

NEW YORK NON-NATIVE PLANT INVASIVENESS RANKING FORM

Scientific name: Hydrocharis morsus-ranae L. USDA Plants Code: HYMO6
 Common names: Frogbit
 Native distribution: Eurasia
 Date assessed: 16 May 2008
 Assessors: Steve Glenn
 Reviewers: LIISMA SRC
 Date Approved: June 16, 2008 Form version date: 10 July 2009

New York Invasiveness Rank: Very High Invasive Nature (score greater than 0.8)

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

Invasiveness Ranking Summary (see details under appropriate sub-section)		Total (Total Answered*) Possible	Total
1	Ecological impact	40 (<u>40</u>)	34
2	Biological characteristic and dispersal ability	25 (<u>22</u>)	19
3	Ecological amplitude and distribution	25 (<u>25</u>)	22
4	Difficulty of control	10 (<u>10</u>)	8
Outcome score		100 (<u>97</u>) ^b	83^a
Relative maximum score [†]			85.57
New York Invasiveness Rank [§]		Very High Invasive Nature (score greater than 0.8)	

* 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
 Not Assessable: not persistent in NY, or not found outside of cultivation.

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

A1.1. Has this species been documented to persist without cultivation in NY? (reliable source; voucher not required)

<input checked="" type="checkbox"/>	Yes – continue to A1.2
<input type="checkbox"/>	No – continue to A2.1

A1.2. In which PRISMs is it known (see inset map)?

<input checked="" type="checkbox"/>	Adirondack Park Invasive Program
<input checked="" type="checkbox"/>	Capital/Mohawk
<input type="checkbox"/>	Catskill Regional Invasive Species Partnership
<input checked="" type="checkbox"/>	Finger Lakes
<input checked="" type="checkbox"/>	Long Island Invasive Species Management Area
<input type="checkbox"/>	Lower Hudson
<input checked="" type="checkbox"/>	Saint Lawrence/Eastern Lake Ontario
<input type="checkbox"/>	Western New York



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Documentation:

Sources of information:
Weldy & Werier, 2005.

A2.1. What is the likelihood that this species will occur and persist outside of cultivation, given the climate in the following PRISMs? (obtain from PRISM invasiveness ranking form)

- Not Assesse Adirondack Park Invasive Program
- Not Assesse Capital/Mohawk
- Not Assesse Catskill Regional Invasive Species Partnership
- Not Assesse Finger Lakes
- Moderately Long Island Invasive Species Management Area
- Not Assesse Lower Hudson
- Not Assesse Saint Lawrence/Eastern Lake Ontario
- Not Assesse Western New York

Documentation:

Sources of information (e.g.: distribution models, literature, expert opinions):
Catling, P. M. et al. 2003; Weldy & Werier, 2005.

If the species does not occur and is not likely to occur in any of the PRISMs, then stop here as there is no need to assess the species. Rank is “Not Assessable.”

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	Not Assessed
Capital/Mohawk	Not Assessed
Catskill Regional Invasive Species Partnership	Not Assessed
Finger Lakes	Not Assessed
Long Island Invasive Species Management Area	Restricted
Lower Hudson	Not Assessed
Saint Lawrence/Eastern Lake Ontario	Not Assessed
Western New York	Not Assessed

Documentation:

Sources of information:
Brooklyn Botanic Garden, 2008.

