

Species Status Assessment

Common Name: Rayed bean

Date Updated: 3/10/2025

Scientific Name: *Paetulunio fabalis*

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):

Paetulunio fabalis (Previously *Villosa fabalis*; MolluscaBase 2024) belongs to the subfamily Ambleminae and the tribe Lampsilini, which includes 17 extant and 6 likely extirpated New York species of the genera *Actinonaias*, *Epioblasma*, *Lampsilis*, *Leptodea*, *Ligumia*, *Obovaria*, *Potamilus*, *Ptychobranthus*, *Toxolasma*, *Truncilla*, and *Villosa* (Haag 2012, Graf and Cummings 2011). *P. fabalis* is in the genus *Paetulunio*, and the species name *fabalis*, meaning “faba” or “bean,” aptly describes its small, solid, bean-shape and size (Watters et al. 2009).

P. fabalis is most often found in high quality creeks or small rivers, in sand and gravel, often deeply buried among the roots of aquatic vegetation in and near riffles or along the river’s edge (Strayer and Jirka 1997, Metcalf-Smith et al. 2005, Watters et al. 2009, NatureServe 2013). However, this species has also been found in the Great Lakes, as well as some larger streams and rivers (Strayer and Jirka 1997). In New York this species has been found live in only six waterbodies in the Allegheny basin, where it was recently found in 19% of the sites that were surveyed (The Nature Conservancy 2009). Two additional waterbodies have documented shell findings in the Allegheny basin. *P. fabalis* is federally and state listed as an endangered species, and portions of the Allegheny watershed have been proposed as critical habitat by the United State Fish & Wildlife Service (USFWS, 2024).

I. Status

a. Current legal protected Status

- i. **Federal:** Endangered **Candidate:** No
- ii. **New York:** Endangered

b. Natural Heritage Program

- i. **Global:** G2 - Imperiled
- ii. **New York:** S1 – Critically Imperiled **Tracked by NYNHP?:** Yes

Other Ranks:

- New York 2025 SGCN status: High Priority Species of Greatest Conservation Need
- IUCN Red List: Endangered (2012)
- Northeast Regional SGCN: Yes (2023)
- Midwest Regional SGCN: Yes
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC): Endangered (2010)
- American Fisheries Society Status: Special Concern (1993)

Status Discussion:

This species is declining throughout its range to an extent where 70% of streams formerly occupied no longer contain viable populations, and distribution is greatly fragmented (NatureServe, 2020). Remaining *P. fabalis* populations are small and geographically isolated making them susceptible to a single catastrophic event and limiting potential for making natural repopulation or any genetic interchange between disjunct populations. Long-term viability of extant populations is questionable, particularly in the presence of introduced competitors such as zebra mussel ((NatureServe 2020).

II. Abundance and Distribution Trends

Region	Present?	Abundance	Distribution	Time Frame	Listing status	SGCN?
North America	Yes	Choose an item.	Choose an item.		Endangered	(blank)
Northeastern US	Yes	Choose an item.	Choose an item.			Yes
New York	Yes	Choose an item.	Choose an item.		Endangered	Yes
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	2005-2014	Endangered, S1S2	Yes
Vermont	No	N/A	N/A			No
Ontario	Yes	Stable	Stable	2003-2013	Endangered, S1	(blank)
Quebec	No	Choose an item.	Choose an item.			(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*):

Trends for New York populations are difficult to determine as most historic data comes from opportunistic naturalist collections, as opposed to more comprehensive baseline surveys. For example, mussels were documented for the first time in 50 of the 106 streams surveyed to date by the Southern Lake Ontario mussel inventory project (Mahar and Landry 2013). This is because many of these streams had never before been surveyed for mussels, not because mussel distribution has dramatically increased. In North America, approximately 2/3 to 3/4 of native mussel species are extinct, listed as endangered or threatened, or are in need of conservation status (Williams et al. 1993, Stein et al. 2000). Based on New York’s Natural Heritage S-rank, sparse

historical data, and the plight of North America's freshwater mussels, it is assumed that trends are declining due to a myriad of environmental stressors.

