CONSERVATION OF THE ILLINOIS FLORA: A CLIMATE CHANGE VULNERABILITY ASSESSMENT OF 73 PLANT SPECIES

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EXECUTIVE SUMMARY

It will be important for land managers, ecological researchers and policymakers to understand how predicted climate changes may affect the flora of Illinois. A climate change vulnerability assessment was completed in 2011 for the 162 Animal Species in Greatest Need of Conservation using NatureServe's Climate Change Vulnerability Index (CCVI) tool. Here we selected 73 plant species found in Illinois and calculated their relative vulnerabilities to predicted climate changes, also using the NatureServe CCVI tool.

We selected species from several groups that we felt would be broadly representative of the Illinois flora. These groups included: rare plants, invasive plants, important prairie species, important woodland/savanna species, important forest species, and plants important to society. We compiled and entered data regarding both the species' exposures to predicted climate changes and their sensitivities to those changes. Exposures were determined by overlapping species range maps for Illinois with maps of temperature and moisture (AET:PET) predictions for the middle of this century. Species sensitivities were determined by interviewing between 4 and 12 experts for each plant species. Experts answered questions found in the CCVI tool regarding the species' biologies, ecologies and behaviors. Results for each individual survey were averaged for each species. Results fell into one of five vulnerability categories: Extremely Vulnerable, Highly Vulnerable, Moderately Vulnerable, Not Vulnerable/Presumed Stable, and Not Vulnerable/Increase Likely.

Results for these 73 species in Illinois fell into all 5 vulnerability categories, with the majority (67%) falling into the Presumed Stable category. The species most vulnerable to predicted climate changes were all of conservation concern; most were federal or state listed species. Native species tended to be more vulnerable than non-natives, and plants important to prairies, savannas and forests were equally vulnerable to predicted changes. The four species were ranked as likely to increase in population size or range extent due to predicted climate changes were: *Ailanthus altissima* (tree of heaven), *Ambrosia artemisiifolia* (ragweed), *Microstegium vimineum* (Japanese stiltgrass) and *Toxicodendron radicans* (poison ivy).

We advocate for 8 important next-steps to ensure adequate conservation of Illinois plants in a future with climate change, based on the findings of this report:

1) Investigate the climate change vulnerabilities of all rare plants in Illinois. Rare plants are the most vulnerabile group of species in this report.
2) Prioritize research on plants' abilities to phenologically track changes in seasonality, population genetics, species interactions, dispersal distances, thermal and hydrological tolerances and soil preferences/tolerances.
3) Continue to monitor population trends. Increase capacity to monitor species with the most uncertain responses to climate changes, the most vulnerable species, and all rare species.
4) Monitor invasive species for changes in populations and behavior. Assess all invasive species using NatureServe's CCVI tool or another tool.
5) Increase connectivity between natural areas. Increase acreage of natural areas.
6) Managers, policymakers, researchers and the public should work together to fully consider the role that assisted migration should or should not play in Illinois plant conservation.
7) Compile work done by various agencies and NGOs on the climate change vulnerabilities of Illinois species and ecosystems to detect trends, and to identify appropriate research, management and policy priorities.
8) Use adaptive management approaches to care for natural areas in Illinois in order to best achieve land management goals in an uncertain future.

INTRODUCTION

Illinois is host to approximately 2,107 species of native plants (Pearse et al. 2015; Mohlenbrock 2014), with 9 plant community types (White & Madany 1978). However, the condition of Illinois' ecosystems has been declining for decades due to fragmentation, habitat loss, exotic species invasions, hydrologic modifications and other anthropogenic

stressors and disturbances (Illinois Department of Energy and Natural Resources 1994). While the health of these plant communities and the plant populations in them have been studied and monitored by many groups (e.g., Carroll et al. 2002), one stress that has not been investigated is climate change.

In 2011, an assessment of the climate change vulnerability of the 162 animal Species in Greatest Need of Conservation was conducted (Walk et al. 2011). This report used NatureServe's Climate Change Vulnerability Index tool (Young et al. 2011) to understand how species' biology and ecology would determine their vulnerability to predicted climate changes. Geographically, the report investigated species within the natural divisions or watersheds where they occur, rather than across the entire state. This was done so that the results would be compatible with conservation recommendations of the Illinois Comprehensive Wildlife Conservation Plan and Strategy. Not surprisingly, the authors' findings predicted relatively more losses of species in northern Illinois compared to the rest of the state, due to the northward migration of species. Regions with the greatest proportions of natural land cover and the greatest topography were deemed likely to serve as climate refugia in the state. Large rivers and their adjacent natural divisions may serve as important migration corridors. And finally, the authors found that areas of intensive agriculture were likely to serve as migratory barriers to some species. This report on the animal Species in Greatest Need of Conservation was an important first step towards understanding how climate changes may affect the state's biota.

