Vulnerability of 70 Plant Species of Greatest Conservation Need to Climate Change in New Jersey

Zigadenus leimanthoides

Cypripedium reginae

Prepared by:
Richard M. Ring
Elizabeth A. Spencer
(New York Natural Heritage Program), for:
The New Jersey Natural Heritage Program,
DEP - Office of Natural Lands Management
Mail Code 501-04
P.O. Box 420
501 E. State Street
Station Plaza #5, 4th Floor
Trenton, New Jersey 08625-0420

June 2013

Acknowledgments:

Thanks to Natureserve, the New Jersey Natural Heritage Program, and Fiona McKinney and Dorothy Evans, NY Natural Heritage Program, for arranging and guiding this collaboration. Thanks to the New Jersey Natural Heritage Program and to Nick Conrad of the New York Natural Heritage Program for arranging to share sensitive data between the two Natural Heritage Programs. Thanks to Matthew Schlesinger and Kelly Perkins for answering questions regarding the CCVI spreadsheet tool. Thanks also to John Schmid for assistance with GIS. Special thanks to Kathleen Strakosch Walz for sharing her knowledge of the New Jersey landscape regions and habitats and the rare plant species contained therein. We modeled some tables and the Appendices after Schlesinger et al (2011).

This work was conducted as part of the Natureserve project, "Creating a National Wildlife Conservation System by Improving and Promoting State Wildlife Action Plans". Funding was provided by the Doris Duke Charitable Foundation.

Table of contents

Introduction and Methods

Ongoing and predicted climate change is widely acknowledged to be one of the greatest global threats to biodiversity (Thuiller 2007), and has been identified as a major threat to the already-stressed ecosystems of the Mid-Atlantic region (Rogers and McCarty 2000). Efforts are ongoing throughout the Northeast to evaluate and address this threat (Frumhoff et al. 2007). One planning tool that is increasingly employed for focusing conservation and management attention on appropriate targets is the vulnerability assessment. The Association of Fish and Wildlife Agencies (2009) has promoted these kinds of assessments as a useful way for states to address climate change in their State Wildlife Action Plan revisions. In order to better integrate the conservation of plant species into the New Jersey State Wildlife Action Plan, this analysis of the vulnerability to climate change of seventy plant Species of Greatest Conservation Need (SGCN) in New Jersey was initiated (Table 1).

The 70 state endangered plant species were selected from two distinct Landscape Regions of New Jersey; Skylands (40 species) and Pinelands (30 species; see Table 1 below). We used Natureserve's Climate Change Vulnerability Index (CCVI), release 2.1 (Young et al. 2011). Here we summarize the CCVI methods and discuss specific items unique to New Jersey. Readers are referred to Young et al. (2010) and (Byers and Norris 2011) for a fuller documentation.

The CCVI bases its determination of vulnerability to climate change on two main components: ***exposure*** to future projected climate change and ***sensitivity*** to climate change, and scores various factors related to each of these (Table 1). Descriptions of each factor and examples of how to score them are available in the spreadsheet to help assessors make choices with scoring. Each species is scored for each factor from "decrease vulnerability" to "greatly increase vulnerability" (or a subset range of these categories), with three to six of these categories available for each factor. Some factors are optional, but a minimum number of factors in each group must be filled out to avoid an Index score of "Insufficient Evidence." Documented or modeled responses to climate change are incorporated as a final factor (Table 2). These were not always available for the selected species.

We used mapped Element Occurrence data from the New Jersey Natural Heritage Database (New Jersey Natural Heritage Program 2012) viewed in a geographic information system to score the factors with a geographic component. Primary and secondary literature on the species' ecology and biology were consulted to score the factors intrinsic to the species themselves. For fuller documentation and explanation of the CCVI's methodology, please refer to Young et al (2011) and (Byers and Norris 2011).

Table 1. List of NJ State Wildlife Action Plan State Endangered Plant Species included in the CCVI.

NJ SWAP Landscape Region	Habitat Type	Number of State Endangered Plant Species
Pinelands	Pine Barren Savanna	14
Pinelands	Coastal Plain Intermittent Pond	17
Skylands	Calcareous Fen	28
Skylands	Calcareous Sinkhole Pond	13
2 REGIONS	4 HABITATS	70 PLANTS*
* Note that 2 plant species occur in 2 different habitats but are counted only once in the total		

REGION: PINELANDS	**Common name**	***Scientific name***
Habitat type: Pine Barren Savanna: 14 species		
	Pickering's Reed Grass	*Calamagrostis pickeringii*
	Spreading Pogonia	*Cleistes divaricata*
	Rough Cotton-grass	*Eriophorum tenellum*
	Pine Barren Boneset	*Eupatorium resinosum*
	New Jersey Rush	*Juncus caesariensis*
	Bog Asphodel	*Narthecium americanum*
	Yellow Fringeless Orchid	*Platanthera integra*
	Knieskern's Beaked-rush	*Rhynchospora knieskernii*
	Long's Woolgrass	*Scirpus longii*
	Lace-lip Ladies'-tresses	*Spiranthes laciniata*
	False Asphodel	*Tofieldia racemosa*
	Reversed Bladderwort*	*Utricularia resupinata*
	Fringed Yellow-eyed-grass	*Xyris fimbriata*
	Death-camus	*Zigadenus leimanthoides*
Habitat type: Coastal Plain Intermittent Pond: 17 species		
	Southern Boltonia	*Boltonia asteroides var. glastifolia*
	Wrinkled Jointgrass	*Coelorachis rugosa*
	Marsh Flat Sedge	*Cyperus pseudovegetus*
	Hirst Brothers' Panic Grass	*Dichanthlium hirstii (=Panicum hirstii)*
	Larger Buttonweed	*Diodia virginiana*
	Knotted Spike-rush	*Eleocharis equisetoides*
	Featherfoil	*Hottonia inflata*
	Barton's St. John's-wort	*Hypericum adpressum*
	Clasping-leaf St. John's-wort	*Hypericum gymnanthum*
	Boykin's Lobelia	*Lobelia boykinii*
	Narrow-leaf Primrose-willow	*Ludwigia linearis*
	Awned Meadow-beauty	*Rhexia aristosa*

	Small-head Beaked-rush	*Rhynchospora microcephala*
	Slender Arrowhead	*Sagittaria teres*
	Torrey's Bulrush*	*Schoenoplectus torreyi*
	Dwarf White Bladderwort	*Utricularia olivacea*
	Reversed Bladderwort*	*Utricularia resupinata*
REGION: SKYLANDS	**Common name**	**Scientific name**
Habitat type: Calcareous Fen: 28 species		
	Bog Rosemary	*Andromeda glaucophylla*
	Rush Aster	*Aster borealis*
	Foxtail Sedge	*Carex alopecoidea*
	Water Sedge	*Carex aquatilis*
	Lesser Panicled Sedge	*Carex diandra*
	Handsome Sedge	*Carex formosa*
	Cyperus-like Sedge	*Carex pseudocyperus*
	Tuckerman's Sedge	*Carex tuckermanii*
	Wood's Sedge	*Carex woodii*
	Marsh Cinquefoil	*Comarum palustris*
	Hemlock-parsley	*Conioselinum chinense*
	Small White Lady's-slipper	*Cypripedium candidum*
	Showy Lady's-slipper	*Cypripedium reginae*
	Few-flower Spike-rush	*Eleocharis quinqueflora*
	Variegated Horsetail	*Equisetum variegatum*
	Queen-of-the-prairie	*Filipendula rubra*
	Labrador Marsh Bedstraw	*Galium labradoricum*
	Small Bedstraw	*Galium trifidum*
	Northern Panic Grass	*Panicum boreale*
	Capillary Beaked-rush	*Rhynchospora capillacea*
	Orange Coneflower	*Rudbeckia fulgida*
	Shining Willow	*Salix lucida ssp. lucida*
	Bog Willow	*Salix pedicellaris*
	Strict Blue-eyed Grass	*Sisyrinchium montanum*
	Arborvitae	*Thuja occidentalis*
	Seaside Arrow-grass	*Triglochin maritima*
	Spreading Globe Flower	*Trollius laxus ssp. laxus*
	Sessile Water-speedwell	*Veronica catenata*
Habitat type: Calcareous Sinkhole Pond: 13 species		
	Large Water-plantain	*Alisma triviale*
	Appalachian Mountain Boltonia	*Boltonia montana*
	Cloud Sedge	*Carex haydenii*
	Hop-like Sedge	*Carex lupuliformis*
	Small Floating Manna Grass	*Glyceria borealis*

	Larger Canadian St. John's Wort	*Hypericum majus*
	Water-marigold	*Megalodonta beckii*
	Lake Water-cress	*Neobeckia lacustris*
	Wiry Panic Grass	*Panicum flexile*
	Arum-leaf Arrowhead	*Sagittaria cuneata*
	Torrey's Bulrush*	*Schoenoplectus torreyi*
	Small Burr-reed	*Sparganium natans*
	Lesser Bladderwort	*Utricularia minor*

Table 2. Variables assessed in the CCVI. See Young et al. (2011) for details.

Factors that influence exposure to climate change:

Direct exposure to local projected climate change
Percent of species' range in five categories of increasing temperature
Percent of species' range in six categories of changing moisture regime
Indirect exposure to climate change
Exposure to sea level rise
Distribution relative to natural barriers
Distribution relative to anthropogenic barriers
Predicted impact of land use changes resulting from human responses to climate change

Factors that influence sensitivity to climate change:

Dispersal and movements
Predicted sensitivity to changes in temperature
Predicted sensitivity to changes in precipitation, hydrology, or moisture regime
Dependence on a specific disturbance regime likely to be impacted by climate change
Dependence on ice, ice-edge, or snow-cover habitats
Restriction to uncommon geological features or derivatives
Dependence on other species to generate habitat
Dietary versatility (animals only)
Pollinator versatility (plants only)
Dependence on other species for propagule dispersal
Other interspecific interactions
Measured genetic variation
Occurrence of bottlenecks in recent evolutionary history
Phenological response to changing seasonal temperature and precipitation dynamics

Documented or modeled response to climate change

Documented response to recent climate change
Modeled future (2050) change in population or range size
Overlap of modeled future (2050) range with current range
Occurrence of protected areas in modeled future (2050) distribution
Other intrinsic factors
Taxonomic group
Obligation to cave or groundwater aquatic habitats
Relation of species' range to assessment area
State conservation status rank (S-rank)
Global conservation status rank (G-rank)

Exposure to Climate Change:

Exposure is further subdivided into exposure to local climate change (projected changes in temperature and moisture availability within the species' range) and indirect exposure to climate change (distribution relative to sea level rise, natural and anthropogenic barriers to dispersal, and new land uses aiming to mitigate climate change). These factors are scored based on the percentage of the species' range within New Jersey that falls into categories of projected changes temperature or moisture. Projections for the year 2050 downloaded from The Nature Conservancy's Climate Wizard (www.climatewizard.org) are shown in Figure 1. Note that there was little or no variability in the projected 2050 temperature and hydrological changes within the study area of New Jersey. Effects of predicted sea level rise in New Jersey were assessed using visualizations of 1 meter sea level rise produced by ClimateGEM (http://www.geo.arizona.edu/dgesl/research/other/climateGEM/climateGEM.htm), as detailed in Young et al (2011).

