NEW YORK
NON-NATIVE PLANT INVASIVENESS RANKING FORM

Scientific name:	Hydrilla verticillata	USDA Plants Code: HYVE3
Common names:	Waterthyme	
Native distribution:	Asia	
Date assessed:	28 April 2008; edited 29 Sept. 2008	
Assessors:	Steve Glenn & Gerry Moore	
Reviewers:	LIISMA Scientific Review Committee	
Date Approved:	16 June 2008	Form version date: 22 October 2008

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	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	Common	Very High
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 (40)	40
2	Biological characteristic and dispersal ability	25 (22)	19
3	Ecological amplitude and distribution	25 (21)	17
4	Difficulty of control	10 (10)	9
	Outcome score	100 (93)[b]	85[a]
	Relative maximum score †		91.40
	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

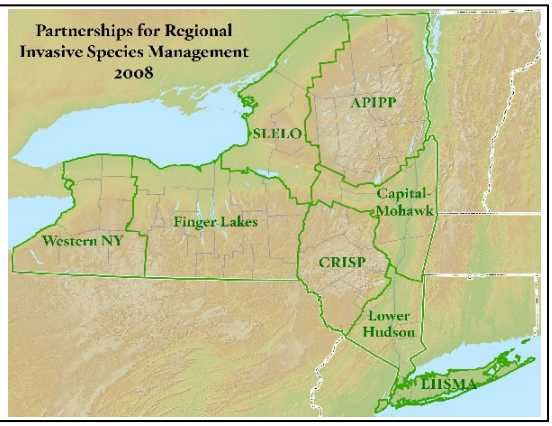
A. DISTRIBUTION (KNOWN/POTENTIAL): Summarized from individual PRISM forms

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

- ☐ Yes – continue to A1.2
- ☒ No – continue to A2.1

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:
Weldy & Werier, 2005; Brooklyn Botanic Garden, 2008

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

Documentation:
Sources of information (e.g.: distribution models, literature, expert opinions):
Batcher, M. S. (no date, circa 2000); Brooklyn Botanic Garden, 2008; George Safford Torrey Herbarium, 2008; United States Department of Agriculture, 2008.

If the species does not occur and is not likely to occur with 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	Not Assessed
Capital/Mohawk	Not Assessed
Catskill Regional Invasive Species Partnership	Not Assessed
Finger Lakes	Not Assessed
Long Island Invasive Species Management Area	Not Present
Lower Hudson	Not Assessed
Saint Lawrence/Eastern Lake Ontario	Not Assessed
Western New York	Not Assessed

Documentation:
Sources of information:
Weldy & Werier, 2005; 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
☒ Salt/brackish waters	☐ Salt/brackish marshes	☐ Cultivated*
☒ Freshwater tidal	☐ Freshwater marshes	☐ Grasslands/old fields
☒ Rivers/streams	☐ Peatlands	☐ Shrublands
☒ Natural lakes and ponds	☐ Shrub swamps	☐ Forests/woodlands
☒ Vernal pools	☐ Forested wetlands/riparian	☐ Alpine
☒ Reservoirs/impoundments*	☐ Ditches*	☐ Roadsides*
	☐ Beaches and/or coastal dunes	

Other potential or known suitable habitats within New York:
May invade sluggish rivers and streams, but perhaps limited in water bodies with fast-flowing water or predominantly sandy substrates. Can grow in water with up to 7% salinity.

Documentation:
Sources of information:
Barko & Smart, 1986; Batcher (no date, circa 2000).

B. INVASIVENESS RANKING

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)

Sediment levels increase affecting the hydrology of water bodies. Can alter water and sediment chemistry- one study found the contents of organic matter, cationic exchange capacity (CEC), Ca, Fe, Al, exchangeable Ca, Fe-ox and Al-ox of the sediments with Hydrilla verticillata were higher than those of the control sediments, and the contents of total phosphorus (TP), Olsen-P and reactive dissolve phosphorus (RDP) were lower. The sediments with H. verticillata had stronger P sorption ability and weaker ability of P release. H. verticillata did not significantly affect the trends of the sorption isotherms and kinetics of the released P on the sediments. H. verticillata can significantly increase the ability of P sorption, decrease in the ability of P desorption on sediments was one of the mechanism that maintained lower P levels of the overlying water through affecting the contents of organic matter, CEC, Ca, Fe, Al, exchangeable Ca, Fe-ox and Al-ox in sediments.

Another study found in several Hydrilla-dominated lakes, mean total P concentration (126 mu g/l) at inflow was reduced to 106 mu g/l at outflow. The maximum inflow total P concentration in a lake with positive nutrient reduction was 148 mu g/l. Total P removal efficiency by Hydrilla-dominated lakes and wetlands was comparable to or higher than systems dominated by emergent and other submerged plants. Mean total P settling rates for lakes and a constructed wetland dominated by Hydrilla were estimated at 19 and 34 m/year, respectively

Sources of information:

Batcher, (no date, circa 2000); Gu, 2006; Wang et al., 2007.

