NEW YORK
FISH & AQUATIC INVERTEBRATE INVASIVENESS RANKING FORM

Scientific name:	Dreissena rostriformis bugensis
Common names:	Quagga Mussel
Native distribution:	Indigenous to the Dneiper River drainage of Ukraine and Ponto-Caspian Sea
Date assessed:	6/12/2013
Assessors:	D. Adams
Reviewers:	
Date Approved:	Form version date: 3 January 2013

New York Invasiveness Rank: Very High (Relative Maximum Score >80.00)

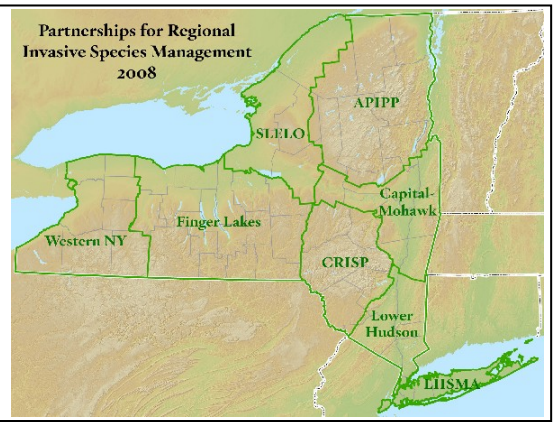
Distribution and Invasiveness Rank (*Obtain from PRISM invasiveness ranking form*)			
	Status of this species in each PRISM:	Current Distribution	PRISM Invasiveness Rank
1	Adirondack Park Invasive Program	Common	Not Assessed
2	Capital/Mohawk	Common	Not Assessed
3	Catskill Regional Invasive Species Partnership	Common	Not Assessed
4	Finger Lakes	Common	Not Assessed
5	Long Island Invasive Species Management Area	Restricted	Not Assessed
6	Lower Hudson	Common	Not Assessed
7	Saint Lawrence/Eastern Lake Ontario	Common	Not Assessed
8	Western New York	Common	Not Assessed

Invasiveness Ranking Summary (see details under appropriate sub-section)		Total (Total Answered*) Possible	Total
1	Ecological impact	30 (30)	30
2	Biological characteristic and dispersal ability	30 (30)	22
3	Ecological amplitude and distribution	30 (30)	30
4	Difficulty of control	10 (10)	6
	Outcome score	100 (100)[b]	88[a]
	Relative maximum score †		88
	New York Invasiveness Rank §	Very High (Relative Maximum Score >80.00)	

* For questions answered "unknown" do not include point value in "Total Answered Points Possible." If "Total Answered Points Possible" is less than 70.00 points, then the overall invasive rank should be listed as "Unknown."
†Calculated as 100(a/b) to two decimal places.
§Very High >80.00; High 70.00−80.00; Moderate 50.00−69.99; Low 40.00−49.99; Insignificant <40.00

A. DISTRIBUTION (KNOWN/POTENTIAL): Summarized from individual PRISM forms

A1.1. Has this species been documented in NY? (reliable source; voucher not required)	
☒	Yes – continue to A1.2
☐	No – continue to A2.1; Yes ☐ NA; Yes ☐ USA
A1.2. In which PRISMs is it known (see inset map)?	
☒	Adirondack Park Invasive Program
☒	Capital/Mohawk
☒	Catskill Regional Invasive Species Partnership
☒	Finger Lakes
☐	Long Island Invasive Species Management Area
☒	Lower Hudson
☒	Saint Lawrence/Eastern Lake Ontario



☒	Western New York

Documentation:
Sources of information:

A2.0. Is this species listed on the Federal Injurious Fish and Wildlife list?
☒ Yes – the species will automatically be listed as Prohibited, no further assessment required.
☐ No – continue to A2.1

A2.1. What is the likelihood that this species will occur and persist given the climate in the following PRISMs? (obtain from PRISM invasiveness ranking form and/ or Climatch score)

Very Likely	Adirondack Park Invasive Program
Very Likely	Capital/Mohawk
Very Likely	Catskill Regional Invasive Species Partnership
Very Likely	Finger Lakes
Moderately Likely	Long Island Invasive Species Management Area
Very Likely	Lower Hudson
Very Likely	Saint Lawrence/Eastern Lake Ontario
Very Likely	Western New York

Documentation:
Sources of information (e.g.: distribution models, literature, expert opinions):

If the species does not occur and is not likely to survive and reproduce within any of the PRISMs, then stop here as there is no need to assess the species.