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 |
|--|--|--|
| <input type="checkbox"/> Salt/brackish waters | <input type="checkbox"/> Salt/brackish marshes | <input type="checkbox"/> Cultivated* |
| <input type="checkbox"/> Freshwater tidal | <input type="checkbox"/> Freshwater marshes | <input type="checkbox"/> Grasslands/old fields |
| <input checked="" type="checkbox"/> Rivers/streams | <input type="checkbox"/> Peatlands | <input type="checkbox"/> Shrublands |
| <input checked="" type="checkbox"/> Natural lakes and ponds | <input type="checkbox"/> Shrub swamps | <input type="checkbox"/> Forests/woodlands |
| <input type="checkbox"/> Vernal pools | <input checked="" type="checkbox"/> Forested wetlands/riparian | <input type="checkbox"/> Alpine |
| <input checked="" type="checkbox"/> Reservoirs/impoundments* | <input type="checkbox"/> Ditches* | <input type="checkbox"/> Roadsides* |
| | <input type="checkbox"/> Beaches and/or coastal dunes | |

Other potential or known suitable habitats within New York:

Documentation:

Sources of information:
Catling et al., 2003; Jean, & Bouchard, 1993.

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B. INVASIVENESS RANKING

Questions apply to areas similar in climate and habitats to New York unless specified otherwise.

1. ECOLOGICAL IMPACT

1.1. Impact on Natural Ecosystem Processes and System-Wide Parameters (e.g. fire regime, geomorphological changes (erosion, sedimentation rates), hydrologic regime, nutrient and mineral dynamics, light availability, salinity, pH)

- 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 (e.g., has a perceivable but mild influence on soil nutrient availability) 3
- C. Significant alteration of ecosystem processes (e.g., increases sedimentation rates along streams or coastlines, reduces open water that are important to waterfowl) 7
- D. Major, possibly irreversible, alteration or disruption of ecosystem processes (e.g., the species alters geomorphology and/or hydrology, affects fire frequency, alters soil pH, or fixes substantial levels of nitrogen in the soil making soil unlikely to support certain native plants or more likely to favor non-native species) 10
- U. Unknown

Score

10

Documentation:
 Identify ecosystem processes impacted (or if applicable, justify choosing answer A in the absence of impact information):
 Limits water flow in surface hydrologic systems; reduced light to submersed vegetation
Sources of information:
 Catling et al., 2003; S. Young pers. obser.

1.2. Impact on Natural Community Structure

- A. No perceived impact; establishes in an existing layer without influencing its structure 0
- B. Influences structure in one layer (e.g., changes the density of one layer) 3
- C. Significant impact in at least one layer (e.g., creation of a new layer or elimination of an existing layer) 7
- D. Major alteration of structure (e.g., covers canopy, eradicating most or all layers below) 10
- U. Unknown

Score

10

Documentation:
 Identify type of impact or alteration:
 .Forms large masses of interlocking plants; reduces light to submersed vegetation
Sources of information:
 Catling et al., 2003; S. Young pers. obser.

1.3. Impact on Natural 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 in 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

7

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Documentation: Identify type of impact or alteration: Diminishes native submerged aquatic plant communities by reducing available light; although one study in Canada suggests <i>Hydrocharis morsus-ranae</i> is no more likely to dominate a wetland than native species. Sources of information: Catling et al., 2003; Houlahan, & Findlay, 2004.	
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1.4. Impact on other species or species groups (cumulative impact of this species on the animals, fungi, microbes, and other organisms in the community it invades. Examples include reduction in nesting/foraging sites; reduction in habitat connectivity; injurious components such as spines, thorns, burrs, toxins; suppresses soil/sediment microflora; interferes with native pollinators and/or pollination of a native species; hybridizes with a native species; hosts a non-native disease which impacts a native species)

- | | |
|---|----|
| A. Negligible perceived impact | 0 |
| B. Minor impact | 3 |
| C. Moderate impact | 7 |
| D. Severe impact on other species or species groups | 10 |
| U. Unknown | |

Score 7

Documentation: Identify type of impact or alteration: Reduction of native aquatic animals; autumn decay of large biomass can cause excessive oxygen depletion leading to fish mortality. Sources of information: Catling et al., 2003.	
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Total Possible	40
Section One Total	34

2. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

2.1. Mode and rate of reproduction

- | | |
|--|---|
| A. No reproduction by seeds or vegetative propagules (i.e. plant sterile with no sexual or asexual reproduction). | 0 |
| B. Limited reproduction (fewer than 10 viable seeds per plant AND no vegetative reproduction; if viability is not known, then maximum seed production is less than 100 seeds per plant and no vegetative reproduction) | 1 |
| C. Moderate reproduction (fewer than 100 viable seeds per plant - if viability is not known, then maximum seed production is less than 1000 seeds per plant - OR limited successful vegetative spread documented) | 2 |
| D. Abundant reproduction with vegetative asexual spread documented as one of the plants prime reproductive means OR more than 100 viable seeds per plant (if viability is not known, then maximum seed production reported to be greater than 1000 seeds per plant.) | 4 |
| U. Unknown | |

Score 4

Documentation: Describe key reproductive characteristics (including seeds per plant): Vegetative reproduction is very important in spread and colonization. In the fall, turions separate from the plant, sinking to the bottom where they overwinter. In the spring, these turions grow into small floating rosettes followed by extremely rapid stoloniferous growth. Seed production can be prolific at times- one study found 3000 seeds per square meter. Sources of information:	
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Catling et al., 2003.

2.2. Innate potential for long-distance dispersal (e.g. bird dispersal, sticks to animal hair, buoyant fruits, pappus for wind-dispersal)

- | | | |
|----|--|---|
| A. | Does not occur (no long-distance dispersal mechanisms) | 0 |
| B. | Infrequent or inefficient long-distance dispersal (occurs occasionally despite lack of adaptations) | 1 |
| C. | Moderate opportunities for long-distance dispersal (adaptations exist for long-distance dispersal, but studies report that 95% of seeds land within 100 meters of the parent plant) | 2 |
| D. | Numerous opportunities for long-distance dispersal (adaptations exist for long-distance dispersal and evidence that many seeds disperse greater than 100 meters from the parent plant) | 4 |
| U. | Unknown | |

Score 4

Documentation:

Identify dispersal mechanisms:

Water (hydrochory) by seeds and turions, which are clusters of bud-like leaves that act like a seed. Attaching to animals (epizoochory) by viscid seed coats and entire plants which adhere to waterfowl.

Sources of information:

Catling et al., 2003.

2.3. Potential to be spread by human activities (both directly and indirectly – possible mechanisms include: commercial sales, use as forage/revegetation, spread along highways, transport on boats, contaminated compost, land and vegetation management equipment such as mowers and excavators, 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) | 3 |
| U. | Unknown | |

Score 3

Documentation:

Identify dispersal mechanisms:

Commercially available from aquarium and gardening industries. Spread by fishermen via watercraft, motors, and baitbucket discharges. Intentionally introduced by duck -hunting clubs as food for waterfowl.

Sources of information:

Catling et al., 2003.

2.4. Characteristics that increase competitive advantage, such as shade tolerance, ability to grow on infertile soils, perennial habit, fast growth, nitrogen fixation, allelopathy, etc.

- | | | |
|----|---|---|
| A. | Possesses no characteristics that increase competitive advantage | 0 |
| B. | Possesses one characteristic that increases competitive advantage | 3 |
| C. | Possesses two or more characteristics that increase competitive advantage | 6 |
| U. | Unknown | |

Score 6

Documentation:

Evidence of competitive ability:

Perennial, fast growth

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Prolific asexual reproduction via turions.
Sources of information:
Catling et al., 2003.

2.5. Growth vigor

- A. Does not form thickets or have a climbing or smothering growth habit 0
- B. Has climbing or smothering growth habit, forms a dense layer above shorter vegetation, forms dense thickets, or forms a dense floating mat in aquatic systems where it smothers other vegetation or organisms 2
- U. Unknown

Score 2

Documentation:
Describe growth form:
Forms large masses of interlocking plants.
Sources of information:
Catling et al., 2003.