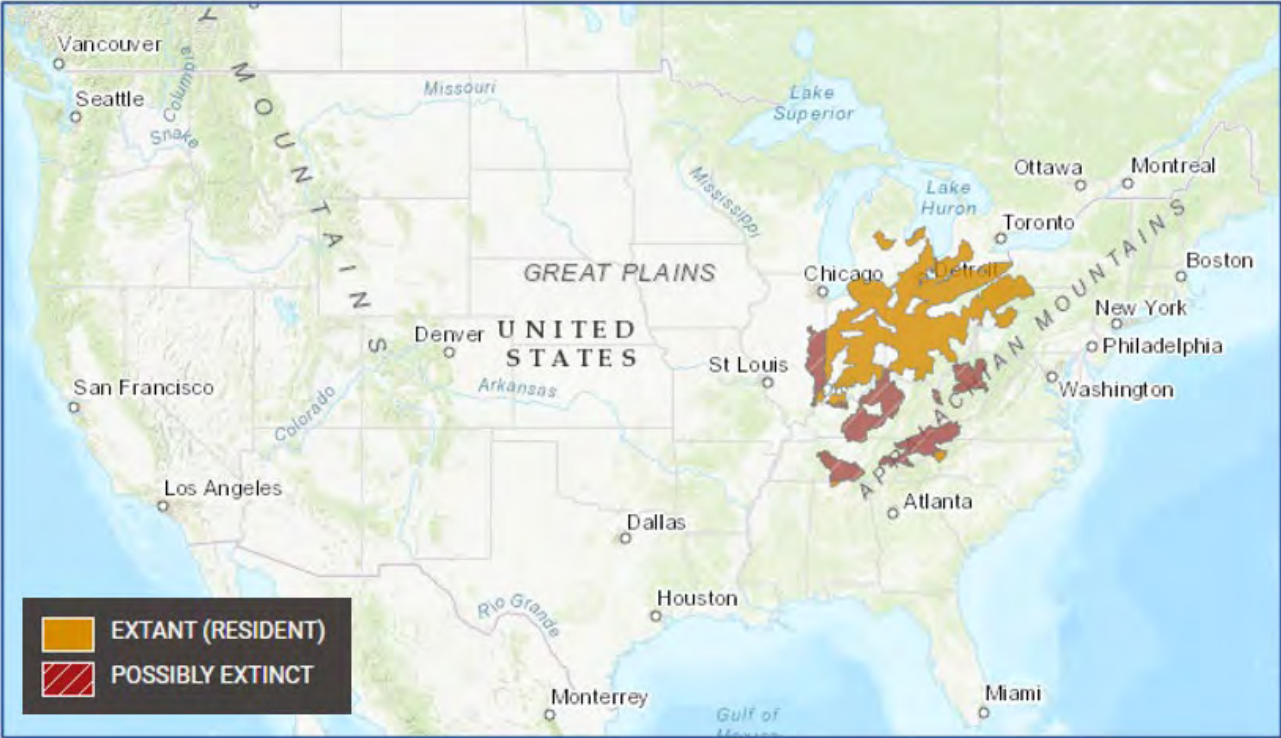


Figure 1. Rayed bean distribution (IUCN Redlist)