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 dense mats on water surface reducing light levels and physically displaces native species in this layer and below.
Sources of information:
.Batcher (no date, circa 2000).

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 10

Documentation:
Identify type of impact or alteration:
Dense mats on surface reduce light levels, physically displacing native species.
Sources of information:
Batcher (no date, circa 2000).

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 10

Documentation:
Identify type of impact or alteration:
An epiphytic cyanobacterial species (order Stigonematales) associated with Hydrilla is linked to avian vacuolar myelinopathy (AVM), an emerging avian disease affecting herbivorous waterbirds (American coots- Fulica americana) and their avian predators (bald eagles- Haliaeetus leucocephalus). The effects on fish populations is mixed.
Sources of information:
Batcher (no date, circa 2000); Wilde et al., 2005.

Total Possible 40
Section One Total 40

2. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY

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

A.	No reproduction by seeds or vegetative propagules (i.e. plant sterile with no sexual or	0

asexual reproduction).

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):
Can reproduce from rootstocks, stem fragments, turions, and seeds.
Sources of information:
Batcher (no date, circa 2000).

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:
Epizoochory (seed dispersal on the exterior of animals) - waterfowl could transport stem fragments.
Sources of information:
Batcher (no date, circa 2000).

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:
Stem fragments could easily be transported on boots, boats and motor propeller blades. Also could be introduced through discarded contents of aquaria.

Sources of information:
Batcher (no date, circa 2000).

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.
Has a large ecological amplitude, one study found nine biotypes based on sex expression, ploidy level, and MEPs (multienzyme phenotypes) suggested the possibility of ecological differentiation among different biotypes. The monoecious type is probably better adapted to cooler climates. Can tolerate a wide range of water chemistry conditions; and has a high rate of photosynthesis and can switch to an efficient C4-like carbon metabolism.
Has low light requirements and can grow as deep as 15 meters.
A couple of studies suggest that sandy substrates might be somewhat limiting on Hydrilla growth. Another study suggests that low nitrogen sediment levels may also limit Hydrilla growth.
Sources of information:
Batcher (no date, circa 2000); Barko & Smart. 1986; Mony et al. 2007; Nakamura & Kadono, 2000; Rybicki et al., 2001.

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 a dense floating mat.
Sources of information:
Batcher (no date, circa 2000).

2.6. Germination/Regeneration

A. Requires open soil or water and disturbance for seed germination, or regeneration from vegetative propagules. 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:

Sources of information:

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:

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
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 2

Documentation:
Identify reason for selection, or evidence of weedy history:
Three infestations in New York discovered August 2008 with many acres infested; human disturbance and some hydrologic alteration; one or two other invasive plant species present. Too early to tell if pristine ponds will be invaded. Sugar Loaf, Orange Co. NY: Creamery Pond, 9 acres with dense infestation 6 acres, and moderate 3 acres. Two infested waterbodies in Sayville/Bayport, Suffolk Co. NY: Sans Soucci Ponds County Nature Preserve Sayville/Bayport NY, 8 acres infested and significant hydrologic alteration (dikes and culverts separating water body into 11 "ponds" of which two have Hydrilla; Lotus Lake (Roosevelt Estate Suffolk Co. Park) a 13 acre pond with infestation likely throughout but not fully sureyed. The Suffolk Co. ponds have no boat access, but since there are homes on or near the shores human disturbance is likely. One or two invasive plant species present in the Suffolk County ponds (Myriophyllum heterophyllum and/or another invasive species). Some ponds in New England are infested but information on size was not readily available.
Sources of information:
Kishbaugh, Scott NYS DEC personal communication.
http://nbii-nin.ciesin.columbia.edu/ipane/datamaps/ipane.db.output.pl

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 two or more of the habitats given at A2.3, with at least one a natural habitat. 1
C. Known to occur in three or more of the habitats given at A2.3, with at least two a natural habitat. 2
D. Known to occur in four or more of the habitats given at A2.3, with at least three a natural habitat. 4
E. Known to occur in more than four of the habitats given at A2.3, with at least four a natural 6

habitat.

U. Unknown

Score 6

Documentation:
Identify type of habitats where it occurs and degree/type of impacts:
All sluggish water bodies without high sandy substrates.
Sources of information:
Batcher (no date, circa 2000).

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 U

Documentation:
Identify type of disturbance:
The three infested ponds in NYS have some human disturbance and hydologic alteration, but it is too early to tell if Hydrilla will establish in "pristine" ponds free of disturbance.
Sources of information:
Kishbaugh, Scott, NYS DEC. Batcher (no date, circa 2000).