2.6. Germination/Regeneration

- A. Requires open soil or water and disturbance for seed germination, or regeneration from vegetative propagules to germinate 0
- B. Can germinate/regenerate in vegetated areas but in a narrow range or in special conditions 2
- C. Can germinate/regenerate in existing vegetation in a wide range of conditions 3
- U. Unknown (No studies have been completed)

Score U

Documentation:
Describe germination requirements:
Few germinated seedlings found in wild, reproduction mostly asexual.
Sources of information:
Catling et al., 2003.

2.7. Other species in the genus invasive in New York or elsewhere

- A. No 0
- B. Yes 3
- U. Unknown

Score 0

Documentation:
Species:
Weldy & Werier, 2005; Brooklyn Botanic Garden, 2008.

Total Possible 22
Section Two Total 19

3. ECOLOGICAL AMPLITUDE AND DISTRIBUTION

3.1. Density of stands in natural areas in the northeastern USA and eastern Canada (use same definition as Gleason & Cronquist which is: "The part of the United States covered extends from the Atlantic Ocean west to the western boundaries of Minnesota, Iowa, northern Missouri, and southern Illinois, south to the southern boundaries of Virginia, Kentucky, and Illinois, and south to the Missouri River in Missouri. In Canada the area covered includes Nova Scotia, Prince Edward Island, New Brunswick, and parts of Quebec and Ontario lying south of the 47th parallel of latitude")

- A. No large stands (no areas greater than 1/4 acre or 1000 square meters) 0
- B. Large dense stands present in areas with numerous invasive species already present or disturbed landscapes 2

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- C. Large dense stands present in areas with few other invasive species present (i.e. ability to invade relatively pristine natural areas) 4
- U. Unknown

Score

Documentation:

Identify reason for selection, or evidence of weedy history:
Large dense stands of interlocking plants can be present where other invasive species are not present.
Sources of information:
Catling et al., 2003.

3.2. 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 one natural habitat given at A2.3 1
- C. Known to occur in two natural habitats given at A2.3 2
- D. Known to occur in three natural habitat given at A2.3 4
- E. Known to occur in four or more natural habitats given at A2.3 6
- U. Unknown

Score

Documentation:

Identify type of habitats where it occurs and degree/type of impacts:
Pond, lakes, rivers, forested wetlands.
Sources of information:
Catling et al., 2003; Jean, & Bouchard, 1993.

3.3. Role of disturbance in establishment

- 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. 4
- U. Unknown

Score

Documentation:

Identify type of disturbance:

Sources of information:
Catling et al., 2003.

3.4. Climate in native range

- A. Native range does not include climates similar to New York 0
- B. Native range possibly includes climates similar to at least part of New York. 1
- C. Native range includes climates similar to those in New York 3
- U. Unknown

Score

Documentation:

Describe what part of the native range is similar in climate to New York:
Sweden and Finland to Italy, east to the Caucasus.
Sources of information:
Catling et al., 2003

3.5. Current introduced distribution in the northeastern USA and eastern Canada (see question 3.1 for definition of geographic scope)

- A. Not known from the northeastern US and adjacent Canada 0
- B. Present as a non-native in one northeastern USA state and/or eastern Canadian province. 1

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- C. Present as a non-native in 2 or 3 northeastern USA states and/or eastern Canadian provinces. 2
- D. Present as a non-native in 4–8 northeastern USA states and/or eastern Canadian provinces, and/or categorized as a problem weed (e.g., “Noxious” or “Invasive”) in 1 northeastern state or eastern Canadian province. 3
- E. Present as a non-native in >8 northeastern USA states and/or eastern Canadian provinces. and/or categorized as a problem weed (e.g., “Noxious” or “Invasive”) in 2 northeastern states or eastern Canadian provinces. 4
- U. Unknown

Score

3

Documentation:
 Identify states and provinces invaded:
 MI, NY, VT; Ontario, Quebec, Canada
 Sources of information:
 See known introduced range in plants.usda.gov, and update with information from states and Canadian provinces.
 Catling, P. M. et al., 2003; Jean, & Bouchard., 1993; United States Department of Agriculture, 2008

