

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



Zigadenus leimanthoides



Cypripedium reginae

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

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

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

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.

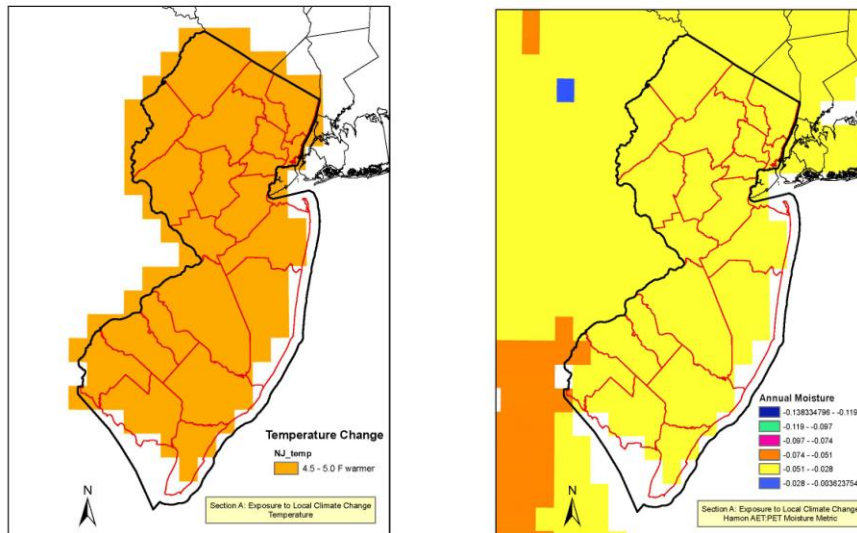


Figure 1. (Left) Projected temperature increase for New Jersey by 2050. (Right) Projected decreases in moisture availability for New Jersey by 2050. (Data from www.climatewizard.org)

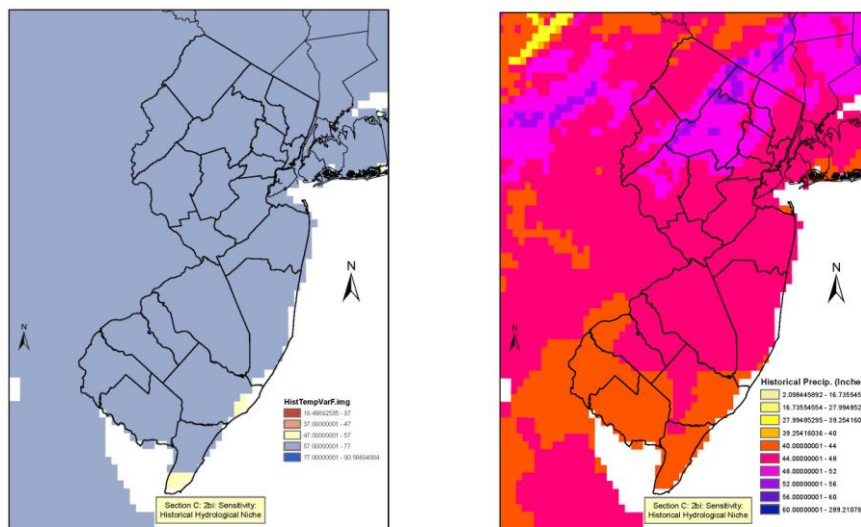


Figure 2. Historic temperature variability (left) and precipitation (right) in New Jersey over the past 50 years (Data from www.climatewizard.org.)

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

<u>REGION: PINELANDS</u>					
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%)		
<u>REGION: SKYLANDS</u>					
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.