A2.2. What is the current distribution of the species in each PRISM? (obtain rank *from PRISM invasiveness ranking forms*)

	Distribution
Adirondack Park Invasive Program	Common
Capital/Mohawk	Common
Catskill Regional Invasive Species Partnership	Common
Finger Lakes	Common
Long Island Invasive Species Management Area	Restricted
Lower Hudson	Common
Saint Lawrence/Eastern Lake Ontario	Common
Western New York	Common

Documentation:
Sources of information:

A2.3. Describe the potential or known suitable habitats within New York. Natural habitats include all habitats not under active human management. Managed habitats are indicated with an asterisk.

Aquatic Habitats	Wetland Habitats	Upland Habitats
☐ Marine	☐ Salt/brackish marshes	☐ Cultivated*
☐ Salt/ brackish waters	☐ Freshwater marshes	☐ Grasslands/old fields
☒ Freshwater tidal	☐ Peatlands	☐ Shrublands
☒ Rivers/streams	☐ Shrub swamps	☐ Forests/woodlands
☒ Natural lakes and ponds	☐ Forested wetlands/riparian	☐ Alpine
☐ Vernal pools	☐ Ditches*	☐ Roadsides*
☒ Reservoirs/ impoundments*	☐ Beaches/or coastal dunes	☐ Cultural*

Other potential or known suitable habitats within New York:

Documentation:
Sources of information:
www.nas.er.usgs.gov

B. INVASIVENESS RANKING

1. ECOLOGICAL IMPACT

1.1. Impact on Ecosystem Processes and System-wide Parameters (e.g., water cycle, energy cycle, nutrient and mineral dynamics, light availability, or geomorphological changes (erosion and sedimentation rates).

A.	No perceivable impact on ecosystem processes based on research studies, or the absence of impact information if a species is widespread (>10 occurrences in minimally managed areas), has been well-studied (>10 reports/publications), and has been present in the northeast for >100 years.	0
B.	Influences ecosystem processes to a minor degree, has a perceivable but mild influence	3
C.	Significant alteration of ecosystem processes	7
D.	Major, possibly irreversible, alteration or disruption of ecosystem processes	10
U.	Unknown	

Score 10

Documentation:
Identify ecosystem processes impacted (or if applicable, justify choosing answer A in the absence of impact information)
Quaggas are prodigious water filterers, removing substantial amounts of phytoplankton and suspended particulate from the water. Quaggas in turn decrease the food source for zooplankton, therefore altering the food web. Impacts include increases in water transparency, decreases in mean chlorophyll a concentrations and accumulation of pseudofeces.
Sources of information:
www.nas.er.usgs.gov

1.2. Impact on Natural Habitat/ Community Composition

A.	No perceived impact; causes no apparent change in native populations	0
B.	Influences community composition (e.g., reduces the number of individuals of one or more native species in the community)	3
C.	Significantly alters community composition (e.g., produces a significant reduction in the population size of one or more native species in the community)	7
D.	Causes major alteration in community composition (e.g., results in the extirpation of one or several native species, reducing biodiversity or change the community composition towards species exotic to the natural community)	10
U.	Unknown	

Score 10

Documentation:
Identify type of impact or alteration:
Water clarity increases light penetration causing a proliferation of aquatic plants that can change species dominance and alter the entire ecosystem. Quagga are able to colonize both hard and soft substrata and therefore have the potential to negatively impact native freshwater mussels and invertebrates.
Sources of information:
www.nas.er.usgs.gov

1.3. Impact on other species or species groups, including cumulative impact of this species on other organisms in the community it invades. (e.g., interferes with native predator/ prey dynamics; injurious components/ spines; reduction in spawning; hybridizes with a native species; hosts a non-native disease which impacts a native species)

