging, impoundments, intensive timber harvesting, heavy recreational use, and other activities accelerate erosion and increase sedimentation. Sediment that blankets a river bottom can suffocate mussels. Accelerated sedimentation may also reduce feeding and respiratory ability for snuffbox mussels, leading to decreased growth, reproduction, and survival.

Nonnative Species
The invasion of the nonnative zebra mussel into the U.S. poses a serious threat. Zebra mussels proliferate in such high numbers that they use up food resources and attach to native mussel shells in such large numbers that the native mussel cannot eat or breath. In free-flowing, relatively shallow rivers, zebra mussels do not appear to be as devastating to native mussels as they are in impounded rivers or lake environments. Some species have even been shown to be recovering beyond pre-zebra mussel invasion levels, while others have been effectively eliminated from the western basin of Lake Erie by these exotics (Strayer 2009). Another invasive species, the round goby, is a nonnative fish species that may displace native host fish species, thus reducing the ability of the snuffbox to reproduce (USFWS Snuffbox Factsheet, January 2012). In a recent study performed by Schwalb et al. in 2011, a log perch (*Percina caprodes)*, a known obligate host fish for *E. triquetra* population was studied by its dispersal potential. This study found that *P. caprodes* remain in a small area, which could restrict the dispersal and/or (re)colonization of *E. triquetra*, which may explain why the species populations are unable to rebound quickly from a sharp decline.

General threats to mussels that are likely relevant range wide:

Impoundments – Range wide
Range wide, impoundments likely contributed to the reduced distribution of mussels that we see today. Vaughn and Taylor (1999) observed a mussel extinction gradient with a gradual, linear increase in mussel species richness and abundance with increasing distance downstream from impoundments. Species and their hosts that require shallow, oxygenated, fast-flowing water quickly are eliminated. Continuously cold water from both increased water depth upstream of the dam and dam discharges downstream of the dam may prevent reproduction. Impoundment increases silt load and eutrophication, resulting in changes in the fish fauna, and therefore the availability of hosts. Dams represent distributional barriers to fish hosts, and therefore to the mussels themselves. The zoogeographic patterns of several species suggest a dam-limited range. Dams also act as sediment traps, often having many feet of silt and debris caught on their upstream side. These areas generally are without mussels. Below the dam, the tailwaters often have dense mussel beds, as these reaches are the only areas left that still have oxygenated, fast moving water. This is exemplified by the distribution of beds in the lower Muskingum River, Ohio (Stansbery & King 1983; ESI 1993c).

In addition, improperly sized and poorly installed or poorly maintained culverts have impacts similar to dams in that they fragment habitat, preventing the movement by host fish, and effectively isolating mussel populations. And because culverts are located at nearly every road-stream intersection, there is the potential for landscape level fragmentation of mussel habitat.

Agricultural Runoff
Aquatic habitats lacking vegetated buffers of adequate width are threatened by runoff from urban areas, roads, lawns, and agricultural land (Gillis 2012). If best management practices are not closely adhered to, mussel habitat adjacent to wood harvest or agricultural land is subjected to

pesticide, fertilizer, and silt/sediment runoff. During recent mussel surveys in Western and Central New York, it has been documented that sufficient vegetated riparian buffers are often lacking along known mussel streams (Mahar & Landry 2013), indicating that runoff is a major threat to resident mussel populations.

The presence of pesticides and fertilizers in our rural watersheds is nearly ubiquitous (Haag 2012). And because pesticides and their associated surfactants adsorb onto sediment particles, sedimentation may act as a vector for their transport into the aquatic system (Haag 2012). Mussels are more sensitive to pesticides than many other animals (Watters et al. 2009). Although effects of pesticides are species-specific, sub-lethal levels of PCBs, DDT, malathion, and other compounds inhibit respiratory efficiency and accumulate in the tissues. Atrazine and permethrin at sublethal concentrations reduced juvenile growth (Bringolf et al. 2007a, 2007b) and environmental levels of atrazine altered mussel movement and aggregation behavior (Flynn and Spellman 2009). Pesticides can affect mussels in many ways, but the full range of long-term effects remains unknown (Haag 2012).

