Species Status Assessment

Class: **Bivalvia**
Family: **Unionidae**
Scientific Name: ***Pleurobema sintoxia***
Common Name: **Round pigtoe**

Species synopsis:

Pleurobema sintoxia belongs to the subfamily Ambleminae and the tribe Pleurobemini, which includes four extant and one likely extirpated New York species in the genera Elliptio, Fusconaia, and Pleurobema (Haag 2012). **).** *P. sintoxia* is one of two species of the genus Pleurobema that have been found in New York (Strayer and Jirka 1997). In general, the shells of this tribe are unsculptured and larvae are brooded only in the outer demibranchs (with exceptions) (Graf and Cummings 2011). The genus name *pleurobema,* meaning step, refers to the ribs found between the shell annulae (Watters et al 2009).

In Strayer and Jirka's The Pearly Mussels of New York State (1997), this New York species is referred to as *Pleurobema cordatum.* However*, P. cordatum* is part of a complex of closely related species or ecophenotypes (*P. cordatum; P. coccineum =* P. *sintoxia; P. plenum; P. rubrum = P. pyramidatum)* that are found throughout the Ohio River drainage and in parts of the Mississippi and Great Lakes basins. These were widely regarded as intergrading ecophenotypes (e.g., Ortmann 1919), but more recently they have been recognized as distinct species (Stansbery and King 1983; Williams et al. 1993). Only the *coccineum* form (and its large lake ecophenotype form *pauperculum)* has been seen in New York (Strayer & Jirka 1997), while *P. cordatum* refers to a similar species not found in New York State. Both Watters et al. (2009) and Strayer and Jirka (1997) note that both *P. coccineum* and *P. pauperculum* fall under the species designation *P. sintoxia*. In addition, New York Natural Heritage Program refers to this New York species as *P. sintoxia.*

In New York, habitat for *P. coccineum* includes creeks and rivers of all sizes, but is especially frequent in large creeks and small- to medium-sized rivers (Strayer & Jirka 1997), The *P. pauperculum* ecophenotype lives in large lakes, rivers, and large streams and can be found in Lake Erie, the Niagara River, and the larger streams in the Allegheny basin (Strayer & Jirka 1997).

Impoundments have caused declines for this species across its range, with long term trends suggesting between 30% and 50% declines (NatureServe 2013). Although rare and ranked as "critically imperiled" in New York, this edge of range species is considered "apparently secure" throughout its range. In North America, approximately 2/3 to ¾ 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). While population trends in New York are unknown, based on sparse historical information it is assumed that they too are declining due to a myriad of environmental stressors.

Status

a. Current and Legal Protected Status

i. Federal ____ __None______________________________**Candidate?** ___No__

ii. New York _______None – Species of Greatest Conservation Need__________

b. Natural Heritage Program Rank

i. Global ___G4 – Apparently Secure______________________________________

ii. New York ___S1_**-** Critically Imperiled___ **Tracked by NYNHP?** ___Yes___

Other Rank:

Canadian Species at Risk Act (SARA) Schedule 1/Annexe 1 Status: E (2005)
Committee on the Status of Endangered Wildlife in Canada (COSEWIC): Endangered (2004)
American Fisheries Society Status: Currently Stable (1993)

Status Discussion:

The large river *P. sintoxia* populations have become increasingly rare. Distribution is greatly fragmented but remains relatively wide, much as it was historically. Long-term viability of many populations is questionable, especially those in large rivers where zebra mussel populations are now established. Outside these areas the species appears to maintain stable populations (NatureServe 2013).

II. Abundance and Distribution Trends

a. North America

i. Abundance

__X__ declining ____increasing _____stable ____unknown

ii. Distribution:

____ declining ____increasing ___X__stable ____unknown

Time frame considered: ____

b. Regional

i. Abundance

__X___ declining ____increasing ____stable _____unknown

ii. Distribution:

____ declining ____increasing __X___stable ______unknown

Regional Unit Considered:_______Midwest______________________________
Time Frame Considered: ____

c. Adjacent States and Provinces

CONNECTICUT **Not Present** ___X___ **No data** ______

MASSACHUSETTS **Not Present** ___X___ **No data** ______

NEW JERSEY **Not Present** ___X___ **No data** ______

ONTARIO **Not Present** ________ **No data** ______

i. Abundance

__X__ declining ____increasing ______stable ____unknown

ii. Distribution:

____ declining ____increasing __X___stable ____unknown

Time frame considered: ________2003-2013________________________
Listing Status: __S1____Federally and Provincially Endangered__________

Abundance of the St Clair delta population has declined 15% since 2004 (DFO unpublished data).