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

- A. Present in none of the PRISMs 0
- B. Present in 1 PRISM 1
- C. Present in 2 PRISMs 2
- D. Present in 3 PRISMs 3
- E. Present in more than 3 PRISMs or on the Federal noxious weed lists 4
- U. Unknown

Score

4

Documentation:
 Describe distribution:
 In 4 Prisms
 Sources of information:
 New York Flora Association, 2008

Total Possible

25

 Section Three Total

22

4. DIFFICULTY OF CONTROL

4.1. Seed banks

- A. Seeds (or vegetative propagules) remain viable in soil for less than 1 year, or does not make viable seeds or persistent propagules. 0
- B. Seeds (or vegetative propagules) remain viable in soil for at least 1 to 10 years 2
- C. Seeds (or vegetative propagules) remain viable in soil for more than 10 years 3
- U. Unknown

Score

2

Documentation:
 Identify longevity of seed bank:
 Turions overwinter, can remain viable for at least 2 years.
 Sources of information:
 Catling, P. M. et al., 2003

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4.2. Vegetative regeneration

- A. No regrowth following removal of aboveground growth 0
- B. Regrowth from ground-level meristems 1
- C. Regrowth from extensive underground system 2
- D. Any plant part is a viable propagule 3
- U. Unknown

Score

2

Documentation:

Describe vegetative response:

Vegetative reproduction via turions is very important in spread and colonization.

Sources of information:

Catling, P. M. et al., 2003

4.3. Level of effort required

- A. Management is not required: e.g., species does not persist without repeated anthropogenic disturbance. 0
- B. Management is relatively easy and inexpensive: e.g. 10 or fewer person-hours of manual effort (pulling, cutting and/or digging) can eradicate a 1 acre infestation in 1 year (infestation averages 50% cover or 1 plant/100 ft²). 2
- C. Management requires a major short-term investment: e.g. 100 or fewer person-hours/year of manual effort, or up to 10 person-hours/year using mechanical equipment (chain saws, mowers, etc.) for 2-5 years to suppress a 1 acre infestation. Eradication is difficult, but possible (infestation as above). 3
- D. Management requires a major investment: e.g. more than 100 person-hours/year of manual effort, or more than 10 person hours/year using mechanical equipment, or the use of herbicide, grazing animals, fire, etc. for more than 5 years to suppress a 1 acre infestation. Eradication may be impossible (infestation as above). 4
- U. Unknown

Score

4

Documentation:

Identify types of control methods and time-term required:

Herbicidal, mechanical, drawdowns, bio-control.

Sources of information:

Catling, P. M. et al., 2003; Michewicz, J. E. & R. D. Blackburn, 1972

Total Possible

10

Section Four Total

8

Total for 4 sections Possible

97

Total for 4 sections

83

C. STATUS OF CULTIVARS AND HYBRIDS:

At the present time (May 2008) there is no protocol or criteria for assessing the invasiveness of cultivars 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.

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.

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Some cultivars of the species known to be available:

References for species assessment:

Brooklyn Botanic Garden. 2008. AILANTHUS database. [Accessed on 6 June 2008].

Catling, P. M. et al. 2003. The biology of Canadian weeds. 124. *Hydrocharis morsus-ranae* L. *Canad. J. Pl. Sci.* 83: 1001-1016.

Houlahan, J. E. & C. S. Findlay. 2004. Effect of invasive plant species on temperate wetland plant diversity. *Conserv. Biol.* 18: 1132-1138.

Jean, M. & A. Bouchard. 1993. Riverine wetland vegetation: importance of small-scale and large-scale environmental variation. *J. Veg. Sci.* 4: 609-620.

Michewicz, J. E. & R. D. Blackburn. 1972. The white amur for aquatic weed control. *Weed Sci.* 20: 106-110.