Fertilizer runoff is also a concern. High inputs of nitrogen from fertilizers can cause increases in ammonia in the water and the substrate, leading to direct toxicity for a wide range of mussel species. Mussels, especially in their early life stages, are more sensitive to un-ionized ammonia than other organisms, and high sensitivity is seen across a range of species and life histories (Haag 2012). In addition, ammonia adsorbs to sediment particles, resulting higher nitrogen concentrations in the substrate than in the overlying water. The nitrogen present in the interstitial spaces in the substrate is thought to result in juvenile mortality and to prevent recruitment by some mussel species (Strayer and Malcom 2012). Studies have suggested decreasing sediment loads entering aquatic systems as the best way to decrease the impact of numerous stressors for mussels in general (Roley et al. 2012).

Treated and Untreated Wastewater

Recent studies show that mussel richness and abundance decreases with increased proximity to sewage effluent (Wildenberg 2012). The input of biomaterial from wastewater treatment plants depletes dissolved oxygen levels, negatively impacting mussels. Ammonia from wastewater treatment plants has been found to be toxic to glochidia (Goudraeu et al. 1993) and at sub-lethal exposure, adult mussels exhibit decreased respiratory efficiency (Anderson et al. 1978). Endocrine disrupters from pharmaceuticals also originate from municipal sewage effluents and are increasing common in rivers and lakes (Haag 2012). In mussels, chronic exposure to estrogenic compounds in effluents caused feminization of male mussels, but these individuals did not produce eggs, suggesting major disruption of reproductive function (Gagne et al. 2011). The long-term effects of these compounds on mussels are unknown (Haag 2012).

Runoff from Developed Land

Developed lands are likely sources runoff containing metals and road salts.
Mussels are particularly sensitive to heavy metals, more so than many other animals used in toxicological tests (Keller & Zam 1991). Low levels of metals may interfere with the ability of glochidia to attach to the host (Huebner & Pynnonen 1992), suggesting that U.S. EPA ambient water quality criteria may not adequately protect mussels from toxic metals (Wang et al. 2011). In addition, increases in salinity from the runoff of salt used for clearing roads in winter may be lethal to glochidia and juvenile mussels (Keller & Zam 1991; Liquori & Insler 1985; Pandolfo et al. 2012). Based on these studies, the U.S. EPA's ambient water quality criterion for acute chloride exposures may not be protective of all freshwater mussels (Pandolfo et al. 2012).

Invasive Species

Invasive zebra and quagga mussels (*Dreissena polymorpha* and *Dreissena bugenis*) have been repeatedly cited as a threat to native mussel populations (Strayer & Jirka 1997; Watters et al. 2009). En masse, Dreissenids outcompete native mussels by removing food and oxygen from the water. They can also reduce reproductive success by filtering native mussel male gametes from the water column. They can foul the shells of the native mussels to the point that their valves can no longer open. In heavily invested areas, they may transform a habitat by hardening the substrate, such that dislodged mussels are not able to rebury (USFWS 1994). In addition, ammonia from Asian clam die offs has been shown to be capable of exceeding acute effect levels of some mussel species (Cherry et al. 2005). Didymo (*Didymosphenia geminata*), a filamentous diatom, can form extensive mats that can smother stream bottom and occlude habitat for mussels (Spaulding & Elwell, 2007).

Climate Change

Global climate change is expected (among other disruptions) to cause an increase in surface water temperatures. Although many species are tolerant of warm water, higher water temperatures may be an added stress for some. Increased water temperatures may also increase algal growth, which could result in reductions in dissolved oxygen levels at night (Morris & Burridge 2006). Galbraith et al. (2010) recently showed how regional climate patterns coupled with changing local water regimes and management strategies have shifted mussel populations from thermally sensitive species to thermally tolerant species.

In addition, warmer stream temperatures due to the combined effects of land use, such as removal of shaded buffers, and climate change may contribute to the loss of coldwater fisheries and mussel populations in some watersheds (Nedeau 2008). Temperature induced changes in fish communities could have a profound influence on the availability of hosts for freshwater mussels. Mussels that inhabit small streams and rivers and rely on fish adapted for cooler water might be most affected by climate change (Nedeau 2008).