However, there are a few reasons why understanding the climate responses of plants may be important. First, animals rely on plants. To fully understand the vulnerability of animal species in Illinois, we must understand how the plants they rely on for energy and habitat may change. Second, while certain patterns emerge, especially with respect to geography, regarding the vulnerability of animals in the state, different patterns may exist for plants. Plants, on the whole, tend to be less mobile than animal species, possibly increasing their vulnerability to changes in climate. On a related note, plants have various strategies for surviving various climates on the annual to decadal scales: some form seed banks, other perennial species may flower only in response to favorable weather conditions. These strategies may render them differently vulnerable to changes in climate many animals. Third, plant conservation is inherently valuable. Understanding how plant species found in Illinois will respond to predicted changes in climate will be critical to their conservation in the coming decades.

Our goals for this report are to provide information to guide land management decisions in Illinois, help researchers to generate hypotheses and highlight research needs to scientists and funding agencies in the state. The work we present in this report is intended to be used in conjunction with Walk and colleagues' (2011) previous assessment of the animal Species in Greatest Need of Conservation to best guide research, management and policy regarding natural systems in Illinois.

METHODS

Tool for Assessing Climate Change Vulnerability

We used NatureServe's Climate Change Vulnerability Index tool in order to assess the vulnerability of our target plant species. The tool ranks the climate change vulnerability of any species based on its exposure and sensitivity to predicted changes in climate using information on the species' distributions, biologies and ecologies. An important caveat of this tool is that it does not assess current conservation threats to the species that are not related to a change in climate. The results in this report, then, are intended to be used in conjunction with other conservation assessments for a full understanding of each plant's conservation status. Please see the document, *Guidelines for Using the NatureServe Climate Change Vulnerability Index* for a fuller explanation of the CCVI methods (Young et al. 2011).

Species Selection

While many states and regions have investigated the climate change vulnerabilities of their most endangered species (e.g., Ring et al. 2013; Anacker et al. 2013), we decided to take a broader approach in our study. Researchers have found that CCVI results may or may not correlate with rareness (Hoving et al. 2013; Dubois et al. 2011; Bova et al. 2012; Byers & Norris 2011; Young et al. 2012), and we felt that by investigating the vulnerabilities of several groups of plants we could provide more insight for managers, for example, by clarifying which groups of plants could be more or less vulnerable, or which groups should be investigated with further CCVI work. We selected species from each of several representative groups that we felt would be broadly informative:

- Rare plants, including several listed as Endangered or Threated by state or federal agencies
- Invasive species, both recently established and older invaders
- Important prairie species
- Important savanna/woodland species
- Important forest species
- "Charismatic" or widely known plants, including the state tree, poison ivy, lawn grasses, etc.
- Economically important taxa (forestry, agricultural weeds, etc.)

Furthermore, we chose to include a wide representation of functional groups: annuals, perennials; woody plants, forbs and grasses. We also chose plants with different ranges and distributions: some plants are endemics with narrow ranges, others are common on a continental or global scale. They also range in moisture preferences, soil preferences, temperature preferences, dispersal mechanisms, pollination syndromes, and in associations with soil biota. Our final list included 73 species from 35 families, which we feel are broadly representative of the state's flora.

Determining Exposure to Predicted Climate Changes

In order to assess the exposure of each plant to climate change, we developed presence-absence maps at the county level of resolution using several sources for each of the plants on our list ((Iverson et al. 1999) ILPIN, INHS Herbarium Online Records, Gbif, EDD maps, Herkert & Ebinger). We used mid-century (2040-2069) climate projections based on ensemble-averages of general circulation models and the medium, A1B emissions scenario. Carbon emissions are already exceeding both the medium, A1B and all other higher carbon emissions scenarios imagined by the IPCC. However, we chose to use the medium scenario for a number of reasons: 1) The tools made available by NatureServe for CCVI assessments are geared toward this carbon emissions scenario for both temperature and moisture predictions, 2) this is the scenario used for the assessment of the climate change vulnerability of Illinois animals Species in Greatest Need of Conservation, and 3) for Illinois, the mid-century temperature predictions under the medium scenario are actually higher than they are under the high, A2 scenario.