Sensitivity

Sensitivity to climate change is assessed in the CCVI based on a variety of factors, including dispersal capability; past climate regime and reliance on specific thermal and hydrological conditions; dependence on disturbance; dependence on snow or ice cover; restriction to certain geological types; reliance on interspecific interactions (e.g., herbivory and predator/prey relationships); genetic variation; and climate-related changes in phenology (Table 2). ClimateWizard's Annual Temperature Variation and Mean Annual Precipitation maps for 1951-2006 were used to assess the historical thermal and hydrological niches for each species (Figure 2). As was the case with the 2050 projections (Figure 1), the Annual Temperature Variation map showed little variation within the study area, though there was considerable variation in the map of Mean Annual Precipitation. The dispersal and movements factor was assessed by considering each species' mode of dispersal in relation to their positions in the New Jersey (element occurrence data) and New Jersey Land Use Land Cover and Wildland-Urban Interface data layers (NJ DEP 2010).

We followed closely the definitions and examples given in the Guidelines (Young et al 2011) for each factor. For some species, specific information on certain factors (pollinators, dispersal mechanisms, genetic variation, etc.) was unknown. Where possible we used knowledge of closely related species and/or reasonable assumptions based on the best available information. After all factors are ranked, the CCVI calculator places each species into either one of five categories of vulnerability or the category indicating lack of evidence. Definitions, and the abbreviations that are used throughout this document, follow (from Young et al. 2010).

Extremely Vulnerable (EV): Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050.
Highly Vulnerable (HV): Abundance and/or range extent within geographical area assessed likely to decrease significantly by 2050.

Moderately Vulnerable (MV): Abundance and/or range extent within geographical area assessed likely to decrease by 2050.
Not Vulnerable/Presumed Stable (PS): Available evidence does not suggest that abundance and/or range extent within the geographical area assessed will change (increase/decrease) substantially by 2050. Actual range boundaries may change.
Not Vulnerable/Increase Likely (IL): Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.
Insufficient Evidence (IE): Available information about a species' vulnerability is inadequate to calculate an Index score.

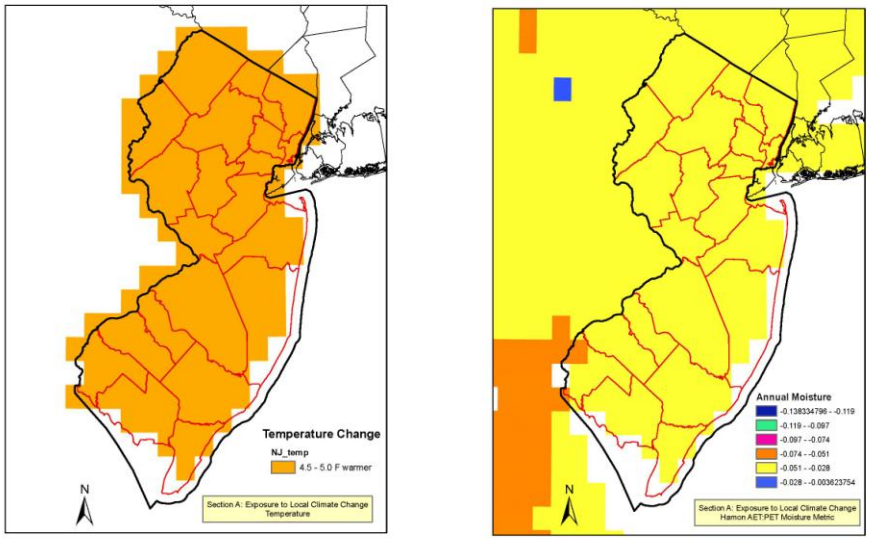

Figure 1. (Left) Projected temperature increase for New Jersey by 2050. (Right) Projected decreases in moisture availability for New Jersey by 2050. (Data from www.climatewizard.org)

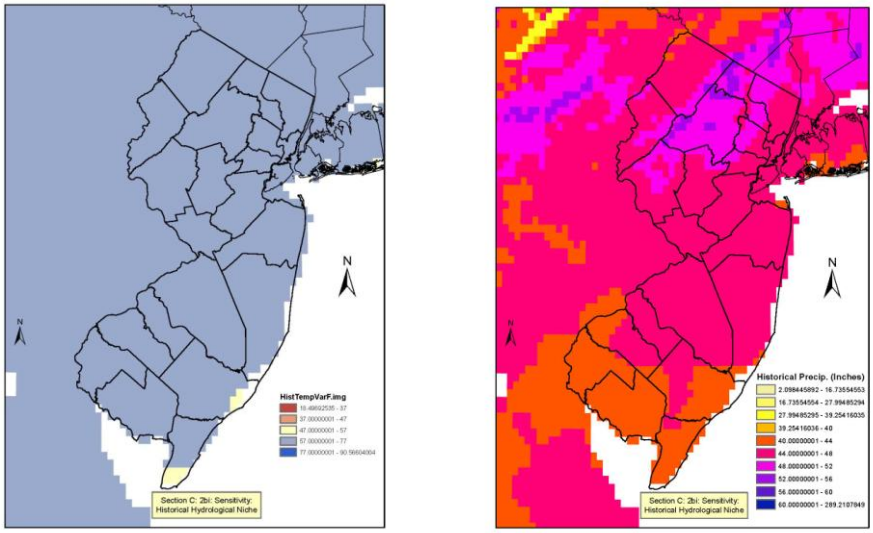

Figure 2. Historic temperature variability (left) and precipitation (right) in New Jersey over the past 50 years (Data from www.climatewizard.org.)

Results

CCVI scores ranged from Extremely Vulnerable to Presumed Stable (see Table 3 and Appendix A). In all, 50 of the 70 rare plant species received vulnerability scores as follows: Extremely Vulnerable (1 species), Highly Vulnerable (8 species), and Moderately Vulnerable (41 species). Twenty of the 70 were Presumed Stable or had Insufficient Evidence, including 18 scored Presumed Stable and two species, *Panicum boreale* and *Sparganium minimum*, which received scores of Insufficient Evidence. The habitat requirements of the rare plant species selected may make them especially vulnerable to the predicted climate changes. All of the species indexed are wetland (most) or aquatic species, and thus the overall drying (despite increased precipitation) indicated by the Hamon AET: PET metric used in the CCVI led to rankings of increased vulnerability of varying degrees. Many of the species were also ranked as more vulnerable because they are found on uncommon geological features such as coastal plain intermittent ponds and calcareous sinkhole ponds.

Species from the two regions scored somewhat differently overall. Only 7 out of 41(17%) Skylands Region species were scored Presumed Stable, while 10 out of 31(33%) Pinelands Region species received a score of Presumed Stable. The majority of state endangered species in each region and habitat were scored as Moderately Vulnerable (see Table 3). Many of the Skylands species are already at or near the southern limit of their ranges in New Jersey, and thus might be expected to be especially threatened by a warming climate there. The Pinelands suite of species includes many species near the northern limit of their ranges. The Skylands species also tended to score higher vulnerabilities for both anthropogenic and natural barriers; the Pinelands landscape overall is both more intact and protected from human disturbance and more geologically uniform than the Skylands' more populated and geologically complex landscape. Even so, a majority of Pinelands species also were scored as Moderately or Highly Vulnerable. The dependence of many of these species on habitats that are geologically uncommon, vulnerable to hydrologic changes, or both, increased their vulnerability scores for associated factors.

The lack of much variability in both projected climate changes (Figure 2) and in historical temperature variability (Figure 3) must limit the role of this set of variables in the overall assessment, and highlights the need for a need for finer scale climate predictions and categorizations done specific to New Jersey. This would allow the potential for a greater separation among species at the state scale. We suspect that the relative degree of exposure to changing temperature and moisture is an important determinant of a species' likely response. Future versions of the CCVI could allow for user-defined categories based on the scale of New Jersey and the ability to utilize these data in future CCVI assessments would be very beneficial.

It would have been helpful if the algorithms used to calculate scores were made more transparent and flexible, much as NatureServe has done for its Element Rank Calculator (NatureServe 2009). Such transparency would allow users to understand the results and the relative weightings of factors. Without this information, we were unable to determine the degree to which

our analysis of the relative importance of factors used in the CCVI reflected ecological importance versus the weights of each factor in the algorithm. Further, user-defined weights would allow assessors to adjust the importance of factors for their specific situation; this feature is allowed in some similar calculators (e.g., University of Washington 2011).

Table 3: Summary of Climate Change Vulnerability Index scores for 70 State Endangered Plant Species in New Jersey

REGION: PINELANDS					
Habitat type: Pine Barren Savanna – 14 Species					
EV (Extremely Vulnerable)	HV (Highly Vulnerable)	MV (Moderately Vulnerable)	PS (Not Vulnerable / Presumed Stable)	IL (Not Vulnerable / Increase Likely)	IE (Insufficient Evidence)
		6 (43%)	**8** (57%)		
Habitat type: Coastal Plain Intermittent Pond – 17 Species					
EV (Extremely Vulnerable)	HV (Highly Vulnerable)	MV (Moderately Vulnerable)	PS (Not Vulnerable / Presumed Stable)	IL (Not Vulnerable / Increase Likely)	IE (Insufficient Evidence)
1 (6%)	**4** (24%)	**8** (47%)	**4** (24%)		
REGION: SKYLANDS					
Habitat type: Calcareous Fen – 28 Species					
EV (Extremely Vulnerable)	HV (Highly Vulnerable)	MV (Moderately Vulnerable)	PS (Not Vulnerable / Presumed Stable)	IL (Not Vulnerable / Increase Likely)	IE (Insufficient Evidence)
	2 (7%)	**21** (75%)	**5** (18%)		
Habitat type: Calcareous Sinkhole Pond – 13 Species					
EV (Extremely Vulnerable)	HV (Highly Vulnerable)	MV (Moderately Vulnerable)	PS (Not Vulnerable / Presumed Stable)	IL (Not Vulnerable / Increase Likely)	IE (Insufficient Evidence)
	3 (23%)	**6** (46%)	**2** (15%)		**2** (15%)

* Note that 2 plant species (*Schoenoplectus torreyi* and *Utricularia resupinata*) occur in 2 different habitats, thus the total here of 72 for the 70 rare species.