Habitat Modifications

Ecosystem modifications, such as in-stream work associated with canal, navigational channel, or flood control dredging, bridge replacements, gravel mining, and vegetation removal kill mussels and destroy their habitat. For example, dredging for vegetation removal has been shown to remove up to 23% of mussels in spoils (Aldridge 2000). Further evidence for disruption was provided by mussel surveys adjacent to approximately 20 river miles of Conewango Creek that had been channelized and straightened in the first half of the 20th century. The resulting “dredge” had no riffle or run habitat and sites just below and above this channelized section contained few or no mussels (The Nature Conservancy 2009). Although limited in geographic scope these habitat modification activities have long term impacts on mussels and their distribution (Aldridge 2000). Seasonal draw downs of water bodies have been shown to impact unionid age distributions (Richardson et al. 2002).

Levees and flood walls confine larger rivers, preventing the river from inundating its natural floodplains and wetlands to minimize flood damage. Additionally, many smaller streams have been channelized and bermed by landowners and highway departments to protect farm fields and other structures. Channelization and dredging associated with flood control projects are catastrophic to mussels and have been implicated in the decline of some populations (Watters et al. 2009). The result of these projects is altered seasonality of flow and temperature regimes, increased stream velocities, unstable substrates, changed patterns of sediment scour and deposition, including streambank erosion, altered transport of particulate organic matter (the food base for mussels), and a general degradation of stream habitat (Benke 1999; Yeager 1993; Nedeau 2008).

Oil and Gas Extraction

Oil and gas exploration and extraction present numerous threats to freshwater mussels NatureServe 2023; USFWS 2022). These activities can result in exposure to heavy metal and chemical pollutants from accidental spills, discharges, and increased sedimentation. Discharge of wastewater can introduce chlorides and other chemicals into the water system, which are acutely toxic to freshwater mussels (**Patnode et al., 2015**). During pipeline construction, excess sedimentation can result from bank slippage, trenching, construction of access roads, and well pads (**Ellis 1936, Anderson & Kreeger 2010).** These suspended sediments and contaminants can result in mortality and sublethal effects on feeding processes and habitat quality for mussels (**USFWS, 2022)**

Threat Level 1	Threat Level 2	Threat Level 3	Spatial Extent	Severity	Immediacy	Trend	Certainty
3. Energy Production & Mining	3.3 Renewable Energy	3.3.1 Hydroelectric dams	Large	Moderate	Near-term	Intensifying	High
3. Energy Production & Mining	3.1 Oil & Gas Drilling	Choose an item.	Small	Moderate	Long-term	Past or lessening	Moderate
4. Transportation & Service Corridors	4.1 Roads & Railroads	4.1.3 Bridges	Restricted	Slight	Immediate	Stable and ongoing	Low
7. Natural System Modifications	7.2 Dams & Water Management/Use	7.2.1 Water level management using dams	Large	Moderate	Near-term	Intensifying	High
7. Natural System Modifications	7.2 Dams & Water Management/Use	7.2.3 Water management using culverts	Large	Slight	Long-term	Unknown	High
7. Natural System Modifications	7.3 Other Ecosystem Modifications	7.3.3 Natural erosion & sedimentation	Large	Moderate	Near-term	Intensifying	High
8. Invasive & Other Problematic Species	8.1 Invasive Non-Native Plants & Animals	8.1.3 Aquatic animals	Large	Extreme	Near-term	Stable and ongoing	High
8. Invasive & Other Problematic Species	8.5 Intrinsic Biological Limitations	8.5.1 Loss of genetic diversity	Large	Moderate	Long-term	Intensifying	High
9. Pollution	9.1 Domestic & Urban Wastewater	9.1.1 Domestic wastewater	Small	Moderate	Near-term	Unknown	High
9. Pollution	9.1 Domestic & Urban Wastewater	9.1.2 Runoff	Restricted	Moderate	Near-term	Unknown	Moderate
9. Pollution	9.3 Agricultural & Forestry Effluents	9.3.2 Soil erosion, sedimentation	Large	Extreme	Near-term	Unknown	High
9. Pollution	9.3 Agricultural & Forestry Effluents	9.3.3 Herbicides & pesticides	Restricted	Moderate	Near-term	Unknown	Moderate

11. Climate Change	11.3 Changes in Temperature Regimes	11.3.3 Gradual temperature change	Large	Moderate	Long-term	Intensifying	Low
11. Climate Change	11.3 Changes in Temperature Regimes	11.3.4 Increase in temperature fluctuations	Large	Moderate	Long-term	Intensifying	Low

Table 2. Threats to Snuffbox.