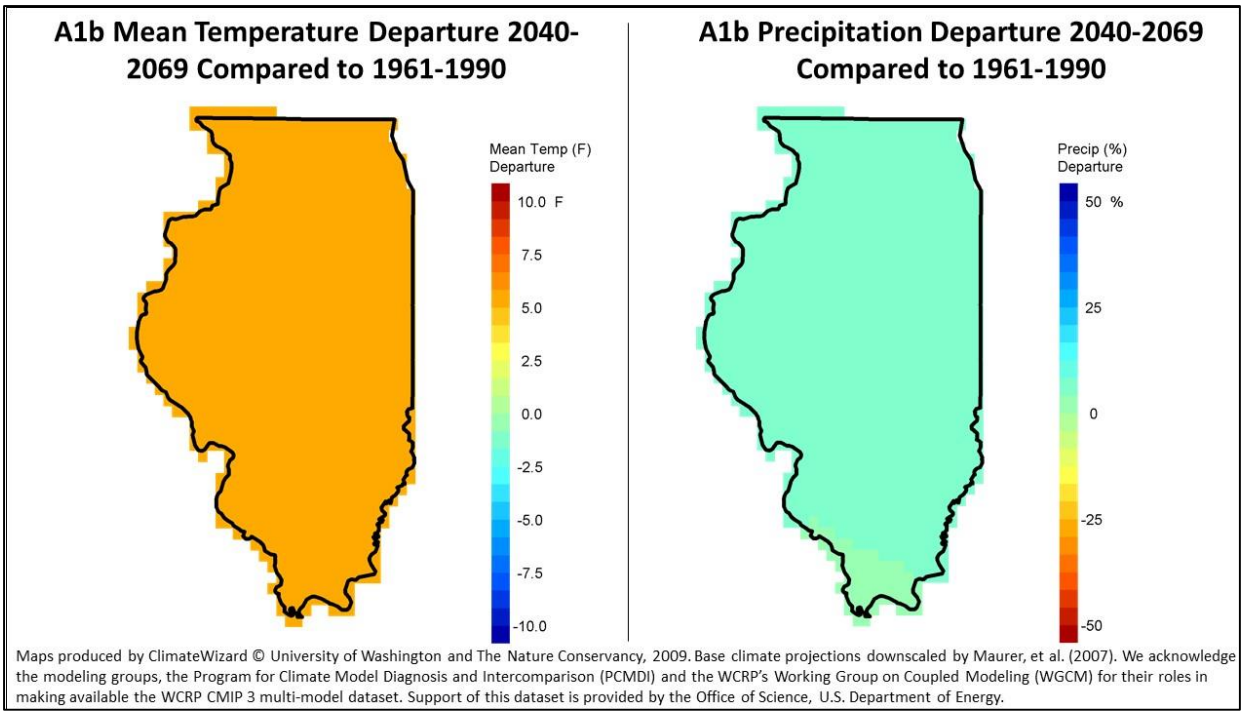

Figure 1: Maps showing mid-century temperature and moisture changes predicted by ensemble-averages of general circulation models using the medium A1B carbon emissions scenario.

We overlapped the ranges of each plant with the climate predictions for Illinois and followed NatureServe's methods (Young, et al., 2011) for determining the predicted future changes in climate over the plants' ranges as well as the historical temperature and precipitation regimes that the species have experienced.

Determining Sensitivities to Predicted Climate Changes

In order to answer the bulk of the questions regarding species' natural history and biology in the NatureServe tool, NatureServe suggests using several sources of information, including NatureServe Explorer, Natural History Program files, and the published literature (Young et al., 2011). Other users of this tool have used additional sources of information including state native plant societies databases and literature (developed by, e.g., California Native Plant Society), state natural heritage/diversity databases, state species abstracts, atlases (e.g. Michigan Breeding Bird Atlas), and expert consultations (Anacker, et al., 2013; Anacker, et al., 2012; Beyers & Norris, 2011; Furedi, et al., 2011; Hoving, et al., 2013; Leibezeit, et al., 2012).

For this report, information as to the sensitivity (Section C) as well as natural and anthropogenic migratory barriers (Factors B3a, B3b) was provided by experts. Expert elicitation is an important way of garnering conservation-relevant information in data-poor situations (Martin, et al., 2012; Teck, et al., 2010). All experts consulted were familiar with a minimum of one of the plants on our list from populations within the state of Illinois. Experts were all given the same training on answering the assigned questions; the training included a walk-through of the tool and the factors B3a, B3b, and in Section C with the trainer (J. Baty), answering all the questions for a common weed (dandelion; *Taraxacum officinale*) for practice. During this walk-through interpretation of the questions and answer options was standardized. Experts were encouraged to contact us with further questions as they worked. Experts answered the questions in the form of an MS Word document in which the text was very closely based on the NatureServe verbiage; examples and scenarios citing animals were cut from the text in the interest of length (see Appendix B). In addition, each question included a section for their comments on the species so that experts could clarify their answers, include citations, specify caveats, or add anything else they deemed useful. The survey included two additional non-CCVI questions that were open-ended with regards to climate predictions. Questions were based on Hameed et al., 2013.