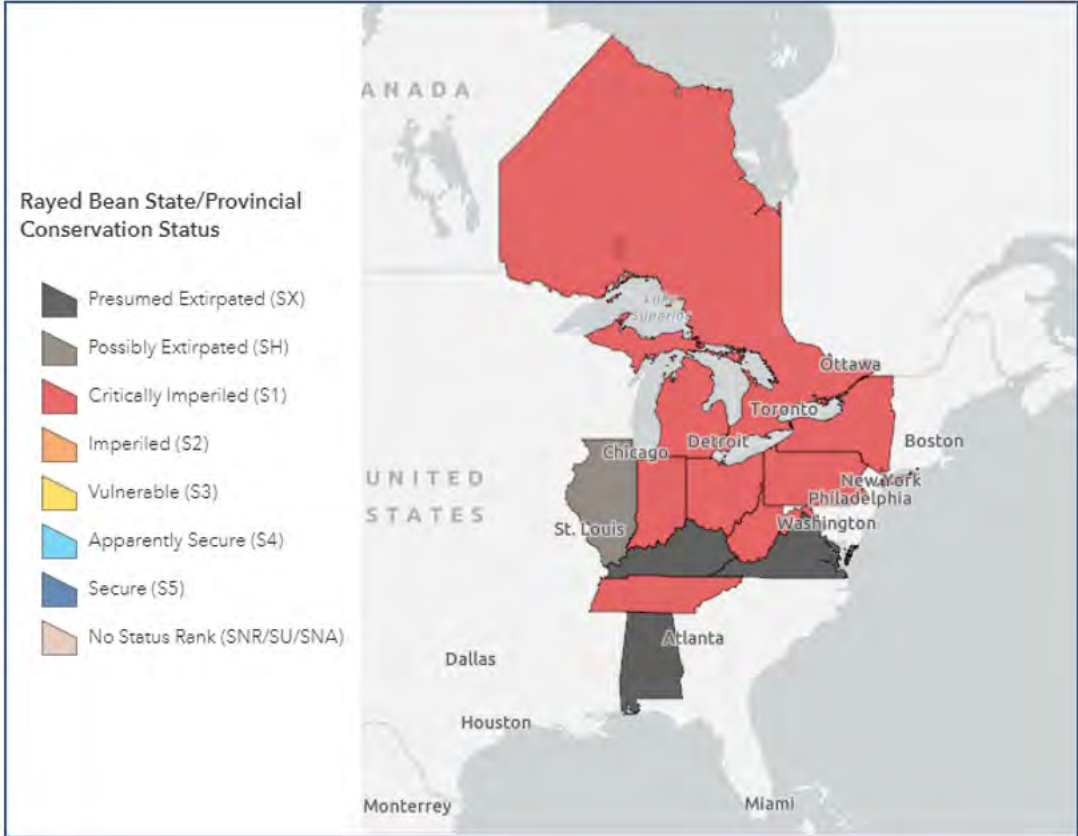


Figure 2. Rayed bean status (NatureServe 2024)

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

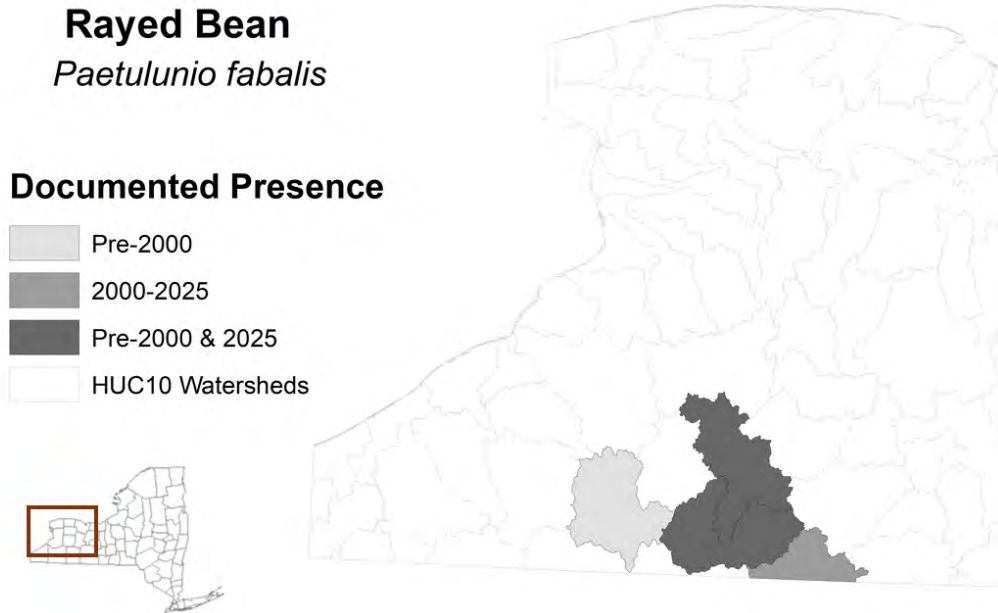


Figure 3. Records of rayed bean in New York (NYSDEC 2025)

Years	# of Distinct Waterbodies	% of State
Total	8	0.6%

Table 1. Records of rayed bean in New York.