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

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

Scientific Name	Common Name	GRank	SRank	Index	Confidence	Index Notes	Assessment Sources and Notes*
<i>Hypericum gymnanthum</i>	Clasping-leaf St. John's-wort	G4	S1	MV	VH		(Hilty 2012)
<i>Lobelia boykinii</i>	Boykin's Lobelia	G2G3	S1	HV	VH		(Royo et al. 2008)
<i>Ludwigia linearis</i>	Narrow-leaf Primrose-willow	G5	S1	MV	VH		((Kirkman et al. 2000)
<i>Rhexia aristosa</i>	Awned Meadow-beauty	G3	S1	HV	VH		(Hilty 2012))
<i>Rhynchospora microcephala</i>	Small-head Beaked-rush	G5T5	S1	MV	VH		(Flora of North America Editorial Committee 2003)
<i>Sagittaria teres</i>	Slender Arrowhead	G3	S1	EV	VH		(MANHESP 2007)
<i>Schoenoplectus torreyi</i>	Torrey's Bulrush	G5	S1?	HV	VH		Dispersal (Mueller and van der Valk 2002, Calhoun and deMaynadier 2008); (Cusick 1985)
<i>Utricularia olinacea</i>	Dwarf White Bladderwort	G4	S1	PS	VH		Dispersal (Capers et al 2009)
<i>Utricularia resupinata</i>	Reversed Bladderwort	G4	S1	PS	VH		Dispersal (Capers et al 2009)
SKYLANDS SPECIES							
Calcareous Fen Habitat							
<i>Andromeda polifolia var. glaucophylla</i>	Bog Rosemary	G5	S1	MV	VH		Disturbance regime and hydrological/physiological tolerance (Taylor 2007) Phenological response to climate change (Aerts et al. 2004)
<i>Aster borealis</i>	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	Confidence	Index Notes	Assessment Sources and Notes*
<i>Carex alopecoidea</i>	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)
<i>Carex aquatilis</i>	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)
<i>Carex diandra</i>	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)
<i>Carex formosa</i>	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)
<i>Carex pseudocyperus</i>	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 Committee 2003)
<i>Carex tuckermanii</i>	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	Confidence	Index Notes	Assessment Sources and Notes*
<i>Carex woodii</i>	Wood's Sedge	G4	S1.1	MV	VH		(Minnesota Department of Natural Resources 2011b)
<i>Comanrum palustris</i>	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)
<i>Comoselinum chinense</i>	Hemlock-parsley	G5	S1	MV	VH		Disturbance, flooding (Macek and Lepš 2008); Pollination and flowering (Olesen and Warncke 1992); Dispersal (Skoglund 1990)
<i>Cypripedium candidum</i>	Small White Lady's-slipper	G4	S1	PS	VH		Seed Dispersal (Connolly n.d.); Climate change range (Natural Resources Canada 2011)
<i>Cypripedium reginae</i>	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)
<i>Eleocharis quinqueflora</i>	Few-flower Spike-rush	G5	S1	MV	VH		Wind and water dispersal (Illinois Plant Information Network 2012)
<i>Equisetum variegatum</i>	Variiegated 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)
<i>Filipendula rubra</i>	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	Confidence	Index Notes	Assessment Sources and Notes*
<i>Galium labradoricum</i>	Labrador Marsh Bedstraw	G5	S1	MV	VH		Physiological hydrological regime (Duval and Waddington 2011) Climate change range shift (Natural Resources Canada 2011)
<i>Galium trifidum</i>	Small Bedstraw	G5T5	S2	MV	VH		(Minnesota Wildflowers 2012)
<i>Hypericum majus</i>	Larger Canadian St. John's Wort	G5	S1	MV	VH		Pollination, flooding disturbance (Hill 2007)
<i>Panicum boreale</i>	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)
<i>Rhynchospora capillacea</i>	Capillary Beaked-rush	G4	S1	MV	High		(Cullina 2002)