1. *This species may be sensitive to what climate changes? Consider all possible changes related to temperature, wind and precipitation, averages and extremes. For each climate condition, please explain why and in what ways the species is sensitive and how the species might respond.*
2. *Are there biotic or abiotic interactions that may make species more or less sensitive to climate changes? Explain how each interaction may affect the plant's sensitivity to climate changes.*

We used comment box comments and answers to the two additional questions to populate the species descriptions accompanying the CCVI results in this report (Appendix A). This text will help to enrich and clarify the CCVI results to readers of this report.

Compiling Results

Between August 2014 and January 2015, sixty-two plant experts were contacted. These initial contacts resulted in 30 experts sending in responses for between 1 and 73 plants (mean: 18.4 species/expert; median: 5.5 species/expert), resulting in 564 returned surveys. Each plant was reported on by between 4 and 12 experts (mean: 7.8 experts/species; median: 7.5 experts/species). Each set of responses was entered separately, as an individual case, into the NatureServe tool. This resulted in 564 results. One of the outputs of the tool is a distribution of frequencies for results falling into each of the 5 Index scores. This output generated using a statistical simulation with 1,000 iterations (See Young et al., 2011 for more detail). The frequency distribution of results for each expert's assessment of a given plant were averaged, and these scores are reported here. This method allowed for weighting of the experts' responses. For example, if 4 out of 5 experts answered the question with the same choice, this method weights that choice more heavily.

The five results categories and their definitions are as follows:

Extremely Vulnerable: Abundance and/or range extent within Illinois extremely likely to substantially decrease or disappear by 2050.

Highly Vulnerable: Abundance and/or range extent within Illinois likely to decrease significantly by 2050.

Moderately Vulnerable: Abundance and/or range extent within Illinois likely to decrease by 2050.

Presumed Stable: Available evidence does not suggest that abundance and/or range extent within Illinois will change (increase or decrease) substantially by 2050. Actual range boundaries may change.

Increase Likely: Available evidence suggests that abundance and/or range extent within Illinois is likely to increase by 2050.

RESULTS and DISCUSSION

Of the 73 plants included in the report, 67% fell into the category of Presumed Stable under predicted climate changes. Twenty-eight percent of plant species assessed were predicted to be vulnerable to predicted climate changes and 5 percent of the plants assessed were predicted likely to increase in abundance and/or range extent by 2050 (Figure 2).

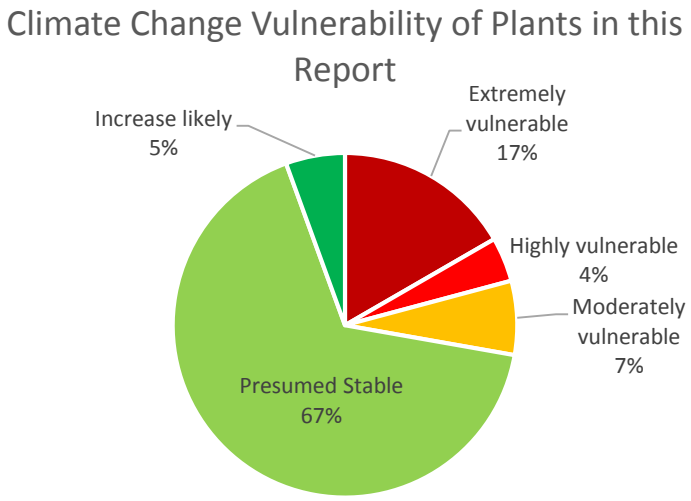

Figure 2: Most of the plants examined in this report are not expected change in range size or abundance with predicted climate changes.

Of the twelve plants in this report that were determined to be Extremely Vulnerable to predicted climate changes, all have other serious conservation concerns associated with them (Table 1). One may be extirpated from Illinois. Four are recognized as Federally Threatened. An additional three are recognized as being threatened on the state level. The remaining three species are ranked by NatureServe as being vulnerable, imperiled or critically imperiled at the state level. These twelve species may be candidates for additional conservation focus due to climate change, even beyond their current imperilment.

SPECIES NAME	LEGAL STATUS	NATURESERVE RANK
Apios priceana	(presumed extirpated)	G3; SX
Cirsium pitcheri	State Threatened; Federally Threatened	G2G3; S1
Cypripedium candidum	State delisted	G4; S2
Dalea foliosa	State Endangered; Federally Endangered	G2G3; S1
Drosera intermedia		G5; S2
Isotria medeoloides	(presumed extirpated)	G2?; S1
Minuartia patula	State Threatened	G4; SNR
Pinus strobus		G5; S1
Platanthera leucophaea	State Endangered; Federally Threatened	G2G3; S1
Sarracenia purpurea	State Endangered	G5; S1
Tetraneuris herbacea	State Endangered; Federally Threatened	G3; S1
Trillium grandiflorum		G5; S3?