Details of historic and current occurrence:

2024: *P. fabalis* has been found in 8 waterbodies and 4 of New York’s HUC 10 watersheds.

In New York, *P. fabalis* has been identified at several sites in the Allegheny basin. In addition, there is an old, questionable record of this species from the Chemung River. Later collectors did not report this species from the Susquehanna basin, so the record is probably erroneous. Nevertheless, some fish and mussels from the Interior Basin did enter the Susquehanna basin, so it is possible that *P. fabalis* does live in the western tributaries of the Susquehanna. Although *P. fabalis* is found in western Lake Erie and its tributaries, it has not yet been collected from the eastern part of the basin in Ontario, Pennsylvania, or New York (Strayer and Jirka 1997).

Since 1970, *P. fabalis* has been found in eight New York State waterbodies (Figure 2). In a recent survey of the Allegheny basin, The Nature Conservancy found a total of 79 live *P. fabalis* at 20 of 105 sites surveyed. This species was found primarily in Olean and lower Ischua Creeks, mid-

reaches of Cassadaga Creek, and Conewango Creek, and at lower numbers in the Allegheny River upstream of Olean. Populations were considered viable at 35% of the sites where *P. fabalis* was found (The Nature Conservancy 2009). This species also occurred in Chautauqua Lake (Strayer and Jirka 1997), but has since been extirpated from the lake.

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	100 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:** Small to Medium River
- b. **Geology:** Moderately Buffered
- c. **Temperature:** Transitional Cool to Warm
- d. **Gradient:** Low Gradient to Moderate-High Gradient

Habitat or Community Type Trend in New York

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

P. fabalis is most often found in high quality creeks or small rivers in sand and gravel, often deeply buried among the roots of aquatic vegetation in and near riffles or along the river’s edge (Strayer and Jirka 1997, Metcalf-Smith et al. 2005, Watters et al. 2009, NatureServe 2013). This species also exists in larger rivers and is known to occur in the shallow wave-washed areas of glacial lakes (NatureServe 2013). In Lake Erie, it is generally associated with islands in the western portion of the lake.

P. fabalis are sensitive to pollution, eutrophication, siltation, habitat perturbation, inundation, invasive species, and loss of glochidial hosts (COSEWIC as cited in NatureServe 2013).

V. Species Demographic, and Life History:

Breeder in NY?	Non-breeder in NY?	Migratory Only?	Summer Resident?	Winter Resident?	Anadromous/Catadromous?
Yes	No	No	Yes	Yes	(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, *P. fabalis* 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 habitat, they will burrow into the substrate, where they may remain for several years (Watters et al 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 capability for *P. fabalis* is expected to be relatively limited as the three suspected fish hosts are darters and most darters have limited home ranges (Strayer and Jirka 1997, White et al. 1996, COSEWIC 2003 as cited in NatureServe 2013).

The glochidial fish hosts for *P. fabalis* have not been well studied, however they are thought to include Tippecanoe darter (*Etheostoma tippecanoe*) (Strayer and Jirka 1997, White et al. 1996). Additional potential hosts were found for Canadian populations including rainbow darter (*Etheostoma caeruleum*), greenside darter (*Etheostoma blennioides*), mottled sculpin (*Cottus bairdii*), and largemouth bass (*Micropterus salmoides*) (Woolnough 2003).