United States Department of Agriculture, National Resources Conservation Service. Brooklyn Botanic Garden. 2008. The PLANTS Database. National Plant Data Center, Baton Rouge, Louisiana [Accessed on 6 June 2008].

Weldy, T. and D. Werier. 2005. New York Flora Atlas. [S. Catling, P. M. Landry, K.N. Campbell, and L.D. Mabe (original application development), Florida Center for Community Design and Research. University of South Florida]. New York Flora Association, Albany, New York. [Accessed on 6 June 2008].

et al. 2003. The biology of Canadian weeds. 124. *Hydrocharis morsus-ranae* L. *Canad. J. Pl. Sci.* 83: 1001-1016.

Citation: This NY ranking 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. Note that the order of authorship is alphabetical; all three authors contributed substantially to the development of this protocol.

Acknowledgments: The NY form incorporates components and approaches used in several other systems, cited in the references below. Valuable contributions by members of the Long Island Invasive Species Management Area's Scientific Review Committee were incorporated in revisions of this form. Original members of the LIISMA SRC included representatives of the Brooklyn Botanic Garden; The Nature Conservancy; New York Natural Heritage Program, New York Sea Grant; New York State Office of Parks, Recreation and Historic Preservation; National Park Service; Brookhaven National Laboratory; New York State Department of Environmental Conservation Region 1; Cornell Cooperative Extension of Suffolk/Nassau Counties; Long Island Nursery and Landscape Association; Long Island Farm Bureau; SUNY Farmingdale Ornamental Horticulture Department; Queens College Biology Department; Long Island Botanical Society; Long Island Weed Information Management System database manager; Suffolk County Department of Parks, Recreation and Conservation; Nassau County Department of Parks, Recreation and Museums; Suffolk County Soil & Water Conservation District.

References for ranking form:

Carlson, Matthew L., Irina V. Lapina, Michael Shephard, Jeffery S. Conn, Roseann Densmore, Page Spencer, Jeff Heys, Julie Riley, Jamie Nielsen. 2008. Invasiveness ranking system for non-native plants of Alaska. Technical Paper R10-TPXX, USDA Forest Service, Alaska Region, Anchorage, AK XX9. Alaska Weed Ranking Project may be viewed at: http://akweeds.uaa.alaska.edu/akweeds_ranking_page.htm.

Heffernan, K.E., P.P. Coulling, J.F. Townsend, and C.J. Hutto. 2001. Ranking Invasive Exotic Plant Species in Virginia. Natural Heritage Technical Report 01-13. Virginia Dept. of Conservation and Recreation, Division of Natural Heritage, Richmond, Virginia. 27 pp. plus appendices (total 149 p.).

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Morse, L.E., J.M. Randall, N. Benton, R. Hiebert, and S. Lu. 2004. An Invasive Species Assessment Protocol: Evaluating Non-Native Plants for Their Impact on Biodiversity. Version 1. NatureServe, Arlington, Virginia. <http://www.natureserve.org/getData/plantData.jsp>

Randall, J.M., L.E. Morse, N. Benton, R. Hiebert, S. Lu, and T. Killeffer. 2008. The Invasive Species Assessment Protocol: A Tool for Creating Regional and National Lists of Invasive Nonnative Plants that Negatively Impact Biodiversity. *Invasive Plant Science and Management* 1:36–49

Warner, Peter J., Carla C. Bossard, Matthew L. Brooks, Joseph M. DiTomaso, John A. Hall, Ann M. Howald, Douglas W. Johnson, John M. Randall, Cynthia L. Roye, Maria M. Ryan, and Alison E. Stanton. 2003. Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands. Available online at www.caleppc.org and www.swvma.org. California Exotic Pest Plant Council and Southwest Vegetation Management Association. 24 pp.

Williams, P. A., and M. Newfield. 2002. A weed risk assessment system for new conservation weeds in New Zealand. *Science for Conservation* 209. New Zealand Department of Conservation. 1-23 pp.