Table 1: Twelve species found to be Extremely Vulnerable to predicted climate changes. (NatureServe Rankings: G= Globally; S= Statewide; X= Presumed Extirpated; 1= Critically Imperiled; 2= Imperiled; 3= Vulnerable; 4= Apparently Secure; 5= Secure; NR=Not Ranked

CCVI Scores by Rarity

Of the species assessed, plants that are rarer on a global scale were ranked as vulnerable more often than common or invasive species (Fisher's chi-squared p = 0.0001674) (Figure 3). Similarly, plants that are rarer on the state scale were ranked as vulnerable more often than common or invasive species (Fisher's chi-squared, p = 0.0001295) (Figure 4). Plants not ranked in Illinois (SNR) were excluded from the state-level analysis.

Other similar studies have found various patterns with regards to rarity and vulnerability to climate changes. A report on 400 animal species in Michigan found results similar to ours, with many rare species being vulnerable, many common species being not vulnerable, and exceptions to both of those cases (Hoving, et al., 2013). Similarly, Young and colleagues found that Nevada animals that were more imperiled (state-wide and globally) were predicted to be more vulnerable to climate changes (Young, et al., 2012). For a randomly selected set of animals in the National Park Service's Mediterranean Coast Network, those currently listed as federally threatened or endangered were ranked as being more vulnerable to climate change (Bove, et al., 2012). However, West Virginia animals with high global Conservation Status Ranks were found to be statistically only slightly more vulnerable than globally common species (Beyers & Norris, 2011). In Florida, rare and common animals fell equally into categories of high vulnerability (EV, HV, MV) and lower vulnerability (PS, IL) (DuBois, et al., 2011). Also in contrast to our results, Schlesinger and colleagues found that in New York, global conservation status rank of animals was unrelated to vulnerability, except for the most globally imperiled species (Schlesinger, et al., 2011). None of these other studies have included plants. A study by Anacker and colleagues found that rarity type did not correlate with vulnerability to climate change in California plants (Anacker et al., 2013).

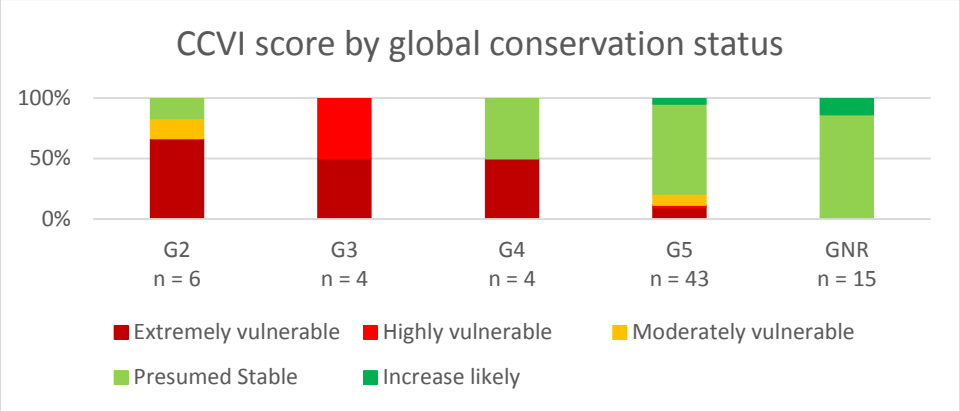

Figure 3: CCVI scores and the global conservation statuses of plants in this report. Global status: 2= Imperiled, 3= Vulnerable, 4= Apparently Secure, 5= Secure, NR= Not Ranked (here, invasive)

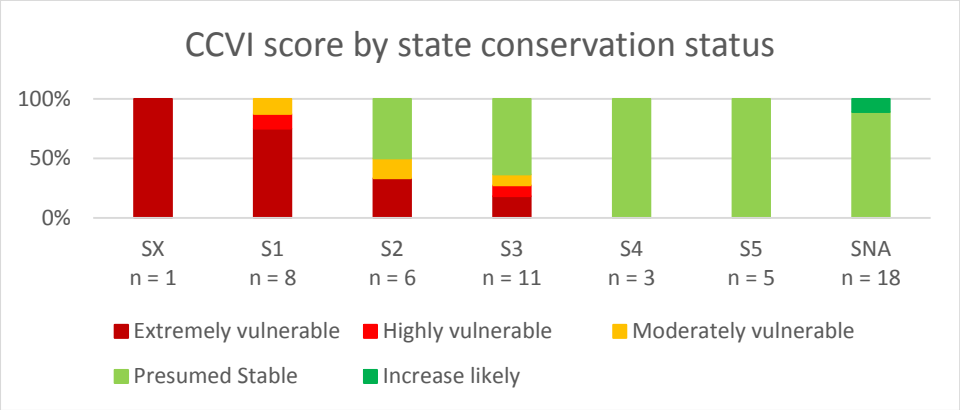

Figure 4: CCVI scores and IL conservation statuses. Statewide status: X= Presumed Extirpated, 1= Critically Imperiled, 2= Imperiled, 3= Vulnerable, 4= Apparently Secure, 5= Secure, NA= Not Applicable (here, invasive). Note: plants ranked SNR not included in graph