A.	Negligible perceived impact	0
B.	Minor impact (e.g. impacts 1 species, <20% population decline, limited host damage)	3

C. Moderate impact (e.g. impacts 2-3 species and/ or 20-29% population decline of any 1 species, kills host in 2-5 years, ,) 7
D. Severe impact on other species or species groups (e.g. impacts >3 species and/ or ≥30% population decline of any 1 species, kills host within 2 years, extirpation) 10
U. Unknown

Score 10

Documentation:
Identify type of impact or alteration:
As the waste particles decompose, oxygen is used up, and the pH becomes very acidic and toxic byproducts are produced. Quagga mussels accumulate organic pollutants within their tissues to levels more than 300,000 times greater than concentrations in the environment, which can be passed up the food chain.
Sources of information:
www.nas.er.usgs.gov

Total Possible 30
Section One Total 30

2. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

2.1. Mode and rate of reproduction (provisional thresholds, more investigation needed)

A. No reproduction (e.g. sterile with no sexual or asexual reproduction). 0
B. Limited reproduction (e.g., intrinsic rate of increase <10%, low fecundity, complete one life cycle) 1
C. Moderate reproduction (e.g., intrinsic rate of increase between 10-30%, moderate fecundity, complete 2-3 life cycles) 2
D. Abundant reproduction (e.g., intrinsic rate of increase >30%, parthenogenesis, large egg masses, complete > 3 life cycles) 4
U. Unknown

Score 4

Documentation:
Describe key reproductive characteristics:
The genus Dreissena is highly polymorphic and prolific with high potential for rapid adaptation attributing to its rapid expansion and colonization.
Sources of information:
www.nas.er.usgs.gov

2.2. Migratory behavior

A. Always migratory in its native range 0
B. Non-migratory or facultative migrant in its native range 2
U. Unknown

Score 2

Documentation:
Describe migratory behavior:

Sources of information:
www.nas.er.usgs.gov

2.3. Biological potential for colonization by long-distance dispersal/ movement (e.g., veligers, resting stage eggs, glochidia)

A. No long-distance dispersal/ movement mechanisms 0
B. Adaptations exist for long-distance dispersal, but studies report that most individuals (90%) establish territories within 5 miles of natal origin or within a distance twice the home range of the typical individual, and tend not to cross major barriers such as dams and watershed divides 1

C. Adaptations exist for long-distance dispersal, movement and evidence that offspring often disperse greater than 5 miles of natal origin or greater than twice the home range of typical individual and will cross major barriers such as dams and watershed divides 2

U. Unknown

Score 2

Documentation:
Identify dispersal mechanisms:
The introduction of quagga mussels into the Great Lakes appears to be the result of ballast water discharge from transoceanic ships that were carrying veligers, juveniles or adult mussels. There are other factors that can aid in the spread across North American waters such as larval drift in river systems or fishing and boating activities that allow for overland transport or movement between water basins.
Sources of information:
www.nas.er.usgs.gov

2.4. Practical potential to be spread by human activities, both directly and indirectly – possible vectors include: commercial bait sales, deliberate illegal stocking, aquaria releases, boat trailers, canals, ballast water exchange, live food trade, rehabilitation, pest control industry, aquaculture escapes, etc.)

A. Does not occur 0

B. Low (human dispersal to new areas occurs almost exclusively by direct means and is infrequent or inefficient) 1

C. Moderate (human dispersal to new areas occurs by direct and indirect means to a moderate extent) 2

D. High (opportunities for human dispersal to new areas by direct and indirect means are numerous, frequent, and successful) 4

U. Unknown

Score 4

Documentation:
Identify dispersal mechanisms:
The introduction of quagga mussels into the Great Lakes appears to be the result of ballast water discharge from transoceanic ships that were carrying veligers, juveniles or adult mussels. There are other factors that can aid in the spread across North American waters such as larval drift in river systems or fishing and boating activities that allow for overland transport or movement between water basins.
Sources of information:
www.nas.er.usgs.gov

2.5. Non-living chemical and physical characteristics that increase competitive advantage (e.g., tolerance to various extremes, pH, DO, temperature, desiccation, fill vacant niche, charismatic species)

A. Possesses no characteristics that increase competitive advantage 0

B. Possesses one characteristic that increases competitive advantage 4

C. Possesses two or more characteristics that increase competitive advantage 8

U. Unknown

Score 4

Documentation:
Evidence of competitive ability:
Quaggas are able to colonize both hard and soft subtrata.
Sources of information:
www.nas.er.usgs.gov

2.6. Biological characteristics that increase competitive advantage (e.g., high fecundity, generalist/ broad niche space, highly evolved defense mechanisms,

behavioral adaptations, piscivorous, etc.)