<i>Rudbeckia fulgida</i>	Orange Coneflower	G5T4?	S1	MV	VH		Reproductive ecology (Molano-Flores 2000)
<i>Salix lucida ssp. lucida</i>	Shining Willow	G5T5	S1?	MV	VH		phenology (Mosseler and Papadopol 1989)
<i>Salix pedicellaris</i>	Bog Willow	G5	S1	PS	VH		Drought resistance (Savage et al 2011)
<i>Sisyrinchium montanum</i>	Strict Blue-eyed Grass	G5T4T5	S2	MV	VH		Climate Change (DENR 2010)
<i>Thuja occidentalis</i>	Arborvitae	G5	S1	MV	VH		(Johnson 1990, Prasad et al. 2007)
<i>Triglochin maritima</i>	Seaside Arrow-grass	G5	S1	MV	VH		(Jones 2000) Effects of drought on fen water table (Duval and Waddington 2011)
<i>Trollius laxus ssp. laxus</i>	Spreading Globe Flower	G4T3	S1	PS	VH		Dispersal ((Jones 2000); Effects of drought on fen water table (Duval and Waddington 2011)
<i>Veronica catenata</i>	Sessile Water-speedwell	G5	S1	PS	VH		Climate Change (DENR 2010)
Calcareous Sinkhole Pond Habitat							
<i>Alisma triviale</i>	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	Confidence	Index Notes	Assessment Sources and Notes*
<i>Boltonia montana</i>	Appalachian Mountain Boltonia	G1G2	S1	MV	VH		Physiological hydrology and habitat (Walz et al 2001); Reproduction/Dispersal (Virginia Botanical Associates 2012)
<i>Carex haydenii</i>	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)
<i>Carex lupuliniformis</i>	Hop-like Sedge	G4	S1	MV	VH		Possible benefits from fire (Shimp 2005); (New York Natural Heritage Program 2011d)
<i>Glyceria borealis</i>	Small Floating Manna Grass	G5	SH.1	HV	VH		(Maine Natural Area Program 2010)
<i>Hypericum majus</i>	Larger Canadian St. John's Wort	G5	S1	MV	VH		Pollination, flooding disturbance (Hill 2007)
<i>Megalodonta beckii</i>	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)
<i>Neobeckia aquatica</i>	Lake Water-cress	G4?	SH	MV	VH		Climate change range shifts (Natural Resources Canada 2011)
<i>Panicum flexile</i>	Wiry Panic Grass	G5	S1	IE	—		(Spooner et al. 1984)
<i>Sagittaria cuneata</i>	Arum-leaf Arrowhead	G5	S1	MV	VH		(Walz et al 2001, (Muenchow and Delesalle 1994)); Climate change range shift (Natural Resources Canada) 2011
<i>Schoenoplectus torreyi</i>	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	Confidence	Index Notes	Assessment Sources and Notes*
<i>Sparganium natans</i>	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)
<i>Utricularia minor</i>	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)
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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																				
<i>Calamagrostis pickeringii</i>	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
<i>Cleistes divaricata</i>	Spreading Pogonia	SD	N	N	GI	Inc	Dec	N	N	N	N/A	N	N	N	U	N	U	U	U	U
<i>Eriophorum tenellum</i>	Rough Cotton-grass	N	N	N	SI	Inc	N	N	N	N	N/A	N	N	N	U	N	U	U	Inc-SI	U
<i>Eupatorium resinotum</i>	Pine Barren Boneset	N	N	N	Inc	SI	SI	N	N	N	N/A	N	N	N	U	N	U	U	U	U
<i>Juncus caesariensis</i>	New Jersey Rush	SI	N	N	Inc	SI	N	N	N	N	N/A	N	N	N	U	N	U	U	U	U
<i>Narthecium americanum</i>	Bog Asphodel	N	N	N	Inc	SI	N	N	N	N	N/A	N	N	N	U	N	U	U	U	U
<i>Platanthera integra</i>	Yellow Fringeless Orchid	N	Inc	N	Inc	SI	SD	N	N	N	N/A	N	N	N	U	N	U	U	U	U
<i>Rhynchospora knieskernii</i>	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
<i>Scirpus longii</i>	Long's Woolgrass	SD	N	N	Inc	Inc	N	N	N	N	N/A	N	N	N	SD	N/A	U	U	U	U
<i>Spiranthes laciniata</i>	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