CCVI Scores by Plant Origins

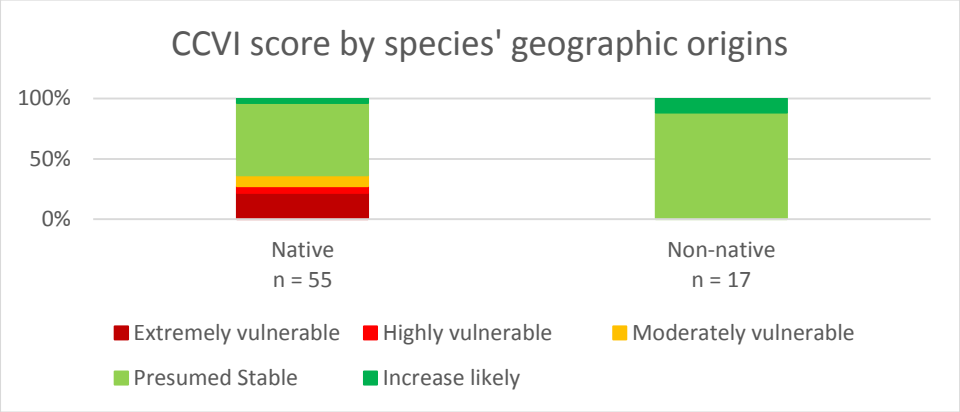

Figure 5: CCVI scores and geographic origins of plant species.

Of the species assessed here, native species are more likely than non-natives to be vulnerable to predicted climate changes (Fisher's chi-squared, P = 0.0431) (Figure 5). The non-native species in this report will not be vulnerable to predicted climate changes. Non-native species that are predicted to increase in abundance or range size in Illinois with predicted climate changes include tree of heaven (*Ailanthus altissima*) and Japanese stiltgrass (*Microstegium vimineum*). The NatureServe CCVI tool is not designed to be used on non-native species, so results for non-native plants should be considered less certain than those for natives. Specifically, CCVI questions regarding genetic bottlenecks and the climate (temperature & climate) of the species' historical ranges could produce off-base results from the tool.

CCVI Scores by Habitat Type

In this report, 24 species that are important to prairies, savannas or forests were studied. We found no differences in the vulnerability of these twenty-four species based on their habitat preferences (Fisher's chi-squared, P = 0.2036) (Figure 6).

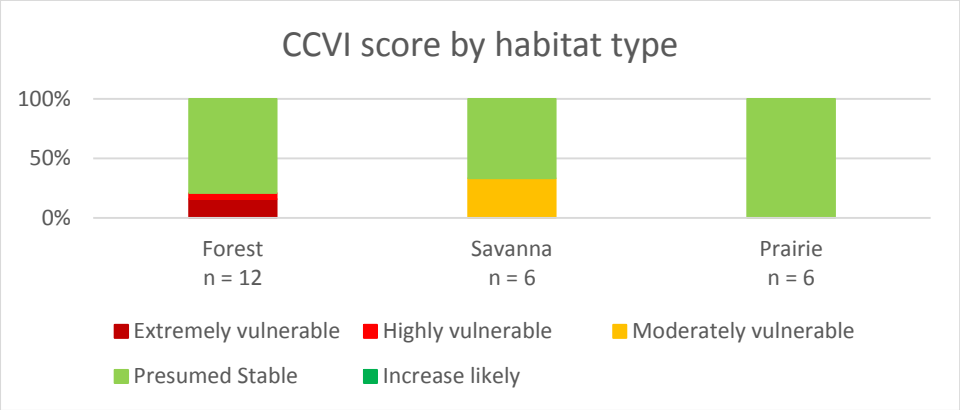

Figure 6: CCVI scores of plants important to prairies, savannas and forests in Illinois.

This result could mean that prairies, savannas and forests in general may be similarly susceptible to predicted climate changes, but further investigation is warranted. CCVI work done on the animals in Greatest Need of Conservation in Illinois revealed that species in the northern part of the state would be more vulnerable to climate changes and that species found in areas with greater natural cover and greater topography would be less vulnerable (Walk et al. 2011). Understanding how important habitats in Illinois are expected to change with climate changes could be particularly important for conservation of species about which little is known or which form intricate but poorly understood interactions with the plants, animals, fungus and other species around them.