A.	Possesses no characteristics that increase competitive advantage	0
B.	Possesses one characteristic that increases competitive advantage	4
C.	Possesses two or more characteristics that increase competitive advantage	8
U.	Unknown	

Score 4

Documentation:
Evidence of competitive ability:
The genus Dreissena is highly polymorphic and prolific.
Sources of information:
www.nas.er.usgs.gov

2.7. Other species in the family and/ or genus invasive in New York or elsewhere?

A.	No	0
B.	Yes	2
U.	Unknown	

Score 2

Documentation:
Identify species:
Dresissena polymorpha, zebra mussel.

Total Possible 30
Section Two Total 22

3. ECOLOGICAL AMPLITUDE AND DISTRIBUTION

3.1. Current introduced distribution in the northern latitudes of USA and southern latitude of Canada (e.g., between 35 and 55 degrees).

A.	Not known from the northern US or southern Canada.	0
B.	Established as a non-native in 1 northern USA state and/or southern Canadian province.	1
C.	Established as a non-native in 2 or 3 northern USA states and/or southern Canadian provinces.	2
D.	Established as a non-native in 4 or more northern USA states and/or southern Canadian provinces, and/or categorized as a problem species (e.g., "Invasive") in 1 northern state or southern Canadian province.	3
U.	Unknown	

Score 3

Documentation:
Identify states and provinces:
First sights in the Great Lakes in 1989, since found in Lake Michigan, Lake Huron, Lake Erie, Lake Ontario, Lake St. Clair, Saginaw Bay, and throughout the St. Lawrence River north to Quebec City. Inland occurances have been reported in Iowa, Kentucky, Michigan, Minnesota, New York, Ohio, and Pennsylvania.
Sources of information:
- See known introduced range at www.usda.gov, and update with information from states and Canadian provinces.

www.nas.er.usgs.gov

3.2. Current introduced distribution of the species in natural areas in the eight New York State PRISMs (Partnerships for Regional Invasive Species Management)

A.	Established in none of the PRISMs	0
B.	Established in 1 PRISM	1

C. Established in 2 or 3 PRISMs 3
D. Established in 4 or more PRISMs 5
U. Unknown

Score 5

Documentation:
Describe distribution:

Sources of information:
www.nas.er.usgs.gov

3.3. Number of known, or potential (each individual possessed by a vendor or consumer), individual releases and/ or release events

A. None 0
B. Few releases (e.g., <10 annually). 2
C. Regular, small scale releases (e.g., 10-99 annually). 4
D. Multiple, large scale (e.g., ≥100 annually). 6
U. Unknown

Score 6

Documentation:
Describe known or potential releases:
The introduction of quagga mussels into the Great Lakes appears to be the result of ballast water discharge from transoceanic ships that were carrying veligers, juveniles or adult mussels. There are other factors that can aid in the spread across North American waters such as larval drift in river systems or fishing and boating activities that allow for overland transport or movement between water basins.
Sources of information:
www.nas.er.usgs.gov

3.4. Current introduced population density, or distance to known occurrence, in northern USA and/ or southern Canada.

A. No known populations established. 0
B. Low to moderate population density (e.g., ≤1/4 to < 1/2 native population density) with few other invasives present and/ or documented in 1 or more non-adjacent state/ province and/ or 1 unconnected waterbody. 1
C. High or irruptive population density (e.g., ≥1/2 native population density) with numerous other invasives present and/ or documented in 1 or more adjacent state/ province and/ or 1 connected waterbody. 2
U. Unknown