Are there regulatory mechanisms that protect the species or its habitat in New York?

Yes: ✓____ **No:**_____ **Unknown:**_____

If yes, describe mechanism and whether adequate to protect species/habitat:

In February 2012, the U.S. Fish and Wildlife added the snuffbox to the list of endangered species giving the species full protection under the Endangered Species Act. The ESA provides protection against practices that kill or harm the species and requires planning for recovery and conservation actions.

Mussel habitats receive some generic protection under several New York State regulations (NYCRR) promulgated under the authority of the New York Environmental Conservation Law (ECL), specifically Part 608 of the NYCRR: Use and Protection of Waters, and Part 617 of the NYCRR: State Environmental Quality Review (SEQR). Part 608 provides protection of some mussel habitats by regulating and requiring environmental review of the modification or disturbance of any "protected stream", its bed or bank, and removal of sand, gravel or other material from its bed or banks (608.2 Disturbance of Protected Streams). This does not provide adequate protection of mussels and their habitats as it only protects streams or particular portions of a streams for which there has been adopted by NYSDEC or any of its predecessors any of the following classifications or standards: AA, AA(t), A, A(t), B, B(t) C(t), or Streams designated (t)(trout) also include those more specifically designated (ts)(trout spawning). Mussels habitats may also receive some additional protections as the construction, repair, breach or removals of dams, and the excavation and placement of fill in navigable waters are subject to regulation and environmental review under Part 608, 608.3 and 608.5 respectively. Under Part 608, projects requiring a permit can be conditioned by NYSDEC to include best management practices, such as sediment and erosion protections. Through the review process, these projects can also be modified to reduce impacts in order to meet permit issuance standards.

Under Part 608, protection of unlisted species of mussels is general and relatively limited. More importantly, Class C and D waters with mussels do not receive protection under these regulations. A significant portion of the New York's mussel resources occur within Class C and D waters. An additional but not insignificant gap in protection occurs because agricultural activities consisting of the crossing and re-crossing of a protected stream by livestock or wheeled farming equipment normally used for traditional agricultural purposes or of withdrawing irrigation water in a manner which does not otherwise alter the stream, are exempt from these regulations and environmental review.

Water quality certifications required by Section 401 of the Federal Water Pollution Control Act, Title 33 United States Code 1341(see subdivision (c) of this Section) may provide protection for freshwater mussels and their habitats from some activities that would potentially have adverse impacts by regulating construction or operation of facilities that may result in any discharge into navigable waters. Water quality certifications set water quality-related effluent limitations, water quality standards, thermal discharge criteria, effluent prohibitions and pretreatment standards for projects on navigable waters.

The State Environmental Quality Review (SEQR, Part 617 NYCRR) may also protect mussels and their habitats by requiring the consideration of environmental factors into the existing planning, review and decision-making processes of state, regional and local government agencies for activities that require discretionary approval. SEQR requires the preparation of an Environmental Impact Statement, including an alternatives analysis, for those activities that may result in a substantial adverse change in ground or surface water quality; a substantial increase in potential for erosion, flooding, leaching or drainage problems; the removal or destruction of large quantities of vegetation or fauna; substantial interference with the movement of any resident or migratory fish or wildlife species; impacts on a significant habitat area; substantial adverse impacts on a threatened or endangered species of animal or plant, or the habitat of such a species; other significant adverse impacts to natural resources; or, a substantial change in the use, or intensity of use, of land including agricultural, open space or recreational resources, or in its capacity to support existing uses.

New York State has numerous laws and regulations that both directly or indirectly protect waters of the state (mussel habitats) including regulations governing direct discharges to surface and groundwater, storm water, agricultural activities, pesticides, flood control, and dams. Without these regulations, mussels would certainly be in worse shape; however, most of these generic protections are not adequate in scope or specific enough to mussel threats to protect the mussel resources of New York State.

Describe knowledge of management/conservation actions that are needed for recovery/conservation, or to eliminate, minimize, or compensate for the identified threats:

- Assess the need and opportunity for relocation/reintroduction efforts. Conduct relocation or reintroduction where adequate sources can be identified and appropriate stream conditions exist (water quality, habitat, host species etc).