PENNSYLVANIA **Not Present** ________ **No data** ______

i. Abundance

____ declining ____increasing ____stable __x___unknown

ii. Distribution:

____ declining ____increasing ____stable ___x__unknown

Time frame considered: ____
Listing Status: ___S2_____________________________ SGCN? ___No_____

QUEBEC **Not Present** ___X___ **No data** ______

VERMONT **Not Present** ___X___ **No data** _______

d. NEW YORK **No data _______**

i. Abundance

__X__ declining ____increasing ____stable _____unknown

ii. Distribution:

__X__ declining ____increasing ____stable ______unknown

Time frame considered: ____

Monitoring in New York.

As part of a State Wildlife Grant, NYSDEC Region 8 Fisheries and Wildlife staff is conducting a baseline survey of tributaries in central and western New York for native freshwater mussels 2009 – 2017.

Trends Discussion:

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 & 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 ¾ 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.

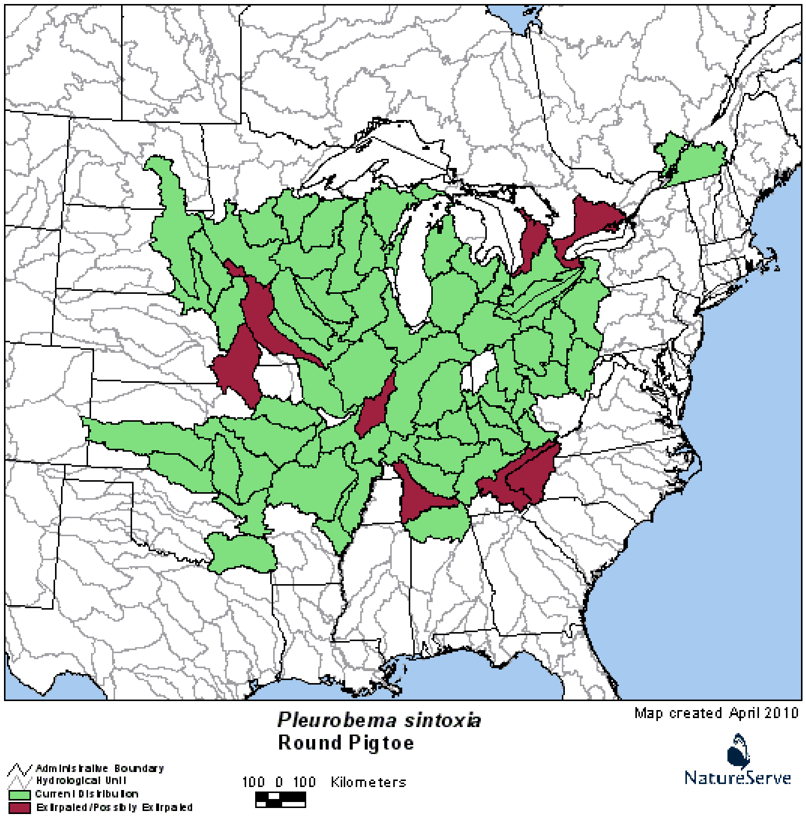

Figure 1. *P. sintoxia* distribution in North America (NatureServe 2013).