Score 2

Documentation:
Describe population density:
If the native habitat of quagga mussels is to provide any sort of indictor, the quagga mussel will most likley take over areas where the zebra mussel is now established to become the dominant dreissenid of the Great Lakes. Desities in dam water intakes have been measured at 35,000 per square meter in 2010.
Sources of information:
www.nas.er.usgs.gov

3.5. Number of habitats the species may invade

A. Not known to invade any natural habitats given at A2.3. 0

B. Known to occur in 2 or 3 of the habitats given at A2.3, with at least 1 or 2 natural habitat(s). 2
C. Known to occur in 4 or more of the habitats given at A2.3, with at least 3 natural habitats. 3
U. Unknown.

Score 3

Documentation:
Identify type of habitats where it occurs and degree/type of impacts:
Quaggas inhabit freshwater rivers, lakes, and reservoirs having a preference for deeper cooler waters compared to zebra mussels, they are not known to tolerate salinities greater than 5 ppt.
Sources of information:
www.nas.er.usgs.gov

3.6. Role of anthropogenic (human related) and natural disturbance in establishment (e.g. water level management, man-made structures, high vehicle traffic, major storm events, etc).

A. Requires anthropogenic disturbances to establish. 0
B. May occasionally establish in undisturbed areas but can readily establish in areas with natural or anthropogenic disturbances. 2
C. Can establish independent of any known natural or anthropogenic disturbances. 3
U. Unknown.

Score 3

Documentation:
Identify type of disturbance:

Sources of information:
www.nas.er.usgs.gov

3.7. Climate in native range (e.g., med. to high, ≥5, Climatch score; within 35 to 55 degree latitude; etc.)

A. Native range does not include climates similar to New York (e.g., <10%). 0
B. Native range possibly includes climates similar to portions of New York (e.g., 10-29%). 4
C. Native range includes climates similar to those in New York (e.g., ≥30%). 8
U. Unknown.

Score 8

Documentation:
Describe known climate similarities:
Indigenous to the Ukraine and Ponto-Caspian Sea. Water temperatures of 28 degrees C begin to cause significant mortality, and 32-35 degrees are considered lethal.
Sources of information:
www.nas.er.usgs.gov

Total Possible 30
Section Three Total 30

4. DIFFICULTY OF CONTROL

4.1. Re-establishment potential, nearby propagule source, known vectors of re-introduction (e.g. biological supplies, pets, aquaria, aquaculture facilities, connecting waters/ corridors, mechanized transportation, live wells, etc.)

A. No known vectors/ propagule source for re-establishment following removal. 0
B. Possible re-establishment from 1 vector/ propagule source following removal and/ or viable <24 hours. 1
C. Likely to re-establish from 2-3 vectors/ propagule sources following removal and/ or viable 2

2-7 days.

D. Strong potential for re-establishment from 4 or more vectors/ propagule sources following removal and/or viable >7 days. 3

U. Unknown

Score 2

Documentation:
Identify source/ vectors:
The introduction of quagga mussels into the Great Lakes appears to be the result of ballast water discharge from transoceanic ships that were carrying veligers, juveniles or adult mussels. There are other factors that can aid in the spread across North American waters such as larval drift in river systems or fishing and boating activities that allow for overland transport or movement between water basins.
Sources of information:
www.nas.er.usgs.gov

4.2. Status of monitoring and/ or management protocols for species

A. Standardized protocols appropriate to New York State are available. 0

B. Scientific protocols are available from other countries, regions or states. 1

C. No known protocols exist. 2

U. Unknown

Score 0

Documentation:
Describe protocols:
In August 1991 a mussel with a different genotype was found in a random zebra mussel sample from the Erie Canal near Palmyra NY.
Sources of information:
www.nas.er.usgs.gov

4.3. Status of monitoring and/ or management resources (e.g. tools, manpower, travel, traps, lures, ID keys, taxonomic specialists, etc.)