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 3

Documentation:
Describe what part of the native range is similar in climate to New York:
Asia, but the monoecious biotype has a demonstrated range as far north as coastal Maine. Note: Kishbaugh has sent NY specimens for genetic analysis 2008 which will determine monoecious or dioecious.
Sources of information:
Batcher (no date, circa 2000); George Safford Torrey Herbarium, 2008.

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
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 4

Documentation:
Identify states and provinces invaded:
NY, CT, DC, DE, MA, MD, ME, NJ, PE, VA.

Sources of information: See known introduced range in plants.usda.gov, and update with information from states and Canadian provinces.
Brooklyn Botanic Garden, 2008; George Safford Torrey Herbarium, 2008; 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 2

Documentation:
Describe distribution:
One occurrence in Lower Hudson (Orange Co.) and two in Suffolk Co. (LIISMA).
Sources of information:
Kishbaugh, Scott. NYS DEC personal communication.

Total Possible 21
Section Three Total 17

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 more important than seeds and documented to survive over four years in undisturbed sediments; can sometimes even survive at least 12 month drawdowns.
Sources of information:
Batcher (no date, circa 2000); Chen et al. 2001; Doyle & Smart. 2001.

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 3

Documentation:
Describe vegetative response:
Root stocks, stem fragments, turions.
Sources of information:

Batcher (no date, circa 2000).

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 ft^2).	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:
1. Mechanical - specialized machines at over $1000 per acre.
2. Chemical - copper sulfate, endothal, fluridone (Avast and Sonar, two slow release pellet formulations of fluridone effectively controlled hydrilla by 92 days after initial application, although dioecious Hydrilla with varying levels of fluridone resistance have been documented in Florida), bensulfuron methyl, and acetic acid have proven effective. Another study found endothall combined with copper or diquat provided >99% control. Also acetolactate synthase (ALS) inhibiting herbicides are currently being tested.
3. Drawdowns - Also effects entire aquatic community and turions can sometimes even survive at least 12 month drawdowns.
4. Biological - Ctenopharyngodon idella (triploid grass carp), one study in South Carolina found provided effective, long-term control at a cost of less than $10 per acre yearly. Bagous affinis (an Asian weevil) larvae consume turions but only useful during drawdowns or intermittent wet and dry shorelines. Hydrellia pakistanae (leaf-mining fly) has shown promise in the south, but its use in the colder Northeast may not be efficacious. Cricotopus lebetis (Diptera) is also under investigation as a possible bio-control agent.

One study suggests that chemical or mechanical management efforts have no discernible impact on the short-term sprouting of Hydrilla tubers in situ.

Various integrated strategies show promise: One laboratory study found a 90% reduction in Hydrilla biomass using a combination of the herbicide endothall and a fungal pathogen Mycoleptodiscus terrestris. Another study tested four pathogenic fungi (F71PJ Acremonium sp., F531 Cylindrocarpon sp., F542, Botrytis sp., and F964 Fusarium culmorum) in combination with Hydrellia pakistanae). Another study suggests that a combination of native plant competition and herbivory by Hydrellia pakistanae suppresses Hydrilla dominance.

One study found aerial photography and videography, global positioning system, and geographic information system technologies effective for detecting and mapping Hydrilla infestations.

Sources of information:
Batcher, (no date, circa 2000); Doyle et al., 2007; Epler et al., 2000; Everitt et al. 2004; Kirk & Henderson, 2006; Koschnick et al., 2003; Koschnick et al., 2007; Netherland & Haller, 2006; Pennington et al., 2001; Puri et al., 2007; Shearer & Nelson, 2002; Wheeler & Center. 2001

Total Possible	10
Section Four Total	9
Total for 4 sections Possible	93
Total for 4 sections	85

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.

Some cultivars of the species known to be available:

References for species assessment:

Barko, J. W. & R. M. Smart. 1986. Sediment-related mechanisms of growth limitation in submersed macrophytes. Ecology 67: 1328-1340.

Batcher, M. S. (no date, circa 2000). Element stewardship abstract for Hydrilla verticillata (L. f.) Royle. The Nature Conservancy, Arlington, VA.

Brooklyn Botanic Garden. 2008. AILANTHUS database. [accessed 28 April 2008].

Bunluesin, S. et al. 2007. Batch and continuous packed column studies of cadmium biosorption by Hydrilla verticillata biomass. J. Biosci. Bioengin. 103: 509-513.

Carvalho, K. M. & D. F. Martin. 2001. Removal of aqueous selenium by four aquatic plants. J. Aquatic Pl. Manag. 39: 33-36.

Chen, Z. Y. et al. 2001. A preliminary study of winter seed bank of dominant submerged macrophytes in Lake Liangzi. Acta Hydrobiol. Sinica 25: 152-158.

Doyle, R. D. & R. M. Smart. 2001. Effects of drawdown and dessication on tubers of Hydrilla, an exotic aquatic weed. Weed Sci. 49: 135-140.