- Evidence of historic occurrence of multiple New York State extirpated mussel species exists for the Niagara River. These species include: *Epioblasma triquetra, Lampsilis teres, Lampsilis abrupta, Obovaria olivaria, Potamilus capax*, *Quadrula pustulosa*, *Quadrula quadrula, Simpsonaias ambigua,* and possibly *Truncilla donaciformis*. To assess the potential for future reintroduction efforts, a pilot program relocating common species to suitable sections of the Niagara River should be initiated and its results assessed to gauge the possible success of reintroduction efforts for extirpated species in this waterbody.

- Through landowner incentive programs or regulation, riparian buffers, particularly those that also provide shade, should be added/maintained/widened, along agricultural fields, subdivisions, and along major roads to decrease the levels of nitrogen, pesticides, sediment, heavy metals, and salts from entering these aquatic systems, as well as to moderate water temperature. Studies have suggested decreasing sediment loads entering aquatic systems as the best way to decrease the impact of numerous stressors for mussels in general (Roley & Tank 2012).

- Require all state agencies to maintain appropriate vegetative buffers along streams, rivers and lakes on state-owned or state managed properties.

- Following any reintroduction efforts, develop and implement a comprehensive monitoring strategy that identifies protocols, including locations and specific intervals, for regular monitoring of known mussel populations to detect assess trends and detect dangerous declines.

- Update wastewater treatment facilities in Buffalo to eliminate combined sewer outflows.

- Coordinate with local wastewater treatment facilities to improve ammonia removal of treated discharge. This has been documented as a threat to Unionids at multiple life stages, and therefore needs to be addressed (Gillis 2012).

- Mussel sensitivity to particular pollutants should be considered or addressed in the regulation of wastewater and stormwater discharges to groundwater and surface waters, State Pollutant Discharge Elimination Systems (SPDES). This should be reflected in effluent limitations for discharges, including discharges from P/C/I facilities (Private/Commercial/Industrial), CAFO facilities (Concentrated Animal Feeding Operations), High Volume Hydraulic Fracturing Discharges, and Wastewater treatment plants, etc. Discharges whose receiving waters have mussels, particularly those with known populations of mussels listed as Endangered, Threatened, Special concern or SGCN, should be carefully reviewed for potential impacts to mussels. For example, deleterious levels of ammonia (a component of many types of discharges) and molluscicides (a commonly used water treatment chemical in discharged water) should not be permitted.

- Within the Great Lakes watersheds, lamprey control efforts should consider specific, potentially adverse, impacts to native freshwater mussels when determining methods, including selection of lampricide formulations and concentrations. Lampricide treatment managers should use caution when using the combination of TFM and niclosamide in streams with known mussel populations and every effort should be made to maintain lampricide concentrations at or near the MLC for sea lamprey to minimize the risk to this important faunal group (Boogaard 2006).

- NYSDEC should consider sensitivity of freshwater mussels to specific pollutants in the establishment and setting of water quality standards and TMDLs for waters containing freshwater mussels. A Total Maximum Daily Load (TMDL) specifies the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. TMDLs account for all contributing sources (e.g. point & nonpoint sources, and natural background levels), seasonal variations in the pollutant load, and incorporate a margin of safety that accounts for unknown or unexpected sources of the pollutant. In essence, a TMDL defines the capacity of the waterbody to absorb a pollutant and still meet water quality standards. The Clean Water Act requires states to identify waterbodies that do not meet water quality standards after application of technology-based effluent limitations. For these "impaired waters," states must consider the development of alternative strategies, including TMDLs, for reducing the pollutants responsible for the failure to meet water quality standards.

Action Category	Action	Description
A.1 Direct Habitat Management	A.1.2.4.1 Plant for erosion management	Implement riparian buffers to reduce sedimentation
A.1 Direct Habitat Management	A.1.3.0.0 Mitigate human environmental impact	Mitigations should be focused on the tributaries into the Niagara River, near Buffalo, NY
A.1 Direct Habitat Management	A.1.3.3.0 Remove and improve anthropogenic infrastructure	Update wastewater treatment facilities in Buffalo
B.3 Outreach	B.3.1.3.0 Targeted Communication	Coordinate with local wastewater treatment to improve ammonia removal in treated discharge