CCVI Scores for Culturally Important Species

Most culturally important species investigated in this report will not be negatively affected by predicted climate changes (Table 2). Two nuisance species, ragweed and poison ivy, may increase. While the exact species of violet designated as the Illinois state flower is not specified, anecdotal accounts suggest that it is most likely *Viola pedata*, which was found to be Moderately Vulnerable to predicted climate changes. Milkweeds, *Asclepias* spp., are important larval food sources for the state insect, the monarch butterfly. This report investigated the vulnerability of six milkweeds and they were all determined to be Presumed Stable, with the exception of the federally endangered Mead's milkweed, which was assessed as Moderately Vulnerable. Mead's milkweed would not be an important food source for the monarch, given its extreme rarity.

IMPORTANCE	COMMON NAME	SCIENTIFIC NAME	VULNERABILITY RANKING
State tree	White oak	*Quercus alba*	Presumed Stable
State flower	Violet	*Viola pedata*	Moderately Vulnerable
State grass	Big bluestem	*Andropogon gerardii*	Presumed Stable
State insect's larval food source	Milkweeds	Asclepias spp.	Presumed Stable, Moderately Vulnerable
Nuisance	Ragweed	*Ambrosia artemisiifolia*	Increase Likely
Nuisance	Poison ivy	*Toxicodendron radicans*	Increase Likely
Parasite	Mistletoe	*Phoradendron serotinum*	Presumed Stable
Lawn, pasture, hay grass	Kentucky bluegrass	*Poa pratensis*	Presumed Stable
Lawn, pasture, hay grass	Tall fescue	*Schedonorus arundinaceus*	Presumed Stable
Hay feed crop	Alfalfa	*Medicago sativa*	Presumed Stable

Table 2: CCVI scores of 14 culturally important plants in Illinois.

Important Biological and Ecological Factors for Determining Vulnerability

Experts repeatedly ranked some factors as more likely to increase or decrease the vulnerability of plants in Illinois as they completed their surveys. In order to determine which factors these were, we assigned each score ("Greatly Increase" through "Decrease") a number between -3 and 2, with 0 resting at "Neutral." We took the mean factor scores for each individual plant species and used a Wilcoxon signed rank test to determine which factors were most commonly ranked as different from "Neutral."

The three factors that were rated highest in terms of increasing vulnerability were: B3b: Distribution relative to anthropogenic barriers, C1: Dispersal and movement, and B3a: Distribution relative to natural barriers (Table 3). These three factors all speak to a species' ability to move across the landscape, and to potentially track suitable climate niches.

The three factors that were rated lowest in terms of increasing vulnerability were: C2d: Dependence on snow, ice-edge, or snow-covered habitats, C6: Phenological response to changing seasonality, and C2c: Dependence on a specific disturbance regime.

Factors	Mean score
B3b: Distribution relative to anthropogenic barriers	-0.96**
C1: Dispersal and movement	-0.47**
B3a: Distribution relative to natural barriers	-0.46**
C2bii: Physiological hydrological niche	-0.18*
C5b: Recent genetic bottlenecks	-0.16**
C4e: Reliance on other interspecific interactions	-0.09**
C4c: Reliance on pollinators	-0.09**
C2aii: Physiological thermal niche	-0.09
C5a: Genetic variation	-0.09
C4a: Reliance on other species to generate habitat	-0.06**
C4d: Reliance on other species for dispersal	-0.05**
C2d: Dependence on ice, ice-edge or snow	-0.02**
C6: Phenological response to changing seasonality	0.09*
C2c: Dependence on specific disturbance regime	0.15**
C3: Geologic/soil restrictions	0.41**

*Table 3: Factors commonly scored by experts as increasing or decreasing the vulnerability of a plant to climate change. Deviation from "Neutral" was tested using a Wilcoxon signed rank test. Negative values indicate increasing vulnerability; positive values indicate decreasing vulnerability. "Greatly Increase" = -3, "Increase" = -2, "Somewhat Increase" = -1, "Neutral" = 0, "Somewhat Decrease" = 1, "Decrease" = 2. * = significant at the 0.05 level; ** = significant at the 0.01 level.*

Research Needs

One of the benefits of this report is that we are able to highlight areas in which expert botanists across the state lack knowledge. These are areas where further research is warranted in Illinois. Areas needing further research are factors which experts marked more than one answer choice or, more extremely, marked the answer as "unknown."

Factors most often marked as "unknown" were C5a/C5b: Measured genetic variation/Genetic bottlenecks in recent evolutionary history, and C6: Phenologial response to changing seasonal temperature and precipitation dynamics (Table 4). In addition, relatively little is known about the interspecific interactions for (Questions C4a-C4e) the plants in this study.