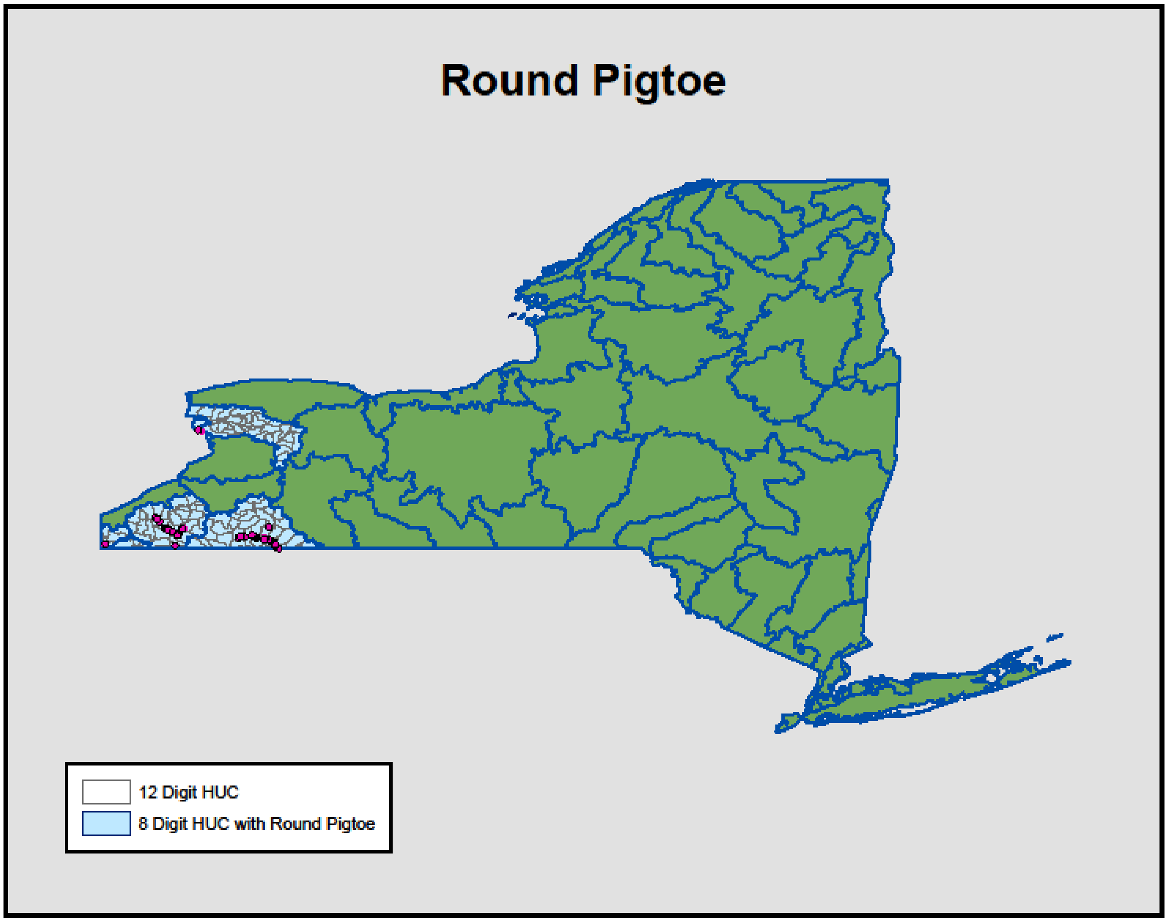

Figure 2: Post 1970 *P. sintoxia* distribution in New York State (Mahar & Landry 2013; Harman & Lord 2010, The Nature Conservancy 2009; New York Natural Heritage Program 2013; White et al. 2011).

III. New York Rarity, if known:

Historic	# of Animals	# of Locations	% of State
prior to 1970	unknown	6 waterbodies	5 of 56 watersheds
prior to 1980			
prior to 1990			

Details of historic occurrence:

Historically, *P. sintoxia* was known from only a few sites in New York State: Lake Erie, the Niagara River, and larger streams in the Allegheny basin, including the Allegheny River, Cassadaga Creek, Conewango Creek, and French Creek. In the first half of the twentieth century, it had been recorded from Tonawanda Creek, but the museum specimens labeled as *P. cordatum* from Tonawanda Creek were confirmed to be *Fusconaia flava,* a common species in the waterbody (Strayer & Jirka 1997).

There are two forms of this species that exist in New York. The *coccineum* form lives in the Allegheny basin, and its large lake ecophenotype form *pauperculum* lives in Lake Erie and the Niagara River (Strayer & Jirka 1997).

Current	# of Animals	# of Locations	% of State
	~224 live	8 waterbodies	4 of 56 HUC 8 watersheds

Details of current occurrence:
Since 1970, *P. sintoxia* has been found in eight New York State waterbodies. *P. sintoxia* is a common species in parts of its range, but it is uncommon at its New York localities, constituting only a few percent of the unionoid community (Strayer & Jirka 1997).