Even fairly basic information on the Sensitivity factors of the CCVI (seed dispersal and pollination, among other factors) is incomplete or lacking for some species. This points to the need to fund traditional natural history studies of these rare plant species – an increasingly rare proposition (Bury 2006, Kramer et al. 2010). Improved climate modeling done specific to New Jersey, as well as additional ecological studies of the lesser-known plants, would allow ranking of more factors in the CCVI, and possibly change some of our ranking decisions made in the current assessment. One advantage of the CCVI as it currently exists is that the results can be returned to the calculator to allow for changes on specific factors, completely redoing the entire index, in order to generate new results. As some of these research needs are met in coming years, the information generated can inform refined vulnerability assessments which may better inform conservation decisions.

Literature Cited

Aerts, R., J. H. C. Cornelissen, E. Dorrepaal, V. Logtestijn, R. S. P, and T. V. Callaghan. 2004. Effects of experimentally imposed climate scenarios on flowering phenology and flower production of subarctic bog species. Global Change Biology 10:1599–1609. doi: 10.1111/j.1365-2486.2004.00815.x.

Allen, C. M. 2003. Coelorachis in Flora of North America Vol 25: Grasses part 2. Retrieved May 14, 2012, from http://herbarium.usu.edu/webmanual/.

Association of Fish and Wildlife Agencies. 2009. Voluntary guidance for states to incorporate climate change into State Wildlife Action Plans & other management plans.

Baskin, C. C., J. M. Baskin, and W. W. McDearman. 1993. Seed germination ecophysiology of two Zigadenus (Liliaceae) species. Castanea:45–53.

Bearberry Creek Water Gardens. 2011, March 22. Bearberry Creek Water Gardens: Section ll: Water Plants (roots, shoots and tubers) Water plants for Wildlife Enhancement and Wetland Reclamation Projects. Retrieved May 11, 2012, from http://www.bbcreek.ca/pdf_files/section2.pdf.

Bowles, M. L. 1983. The tallgrass prairie orchids Platanthera leucophaea (Nutt.) Lindl. and Cypripedium candidum Muhl. ex Willd.: Some aspects of their status, biology, and ecology, and implications toward management. Natural Areas Journal 3:14–37.

Breeden, G., and J. T. Brosnan. 2012. Virginia Buttonweed Factsheet, University of Tennessee. Retrieved May 6, 2012, from (http://www.tennesseeturfgrassweeds.org/admin/Lists/Fact%20Sheets/Attachments/9/W147.pdf).

Bury, R. B. 2006. Natural history, field ecology, conservation biology, and wildlife management: Time to connect the dots. Herpetological Conservation and Biology 1:56–61.

Byers, E., and S. Norris. 2011. Climate change vulnerability assessment of species of concern in West Virginia. West Virginia Division of Natural Resources, Elkins, West Virginia.

Calhoun, A. J. K., and P. G. deMaynadier. 2008. Science and conservation of vernal pools in Northeastern North America. CRC Press, Boca Raton, FL.

Capers, R. S., R. Selsky, and G. J. Bugbee. 2010. The relative importance of local conditions and regional processes in structuring aquatic plant communities. Freshwater Biology 55:952–966.

Carter, R. 1993. Animal dispersal of the North American sedge, Cyperus plukenetii (Cyperaceae). American Midland Naturalist:352–356.

Case, M. A. 1994. Extensive Variation in the Levels of Genetic Diversity and Degree of Relatedness Among Five Species of Cypripedium (Orchidaceae). American Journal of Botany 81:175–184.

Center for Lakes and Reservoirs at Portland State University. 2009, December. Introduction to Common Native and Potential Invasive Freshwater Plants in Alaska. U.S. Fish and Wildlife Service, Alaska Region. Retrieved May 14, 2012, from http://alaska.fws.gov/fisheries/invasive/pdf/AK_Aquatic_Plants_full.pdf.

Center for Plant Conservation. 2010. CPC National Plant Collection Plant Profile: Panicum hirstii. Retrieved April 18, 2012, from http://www.centerforplantconservation.org/collection/cpc_viewprofile.asp?CPCNum=3086.
Connolly, B. (n.d.). Species Delisting Proposal Form: Listing Endangered, Threatened, and Special Concern Species in Massachusetts - Conioselinum chinense. Natural Heritage and Endangered Species Program, Massachusetts Division of Fisheries and Wildlife. Retrieved May 13, 2012, from http://www.mass.gov/dfwele/dfw/nhesp/species_info/pdf/conioselinum.pdf.
Cullina, M. D. 2002. Rhynchospora capillacea Torr. Capillary Beak Rush Conservation and Research Plan for New England. New England Wild Flower Society. Retrieved from http://www.newfs.org/docs/pdf/Rhynchosporacapillacea.pdf.
Cusick, A. 1985. Fact Sheet for Schoenoplectus torreyi. Ohio Department of Natural Resources. Retrieved May 15, 2012, from http://ohiodnr.com/dnap/Abstracts/s/schotorr/tabid/1564/Default.aspx.
Duval, T. P., and J. M. Waddington. 2011. Extreme variability of water table dynamics in temperate calcareous fens: Implications for biodiversity. Hydrological Processes.
Enser, R. W. 2001. ,. 2001. Hypericum adpressum (Creeping St. John's-wort) Conservation and Research Plan. New England Wild Flower Society, Framingham, MA. Retrieved from www.newfs.org.
Flora of North America Editorial Committee. 1993. Flora of North America North of Mexico. New York and Oxford.
Flora of North America Editorial Committee. 2003. Flora of North America North of Mexico, Vol. 23:Cyperaceae. Retrieved from http://www.efloras.org/volume_page.aspx?volume_id=1023&flora_id=1.
Flora of North America Editorial Committee. 2006. Flora of North America North of Mexico, Volume 20: Asteraceae, part 1. Retrieved from http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=104211.
Frumhoff, P. C., J. J. McCarthy, J. M. Melillo, S. C. Moser, and D. J. Wuebbles. 2007. Confronting climate change in the US northeast: science, impacts, and solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA).Union of Concerned Scientists (UCS), Cambridge, MA.
Gage, E., and D. J. Cooper. 2006. Carex diandra Schrank (lesser panicled sedge): A Technical Conservation Assessment. USDA Forest Service, Rocky Mountain Region, Species Conservation Project. Retrieved May 2, 2012, from http://www.fs.fed.us/r2/projects/scp/assessments/carexdiandra.pdf.
Gordon, K. L. no date. Drummond's yellow-eyed grass (Xyris drummondii Malme). US Fish and Wildlife Service. Retrieved April 24, 2012, from http://www.landmanager.org.au/fire-responses-xyris-juncea.
Gray, J. B., T. R. Wentworth, and C. Brownie. 2003. Extinction, colonization, and persistence of rare vascular flora in the longleaf pine-wiregrass ecosystem: responses to fire frequency and population size. Natural Areas Journal 23:210–219.
Gregg, K. B. 1989. Reproductive biology of the orchid Cleistes divaricata (L.) Ames var. bifaria Fernald growing in a West Virginia meadow. Castanea:57–78.
Gregg, K. B. 1991. Reproductive strategy of Cleistes divaricata (Orchidaceae). American Journal of Botany:350–360.
Grootjans, A. P., and B. F. Tooren. 1984. Ecological notes on Carex aquatilis communities. Plant Ecology 57:79–89.
Hickler, M. G. 2003. Eleocharis quadrangulata (Michaux) Roemer & Schultes Square-stemmed spike-rush Conservation and Research Plan for New England. New England Plant Conservation Program, Framingham, MA. Retrieved from http://www.newfs.org/docs/pdf/eleocharisquadrangulata.pdf.
Hill, Steven R. 2007. Conservation Assessment for the American Featherfoil (Hottonia inflata Ell.). Illinois Natural History Survey. Retrieved May 4, 2012, from http://www.ideals.illinois.edu/bitstream/handle/2142/18119/INHS2007_34.pdf?sequence=1.
Hilty, D. J. 2012. Illinois Wildflowers. Retrieved April 28, 2012, from http://www.illinoiswildflowers.info/wetland/plants/cl_stjohnwort.htm.
Illinois Plant Information Network. 2012. Ilpin Information on Eleocharis pauciflora. Retrieved April 28, 2012, from http://www.fs.fed.us/ne/delaware/ilpin/1165.co.

Johnson, W. F. 1990. Thuja occidentalis. Pages 1189 – 1209 Silvics of North America. U.S. Department if Agriculture, Forest service, Washington D.C. Retrieved May 10, 2012, from http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/thuja/occidentalis.htm.
Jones, K., Niovi. 2000. Trollius laxus Salisb. Spreading Globeflower. Page 17. New England Plant Conservation Program Conservation and Research Plan, New England Wild Flower Society, Framingham, MA. Retrieved May 9, 2012, from http://www.newfs.org/docs/pdf/Trolliuslaxus.pdf.
Kirkman, L. K., P. C. Goebel, L. West, M. B. Drew, and B. J. Palik. 2000. Depressional wetland vegetation types: a question of plant community development. Wetlands 20:373–385.
Kramer, A., K. Havens, and B. Zorn-Arnold. 2010. Assessing botanical capacity to address grand challenges in the United States. Retrieved May 1, 2012, from http://www.bgci.org/usa/bcap.
Kubitzki, K., and H. Huber. 1998. Flowering Plants, Monocotyledons: Alismatanae and Commelinanae (Except Gramineae). Springer. Retrieved April 30, 2012, from http://books.google.com/books?id=bNQDsSmx2roC&vq=alisma&source=gbs_navlinks_s.
Macek, P., and J. Lepš. 2008. Environmental correlates of growth traits of the stoloniferous plant Potentilla palustris. Evolutionary Ecology 22:419–435. doi: 10.1007/s10682-007-9235-z.
Machon, N., J.-M. Guillon, G. Dobigny, S. Le Cadre, and J. Moret. 2001. Genetic variation in the horsetail Equisetum variegatum Schleich., an endangered species in the Parisian region. Biodiversity and Conservation 10:1543–1554. doi: 10.1023/A:1011816610775.
Maine Natural Area Program, D. of C. 2010. Galium Labradoricum (Wieg.) Wieg Rare Plant Fact Sheet. Retrieved May 3, 2012, from http://www.maine.gov/doc/nrimc/mnap/features/galilab.htm.
Maine Volunteer Lake Monitoring Program. 2009. Water Marigold - Bidens beckii (Megalodonta beckii). Retrieved May 14, 2012, from http://www.mainevolunteerlakemonitors.org/mciap/herbarium/WaterMarigold.php.
MANHESP. 2007. Massachusetts Natural Heritage Endangered Species Program Fact Sheet: Sagittaria teres. Retrieved from http://www.mass.gov/dfwele/dfw/nhesp/species_info/nhfacts/sagittaria_teres.pdf.
Massachusetts Natural Heritage & Endangered Species Program. 2010a. Massachusetts rare species fact sheet: Carex formosa. Retrieved from http://www.mass.gov/dfwele/dfw/nhesp/species_info/nhfacts/carfor.pdf.
Massachusetts Natural Heritage & Endangered Species Program. 2010b. Massachusetts rare species fact sheet: Carex tuckermanii. Retrieved from http://www.mass.gov/dfwele/dfw/nhesp/species_info/fact_sheets.htm.
Minneseota Department of Natural Resources. 2012. Cypripedium candidum (Small White Lady's-slipper) Rare Species Guide. Retrieved May 13, 2012, from http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=PMORC0Q050.
Minnesota Department of Natural Resources. 2011a. Carex formosa. Retrieved May 5, 2012, from http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=PMCYP034Y0.
Minnesota Department of Natural Resources. 2011b. Carex woodii. Retrieved from http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=PMCYP03EV0.
Minnesota Wildflowers. 2012. Galium trifidum (Three-petal Bedstraw). Retrieved May 3, 2012, from http://www.minnesotawildflowers.info/flower/three-petal-bedstraw.
Molano-Flores, B. 2000. Population Viability Assessment for Sullivant's coneflower (Rudbeckia fulgida Aiton var. sullivantii (C. L. Boynt. & Beadle) Cronq.). Retrieved from http://hdl.handle.net/2142/10045.
Moore, L., S. Friedley, and D. L. Hazlett. 2006. Carex alopecoidea Tuckerman (foxtail sedge): A Technical Conservation Assessment. USDA Forest Service, Rocky Mountain Region, Species Conservation Project. Retrieved from http://www.fs.fed.us/r2/projects/scp/assessments/carexalopecoidea.pdf.
Mosseler, A., and C. S. Papadopol. 1989. Seasonal isolation as a reproductive barrier among sympatric Salix species. Canadian Journal of Botany 67:2563–2570. doi: 10.1139/b89-331.