Doyle, R. D. et al. 2007. Separate and interactive effects of competition and herbivory on the growth, expansion, and tuber formation of Hydrilla verticillata. Biologial Control 41: 327-328.

Epler, J. H. et al. 2000. Redescription of Cricotopus lebetis (Diptera: Chironomidae), a potential biocontrol agent of the aquatic weed Hydrilla (Hydrocharitaceae). The Florida Entomologist 83: 171-180.

Everitt, J. H. et al. 2004. Using spatial information technologies to detect and map waterhyacinth and hydrilla infestations in the Lower Rio Grande. J. Aquatic Pl. Manag. 41: 93-98.

Gallardo-Williams, M. T. et al. 2002. Accumulation and retention of lead by cattail (Typha domingensis), hydrilla (Hydrilla verticillata), and duckweed (Lemna obscura). J. Environ. Sci. Health A. Toxic Hazard. Subst. Environ. Eng. A37(8): 1399-1408.

George Safford Torrey Herbarium. 2008. <http://bgbaseserver.eeb.uconn.edu/index.htm> (accessed 28 April 2008).

Gu, B. 2006. Environmental conditions and phosphorus removal in Florida lakes and wetlands inhabited by Hydrilla verticillata (Royle): implications for invasive species management. Biol. Invasions 8: 1569-1578.

Johnson, F. A. & F. Montalbano. 1987. Considering waterfowl habitat in Hydrilla control policies. Wildlife Soc. Bull. 15: 466-459.

Kirk, J. P. & J. E. Henderson. 2006. Management of hydrilla in the Santee Cooper Reservoirs, South Carolina: experiences from 1982 to 2004. J. Aquatic Pl. Manag. 44: 98-103.

Koschnick, T. J. et al. 2003. Efficacy and residue comparisons between two slow-release formulations of fluridone. J. Aquatic Pl. Manag. 41: 25-27.

Koschnick, T. J. et al. 2007. Effects of three ALS-inhibitors on five emergent native plant species in Florida. J. Aquatic Pl. Manag. 45: 47-51.

Mony, C. et al. 2007. Competition between two invasive Hydrocharitaceae (Hydrilla verticillata (L.f.) (Royle) and Egeria densa (Planch)) as influenced by sediment fertility and season. Aquatic Bot. 86: 236-242.

Nakamura, T. & Y. Kadono. 2000. Genetic diversity of the submerged macrophyte Hydrilla verticillata (L. f.) Royle in a river system in Japan. Limnology 1: 27-31.

Netherland, M. D. & W. T. Haller. 2006. Impact of management on the sprouting of dioecious Hydrilla tubers. J. Aquatic Pl. Manag. 44: 32-35.

New York Flora Association. 2008. New York Flora Atlas. <http://atlas.nyflora.org/> (accessed 28 April 2008).

Pennington, T. G. et al. 2001. Herbicide/copper combinations for improved control of Hydrilla verticillata. J. Aquatic Pl. Manag. 39: 56-58.

Puri, A. et al. 2007. Growth and reproductive physiology of fluridone-susceptible and -resistant Hydrilla (Hydrilla verticillata) biotypes. Weed Sci. 55: 441-445.

Rybicki, N. B. et al. 2001. Investigations of the availability and survival of submersed aquatic vegetation propagules in the tidal Potomac River. Estuaries 24: 407-424.

Shabana, Y. M. et al. 2003. Combining plant pathogenic fungi and the leaf-mining fly, Hydrellia pakistanae, increases damage to hydrilla. J. Aquatic Pl. Manag. 41: 76-81.

Shearer, J. F. & L. S. Nelson. 2002. Integrated use of endothall and a fungal pathogen for management of the submersed aquatic macrophyte Hydrilla verticillata. Weed Tech. 16: 224-230.

Srivastava, S. et al. 2007. Phytochelatins and antioxidant systems respond differentially during arsenite and arsenate stress in Hydrilla verticillata (L.f) Royle. Environ. Sci. Tech. 41: 2930-2936.

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

Wang, S. et al. 2007. Effects of Hydrilla verticillata on phosphorus retention and release in sediments. Water Air Soil Pollution 181: 329-339.

Weldy, T. and D. Werier. 2005. New York Flora Atlas. [S.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. [Accesssed on 6 June 2008].

Wheeler, G. S. & T. D. Center. 2001. Impact of the biological control agent Hydrellia pakistanae (Diptera: Ephydridae) on the submersed aquatic weed Hydrilla verticillata (Hydrocharitaceae). Biol. Control 21: 168-181.

Wilde, S. B. et al. 2005. Avian vacuolar myelinopathy linked to exotic aquatic plants and a novel cyanobacterial species. Environmental Toxicology 20: 348-353.

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.).

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.