<i>Tofieldia racemosa</i>	False Asphodel	SI	N	N	GI	SI	SD	N	N	N	N/A	N	N	N	N	N/A	U	U	Inc-SI	U
<i>Utricularia resupinata</i>	Reversed Bladderwort	SD	N	N	Inc	Inc	N	N	N	N	N/A	N	N	N	N	N/A	U	U	N	N
<i>Xyris fimbriata</i>	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
<i>Zigadenus leimanthoides</i>	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																				
<i>Boltonia asteroides var. glastifolia</i>	Southern Boltonia	N	N	N	Inc	GI	SI	SI	N	N	N/A	N	N	N	U	N	U	U	U	U
<i>Coelorachis rugosa</i>	Wrinkled jointgrass	SI	N	SD	GI	SI	N	N	SI	N	N/A	N	U	N	U	N	U	U	U	U
<i>Cyperus pseudovegetus</i>	Marsh Flat Sedge	U	N	N	Inc	SI	SD	N	SI	N	N/A	N	N	N	U	N	U	U	U	U
<i>Dichanthelium birstii</i> (=Panicum birstii)	Hirst Brothers' Panic Grass	SI	N	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	U	N	U	U	U	U
<i>Diodia virginiana</i>	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
<i>Eleocharis equisetoides</i>	Knotted Spike-rush	SI	N	N	GI	Inc	N	N	SI	N	N/A	N	N	N	U	N	U	U	N	N
<i>Hottonia inflata</i>	Featherfoil	SI	N	N	Inc	Inc	Inc	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
<i>Hypericum adpressum</i>	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
<i>Hypericum gymnanthum</i>	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
<i>Lobelia boykinii</i>	Boykin's Lobelia	SI	N	N	Inc	Inc	N	N	SI	N	N/A	SI	N	N	U	N	U	U	U	U
<i>Ludwigia linearis</i>	Narrow-leaf Primrose-willow	SI	N	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	U	N	U	U	U	U
<i>Rhexia aristosa</i>	Awmed Meadow-beauty	SI	Inc	N	Inc	Inc	SD	N	SI	N	N/A	N	N	N	U	N	U	U	U	U
<i>Rhynchospora microcephala</i>	Small-head Beaked-rush	SI	Inc	N	Inc	SI	SD	N	N	N	N/A	N	N	N	U	N	U	U	U	U
<i>Sagittaria teres</i>	Slender Arrowhead	SI	Inc	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	SD	N/A	U	U	U	U
<i>Schoenoplectus torreyi</i>	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
<i>Utricularia olivacea</i>	Dwarf White Bladderwort	SD	N	N	GI	Inc	N	N	SI	N	N/A	N	N	N	N	N/A	U	U	U	U
<i>Utricularia resupinata</i>	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																				
<i>Andromeda polifolia</i> var. <i>glaucophylla</i>	Bog Rosemary	SI	N	Inc	Inc	Inc	SI	N	SD	N	N/A	N	N	N	U	U	SD	U	U	U
<i>Aster borealis</i>	Rush Aster	N	N	N	GI	SI	SD	N	SI	N	N/A	N	N	N	U	N	U	U	GI-Inc-SI	U
<i>Carex alopecoidea</i>	Foxtail Sedge	SI	N	N	Inc	SI	SD	N	SI	N	N/A	N	N	N	U	N	U	U	GI-Inc-SI	U
<i>Carex aquatilis</i>	Water Sedge	SI	N	N	GI	Inc	N	N	SI	N	N/A	N	N	N	U	N	U	U	Inc-SI	U
<i>Carex diandra</i>	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
<i>Carex formosa</i>	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
<i>Carex pseudocyperus</i>	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
<i>Carex tuckermanii</i>	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
<i>Carex woodii</i>	Wood's Sedge	SI	N	N	GI	SI	N	N	SI	N	N/A	N	N	N	U	N	U	U	Inc-SI	U
<i>Comarum palustre</i>	Marsh Cinquefoil	SI	N	N	Inc	SI	N	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
<i>Conioselinum chinense</i>	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
<i>Cypripedium candidum</i>	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
<i>Cypripedium reginae</i>	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
<i>Eleocharis quinqueflora</i>	Few-flower Spike-rush	N	N	N	GI	SI	N	N	SI	N	N/A	N	N	N	U	N	U	U	U	U
<i>Equisetum variegatum</i>	Variegated Horsetail	N	N	N	Inc	N	SD	N	SI	N	N/A	N	N	N	Inc	N/A	U	U	GI	U
<i>Filipendula rubra</i>	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