Mowbray, T. B. 1984. Final status report: Eupatorium resinosum Torrey ex D.C. USFWS Endangered Species Office, Asheville, North Carolina.
Mueller, M. H., and A. G. van der Valk. 2002. The potential role of ducks in wetland seed dispersal. Wetlands 22:170–178.
Muenchow, G., and V. Delesalle. 1994. Pollinator Response to Male Floral Display Size in Two Sagittaria (Alismataceae) Species. American Journal of Botany 81:568–573. doi: 10.2307/2445731.
Natural Resources Canada. 2011, December 19. Canada's Plant Hardiness Site - Going Beyond the Zones. Retrieved May 15, 2012, from http://planthardiness.gc.ca/index.pl?lang=en.
NatureServe. 2012. NatureServe Explorer: an online encyclopedia of life [web application] Version 7.1. Retrieved from http://www.natureserve.org/explorer.
New Jersey Department of Environmental Protection. 2010. NJDEP 2007 Land Use/Land Cover. http://www.state.nj.us/dep/gis/lulc07cshp.html
New York Natural Heritage Program. 2011a. Online Conservation Guide for Symphyotrichum Boreale. Retrieved from http://www.acris.nynhp.org/guide.php?id=8840.
New York Natural Heritage Program. 2011b. Online Conservation Guide for Carex formosa. Retrieved April 10, 2012, from http://www.acris.nynhp.org/guide.php?id=9481.
New York Natural Heritage Program. 2011c. Online Conservation Guide for Carex haydenii. Retrieved from http://www.acris.nynhp.org/guide.php?id=9488.
New York Natural Heritage Program. 2011d. Online Conservation Guide for Carex lupuliniformis. Retrieved from http://www.acris.nynhp.org/guide.php?id=9501.
New York Natural Heritage Program. 2012. Online Conservation Guide for Sparganium natans. Retrieved May 14, 2012, from http://www.acris.nynhp.org/guide.php?id=9807.
Olesen, I., and E. Warncke. 1992. Breeding system and seasonal variation in seed set in a population of Potentilla palustris. Nordic Journal of Botany 12:373–380. doi: 10.1111/j.1756-1051.1992.tb01318.x.
Penskar, M. R., and S. R. Crispin. 2004. Special Plant Abstract for Fimbristylis puberula (chestnut sedge). Michigan Natural Features Inventory. Retrieved May 13, 2012, from http://mnfi.anr.msu.edu/abstracts/botany/Fimbristylis_puberula.pdf.
Prasad, A. M., L. R. Iverson, S. Matthews, and M. Peters. 2007, ongoing. A Climate Change Atlas for 134 Forest tree Species of the Eastern United States [database]. Northern Research Station, USDA Forest Service, Delaware Ohio. Retrieved from http://www.nrs.fs.fed.us/atlas/tree/RFtreemod_241.html.
Richardson, L. L., and E. H. Thompson. 2001. Panicum flexile (Gattinger) Scribn. Stiff Witch Grass. Page 12. New England Plant Conservation Program Conservation and Research Plan, New England Wild Flower Societ, Framingham, MA. Retrieved May 9, 2012, from http://www.newfs.org/docs/pdf/Panicumflexile.pdf.
Rogers, C. E., and J. P. McCarty. 2000. Climate change and ecosystems of the Mid-Atlantic Region. Climate Research 14:235–244. Retrieved June 26, 2012, .
Royo, A. A., R. Bates, and E. P. Lacey. 2008. Demographic constraints in three populations of Lobelia boykinii: a rare wetland endemic 1. The Journal of the Torrey Botanical Society 135:189–199.
Schneider, G., and (first). 1993, April. Bidens Beckii Torr. - Water-marigold Abstract. Retrieved May 14, 2012, from http://ohiodnr.com/Portals/3/Abstracts/Abstract_pdf/B/Bidens_Beckii.pdf.
Schuyler, A. E. 1990a. Element Stewardship Abstract for Narthecium americanum. New Jersey Department of Environmental Protection - Division of parks and Forestry. Retrieved from http://www.nj.gov/dep/parksandforests/natural/heritage/textfiles/nartham.txt.
Schuyler, A. E. 1990b. Element Stewardship Abstract for Juncus Caesariensis. Retrieved April 15, 2012, from http://pbadupws.nrc.gov/docs/ML0931/ML093160824.pdf.
Seabloom, E., A. van der Valk, and K. Moloney. 1998. The role of water depth and soil temperature in determining initial composition of prairie wetland coenoclines. Plant Ecology 138:203–216. doi: 10.1023/A:1009711919757.
Shimp, E. L. 2005. Shawnee National Forest Biological Evaluation For Regional Forester's Sensitive Plant Species Forest Plan Revision. Retrieved April 22, 2012, from http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5151585.pdf.

Skoglund, S. J. 1990. Seed dispersing agents in two regularly flooded river sites. Canadian Journal of Botany 68:754–760. doi: 10.1139/b90-100.
Spooner, D., J. F. Burns, and (first). 1984. Panicum Boreale - Northern Panic-grass Abstract. Retrieved May 11, 2012, from http://ohiodnr.com/Portals/3/Abstracts/Abstract_pdf/P/Panicum_boreale.pdf.
Spooner, David. 1985. Glyercia Borealis - Northern Manna-Grass Abstract. Retrieved May 11, 2012, from http://ohiodnr.com/Portals/3/Abstracts/Abstract_pdf/G/Glyceria_borealis.pdf.
Strong, M. T., and P. M. Sheridan. 1991. Juncus caesariensis Coville (Juncaceae) in Virginia peat bogs. Castanea:65–69.
Taggart, J. B. 2010. The Vascular Flora of Sandy Run Savannas State Natural Area, Onslow and Pender Counties, North Carolina. Castanea 75:484–499.
Taylor, J. E. 2007. Andromeda polifolia. Retrieved May 1, 2012, from http://www.fs.fed.us/database/feis/plants/shrub/andpol/all.html.
Thuiller, W. 2007. Biodiversity: climate change and the ecologist. Nature 448:550–552. Retrieved June 26, 2012, .
USDA Forest Service. 2010. National roadmap for responding to climate change. Page 30. USDA Forest Service. Retrieved from W:/Library/Articles/author U-Z/USDA Forest Service_2010.pdf.
USFWS. 2011. Rhynchospora knieskernii Fact Sheet. Retrieved from http://www.fws.gov/northeast/njfieldoffice/Endangered/knieskerns.html#examples.
Virgina Botanical Associates. 2012. Boltonia montana Townsend and Karaman-Castro. Retrieved May 14, 2012, from http://vaplantatlas.org/index.php?do=plant&plant=690.
Walz, K. S., R. J. Canace, J. Boyle, R. Witte, M. S. Serfes, W. Honachefsky, J. Kurtz, and R. Dutko. 2001. Identification and protection of reference wetland natural communities in New Jersey: calcareous sinkhole ponds of the Kittatinny Valley. New Jersey Department of Environmental Protection, Division of Parks and Forestry, Office of Natural Lands Management, Natural Heritage Program, Trenton, NJ.
Walz, K.S., S. Sanford, J. Boyle, and Emily W.F. (Russell) Southgate. 2006. Pine Barren Riverside Savannas of New Jersey. New Jersey Department of Environmental Protection, Division of Parks and Forestry, Office of Natural Lands Management, Natural Heritage Program, Trenton, NJ. 169 pp. + Appendices.
Watson, L., and M. J. Dallwitz. 2012, May 18. The families of flowering plants: Sparganiaceae Schultz-Schultzenst. Retrieved May 14, 2012, from http://delta-intkey.com/angio/www/spargani.htm.
Young, B., K. Byers, K. Gravuer, K. Hall, G. Hammerson, and A. Redder. 2011. Guidelines for using the NatureServe climate change vulnerability index v2.1. NatureServe, Arlington, VA.
Zettler, L. W., J. A. Sunley, and T. W. Delaney. 2000. Symbiotic seed germination of an orchid in decline (Platanthera integra) from the Green Swamp, North Carolina. Castanea:207–212.

Appendix A: Key to codes used in tables

Vulnerability Index Scores

EV Extremely Vulnerable: Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050.

HV Highly Vulnerable: Abundance and/or range extent within geographical area assessed likely to decrease significantly by 2050.

MV Moderately Vulnerable: Abundance and/or range extent within geographical area assessed likely to decrease by 2050.

PS Not Vulnerable/Presumed Stable: Available evidence does not suggest that abundance and/or range extent within the geographical area assessed will change (increase/decrease) substantially by 2050. Actual range boundaries may change.

IL Not Vulnerable/Increase Likely: Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.

IE Insufficient Evidence: Available information about a species' vulnerability is inadequate to calculate an Index score.