It has a periodic life history strategy, characterized by moderate to high growth rate, low to intermediate life span, age at maturity, and fecundity, but generally smaller body size than opportunistic species. Most species are long-term brooders. This life history strategy is considered an adaptation to allow species to persist in unproductive habitats or habitats that are subject to large-scale, cyclical environmental variation or stress (Haag 2012).

P. fabalis is reported to be bradyctictic, in that it holds glochidia overwinter for spring release (Ortmann 1909). Gravid females have been found in May, July, and August (Ortmann 1909, 1919). *P. fabalis* individuals may live for 11 years or more, with female characteristics becoming apparent in the shells as early as the second year (Watters et al. 2009).

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

Agricultural Runoff

New York's largest populations of *P. fabalis* are found in the Allegheny basin, in the Allegheny River and its tributaries. Portions of these streams are bordered by agriculture, primarily in the Olean/Allegheny area (New York State Landcover 2010). 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 and Landry 2013), indicating that runoff is a major threat to resident mussel populations.

Although sedimentation is a natural process, poor land use practices, dredging, impoundments, 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 *P. fabalis*, leading to decreased growth, reproduction, and survival (USFWS 2012).

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).

Fertilizers 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 in 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).

Runoff from Developed Land

Several *P. fabalis* populations, considered viable by The Nature Conservancy (2009), are located within the City of Olean and the Village of Allegheny. These sites are likely impacted by storm water runoff from roads and lawns. Viable populations in Cassadaga Creek are bordered by roadways and are potentially at risk from road runoff containing metals and road salts (New York State Landcover 2010). Mussels are particularly sensitive to heavy metals, more so than many other animals used in toxicological tests (Keller and Zam 1991). Low levels of metals may interfere with the ability of glochidia to attach to the host (Huebner and 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 and Zam 1991, Liquori and 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).

Treated Wastewater

P. fabalis populations, considered viable by The Nature Conservancy (2009), are located within the City of Olean and are exposed to treated wastewater from the city of Olean and the village of Allegany either directly to the Allegheny River or through tributaries (SPDES 2007). Recent studies show that mussel richness and abundance decrease 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 are also present from municipal sewage effluents and are increasingly 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). It should be noted that in the Susquehanna Basin, Harmon and Lord (2010) found no evidence that wastewater treatment plants were responsible for reductions in mussel species of greatest conservation need.

Habitat Modifications

Ecosystem modifications, such as dredging, instream work associated with bridge replacement, 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).

Flood Control Projects

Large stretches of *P. fabalis* habitat are within the leveed portions of the Allegheny River and Olean Creek (NYS Flood Protection 2013). Additionally, many smaller streams have been channelized and bermed by landowners and highway departments to protect farm fields and other structures. These structures confine larger rivers, preventing the river from inundating its natural floodplains and wetlands to minimize flood damage. 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).

Invasive Species

Based on the current distribution of zebra mussels (*Dreissena polymorpha*) in New York, only populations in Chautauqua Lake would likely be negatively impacted by the invasive mussels (iMapInvasives 2013). Zebra mussels have been repeatedly cited as a threat to native mussel populations (Strayer and Jirka 1997, Watters et al. 2009). En masse, Dreissenids outcompete native mussels by efficiently filtering food and oxygen from the water. They reduce reproductive success by filtering native mussel male gametes from the water column and 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).

Climate Change

In a recent assessment of the vulnerability of at-risk species to climate change in New York, Schesinger et al. (2011) ranked this species as “moderately vulnerable.” This indicates that abundance and/or range extent within New York is likely to decrease by 2050.

Impoundments – Range wide

Across its range, 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 and King 1983, ESI 1993c).

Adapted to living in flowing water, the *P. fabalis* cannot survive in the still water impounded behind dams. The rayed bean also depends on host fish as a means to move upstream. Because dams block fish passage, mussels are also prevented from moving upstream, which isolates upstream mussel populations from downstream populations, leading to small unstable populations more likely to die out (USFWS 2012).

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.