<i>Galium labradoricum</i>	Labrador Marsh Bedstraw	Inc	N	N	Inc	N	N	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
<i>Galium trifidum</i>	Small Bedstraw	SI	GI	N	Inc	SI	N	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
<i>Hypericum majus</i>	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
<i>Panicum boreale</i>	Northern Panic Grass	SI	N	N	Inc	N	N	N	N	N	N/A	N	N	N	U	U	U	U	U	U
<i>Rhynchospora capillacea</i>	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
<i>Rudbeckia fulgida</i>	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
<i>Salix lucida ssp. lucida</i>	Shining Willow	SI	N	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
<i>Salix pedicellaris</i>	Bog Willow	SI	N	N	Inc	Inc	N	N	N	N	N/A	N	N	N	U	U	U	U	U	U
<i>Sisyrinchium montanum</i>	Strict Blue-eyed Grass	Inc	N	N	GI	SI	N	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
<i>Thuja occidentalis</i>	Arborvitae	SI	N	N	GI	N	N	N	N	N	N/A	N	N	N	U	U	U	U	Inc	U
<i>Triglochin maritima</i>	Seaside Arrow-grass	SI	N	N	GI	SI	N	N	N	N	N/A	N	N	N	U	U	U	U	U	U
<i>Trollius laxus ssp. laxus</i>	Spreading Globe Flower	SI	N	N	Inc	SI	N	N	N	N	N/A	U	N	N	U	U	U	U	U	U
<i>Veronica catenata</i>	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																				
<i>Alisma triviale</i>	Large water-plantain	SD	N	N	Inc	N	SI	N	SD	N	N/A	N	N	N	U	U	U	U	U	U
<i>Boltonia montana</i>	Appalachian Mountain Boltonia	SI	N	N	GI	SI	SI	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
<i>Carex haydenii</i>	Cloud Sedge	SI	N	N	Inc	Inc	N	N	SI	N	N/A	N	N	N	U	N	U	U	GI-Inc-SI	U
<i>Carex lupuliniformis</i>	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
<i>Glyceria borealis</i>	Small Floating Manna Grass	SI	N	N	GI	N	SD	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
<i>Hypericum majus</i>	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
<i>Megalodonta beckii</i>	Water-marigold	N	N	N	Inc	SI	N	N	N	N	N/A	N	N	N	U	U	U	U	SI	SI
<i>Neobeckia aquatica</i>	Lake Water-cress	N	N	N	GI	SI	SI	N	SI	N	N/A	N	N	N	U	U	U	U	N	U
<i>Panicum flexile</i>	Wiry Panic Grass	SI	N	N	Inc	SI	SD	N	SI	N	N/A	N	N	N	U	U	U	U	U	U
<i>Sagittaria cuneata</i>	Arum-leaf Arrowhead	SI	N	N	GI	Inc	SI	N	SI	N	N/A	N	N	N	U	U	U	U	SI	Inc
<i>Sparganium natans</i>	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
<i>Utricularia minor</i>	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)
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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								
<i>Calamagrostis pickeringii</i>	Pickering's Reed Grass	Southern edge of range	100	100	N	N	N	U
<i>Cleistes divaricata</i>	Spreading Pogonia	Northern edge of range	100	100	SI	N	N	N
<i>Eriophorum tenellum</i>	Rough Cotton-grass	Southern edge of range	100	100	SI	SI	N	U
<i>Eupatorium resinosum</i>	Pine Barren Boneset	Northern edge of range	100	100	SI	SI	N	U
<i>Juncus caesariensis</i>	New Jersey Rush	Center of range	100	100	N	SI	N	U
<i>Narthecium americanum</i>	Bog Asphodel	Northern edge of range	100	100	SI	SI	Inc	U
<i>Platanthera integra</i>	Yellow Fringeless Orchid	Northern edge of range	100	100	N	N	N	U
<i>Rhynchospora knieskernii</i>	Knieskern's Beak-rush	Center of range	100	100	SI	N	SI	U
<i>Scirpus longii</i>	Long's Woolgrass	Southern edge of range	100	100	N	N	SI	U
<i>Spiranthes laciniata</i>	Lace-lip Ladies'-tresses	Northern edge of range	100	100	SI	N	SI	U
<i>Tofieldia racemosa</i>	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	Natd barriers	Anth barriers	CC mitigation