Individual Risk Factor Scores

GI Greatly increase vulnerability

Inc Increase vulnerability

SI Somewhat increase vulnerability

N Neutral

SD Somewhat decrease vulnerability

Dec Decrease vulnerability

U Unknown

NatureServe Conservation Status Ranks

G1, S1 Critically imperiled because of rarity (5 or fewer occurrences, or few remaining acres or miles of stream) or factors making it especially vulnerable to extinction range wide (global) or in New Jersey

G2, S2 Imperiled because of rarity (6-20 occurrences, or few remaining acres or miles of stream) or factors demonstrably making it very vulnerable to extinction (global) or extirpation from New Jersey

G3, S3 Either uncommon or local, typically with 21 to 100 occurrences, limited acreage, or miles of stream range wide (global) or in New Jersey

G4, S4 Apparently secure range wide (global) or in New Jersey

G5, S5 Demonstrably secure, though it may be quite rare in parts of its range

Note that combination (or "range") ranks are possible (e.g., S1S2, S2S3). These ranks reflect uncertainty in the information available such that it could not be determined whether one or the other rank was appropriate. They do not indicate a value in between the two numbers.

Appendix B. CCVI Vulnerability Index Scores for 70 Plant SGCN in New Jersey

EV (Extremely Vulnerable)	HV (Highly Vulnerable)	MV (Moderately Vulnerable)	PS (Not Vulnerable / Presumed Stable)	IL (Not Vulnerable / Increase Likely)	IE (Insufficient Evidence)

Scientific Name	Common Name	GRank	SRank	Index	Confi-dence	Index Notes	Assessment Sources and Notes*
PINELANDS SPECIES							
Pine Barren Savanna Habitat							
Calamagrostis pickeringii	Pickering's Reed Grass	G4	S1	PS	Low	Species range may shift and perhaps leave the assessment area.	Climate change range shift (Natural Resources Canada 2011)
Cleistes divaricata	Spreading Pogonia	G4	S1	PS	VH		(Gregg 1991,Gregg 1989)
Eriophorum tenellum	Rough Cotton-grass	G5	S1	MV	VH	Species range may shift and perhaps leave the assessment area.	Climate change range shift (Natural Resources Canada 2011)
Eupatorium resinosum	Pine Barren Boneset	G3	S2	MV	VH		Pollination and dispersal (Mowbray 1984)(Gray et al. 2003)
Juncus caesariensis	New Jersey Rush	G2	S2	MV	VH		(Schuyler 1990b, Strong and Sheridan 1991)
Narthecium americanum	Bog Asphodel	G2	S2	MV	VH		Climate change range shift (Natural Resources Canada 2011)(Schuyler 1990a)
Platanthera integra	Yellow Fringeless Orchid	G3G4	S1	PS	VH		(Zettler et al. 2000, NatureServe 2012)
Rhynchospora knieskernii	Knieskern's Beak-rush	G2	S2	MV	VH		(USFWS 2011)

Scientific Name	Common Name	GRank	SRank	Index	Confi-dence	Index Notes	Assessment Sources and Notes*
Scirpus longii	Long's Woolgrass	G2G3	S2	PS	VH		waterfowl dispersal (Mueller and van der Valk 2002)
Spiranthes laciniata	Lace-lip Ladies'-tresses	G4G5	S1	PS	VH		Habitat, benefits of fire (Taggart 2010)
Tofieldia racemosa	False Asphodel	G5	S1	PS	Low	Species may expand range in assessment area.	Habitat, benefits of fire (Schuyler 1990b, Taggart 2010)
Utricularia resupinata	Reversed Bladderwort	G4	S1	PS	VH		Dispersal (Capers et al 2009)
Xyris fimbriata	Fringed Yellow-eyed-grass	G5	S1	PS	VH		Benefits of fire (Gordon no date)
Zigadenus leimanthoides	Death Camas	G4Q	S1	MV	VH		seed dispersal and pollination (Baskin et al. 1993)
Coastal Plain Intermittent Pond Habitat							
Boltonia asteroides var. glastifolia	Southern Boltonia	G5TNR	S1	HV	VH		(Walz et al. 2001, Flora of North America Editorial Committee 2006)
Coelorachis rugosa	Wrinkled jointgrass	G5	S1	PS	VH		physiological hydrological niche (Allen 2003)
Cyperus pseudovegetus	Marsh Flat Sedge	G4Q	S1	MV	VH		Dispersal (Carter 1993); (Flora of North America Editorial Committee 1993)
Dichanthelium hirstii (=Panicum hirstii)	Hirst Brothers' Panic Grass	G1	S1	MV	VH		(Center for Plant Conservation 2010)
Diodia virginiana	Larger Buttonweed	G5T5	S1	MV	VH		Dispersal (Breeden and Brosnan 2012)
Eleocharis equisetoides	Knotted Spike-rush	G4	S1	MV	VH		(Schuyler 1990a) Hickler 2003)
Hottonia inflata	Featherfoil	G4	S1	PS	VH		Climate Change (DENR 2010); Habitat information (Spooner and Burns 1985) Flooding disturbance (Bearberry Creek Water Gardens 2011)
Hypericum adpressum	Barton's St. John's-wort	G3	S2	MV	VH		(Enser 2001)

Scientific Name	Common Name	GRank	SRank	Index	Confi-dence	Index Notes	Assessment Sources and Notes*
Hypericum gymnanthum	Clasping-leaf St. John's-wort	G4	S1	MV	VH		(Hilty 2012)
Lobelia boykinii	Boykin's Lobelia	G2G3	S1	HV	VH		(Royo et al. 2008)
Ludwigia linearis	Narrow-leaf Primrose-willow	G5	S1	MV	VH		((Kirkman et al. 2000)
Rhexia aristosa	Awned Meadow-beauty	G3	S1	HV	VH		(Hilty 2012))
Rhynchospora microcephala	Small-head Beaked-rush	G5T5	S1	MV	VH		(Flora of North America Editorial Committee 2003)
Sagittaria teres	Slender Arrowhead	G3	S1	EV	VH		(MANHESP 2007)
Schoenoplectus torreyi	Torrey's Bulrush	G5	S1?	HV	VH		Dispersal (Mueller and van der Valk 2002, Calhoun and deMaynadier 2008); (Cusick 1985)
Utricularia olivacea	Dwarf White Bladderwort	G4	S1	PS	VH		Dispersal (Capers et al 2009)
Utricularia resupinata	Reversed Bladderwort	G4	S1	PS	VH		Dispersal (Capers et al 2009)
SKYLANDS SPECIES							
Calcareous Fen Habitat							
Andromeda polifolia var. glaucophylla	Bog Rosemary	G5	S1	MV	VH		Disturbance regime and hydrological/physiological tolerance (Taylor 2007) Phenological response to climate change (Aerts et al. 2004)
Aster borealis	Rush Aster	G4Q	S1	MV	Mod	Species range may shift and perhaps leave the assessment area.	Climate change range shift (Natural Resources of Canada 2011); (New York Natural Heritage Program 2011a)

Scientific Name	Common Name	GRank	SRank	Index	Confi-dence	Index Notes	Assessment Sources and Notes*
Carex alopecoidea	Foxtail Sedge	G5	S1	MV	VH	Species range may shift and perhaps leave the assessment area.	Climate change range shift (Natural Resources of Canada 2011); (Moore et al. 2006)
Carex aquatilis	Water Sedge	G5	S1	MV	Low	Species range may shift and perhaps leave the assessment area.	Climate change range shift (Natural Resources of Canada 2011) ; (Moore et al 2006, (Grootjans and Tooren 1984)
Carex diandra	Lesser Panicled Sedge	G5	S1	MV	VH	Species range may shift and perhaps leave the assessment area.	Climate change range shift (Natural Resources of Canada 2011) ; (Gage and Cooper 2006)
Carex formosa	Handsome Sedge	G4	S1.1	MV	Mod	Species range may shift and perhaps leave the assessment area.	Climate change range shift (Natural Resources of Canada 2011); (Massachusetts Natural Heritage & Endangered Species Program 2010a, Minnesota Department of Natural Resources 2011a, New York Natural Heritage Program 2011b)
Carex pseudocyperus	Cyperus-like Sedge	G5	S1	HV	Mod	Species range may shift and perhaps leave the assessment area.	Climate change range shift (Natural Resources of Canada 2011) ; (Flora of North America Editorial Committte 2003)
Carex tuckermanii	Tuckerman's Sedge	G4	S1	HV	Mod	Species range may shift and perhaps leave the assessment area.	Climate change range shift (Natural Resources of Canada 2011); (Massachusetts Natural Heritage & Endangered Species Program 2010b)

Scientific Name	Common Name	GRank	SRank	Index	Confi-dence	Index Notes	Assessment Sources and Notes*
Carex woodii	Wood's Sedge	G4	S1.1	MV	VH		(Minnesota Department of Natural Resources 2011b)
Comanrum palustris	Marsh Cinquefoil	G5	SH	PS	VH		Disturbance, fire (Richardson and Thompson 2001); Habitat in NJ (Flora of New Jersey Project 2012); Physiological hydrology (Duval and Waddington 2011, Walz et. al. 2001)
Conioselinum chinense	Hemlock-parsley	G5	S1	MV	VH		Disturbance, flooding (Macek and Lepš 2008); Pollination and flowering (Olesen and Warncke 1992); Dispersal (Skoglund 1990)
Cypripedium candidum	Small White Lady's-slipper	G4	S1	PS	VH		Seed Dispersal (Connolly n.d.); Climate change range (Natural Resources Canada 2011)
Cypripedium reginae	Showy Lady's-slipper	G4	S1	MV	VH		Mutualism (Minnesota Department of Natural Resources 2012); Physiological hydrology (Duval and Waddington 2011); Fire as positive disturbance (Bowles 1983); Genetic diversity (Case 1994)
Eleocharis quinqueflora	Few-flower Spike-rush	G5	S1	MV	VH		Wind and water dispersal (Illinois Plant Information Network 2012)
Equisetum variegatum	Variegated Horsetail	G5T5	S1	MV	VH		Mutualism (Shefferson et. al. 2005); Physiological hydrology (Duval and Waddington 2011); Genetic diversity) Kennedy and walker 2007); Climate model (Natural Resources Canada 2011)
Filipendula rubra	Queen-of-the prairie	G4G5	SX	MV	VH	Species range may shift and perhaps leave the assessment area.	Habitat, genetic diversity and dispersal limitation (Machon et al. 2001); (Penskar and Crispin 2004) Climate change range shift (Natural Resources Canada 2011)