In a recent survey of the Allegheny basin, 223 live *P. sintoxia* were found throughout the Upper Allegheny and Conewango sub-basins at 37 of 105 survey sites. It was considered viable at 18 of the sites where it was found. The greatest catches (up to 7 per hour) were in the Allegheny River upstream of Olean, but patches of *P. sintoxia* were found in Conewango**,** Cassadaga, Olean, Ischua, and Oswayo Creeks (The Nature Conservancy 2009). As recently as 2005, recruitment was verified in Cassadaga Creek (NY Natural Heritage Program 2013). Also in the Allegheny basin, NY Natural Heritage Program notes *P. sintoxia* occurrences in French Creek (2013)), and three live individuals were found south-west of French Creek town in 2013 (Burlakova et al., unpublished data).

In addition, in 1990, one live adult and many recently dead shells, including young animals, were found at Beaver Island on the Niagara River, indicating that there is likely a good population at or near this site (NY Natural Heritage Program 2013)), and two live *P. sintoxia* were found there in 2011 (Burlakova, unpublished data). *P. sintoxia* may very well live in creeks tributary to Lake Erie and the Niagara River (Strayer & Jirka 1997).

New York's Contribution to Species North American Range:

% of NA Range in New York	**Classification of New York Range**
____ **100 (endemic)**	____ **Core**
____ **76-99**	__X___ **Peripheral**
____ **51-75**	____ **Disjunct**
____ **26-50**	**Distance to core population:**
__X___ **1-25**	___350___

IV. Primary Habitat or Community Type:

1. Medium River; Low Gradient; Assume Moderately Buffered (Size 3+ rivers); Transitional Cool

2. Small River; Low-Moderate Gradient; Moderately Buffered, Neutral; Transitional Cool

3. Medium River; Low Gradient; Assume Moderately Buffered (Size 3+ rivers)

Habitat or Community Type Trend in New York:

____ Declining ____Stable ____ Increasing __X___Unknown

Time frame of decline/increase: ____

Habitat Specialist? ____ **Yes** ______ **No**

Indicator Species? __X___ **Yes** _____ **No**

Habitat Discussion:

Although *P. sintoxia* is commonly cited as living in medium-sized to large rivers (McMurry et al. 2012; Metcalfe- Smith et al. 2005; Cummings & Mayer 1992; Watters et al. 2009), in New York, it may be found in creeks and rivers of all sizes, but is more likely to be found in large creeks and small- to medium-sized rivers (Strayer & Jirka 1997). Its large lake ecophenotype form *pauperculum* is found in the Great Lakes and the Niagara River (Strayer & Jirka 1997).

P. sintoxia may be found in a variety of substrates from mud and silt to gravel, cobble, and boulder (McMurry et al. 2012; Metcalfe-Smith et al. 2005; Cummings & Mayer 1992). Although most commonly found in moving water, it has been found in water depths of 1 inch to 5 feet in standing to moderately flowing water (Metcalfe-Smith et al. 2005; Watters et al. 2009). This species is somewhat sensitive to pollution, siltation, habitat perturbation, inundation, and loss of glochidial hosts (NatureServe 2013).

V. New York Species Demographics and Life History

__X__ Breeder in New York

__X__ Summer Resident

__X__ Winter Resident

____ Anadromous

____ Non-breeder in New York

____ Summer Resident

____ Winter Resident

____ Catadromous

____ Migratory only

____Unknown

Species Demographics and Life History Discussion:

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. sintoxia* 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 is likely to be a slow process for mussels which use resident fishes with limited home ranges as their hosts (COSEWIC in NatureServe 2013).

P. sintoxia specimens may reach nearly 30 years of age. This species is tachytictic, with eggs present in May and glochidia developed from May through July (Watters et al. 2009). Cyprinids are the most commonly reported hosts. Glochidia have been shown to transform on central stoneroller (*Campostoma anomalum*), spotfin shiner (*Cyprinella spiloptera*), bluegill (*Lepomis macrochirus*), southern redbelly dace (*Phoxinus erythrogaster*), northern redbelly dace (*Phoxinus eos*), and bluntnose minnow (*Pimephales notatus*) (Watters et al. 2009).