A. Established resources are available including commercial and/ or research tools 0

B. Monitoring resources may be available (e.g. partnerships, NGOs, etc) 1

C. No known monitoring resources are available 2

U. Unknown

Score 1

Documentation:
Describe resources:

Sources of information:
www.nas.er.usgs.gov

4.4. Level of effort required

A. Management is not required. (e.g., species does not persist without repeated human mediated action.) 0

B. Management is relatively easy and inexpensive; invasive species can be maintained at low abundance causing little or no ecological harm. (e.g., 10 or fewer person-hours of manual effort can eradicate a local infestation in 1 year.) 1

C. Management requires a major short-term investment, and is logistically and politically challenging; eradication is difficult, but possible. (e.g., 100 or fewer person-hours/year of manual effort, or up to 10 person-hours/ year for 2-5 years to suppress a local infestation.) 2

D. Management requires a major investment and is logistically and politically difficult; eradication may be impossible. (e.g., more than 100 person-hours/ year of manual effort, or more than 10 person hours/year for more than 5 years to suppress a local infestation.) 3

U. Unknown

Score	3

Documentation:
Identify types of control methods and time required:
Prechlorination has been the most common treatment for control, an alternative for drinking water has been potassium permanganate. Thermal treatment of residual water in boats and other water vehicles may be viable options for managing spread. Research on control is promising using a lethal bacteria, pseudomonas flurescens, a common soil bacteria.
Sources of information:
www.nas.er.usgs.gov

Total Possible	10
Section Four Total	6
Total for 4 sections Possible	100
Total for 4 sections	88

C. STATUS OF GENETIC VARIANTS AND HYBRIDS:

At the present time there is no protocol or criteria for assessing the invasiveness of genetic variants independent of the species to which they belong. Such a protocol is needed, and individuals with the appropriate expertise should address this issue in the future. Such a protocol will likely require data on cultivar fertility and identification in both experimental and natural settings.

Genetic variants of the species known to exist: The genus Dreissena is highly polymorphic.

Hybrids (crosses between different parent species) should be assessed individually and separately from the parent species wherever taxonomically possible, since their invasiveness may differ from that of the parent species. An exception should be made if the taxonomy of the species and hybrids are uncertain, and species and hybrids can not be clearly distinguished in the field. In such cases it is not feasible to distinguish species and hybrids, and they can only be assessed as a single unit.

Hybrids of uncertain origin known to exist: Although hybridization between the two introduced dreissenid species is a concern, interspecific fertilization may be rare in nature and hybrids constitute a very small proportion of the Dreissenid community.

References for species assessment:
www.nas.er.usgs.gov

Citation: The New York Fish & Aquatic Invertebrate Invasiveness Ranking Form is an adaptation of the New York Plant Invasiveness Ranking Form. The original plant form may be cited as: Jordan, M.J., G. Moore and T.W. Weldy. 2008. Invasiveness ranking system for non-native plants of New York. Unpublished. The Nature Conservancy, Cold Spring Harbor, NY; Brooklyn Botanic Garden, Brooklyn, NY; The Nature Conservancy, Albany, NY.

Acknowledgments: The New York Fish and Aquatic Invertebrate Invasiveness Ranking Form incorporates components and approaches used in several other systems, cited in the references below. Valuable contributions by members of the Invasive Species Council and Invasive Species Advisory Committee were incorporated in revisions of this form. Members of the Office of Invasive Species Coordination's Four-tier Team, who coordinated the effort, included representatives of the New York State Department of Environmental Conservation* (Division of Fish, Wildlife and Marine Resources, Division of Lands and Forests, Division of Water); The Nature Conservancy; New

York Natural Heritage Program; New York Sea Grant*; Lake Champlain Sea Grant*; New York State Department of Agriculture and Markets (Division of Plant Industry and Division of Animal Industry); Cornell University (Department of Natural Resources and Department of Entomology); New York State Nursery and Landscape Association; New York Farm Bureau; Brooklyn Botanic Garden; Pet Industry Joint Advisory Council*; Trout Unlimited*; United States Department of Agriculture Animal and Plant Health Inspection Service (Plant Protection and Quarantine and Wildlife Services); New York State Department of Transportation; State University of New York at Albany and Plattsburgh*; and Cary Institute of Ecosystem Studies. Those organizations listed with an asterisk comprised the Fish and Aquatic Invertebrate Working Group.

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