Scientific Name	Common Name	GRank	SRank	Index	Confi-dence	Index Notes	Assessment Sources and Notes*
Galium labradoricum	Labrador Marsh Bedstraw	G5	S1	MV	VH		Physiological hydrological regime (Duval and Waddington 2011) Climate change range shift (Natural Resources Canada 2011)
Galium trifidum	Small Bedstraw	G5T5	S2	MV	VH		(Minnesota Wildflowers 2012)
Hypericum majus	Larger Canadian St. John's Wort	G5	S1	MV	VH		Pollination, flooding disturbance (Hill 2007)
Panicum boreale	Northern Panic Grass	G5	S1	MV	VH		Habitat, disturbance (Penskar and Crispin 2010); Dispersal and disturbance (USDA Forest Service 2010); Range shift with climate change (Natural Resources Canada 2011)
Rhynchospora capillacea	Capillary Beaked-rush	G4	S1	MV	High		(Cullina 2002)
Rudbeckia fulgida	Orange Coneflower	G5T4?	S1	MV	VH		Reproductive ecology (Molano-Flores 2000)
Salix lucida ssp. lucida	Shining Willow	G5T5	S1?	MV	VH		phenology (Mosseler and Papadopol 1989)
Salix pedicellaris	Bog Willow	G5	S1	PS	VH		Drought resistance (Savage et al 2011)
Sisyrinchium montanum	Strict Blue-eyed Grass	G5T4T5	S2	MV	VH		Climate Change (DENR 2010)
Thuja occidentalis	Arborvitae	G5	S1	MV	VH		(Johnson 1990, Prasad et al. 2007)
Triglochin maritima	Seaside Arrow-grass	G5	S1	MV	VH		(Jones 2000) Effects of drought on fen water table (Duval and Waddington 2011)
Trollius laxus ssp. laxus	Spreading Globe Flower	G4T3	S1	PS	VH		Dispersal ((Jones 2000); Effects of drought on fen water table (Duval and Waddington 2011)
Veronica catenata	Sessile Water-speedwell	G5	S1	PS	VH		Climate Change (DENR 2010)
Calcareous Sinkhole Pond Habitat							
Alisma triviale	Large water-plantain	G5	S1	PS	VH		response to changing water levels (Seabloom et al. 1998)Habitat ((Kubitzki and Huber 1998)

Scientific Name	Common Name	GRank	SRank	Index	Confi-dence	Index Notes	Assessment Sources and Notes*
Boltonia montana	Appalachian Mountain Boltonia	G1G2	S1	MV	VH		Physiological hydrology and habitat (Walz et al 2001); Reproduction/Dispersal(Virgina Botanical Associates 2012)
Carex haydenii	Cloud Sedge	G5	S1	HV	Mod	Species range may shift and perhaps leave the assessment area.	Climate change range shift (Natural Resources of Canada 2011); (New York Natural Heritage Program 2011c)
Carex lupuliniformis	Hop-like Sedge	G4	S1	MV	VH		Possible benefits from fire (Shimp 2005);(New York Natural Heritage Program 2011d)
Glyceria borealis	Small Floating Manna Grass	G5	SH.1	HV	VH		(Maine Natural Area Program 2010)
Hypericum majus	Larger Canadian St. John's Wort	G5	S1	MV	VH		Pollination, flooding disturbance (Hill 2007)
Megalodonta beckii	Water-marigold	G4G5	S1	MV	VH		Reproduction, Habitat (Maine Volunteer Lake Monitoring Program 2009); Habitat threats (Schneider 1993)Climate change range shift (Natural Resources Canada 2011)
Neobeckia aquatica	Lake Water-cress	G4?	SH	MV	VH		Climate change range shifts (Natural Resources Canada 2011
Panicum flexile	Wiry Panic Grass	G5	S1	IE	—-		(Spooner et al. 1984)
Sagittaria cuneata	Arum-leaf Arrowhead	G5	S1	MV	VH		(Walz et al 2001, (Muenchow and Delesalle 1994)); Climate change range shift (Natural Resources Canada) 2011
Schoenoplectus torreyi	Torrey's Bulrush	G5	S1?	HV	VH		Dispersal (Mueller and van der Valk 2002, Calhoun and deMaynadier 2008); (Cusick 1985)

Scientific Name	Common Name	GRank	SRank	Index	Confi-dence	Index Notes	Assessment Sources and Notes*
Sparganium natans	Small Burr-reed	G5	S1	IE	—-		Climate change range shift (Natural Resources Canada 2011); ((Center for Lakes and Reservoirs at Portland State University 2009, Watson and Dallwitz 2012)); Habitat (New York Natural Heritage Program 2012)
Utricularia minor	Utricularia minor	G4Q	S1	PS	Mod		(Capers et al. 2010)

Appendix C. Intrinsic and Modeled Risk Factor Scores

GI (Greatly Increase)	Inc (Increase)	SI (Significantly Increase)	SD(Somewhat Decrease)	Dec(Decrease)	N (Neutral), N/A (Not Applicable), U (Unassessed)

Scientific Name	Common Name	Dispersal/Movement	historical thermal niche	physiological thermal niche	historical hydrological niche	physiological hydrological niche	Disturbance	Ice/snow	Phys habitat	Other spp for hab	Diet	Pollinators	Other spp disp	Other spp interaction	Genetic var	Gen bottleneck	Phenol response	Doc response	Modeled change	Modeled overlap
PINELANDS SPECIES																				
Pine Barren Savanna Habitat																				
Calamagrostis pickeringii	Pickering's Reed Grass	SI	N	N	GI	SI	U	N	N	N	N/A	N	N	N	U	N	U	U	Inc-SI	U
Cleistes divaricata	Spreading Pogonia	SD	N	N	GI	Inc	Dec	N	N	N	N/A	N	N	N	U	N	U	U	U	U
Eriophorum tenellum	Rough Cotton-grass	N	N	N	SI	Inc	N	N	N	N	N/A	N	N	N	U	N	U	U	Inc-SI	U
Eupatorium resinosum	Pine Barren Boneset	N	N	N	Inc	SI	SI	N	N	N	N/A	N	N	N	U	N	U	U	U	U
Juncus caesariensis	New Jersey Rush	SI	N	N	Inc	SI	N	N	N	N	N/A	N	N	N	U	N	U	U	U	U
Narthecium americanum	Bog Asphodel	N	N	N	Inc	SI	N	N	N	N	N/A	N	N	N	U	N	U	U	U	U
Platanthera integra	Yellow Fringeless Orchid	N	Inc	N	Inc	SI	SD	N	N	N	N/A	N	N	N	U	N	U	U	U	U
Rhynchospora knieskernii	Knieskern's Beak-rush	SI	Inc	N	Inc	SI	SD	N	N	N	N/A	N	N	N	U	N	U	U	U	U

Scientific Name	Common Name	Dispersal/Movement	historical thermal niche	physiological thermal niche	historical hydrological niche	physiological hydrological niche	Disturbance	Ice/snow	Phys habitat	Other spp for hab	Diet	Pollinators	Other spp disp	Other spp interaction	Genetic var	Gen bottleneck	Phenol response	Doc response	Modeled change	Modeled overlap
Scirpus longii	Long's Woolgrass	SD	N	N	Inc	Inc	N	N	N	N	N/A	N	N	N	SD	N/A	U	U	U	U
Spiranthes laciniata	Lace-lip Ladies'-tresses	N	N	N	SI	SI	SD	N	N	N	N/A	N	N	N	N	N/A	U	U	U	U
Tofieldia racemosa	False Asphodel	SI	N	N	GI	SI	SD	N	N	N	N/A	N	N	N	N	N/A	U	U	Inc-SI	U
Utricularia resupinata	Reversed Bladderwort	SD	N	N	Inc	Inc	N	N	N	N	N/A	N	N	N	N	N/A	U	U	N	N
Xyris fimbriata	Fringed Yellow-eyed-grass	U	N	N	Inc	SI	SD	N	N	N	N/A	N	N	N	N	N/A	U	U	U	U
Zigadenus leimanthoides	Death Camas	Inc	N	N	Inc	SI	SD	N	SI	N	N/A	N	N	N	U	N	U	U	U	U
Coastal Plain Intermittent Pond Habitat																				
Boltonia asteroides var. glastifolia	Southern Boltonia	N	N	N	Inc	GI	SI	SI	N	N	N/A	N	N	N	U	N	U	U	U	U
Coelorachis rugosa	Wrinkled jointgrass	SI	N	SD	GI	SI	N	N	SI	N	N/A	N	U	N	U	N	U	U	U	U
Cyperus pseudovegetus	Marsh Flat Sedge	U	N	N	Inc	SI	SD	N	SI	N	N/A	N	N	N	U	N	U	U	U	U
Dichanthelium hirstii (=Panicum hirstii)	Hirst Brothers' Panic Grass	SI	N	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	U	N	U	U	U	U
Diodia virginiana	Larger Buttonweed	SD	N	N	GI	Inc	N	N	SI	N	N/A	N	N	N	U	N	U	U	U	U

Scientific Name	Common Name	Dispersal/Movement	historical thermal niche	physiological thermal niche	historical hydrological niche	physiological hydrological niche	Disturbance	Ice/snow	Phys habitat	Other spp for hab	Diet	Pollinators	Other spp disp	Other spp interaction	Genetic var	Gen bottleneck	Phenol response	Doc response	Modeled change	Modeled overlap
Eleocharis equisetoides	Knotted Spike-rush	SI	N	N	GI	Inc	N	N	SI	N	N/A	N	N	N	U	N	U	U	N	N
Hottonia inflata	Featherfoil	SI	N	N	Inc	Inc	Inc	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
Hypericum adpressum	Barton's St. John's-wort	SI	N	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	U	N	U	U	N	N
Hypericum gymnanthum	Clasping-leaf St. John's-wort	SI	N	N	Inc	Inc	N	N	N	N	N/A	N	N	N	U	N	U	U	U	U
Lobelia boykinii	Boykin's Lobelia	SI	N	N	Inc	Inc	N	N	SI	N	N/A	SI	N	N	U	N	U	U	U	U
Ludwigia linearis	Narrow-leaf Primrose-willow	SI	N	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	U	N	U	U	U	U
Rhexia aristosa	Awned Meadow-beauty	SI	Inc	N	Inc	Inc	SD	N	SI	N	N/A	N	N	N	U	N	U	U	U	U
Rhynchospora microcephala	Small-head Beaked-rush	SI	Inc	N	Inc	SI	SD	N	N	N	N/A	N	N	N	U	N	U	U	U	U
Sagittaria teres	Slender Arrowhead	SI	Inc	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	SD	N/A	U	U	U	U
Schoenoplectus torreyi	Torrey's Bulrush	SI	Inc	N	N	SI	N	N	Inc	N	N/A	N	N	SI	U	N	U	U	GI-Inc-SI-N	SI
Utricularia olivacea	Dwarf White Bladderwort	SD	N	N	GI	Inc	N	N	SI	N	N/A	N	N	N	N	N/A	U	U	U	U
Utricularia resupinata	Reversed Bladderwort	SD	N	N	Inc	Inc	N	N	N	N	N/A	N	N	N	N	N/A	U	U	N	N