VI. Threats:

Agricultural Runoff
New York's largest populations of *P. sintoxia* have been found in the Allegheny River upstream of Olean. Although this watershed is primarily a forested landscape, cultivated cropland is present adjacent to the Allegheny River in portions of this area, as well as in streams with secondary *P. sintoxia* populations in the Conewango basin and French Creek (NYS 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 & 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 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

All eight New York waterbodies that host *P. sintoxia* populations are intermittently bordered by interstate highways, state routes, and/or local roads (NYS Landcover 2010). It is likely that these sites are impacted by storm water runoff containing metals and road salts from roads and lawns (Gillis 2012). 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).

Treated and Untreated Waste Water

In the Niagara River, *P. sintoxia* habitat is located downstream of numerous City of Buffalo combined sewer outflow (CSO) outfalls (Combined Sewer Overflow 2013). In addition, *P. sintoxia* habitat receives storm water runoff and treated waste water from the municipalities of Olean, Portville, Jamestown, and Buffalo (SPDES 2007). Recent studies show that mussel richness and abundance decrease with increased proximity to sewage effluent (Wildenberg 2012). The input of biomaterial from waste water 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 in 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). It should be noted that in the Susquehanna Basin, Harman and Lord (2010) found no evidence that waste water treatment plants were responsible for reductions in mussel species of greatest conservation need.

Flood Control Projects

Flood walls and/or levees have been constructed near municipalities in the Upper Allegheny basin to confine the larger rivers and minimize flood damage. *P. sintoxia* has been found within or adjacent to stream reaches shaped by these flood control features in Olean on the Allegheny River and in Portville on the Allegheny River and Oswayo Creek ("New York State 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). In addition, such flood control projects often require periodic maintenance, including dredging which destroys habitat and kills resident mussels.

Other Habitat Modifications

In addition to channelization and regular channel dredging for maintenance of flood control structures, other ecosystem modifications such as instream work associated with bridge replacement, gravel removal, 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).

Invasive Species

Invasive mussels remain a threat to *P. sintoxia* populations in Niagara River and the Conewango basin. 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). Native mussels have been effectively eliminated from the western basin of Lake Erie by these exotics. 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).

Zebra mussels are present in the lower reaches of Cassadaga and Conewango Creeks. Chautauqua Lake's connection to Cassadaga Creek through Chadakoin Creek, is the main source of this exotic invasive. Although zebra mussels will continue to cause problems for Chautauqua Lake, they currently appear to have minimal impact in the free-flowing, relatively shallow rivers downstream. However, precautions should be taken to avoid invasions by zebra mussels to upstream locations, especially the headwater lakes in the Cassadaga system. Monitoring for zebra mussels in these lakes may provide early detection of this invader (The Nature Conservancy 2009).

Climate Change

The NatureServe Climate Change Vulnerability Index has been used in several states to help identify species that are particularly vulnerable to the effects of climate change. While P. *sintoxia* vulnerability was not evaluated for New York, populations within Michigan are ranked as "highly vulnerable" to climate change (Hoving et al. 2013).

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 & 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, prevent movement by host fish, and effectively isolate mussel populations. And because culverts are located at nearly every road-stream intersection, there is the potential for landscape level fragmentation of mussel habitat.

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

______ No   _____ Unknown

___X___ Yes

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:

- Priority conservation efforts for this species should focus on, but not be limited to, the Allegheny River upstream of Olean.

- Modify marine mussel regulations or the definition of protected wildlife in NYCRR to clarify that freshwater mussels are protected under ECL. Current regulations could be interpreted that freshwater mussels may only be protected as shellfish without a season within the Marine District.

- 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.

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

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.
- Research potential interbreeding between *Alasmidonta varicosa* and *Alasmidonta marginata* and, if occurring, evaluate the potential threat to *A. varicosa* population integrity.
- 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).

Modify regulation:

- Modify marine mussel regulations to be clearer that freshwater mussels are protected under ECL.

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.

VII. References

Aldridge, D. C. (2000). The impacts of dredging and weed cutting on a population of freshwater mussels (Bivalvia: Unionidae). *Biological Conservation*, *95*(3), 247-257.

Anderson, K. B., Sparks, R. E., & Paparo, A. A. (1978). Rapid assessment of water quality, using the fingernail clam, *Musculium transversum*: Final Report. University of Illinois, Urbana. 130p.