Threat Level 1	Threat Level 2	Threat Level 3	Spatial Extent	Severity	Immediacy	Trend	Certainty
1. Residential and Commercial	1.3 Tourism & Recreation Areas	1.3.5 Docks & marinas	Restricted	Serious	Immediate	Stable and ongoing	High
3. Energy Production & Mining	3.3 Renewable Energy	3.3.1 Hydroelectric dams	Large	Moderate	Near-term	Intensifying	High
4. Transportation & Service Corridors	4.1 Roads & Railroads	4.1.3 Bridges	Restricted	Serious	Long-term	Stable and ongoing	High
6. Human Intrusions & Disturbance	6.3 Work & Other Activities	6.3.1 Research activities	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	8.5 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	High
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
11. Climate Change	11.4 Changes in Precipitation & Hydrological Regimes	11.4.2 Droughts	Restricted	Moderate	Long-term	Intensifying	High
11. Climate Change	11.5 Storms & Severe Weather	11.5.1 Storms & severe weather	Restricted	Moderate	Long-term	Intensifying	Moderate

Table 2. Threats to Rayed bean.

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:

New York State Environmental Conservation Law, § 11-0535. 6 NYCRR Part 182: Endangered and Threatened Species of Fish and Wildlife; Species of Special Concern; Incidental Take Permits

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

Section 7(a) of the Federal Endangered Species Act, as amended, requires Federal agencies to evaluate their actions with respect to any species that is proposed or listed as Federally endangered or threatened. Regulations implementing this interagency cooperation provision of the Act are codified at 50 CFR Part 402. Section 7(a)(4) requires Federal agencies to confer informally with the Service on any action that is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed critical habitat. If a species is listed subsequently, Section 7(a)(2) requires Federal agencies to ensure that any activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of such a species or to destroy or adversely modify its critical habitat. If a Federal action may affect a listed species or its critical habitat, the responsible Federal agency must enter into formal consultation with the Service.

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). Mussel 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:

- Priority conservation efforts for this species should focus on, but not be limited to, Olean Creek, Oswayo Creek, and Cassadaga Creek.
- Although efforts to restore populations of *P. fabalis* in WV and KY have already begun, in NY, river system issues should first be addressed prior to restoration. Olean Creek might be an appropriate candidate stream for augmentation efforts due to *P. fabalis* presence, but has relatively low numbers. However, the Olean system, in particular the lower reaches, is highly modified with levees which protect the city of Olean, NY. Population augmentation efforts in these areas may be difficult, whereas greater opportunities for success may exist in areas which are currently uninhabited by *P. fabalis* (e.g., Conewango Creek and Allegheny River downstream of Olean, NY) (The Nature Conservancy 2009)
- 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 et al 2012).

- Require all state agencies to maintain appropriate vegetative buffers along streams, rivers and lakes on state-owned or state managed properties.
- 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.
- 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.
- 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).
- Establish a protocol whereas DEC staff work closely with flood control management to reduce or impacts to native mussels during maintenance flood control projects.
- Establish a protocol whereas DEC staff work closely with state and local highway departments to reduce impacts to native mussels during maintenance and construction projects.
- Replace culverts that disrupt aquatic habitat connectivity to allow for passage of small fish species.
- 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 and 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 sediments
A.1 Direct Habitat Management	A.1.3.0.0 Mitigate human environmental impact	Mitigations should be focused on Cassadaga Creek and the Allegheny River and tributaries in Olean, NY
A.1 Direct Habitat Management	A.1.3.3.0 Remove and improve anthropogenic infrastructure	Replace culverts that disrupt habitat connectivity
B.3 Outreach	B.3.1.3.0 Targeted Communication	-Coordinate with local wastewater treatment to improve ammonia removal in treated discharge -Work with Highway Departments to reduce impacts on mussels -Work with flood control management to reduce impacts to mussels during maintenance and construction projects
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.8.2.1.2 Monitoring and evaluating the results of project activities	

Table 3. Recommended conservation actions for rayed bean.

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.

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.

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