Scientific Name	Common Name	Dispersal/Movement	historical thermal niche	physiological thermal niche	historical hydrological niche	physiological hydrological niche	Disturbance	Ice/snow	Phys habitat	Other spp for hab	Diet	Pollinators	Other spp disp	Other spp interaction	Genetic var	Gen bottleneck	Phenol response	Doc response	Modeled change	Modeled overlap
SKYLANDS SPECIES																				
Calcareous Fen Habitat																				
Andromeda polifolia var. glaucophylla	Bog Rosemary	SI	N	Inc	Inc	Inc	SI	N	SD	N	N/A	N	N	N	U	U	SD	U	U	U
Aster borealis	Rush Aster	N	N	N	GI	SI	SD	N	SI	N	N/A	N	N	N	U	N	U	U	GI-Inc-SI	U
Carex alopecoidea	Foxtail Sedge	SI	N	N	Inc	SI	SD	N	SI	N	N/A	N	N	N	U	N	U	U	GI-Inc-SI	U
Carex aquatilis	Water Sedge	SI	N	N	GI	Inc	N	N	SI	N	N/A	N	N	N	U	N	U	U	Inc-SI	U
Carex diandra	Lesser Panicled Sedge	SI	N	N	Inc	SI	N	N	SI	N	N/A	N	N	N	U	N	U	U	GI-Inc-SI-N	U
Carex formosa	Handsome Sedge	SI	N	N	GI	SI	N	N	SI	N	N/A	N	N	N	U	N	U	U	GI-Inc-SI-N	SI
Carex pseudocyperus	Cyperus-like Sedge	SI	N	N	GI	SI	N	N	SI	N	N/A	N	N	N	U	N	U	U	GI-Inc-SI	U
Carex tuckermanii	Tuckerman's Sedge	SI	N	N	GI	SI	N	N	SI	N	N/A	N	N	N	U	N	U	U	GI-Inc-SI	U
Carex woodii	Wood's Sedge	SI	N	N	GI	SI	N	N	SI	N	N/A	N	N	N	U	N	U	U	Inc-SI	U
Comarum palustre	Marsh Cinquefoil	SI	N	N	Inc	SI	N	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
Conioselinum chinense	Hemlock-parsley	N	N	N	Inc	N	SD	N	N	N	N/A	N	N	N	U	U	U	U	N	U

Scientific Name	Common Name	Dispersal/Movement	historical thermal niche	physiological thermal niche	historical hydrological niche	physiological hydrological niche	Disturbance	Ice/snow	Phys habitat	Other spp for hab	Diet	Pollinators	Other spp disp	Other spp interaction	Genetic var	Gen bottleneck	Phenol response	Doc response	Modeled change	Modeled overlap
Cypripedium candidum	Small White Lady's-slipper	SD	N	N	GI	Inc	SD	N	SI	N	N/A	N	N	SI	Inc	N/A	U	U	U	U
Cypripedium reginae	Showy Lady's-slipper	SD	N	N	Inc	Inc	N	N	SI	N	N/A	N	N	SI	SI	N/A	U	U	N	SI
Eleocharis quinqueflora	Few-flower Spike-rush	N	N	N	GI	SI	N	N	SI	N	N/A	N	N	N	U	N	U	U	U	U
Equisetum variegatum	Variegated Horsetail	N	N	N	Inc	N	SD	N	SI	N	N/A	N	N	N	Inc	N/A	U	U	GI	U
Filipendula rubra	Queen-of-the prairie	SI	N	N	GI	SI	SD	N	SI	N	N/A	N	N	N	SI	N/A	U	U	N	U
Galium labradoricum	Labrador Marsh Bedstraw	Inc	N	N	Inc	N	N	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
Galium trifidum	Small Bedstraw	SI	GI	N	Inc	SI	N	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
Hypericum majus	Larger Canadian St. John's Wort	SI	N	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	U	U	U	U	SI	Inc
Panicum boreale	Northern Panic Grass	SI	N	N	Inc	N	N	N	N	N	N/A	N	N	N	U	U	U	U	U	U
Rhynchospora capillacea	Capillary Beaked-rush	SI	N	N	GI	SI	N	N	SI	N	N/A	N	N	N	U	N	U	U	Inc-SI-N	Inc-SI-N
Rudbeckia fulgida	Orange Coneflower	Inc	N	N	Inc	SI	N	N	SI	N	N/A	N	N	N	U	U	U	U	U	U

Scientific Name	Common Name	Dispersal/Movement	historical thermal niche	physiological thermal niche	historical hydrological niche	physiological hydrological niche	Disturbance	Ice/snow	Phys habitat	Other spp for hab	Diet	Pollinators	Other spp disp	Other spp interaction	Genetic var	Gen bottleneck	Phenol response	Doc response	Modeled change	Modeled overlap
Salix lucida ssp. lucida	Shining Willow	SI	N	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
Salix pedicellaris	Bog Willow	SI	N	N	Inc	Inc	N	N	N	N	N/A	N	N	N	U	U	U	U	U	U
Sisyrinchium montanum	Strict Blue-eyed Grass	Inc	N	N	GI	SI	N	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
Thuja occidentalis	Arborvitae	SI	N	N	GI	N	N	N	N	N	N/A	N	N	N	U	U	U	U	Inc	U
Triglochin maritima	Seaside Arrow-grass	SI	N	N	GI	SI	N	N	N	N	N/A	N	N	N	U	U	U	U	U	U
Trollius laxus ssp. laxus	Spreading Globe Flower	SI	N	N	Inc	SI	N	N	N	N	N/A	U	N	N	U	U	U	U	U	U
Veronica catenata	Sessile Water-speedwell	SI	N	N	Inc	N	N	N	N	N	N/A	N	N	N	U	U	U	U	U	U
Calcareous Sinkhole Pond Habitat																				
Alisma triviale	Large water-plantain	SD	N	N	Inc	N	SI	N	SD	N	N/A	N	N	N	U	U	U	U	U	U
Boltonia montana	Appalachian Mountain Boltonia	SI	N	N	GI	SI	SI	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
Carex haydenii	Cloud Sedge	SI	N	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	U	N	U	U	GI-Inc-SI	U
Carex lupuliniformis	Hop-like Sedge	SI	N	N	GI	Inc	SD	N	SI	N	N/A	N	N	N	U	N	U	U	U	U

Scientific Name	Common Name	Dispersal/Movement	historical thermal niche	physiological thermal niche	historical hydrological niche	physiological hydrological niche	Disturbance	Ice/snow	Phys habitat	Other spp for hab	Diet	Pollinators	Other spp disp	Other spp interaction	Genetic var	Gen bottleneck	Phenol response	Doc response	Modeled change	Modeled overlap
Glyceria borealis	Small Floating Manna Grass	SI	N	N	GI	N	SD	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
Hypericum majus	Larger Canadian St. John's Wort	SI	N	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	U	U	U	U	SI	Inc
Megalodonta beckii	Water-marigold	N	N	N	Inc	SI	N	N	N	N	N/A	N	N	N	U	U	U	U	SI	SI
Neobeckia aquatica	Lake Water-cress	N	N	N	GI	SI	SI	N	SI	N	N/A	N	N	N	U	U	U	U	N	U
Panicum flexile	Wiry Panic Grass	SI	N	N	Inc	SI	SD	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
Sagittaria cuneata	Arum-leaf Arrowhead	SI	N	N	GI	Inc	SI	N	SI	N	N/A	N	N	N	U	U	U	U	SI	Inc
Sparganium natans	Small Burr-reed	N	N	N	Inc	SI-U	N-U	N	U	N	N/A	N	N	N	U	U	U	U	GI	GI
Utricularia minor	Utricularia minor	U	N	N	Inc	SI	SD	N	N	N	N/A	N	N	N	U	N	U	U	Inc-SI-N	U

Appendix D. Exposure and Geography Risk Factor Scores

GI (Greatly Increase)	Inc (Increase)	SI (Significantly Increase)	SD(Somewhat Decrease)	Dec(Decrease)	N (Neutral), N/A (Not Applicable), U (Unassessed)

Scientific Name	Common Name	NY Range Relative to Global Range	Temperature: Pct_range_warmer (4.5 F)	Hamon AET:PET Moisture Metric Pct_range_dryest (-0.073)	Sea level	Natl barriers	Anth barriers	CC mitigation
PINELANDS SPECIES								
Pine Barren Savanna Habitat								
Calamagrostis pickeringii	Pickering's Reed Grass	Southern edge of range	100	100	N	N	N	U
Cleistes divaricata	Spreading Pogonia	Northern edge of range	100	100	SI	N	N	N
Eriophorum tenellum	Rough Cotton-grass	Southern edge of range	100	100	SI	SI	N	U
Eupatorium resinosum	Pine Barren Boneset	Northern edge of range	100	100	SI	SI	N	U
Juncus caesariensis	New Jersey Rush	Center of range	100	100	N	SI	N	U
Narthecium americanum	Bog Asphodel	Northern edge of range	100	100	SI	SI	Inc	U
Platanthera integra	Yellow Fringeless Orchid	Northern edge of range	100	100	N	N	N	U
Rhynchospora knieskernii	Knieskern's Beak-rush	Center of range	100	100	SI	N	SI	U
Scirpus longii	Long's Woolgrass	Southern edge of range	100	100	N	N	SI	U
Spiranthes laciniata	Lace-lip Ladies'-tresses	Northern edge of range	100	100	SI	N	SI	U
Tofieldia racemosa	False Asphodel	Northern edge of range	100	100	N	SI	N	U

Scientific Name	Common Name	NY Range Relative to Global Range	Temperature: Pct_range_warmer (4.5 F)	Hamon AET:PET Moisture Metric Pct_range_dryest (-0.073)	Sea level	Natl barriers	Anth barriers	CC mitigation
Utricularia resupinata	Reversed Bladderwort	Center of range	100	100	SI	N	N	U
Xyris fimbriata	Fringed Yellow-eyed-grass	Northern edge of range	100	100	N	SI	SI	U
Zigadenus leimanthoides	Death Camas	Center of range	100	100	N	SI	SI	U
Coastal Plain Intermittent Pond Habitat								
Boltonia asteroides var. glastifolia	Southern Boltonia	East/west edge of range	100	100	SI	N	N	SI
Coelorachis rugosa	Wrinkled jointgrass	Northern edge of range	100	100	N	N	N	U
Cyperus pseudovegetus	Marsh Flat Sedge	East/west edge of range	100	100	N	SI	SI	U
Dichanthelium hirstii (Panicum hirstii)	Hirst Brothers' Panic Grass	Northern edge of range	100	100	N	SI	N	U
Diodia virginiana	Larger Buttonweed	Northern edge of range	100	100	Inc	SI	N	U
Eleocharis equisetoides	Knotted Spike-rush	Center of range	100	100	Inc	SI	SI	U
Hottonia inflata	Featherfoil	Center of range	100	100	N	N	N	N
Hypericum adpressum	Barton's St. John's-wort	Center of range	100	100	SI	SI	SI	U
Hypericum gymnanthum	Clasping-leaf St. John's-wort	Northern edge of range	100	100	N	SI	N	U
Lobelia boykinii	Boykin's Lobelia	Northern edge of range	100	100	SI	SI	N	U
Ludwigia linearis	Narrow-leaf Primrose-willow	Northern edge of range	100	100	SI	SI	N	U