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

Bringolf, R. B., Cope, W. G., Eads, C. B., Lazaro, P. R., Barnhart, M. C., & Shea, D. (2007). Acute and chronic toxicity of technical-grade pesticides to glochidia and juveniles of freshwater mussels (unionidae). *Environmental Toxicology and Chemistry*, *26*(10), 2086-2093.

Bringolf, R. B., Cope, W. G., Barnhart, M. C., Mosher, S., Lazaro, P. R., & Shea, D. (2007). Acute and chronic toxicity of pesticide formulations (atrazine, chlorpyrifos, and permethrin) to glochidia and juveniles of *Lampsilis siliquoidea*. *Environmental Toxicology and Chemistry*, *26*(10), 2101-2107.

Combined Sewer Overflow (CSO) Outfalls: New York State Department of Environmental Conservation Interactive Maps for Google Maps and Earth. (2013). Retrieved from Department of Environmental Conservation website: http://www.dec.ny.gov/pubs/42978.html

Cummings, K. S., & Mayer, C. A. (1992). *Field guide to freshwater mussels of the Midwest* (p. 194). Champaign, Illinois: Illinois Natural History Survey.

Flynn, K., & Spellman, T. (2009). Environmental levels of atrazine decrease spatial aggregation in the freshwater mussel, *Elliptio complanata. Ecotoxicology and Environmental Safety*, *72*(4), 1228-1233.

Gagné, F., Bouchard, B., André, C., Farcy, E., & Fournier, M. (2011). Evidence of feminization in wild *Elliptio complanata* mussels in the receiving waters downstream of a municipal effluent outfall. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, *153*(1), 99-106.

Gillis, P. L. (2012). Cumulative impacts of urban runoff and municipal wastewater effluents on wild freshwater mussels (*Lasmigona costata*). *Science of the Total Environment*, *431*, 348-356.

Goudraeu, S. E., Neves, R. J., & Sheehan, R. J. (1993). Effects of wastewater treatment plant effluents on freshwater mollusks in the upper Clinch River, Virginia, USA. *Hydrobiologia*, *252*(3), 211-230.

Graf, D. and K. Cummings. (2011). MUSSELp Evolution: North American Freshwater Mussels. The MUSSEL Project. The University of Wisconsin. Available: http://mussel-project.uwsp.edu/evol/intro/north_america.html.

Haag, W. R. (2012). *North American freshwater mussels: natural history, ecology, and conservation*. Cambridge University Press.

Hoving, C. L., Lee, Y. M., Badra, P. J. and Klatt B. J. (2013) A vulnerability assessment of 400 species of greatest conservation need and game species in Michigan.

Harman, W.N. and P.H. Lord (2010). Susquehanna Freshwater Mussel Surveys, 2008-2010. Final report submitted to New York State Department of Environmental Conservation. SUNY Oneonta. Cooperstown, NY. 24 pp, plus appendix.

Huebner, J. D., & Pynnönen, K. S. (1992). Viability of glochidia of two species of Anodonta exposed to low pH and selected metals. *Canadian Journal of Zoology*, *70*(12), 2348-2355.

Keller, A. E., & Zam, S. G. (1991). The acute toxicity of selected metals to the freshwater mussel, *Anodonta imbecilis*. *Environmental Toxicology and Chemistry*, *10*(4), 539-546.

Liquori, V. M., & Insler, G. D. (1985). Gill parasites of the white perch: Phenologies in the lower Hudson River. *New York Fish and Game Journal*, *32*(1), 71-76.

Mahar, A.M. and J.A. Landry. (2013). State Wildlife Grants Final Report: Inventory of Freshwater Mussels in New York's Southeast and Southwest Lake Ontario Basins, 2008-2013. New York State Department of Environmental Conservation. Avon, NY. *In progress*.

McMurray, S.E., Faiman, J.S., Roberts, A., Simmons, B., and Barnhart, C.M. 2012. *A guide to Missouri's freshwater mussels.* Missouri Department of Conservation, Jefferson City, Missouri.

Metcalfe-Smith, J., A. MacKenzie, I. Carmichael, and D. McGoldrick. (2005). Photo Field Guide to the Freshwater Mussels of Ontario. St. Thomas Field Naturalist Club. St. Thomas, ON, 60pp.

Natural Heritage Program Element Occurrences [ARC/INFO coverages] (2013). New York Natural Heritage Program, Albany, NY. Available: NYS Department of Environmental Conservation Master Habitat Data Bank's Data Selector.