<i>Utricularia resupinata</i>	Reversed Bladderwort	Center of range	100	100	SI	N	N	U
<i>Xyris fimbriata</i>	Fringed Yellow-eyed-grass	Northern edge of range	100	100	N	SI	SI	U
<i>Zigadenus leimantoides</i>	Death Camas	Center of range	100	100	N	SI	SI	U
Coastal Plain Intermittent Pond Habitat								
<i>Boltonia asteroides var. glastifolia</i>	Southern Boltonia	East/west edge of range	100	100	SI	N	N	SI
<i>Coelorachis rugosa</i>	Wrinkled jointgrass	Northern edge of range	100	100	N	N	N	U
<i>Cyperus pseudovegetus</i>	Marsh Flat Sedge	East/west edge of range	100	100	N	SI	SI	U
<i>Dichanthelium hirstii</i> (<i>Panicum hirstii</i>)	Hirst Brothers' Panic Grass	Northern edge of range	100	100	N	SI	N	U
<i>Diodia virginiana</i>	Larger Buttonweed	Northern edge of range	100	100	Inc	SI	N	U
<i>Eleocharis equisetoides</i>	Knotted Spike-rush	Center of range	100	100	Inc	SI	SI	U
<i>Hottonia inflata</i>	Featherfoil	Center of range	100	100	N	N	N	N
<i>Hypericum adpressum</i>	Barton's St. John's-wort	Center of range	100	100	SI	SI	SI	U
<i>Hypericum gymnanthum</i>	Clasping-leaf St. John's-wort	Northern edge of range	100	100	N	SI	N	U
<i>Lobelia boykinii</i>	Boykin's Lobelia	Northern edge of range	100	100	SI	SI	N	U
<i>Ludwigia linearis</i>	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
<i>Rhexia aristosa</i>	Awned Meadow-beauty	Northern edge of range	100	100	N	SI	N	U
<i>Rhynchospora microcephala</i>	Small-head Beaked-rush	Northern edge of range	100	100	N	N	SI	U
<i>Sagittaria teres</i>	Slender Arrowhead	Center of range	100	100	SI	Inc	SI	U
<i>Schoenoplectus torreyi</i>	Torrey's Bulrush	Center of range	100	100	N	SI	SI	U
<i>Utricularia olinacea</i>	Dwarf White Bladderwort	Northern edge of range	100	100	N	N	N	U
<i>Utricularia resupinata</i>	Reversed Bladderwort	Center of range	100	100	SI	N	N	U
SKYLANDS SPECIES								
Calcareous Fen Habitat								
<i>Andromeda polifolia</i> var. <i>glaucophylla</i>	Bog Rosemary	Southern edge of range	100	100	N	N	N	N
<i>Aster borealis</i>	Rush Aster	Southern edge of range	100	100	N	N	N	U
<i>Carex alopecoidea</i>	Foxtail Sedge	Southern edge of range	100	100	N	SI	N	U
<i>Carex aquatilis</i>	Water Sedge	Southern edge of range	100	100	N	SI	SI	U
<i>Carex diandra</i>	Lesser Panicked Sedge	Southern edge of range	100	100	N	SI	SI	U
<i>Carex formosa</i>	Handsome Sedge	Southern edge of range	100	100	N	SI	SI	U
<i>Carex pseudocyperus</i>	Cyperus-like Sedge	Southern edge of range	100	100	N	SI	Inc	U
<i>Carex tuckermanii</i>	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
<i>Carex woodii</i>	Wood's Sedge	East/west edge of range	100	100	N	SI	SI	U
<i>Comarum palustre</i>	Marsh Cinquefoil	Southern edge of range	100	100	N	N	N	N
<i>Conioselinum chinense</i>	Hemlock-parsley	Center of range	100	100	N	N	N	N
<i>Cypripedium candidum</i>	Small White Lady's-slipper	Southern edge of range	100	100	N	N	N	N
<i>Cypripedium reginae</i>	Showy Lady's-slipper	Center of range	100	100	N	N	N	N
<i>Eleocharis quinqueflora</i>	Few-flower Spike-rush	Southern edge of range	100	100	N	SI	SI	U
<i>Equisetum variegatum</i>	Variegated Horsetail	Southern edge of range	100	100	N	N	N	N
<i>Filipendula rubra</i>	Queen-of-the prairie	Center of range	100	100	N	N	N	N
<i>Galium labradoricum</i>	Labrador Marsh Bedstraw	Southern edge of range	100	100	N	N	N	N
<i>Galium trifidum</i>	Small Bedstraw	Center of range	100	100	N	N	N	N
<i>Glyceria borealis</i>	Small Floating Manna Grass	Southern edge of range	100	100	N	N	N	N
<i>Hypericum majus</i>	Larger Canadian St. John's Wort	Southern edge of range	100	100	N	N	N	N