Scientific Name	Common Name	NY Range Relative to Global Range	Temperature: Pct_range_warmer (4.5 F)	Hamon AET:PET Moisture Metric Pct_range_dryest (-0.073)	Sea level	Natl barriers	Anth barriers	CC mitigation
Rhexia aristosa	Awned Meadow-beauty	Northern edge of range	100	100	N	SI	N	U
Rhynchospora microcephala	Small-head Beaked-rush	Northern edge of range	100	100	N	N	SI	U
Sagittaria teres	Slender Arrowhead	Center of range	100	100	SI	Inc	SI	U
Schoenoplectus torreyi	Torrey's Bulrush	Center of range	100	100	N	SI	SI	U
Utricularia olivacea	Dwarf White Bladderwort	Northern edge of range	100	100	N	N	N	U
Utricularia resupinata	Reversed Bladderwort	Center of range	100	100	SI	N	N	U
SKYLANDS SPECIES								
Calcareous Fen Habitat								
Andromeda polifolia var. glaucophylla	Bog Rosemary	Southern edge of range	100	100	N	N	N	N
Aster borealis	Rush Aster	Southern edge of range	100	100	N	N	N	U
Carex alopecoidea	Foxtail Sedge	Southern edge of range	100	100	N	SI	N	U
Carex aquatilis	Water Sedge	Southern edge of range	100	100	N	SI	SI	U
Carex diandra	Lesser Panicled Sedge	Southern edge of range	100	100	N	SI	SI	U
Carex formosa	Handsome Sedge	Southern edge of range	100	100	N	SI	SI	U
Carex pseudocyperus	Cyperus-like Sedge	Southern edge of range	100	100	N	SI	Inc	U
Carex tuckermanii	Tuckerman's Sedge	Southern edge of range	100	100	N	SI	Inc	U

Scientific Name	Common Name	NY Range Relative to Global Range	Temperature: Pct_range_warmer (4.5 F)	Hamon AET:PET Moisture Metric Pct_range_dryest (-0.073)	Sea level	Natl barriers	Anth barriers	CC mitigation
Carex woodii	Wood's Sedge	East/west edge of range	100	100	N	SI	SI	U
Comarum palustre	Marsh Cinquefoil	Southern edge of range	100	100	N	N	N	N
Conioselinum chinense	Hemlock-parsley	Center of range	100	100	N	N	N	N
Cypripedium candidum	Small White Lady's-slipper	Southern edge of range	100	100	N	N	N	N
Cypripedium reginae	Showy Lady's-slipper	Center of range	100	100	N	N	N	N
Eleocharis quinqueflora	Few-flower Spike-rush	Southern edge of range	100	100	N	SI	SI	U
Equisetum variegatum	Variegated Horsetail	Southern edge of range	100	100	N	N	N	N
Filipendula rubra	Queen-of-the prairie	Center of range	100	100	N	N	N	N
Galium labradoricum	Labrador Marsh Bedstraw	Southern edge of range	100	100	N	N	N	N
Galium trifidum	Small Bedstraw	Center of range	100	100	N	N	N	N
Glyceria borealis	Small Floating Manna Grass	Southern edge of range	100	100	N	N	N	N
Hypericum majus	Larger Canadian St. John's Wort	Southern edge of range	100	100	N	N	N	N
Panicum boreale	Northern Panic Grass	Center of range	100	100	N	U	U	N
Rhynchospora capillacea	Capillary Beaked-rush	Center of range	100	100	N	SI	SI	U
Rudbeckia fulgida	Orange Coneflower	Center of range	100	100	N	N	N	N
Salix lucida ssp. Lucida	Shining Willow	Center of range	100	100	N	N	N	N
Salix pedicellaris	Bog Willow	Southern edge of range	100	100	N	N	N	N

Scientific Name	Common Name	NY Range Relative to Global Range	Temperature: Pct_range_warmer (4.5 F)	Hamon AET:PET Moisture Metric Pct_range_dryest (-0.073)	Sea level	Natl barriers	Anth barriers	CC mitigation
Sisyrinchium montanum	Strict Blue-eyed Grass	Southern edge of range	100	100	N	N	N	N
Thuja occidentalis	Arborvitae	Center of range	100	100	N	N	N	N
Triglochin maritima	Seaside Arrow-grass	Southern edge of range	100	100	SI	N	N	N
Trollius laxus ssp. laxus	Spreading Globe Flower	Center of range	100	100	N	N	N	N
Veronica catenata	Sessile Water-speedwell	Center of range	100	100	N	N	N	N
Calcareous Sinkhole Pond Habitat								
Alisma triviale	Large water-plantain	Southern edge of range	100	100	N	N	SI	N
Boltonia montana	Appalachian Mountain Boltonia	Northern edge of range	100	100	N	N	N	N
Carex haydenii	Cloud Sedge	Southern edge of range	100	100	N	Inc	Inc	U
Carex lupuliniformis	Hop-like Sedge	Center of range	100	100	N	SI	SI	U
Glyceria borealis	Small Floating Manna Grass	Southern edge of range	100	100	N	N	N	N
Megalodonta beckii	Water-marigold	Southern edge of range	100	100	N	N	N	N
Neobeckia aquatica	Lake Water-cress	Center of range	100	100	N	N	N	N
Panicum flexile	Wiry Panic Grass	Center of range	100	100	N	N	N	N
Sagittaria cuneata	Arum-leaf Arrowhead	Southern edge of range	100	100	N	N	N	N
Schoenoplectus torreyi	Torrey's Bulrush	Center of range	100	100	N	SI	SI	U

Scientific Name	Common Name	NY Range Relative to Global Range	Temperature: Pct_range_warmer (4.5 F)	Hamon AET:PET Moisture Metric Pct_range_dryest (-0.073)	Sea level	Natl barriers	Anth barriers	CC mitigation
Sparganium natans	Small Burr-reed	Southern edge of range	100	100	N	N	N	N
Thuja occidentalis	Arborvitae	Center of range	100	100	N	N	N	N
Utricularia minor	Utricularia minor	Center of range	100	100	N	SI	SI	U

Appendix E. Screen Shot of the CCVI Form.

The NatureServe Climate Change Vulnerability Index

Release 2.1 *7 April 2011; Bruce Young, Elizabeth Byers, Kelly Gravuer, Kim Hall, Geoff Hammerson, Alan Redder*

With input from: *Jay Cordeiro, Kristin Szabo*

Funding for Release 2.0 generously provided by the Duke Energy Corporation.

NatureServe

* = *Required field*

Geographic Area Assessed:	New Jersey	*
Assessor:	Richard Ring	
Species Scientific Name:	Aster borealis	*
English Name:	Rush Aster	
Major Taxonomic Group:	Vascular Plant	*
Relation of Species' Range to Assessment Area:	Southern edge of range	*
G-Rank:	G4Q	
S-Rank:	S1	

Clear Form

Check if species is an obligate of caves or groundwater aquatic systems: *(Must be marked with an "X" for accurate scoring of these species.)*

Assessment Notes (to document special methods and data sources)

New York Natural Heritage Program 2011a

Section A: Exposure to Local Climate Change *(Calculate for species' range within assessment area)*

Temperature *

Severity	Scope (percent of range)
>5.5° F (3.1° C) warmer	0
5.1-5.5° F (2.8-3.1° C) warmer	0
4.5-5.0° F (2.5-2.7° C) warmer	100
3.9-4.4° F (2.2-2.4° C) warmer	0
< 3.9° F (2.2° C) warmer	0
Total:	100 *(Must sum to 100)*

Hamon AET:PET Moisture Metric *

Severity	Scope (percent of range)
< -0.119	0
-0.097 - -0.119	0
-0.074 - -0.096	0
-0.051 - -0.073	0
-0.028 - -0.050	100
>-0.028	0
Total:	100 *(Must sum to 100)*

Section B: Indirect Exposure to Climate Change *(Evaluate for specific geographical area under consideration)*

'k an "X" in all boxes that apply.

Effect on Vulnerability							Factors that influence vulnerability *(* at least three required)*
Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown	
			X				1) Exposure to **sea level rise**
							2) Distribution relative to **barriers**
			X				a) **Natural barriers**
			X				b) **Anthropogenic barriers**
						X	3) Predicted **impact of land use changes resulting from human responses** to climate change

Section C: Sensitivity

'k an "X" in all boxes that apply.

Effect on Vulnerability							Factors that influence vulnerability *(* at least 10 required)*
Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown	
			X				1) **Dispersal and movements**
							2) Predicted **sensitivity to temperature** and **moisture changes**
							a) Predicted **sensitivity to changes in temperature**
			X				i) **historical thermal niche**
			X				ii) **physiological thermal niche**
							b) Predicted **sensitivity to changes in precipitation, hydrology, or moisture regime**
x							i) **historical hydrological niche**
		X					ii) **physiological hydrological niche**
				X			c) Dependence on a **specific disturbance regime** likely to be impacted by climate change
			X				d) Dependence on **ice, ice-edge, or snow-cover habitats**
		x					3) **Restriction to uncommon geological features or derivatives**
							4) **Reliance on interspecific interactions**
			X				a) Dependence on **other species to generate habitat**
						X	b) **Dietary versatility** (animals only)
			X				c) **Pollinator versatility** (plants only)
			X				d) Dependence on **other species for propagule dispersal**
			X				e) Forms part of an **interspecific interaction** not covered by 4a-d
							5) **Genetic factors**
						X	a) Measured **genetic variation**
			X				b) Occurrence of **bottlenecks** in recent evolutionary history *(use only if 5a is "unknown")*
						X	6) **Phenological response to** changing seasonal temperature and precipitation dynamics

Section D: **Documented or Modeled Response to Climate Change** *(Optional; May apply across the range of a species)*

Mark an "X" in all boxes that apply.

Effect on Vulnerability							*(Optional)*
Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown	
						X	1) **Documented response** to recent climate change
						X	2) Modeled **future (2050) change in population** or **range size**
						X	3) **Overlap** of modeled future (2050) range with current range
						X	4) Occurrence of **protected areas in modeled future (2050) distribution**

Climate Change Vulnerability Index

for Aster borealis in New Jersey

Not Vulnerable/Presumed Stable

Notes:

Confidence in Species Information
Very High

* Histogram below

Copy Data to Results Table

Definitions of Index Values

Extremely Vulnerable (EV): Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050.

Highly Vulnerable (HV): Abundance and/or range extent within geographical area assessed likely to decrease significantly by 2050.

Moderately Vulnerable (MV): Abundance and/or range extent within geographical area assessed likely to decrease by 2050.

Not Vulnerable/Presumed Stable (PS): Available evidence does not suggest that abundance and/or range extent within the geographical area assessed will change (increase/decrease) substantially by 2050. Actual range boundaries may change.

Not Vulnerable/Increase Likely (IL): Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.

Insufficient Evidence (IE): Available information about a species' vulnerability is inadequate to calculate an Index score.