Action Category	Action	Description
C.6 Design and Plan Conservation	C.6.5.1.2 Develop a strategy, guideline, monitoring plan or follow-up in a protected area	Develop a plan to monitor mussel population trends
C.7 Legislative and Regulatory Framework or Tools	C.7.1.3.0 Create, amend, or influence regulation	Require state agencies to maintain vegetative buffers along water on state land
C.7 Legislative and Regulatory Framework or Tools	C.7.2.3.0 Create or amend standards	Implement TMDLs to meet water quality standards
C.8 Research and Monitoring	C.8.1.1.1 Characterization, demographic study, population, or inventory	Conduct baseline surveys near where the shell was found to locate extant population
C.8 Research and Monitoring	C.8.1.1.2 eDNA detection	Utilize eDNA to detect extant populations that may be difficult to locate with physical surveys
C.8 Research and Monitoring	C.8.2.1.2 Monitoring and evaluating the results of project activities	Monitor lampricide treatment sites, especially those using a combination of TFM and niclosamide

Table 3. Recommended conservation actions for snuffbox.

The Comprehensive Wildlife Conservation Strategy (NYSDEC 2006) includes recommendations for the following actions for freshwater mussels:

Habitat management:

- Manage areas of important mussel populations by controlling degradation factors (e.g.. Controlling livestock access, point source or non-point source pollution, flow alteration, etc.)
- Develop methods to improve and restore freshwater bivalve habitat.

Habitat research:

- Conduct research to determine habitat parameters necessary for good populations of each species of species-at-risk listed mussels.
- Research flow requirements of freshwater bivalves and model the effects of flow changes both in volume and timing.
- Research all parameters of mussel habitat requirements including temperature, substrate, fish, flow, food, etc.

Habitat restoration:

- Restore degraded habitat areas to allow for recolonization or reintroduction of listed mussels.

Invasive species control:

- Develop a monitoring/control plan that includes measures to detect invasive species problematic to freshwater bivalves in all New York watersheds and actions that will be taken to control them before they become threats.
- Conduct research on control of exotic bivalve species that compete with native mussels and exotic crustaceans or fish which may prey on them.

Life history research:

- Research effects of pesticides and other chemicals, including ammonia, on all life stages of freshwater bivalves: sperm/egg, glochidia, larva, adults.
- Determine fish hosts for species where this is not known for populations living in New York.
- Research population dynamics of listed mussel species including connectivity of populations or subpopulations and genetic distinctness of populations or subpopulations.
- Determine or confirm breeding phenology and habitat conditions necessary for successful breeding for listed mussels (e.g.. mussel density, pop. level of fish host, temp, flow).

New regulation:

- Ban the importation of fish that feed on freshwater mollusks (e.g.. black carp).
- Require inclusion of all stages of freshwater mussels in testing for approval of new pesticides in New York.

Other action:

- Develop an outreach program to private landowners through the Landowner Incentive Program to educate the public about freshwater mussel protection and initiate projects to prevent or repair impacts from land use on mussels.
- Increase regional permit control of development and highway projects that may impact native mussels.
- Develop standard monitoring/survey protocols for development projects in all watersheds in New York.
- Evaluate threats to mussels in each New York watershed and prioritize areas for actions to address the threats.
- Research the best survey methods both for detection of rare species and evaluation of population status and trends.
- Begin evaluation of members of the family Sphaeridae (fingernail clams) for inclusion into the species at risk list.

Population monitoring:

- Conduct population estimates of species-at-risk listed mussel species in NY
- Conduct surveys to determine distribution of species-at-risk listed mussel species in NY.
- Utilize eDNA to detect currently unknown extant populations of *E. triquetra.*

Regional management plan:

- Incorporate freshwater mussel goals and objectives into regional water quality and fish management plans and policies.

Relocation/reintroduction:

- Where appropriate, reintroduce listed mussels into appropriate habitat within their historic range.

Statewide management plan:

- Incorporate freshwater mussel goals and objectives into statewide water quality and fish management plans and policies.

VII. References

Anderson, R.M., and D.A. Kreeger. (2010). Potential for impairment of freshwater mussel populations in DRBC special protection waters as a consequence of natural gas exploratory well development. Prepared for the U.S. Fish and Wildlife Service.

Barnhart, C., Riusech, F., & Baird, M. (1998). Hosts of salamander mussel (Simpsonaias ambigua) and snuffbox (Epioblasma triquetra) from the Meramec River system, Missouri. *Triannual Unionid Report*, *16*, 34.

Benke, A.C. (1990). A perspective on America's vanishing streams. *Journal of the N. American Benthological Society: 9*: 77-88.