<i>Panicum boreale</i>	Northern Panic Grass	Center of range	100	100	N	U	U	N
<i>Rhynchospora capillacea</i>	Capillary Beaked-rush	Center of range	100	100	N	SI	SI	U
<i>Rudbeckia fulgida</i>	Orange Coneflower	Center of range	100	100	N	N	N	N
<i>Salix lucida</i> ssp. <i>Lucida</i>	Shining Willow	Center of range	100	100	N	N	N	N
<i>Salix pedicellaris</i>	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	Nat'l barriers	Anth barriers	CC mitigation
<i>Sisyrinchium montanum</i>	Strict Blue-eyed Grass	Southern edge of range	100	100	N	N	N	N
<i>Thuja occidentalis</i>	Arborvitae	Center of range	100	100	N	N	N	N
<i>Triglochin maritima</i>	Seaside Arrow-grass	Southern edge of range	100	100	SI	N	N	N
<i>Trollius laxus ssp. laxus</i>	Spreading Globe Flower	Center of range	100	100	N	N	N	N
<i>Veronica catenata</i>	Sessile Water-speedwell	Center of range	100	100	N	N	N	N
Calcareous Sinkhole Pond Habitat								
<i>Alisma triviale</i>	Large water-plantain	Southern edge of range	100	100	N	N	SI	N
<i>Boltonia montana</i>	Appalachian Mountain Boltonia	Northern edge of range	100	100	N	N	N	N
<i>Carex haydenii</i>	Cloud Sedge	Southern edge of range	100	100	N	Inc	Inc	U
<i>Carex lupuliniformis</i>	Hop-like Sedge	Center of range	100	100	N	SI	SI	U
<i>Glyceria borealis</i>	Small Floating Manna Grass	Southern edge of range	100	100	N	N	N	N
<i>Megalodonta beckii</i>	Water-marigold	Southern edge of range	100	100	N	N	N	N
<i>Neobeckia aquatica</i>	Lake Water-cress	Center of range	100	100	N	N	N	N
<i>Panicum flexile</i>	Wiry Panic Grass	Center of range	100	100	N	N	N	N
<i>Sagittaria cuneata</i>	Arum-leaf Arrowhead	Southern edge of range	100	100	N	N	N	N
<i>Schoenoplectus torreyi</i>	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
<i>Sparganium natans</i>	Small Burr-reed	Southern edge of range	100	100	N	N	N	N
<i>Thuja occidentalis</i>	Arborvitae	Center of range	100	100	N	N	N	N
<i>Utricularia minor</i>	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.



* = Required field

Geographic Area Assessed:	New Jersey *	Clear Form				
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 *	<table border="1"> <tr> <td>G-Rank:</td> <td>G4Q</td> </tr> <tr> <td>S-Rank:</td> <td>S1</td> </tr> </table>	G-Rank:	G4Q	S-Rank:	S1
G-Rank:	G4Q					
S-Rank:	S1					
Check if species is an obligate of caves or groundwater aquatic systems:	<input type="checkbox"/>	(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						
Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
			X			
			X			
			X			
						X

Factors that influence vulnerability (* at least three required)

- 1) Exposure to **sea level rise**
- 2) Distribution relative to **barriers**
 - a) **Natural barriers**
 - b) **Anthropogenic barriers**
- 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						
Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown
			X			
			X			
			X			
x						
		X				
			X	X		
		x				
			X			
			X			X
			X			
			X			
			X			
			X			X
			X			X

Factors that influence vulnerability (* at least 10 required)

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

(Optional)

- 1) **Documented response** to recent climate change
- 2) Modeled **future (2050) change in population or range size**
- 3) **Overlap** of modeled future (2050) range with current range
- 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

Copy Data to Results Table

* Histogram below

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.