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).

Nedeau, E.J. 2008. *Freshwater Mussels and the Connecticut River Watershed.* Connecticut River Watershed Council, Greenfield, Massachusetts. Xviii+ 132 pp.

New York State Flood Protection Project Details and Maps (2013). Retrieved from Department of Environmental Conservation website: http://www.dec.ny.gov/lands/59934.html

New York State Landcover, Version 1. [SDE raster digital data] (2010). National Gap Analysis Program. Moscow, Idaho. Available: NYS Department of Environmental Conservation Master Habitat Data Bank's Data Selector.

Northeastern Aquatic Habitat Classification System (NAHCS) GIS map for streams and rivers, [vector digital data] (2010). US Environmental Protection Agency, the US Geological Survey, and The Nature Conservancy Eastern Conservation Science. Boston, MA. Available: NYS Department of Environmental Conservation Master Habitat Data Bank's Data Selector.

Ortmann, A. E. (1919). Monograph of the Naiades of Pennsylvania.. (Vol. 8, No. 1). Board of Trustees of the Carnegie Institute.

Pandolfo, T. J., Cope, W. G., Young, G. B., Jones, J. W., Hua, D., & Lingenfelser, S. F. (2012). Acute effects of road salts and associated cyanide compounds on the early life stages of the unionid mussel *Villosa iris*. *Environmental Toxicology and Chemistry*, *31*(8), 1801-1806.

Roley, S. S., J. Tank, and M. A. Williams (2012), Hydrologic connectivity increases denitrification in the hyporheic zone and restored floodplains of an agricultural stream, *J. Geophys. Res.*

Stansbery, D. H., & King, C. C. (1983). Management of Muskingum River mussel (unionid mollusk) populations. *Ohio State University Museum of Zoology Reports for*, *79*.

State Pollutant Discharge Elimination System (SPDES)- New York State [vector digital data]. (2007). Albany, New York: New York State Department of Environmental Conservation. Available: http://gis.ny.gov/gisdata/inventories/details.cfm?dsid=1010&nysgis=

Stein, B. A., Kutner, L. S., Hammerson, G. A., Master, L. L., & Morse, L. E. (2000). State of the states: geographic patterns of diversity, rarity, and endemism. *Precious heritage: the status of biodiversity in the United States. Oxford University Press, New York*, 119-158.

Strayer,D.L. and Malcom, H.M. 2012. Causes of recruitment failure in freshwater mussel populations in southeastern New York. Ecological Applications 22:1780–1790.

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

U.S. Fish and Wildlife Service (USFWS). 1985e. Recovery plan for the pink mucket pearly mussel; *Lampsilis orbiculata* (Hildreth, 1828). U.S. Fish and Wildlife Service, Region 4, Atlanta, Georgia. 47 pp.

The Nature Conservancy (2009). Freshwater Mussel (Unionidae) Distributions, Catches, and Measures of their Viability across the Catches, and Measures of their Viability across the Allegheny River Basin in New York. Report submitted New York State Department of Environmental Conservation. The Nature Conservancy, Central & Western NY Chapter. Rochester, NY. 63 pp.

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.

Wang, N., Mebane, C. A., Kunz, J. L., Ingersoll, C. G., Brumbaugh, W. G., Santore, R. C., ... & Arnold, W. (2011). Influence of dissolved organic carbon on toxicity of copper to a unionid mussel (*Villosa iris*) and a cladoceran (*Ceriodaphnia dubia*) in acute and chronic water exposures. *Environmental Toxicology and Chemistry*, *30*(9), 2115-2125.

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

White, E.L., J.J. Schmid, T.G. Howard, M.D. Schlesinger, and A.L. Feldmann. 2011. New York State freshwater conservation blueprint project, phases I and II: Freshwater systems, species, and viability metrics. New York Natural Heritage Program, The Nature Conservancy. Albany, NY. 85 pp. plus appendix.

Williams, J.D., M.L. Warren, K.S. Cummings, J.L .Harris & R.J. Neves. (1993). Conservation status of freshwater mussels of the United States and Canada. Fisheries 18(9):6-22.

Wildenberg, A. (2012, August). Mussel Community Response to Wastewater Effluent in a Midwestern River. In *AFS 142nd Annual Meeting*. AFS.

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.

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