COSEWIC. (2003). COSEWIC assessment and status report on the kidneyshell *Ptychobranchus fasciolaris* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Canada. 32 pp.

Ellis, M.M. (1936). Erosion silt as a factor in aquatic environments. Ecology, 17(1), 29-42.

Hill, D. M. (1986). Cumberlandian Mollusks Conservation Program, activity 3: identification of fish hosts. *Office of Natural Resources and Economic Development, Tennessee Valley Authority, Knoxville*, *57*.

Hillegass, K. R., & Hove, M. C. (1997). Suitable fish hosts for glochidia of three freshwater mussels: strange floater, ellipse, and snuffbox. *Triannual Unionid Report*, *13*, 25.

Hove, M., Berg, M., Dietrich, K., Gonzalez, C., Hornbach, D., Juleen, K., ... & Kapuscinski, A. (2003). High school students participate in Snuffbox host suitability trials. *Ellipsaria*, *5*, 19-20.

Hove, M. C., & Kapuscinski, A. R. (1998). Ecological relationships between six rare Minnesota mussels and their host fishes. *Final report to the Natural Heritage and Nongame Research Program, Minnesota Department of Natural Resources*.

Hove, M. C., Kurth, J. E., Heath, D. J., Benjamin, R. L., Endris, M. B., Kenyon, R. L., ... & Lee, C. J. (1998). Hosts and host attracting behaviors of five upper Mississippi River mussels. In *Abstracts, World Congress of Malacology, Washington, DC* (Vol. 159).

Mahar, A.M. and J.A. Landry. 2013. NYSDEC SWAP 2015 Species Status Assessment for Snuffbox Prepared on June 2013.

Natureserve. (2013). Natureserve Explorer: An online encyclopedia of life [web application]. Version 7.1. Natureserve, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: February 12, 2013).

Patnode, K.A., E. Hittle, R.M. Anderson, L. Zimmerman, and J.W. Fulton. (2015). Effects of high salinity wastewater discharges on unionid mussels in the Allegheny River, Pennsylvania. Journal of Fish and Wildlife Management. 6(1):55-70.

Schwalb, A. N., Poos, M. S., & Ackerman, J. D. (2011). Movement of logperch—the obligate host fish for endangered snuffbox mussels: implications for mussel dispersal. *Aquatic sciences*, *73*(2), 223-231.

Sherman, R. A. (1993) Glochinial release and reproduction of the Snuffbox mussel, *Epioblasma triquetra*; timing in Southern Michigan. *Bulletin of the North American Benthological Society.* 10, 197.

Strayer, D.L. & K.J. Jirka. (1997). The Pearly Mussels of New York State. New York State Museum Memoir (26): 113 pp., 27 pls.

Therres, G.D. 1999. Wildlife species of regional conservation concern in the northeastern United States. Northeast Wildlife 54:93-100.

USFWS: Snuffbox Fact Sheet. (2012, January). Retrieved from http://www.fws.gov/midwest/endangered/clams/snuffbox/SnuffboxFactSheet.html

U.S. Fish and Wildlife Service. (2022). Species status assessment report for the snuffbox. May 2022 (Version 1.0). Ohio Ecological Services Field Office, Columbus, Ohio.

Vaughn, C. C. and Taylor, C. M. (1999), Impoundments and the Decline of Freshwater Mussels: a Case Study of an Extinction Gradient. *Conservation Biology*, 13: 912–920.

Watters, G. T., Menker, T., Thomas, S., & Kuehnl, K. (2005). Host identifications or confirmations. *Ellipsaria*, *7*(2), 11-12.

Watters, G. T., Hoggarth, M. A., & Stansbery, D. H. (2009). *The freshwater mussels of Ohio*. Columbus: Ohio State University Press.

Yeager, B. (1993). Dams. Pages 57-92 in C.F. Bryan and D. A Rutherford, editors. Impacts on warm water streams: guidelines for evaluation. *American Fisheries Society,* Little Rock, Arkansas.

Yeager, B. L., & Saylor, C. F. (1995). Fish hosts for four species of freshwater mussels (Pelecypoda: Unionidae) in the upper Tennessee River drainage. *American Midland Naturalist*, 1-6.

Zanatta, D. (2009). Incongruent genetic population structure between a unionid and its host fish.