FACTORS	REPLIES MARKED "UNKNOWN"
C6: Phenological response to changing seasonality	56.6%

C5a/C5b: Genetic variation/Recent bottlenecks	44.2% (87.4%, 46.6%, resp.)
C4e: Reliance on other interspecific interactions	6.3%
C4a: Reliance on other species to generate habitat	4.3%
C4c: Reliance on pollinators	4.1%
B3b: Distribution relative to anthropogenic barriers	3.7%
C2aii: Physiological thermal niche	2.4%
C4d: Reliance on other species for dispersal	2.4%
C2c: Dependence on specific disturbance regime	2.0%
B3a: Distribution relative to natural barriers	1.6%
C2d: Dependence on ice, ice-edge or snow	1.6%
C1: Dispersal and movement	1.4%
C3: Geologic/soil restrictions	1.0%
C2bii: Physiological hydrological niche	0.8%

Table 4: Factors marked as "unknown" by experts. Factors most commonly ranked as "unknown" indicate statewide research needs.

Factors most often answered by experts with more than one selection were C1: Dispersal and movement, C5a: Genetic variation, and C2bii: Physiological hydrological niche (Table 5).

FACTORS	MORE THAN ONE ANSWER CHOICE SELECTED
C1: Dispersal and movement	28.3%
C5a: Genetic variation	25.0%
C2bii: Physiological hydrological niche	17.9%
C3: Geologic/soil restrictions	17.7%
C2aii: Physiological thermal niche	17.4%
C2c: Dependence on specific disturbance regime	16.5%
B3a: Distribution relative to natural barriers	14.6%
C6: Phenological response to changing seasonality	14.1%
B3b: Distribution relative to anthropogenic barriers	10.4%
C5b: Recent genetic bottlenecks	5.7%
C4c: Reliance on pollinators	4.9%
C4e: Reliance on other interspecific interactions	3.0%
C4d: Reliance on other species for dispersal	2.5%
C4a: Reliance on other species to generate habitat	2.3%
C2d: Dependence on ice, ice-edge or snow	1.9%

Table 5: Factors with more than one answer choice selected by experts. Factors with more than one answer choice most commonly selected indicate statewide research needs.

CONCLUSIONS

The plants in Illinois will face changes to climate in the coming decades. This report has investigated the vulnerability of 73 of Illinois' plants to predicted climate changes. These plants represent culturally important species, rare species, invasive species and species important to forests, savannas and prairies. The report also clarifies which aspects of Illinois plants' biology and ecology seem to be most important for climate change adaptation and sensitivity, as well as aspects of the plants' biology about which there is greatest uncertainty among experts.

Our findings point to several important next-steps for plant research and conservation in Illinois. First, it will be important to understand the climate change vulnerabilities of all rare plants in Illinois. This report shows that this subset of plants could be the most vulnerable group in the state. Most species ranked by NatureServe as G2 or G3 (Globally Imperiled, Globally Vulnerable, respectively) were ranked as Extremely Vulnerable, Highly Vulnerable or Moderately Vulnerable to predicted changes in climate. In addition all of the twelve species ranked as Extremely Vulnerable are S1, S2 or S3 (Critically Imperiled, Imperiled or Vulnerable, respectively, in Illinois) and most are listed as Threatened or Endangered by state or federal agencies. Understanding which of Illinois' Threatened and Endangered and rare plants are most vulnerable to predicted changes will be critical to the successful conservation of these species in our state.

Secondly, we need to have more knowledge about some aspects of the biology and ecology of plants in Illinois to best understand their vulnerabilities to predicted changes in climate. We highly recommend that more research be conducted on the phenology of plants in this state. Specifically, we need to have a better understanding of whether plants are able to phenologically track changes in the seasonality of precipitation and temperature. In addition, we recommend studying the genetic variation of plant populations in Illinois. Knowing the levels of standing genetic variation will help biologists to predict the ability of the plants to genetically adapt to changes in climate.

We also have relatively little information on how Illinoisan plants interact with other species. To better assess species' vulnerabilities, we will need additional information on plants' relationships with pollinators, propagule dispersers, species that create habitat and other interspecific relationships (such as with soil biota). Other research priorities include: Illinois plants' dispersal distances, thermal and hydrological tolerances, and soil preferences.

Third, it will be important to monitor plants in Illinois to understand whether their populations are tracking the predictions made in this report. Indeed, the Critical Trends Assessment Project (CTAP) has been tracking plants, insects and birds in Illinois since 1997 and is well-positioned to take on this role. Using existing data, researchers should be able to look back and see if the trends predicted in this report are already taking place. In the future, it will be particularly important to monitor species for which there is little agreement as to their future in the state, as well as species which are predicted to be most vulnerable to predicted changes in climate. From a broader, habitat-wide perspective, it will be important to monitor foundational and keystone species as well. Our recommendations for species of top monitoring priority are:

Species with little certainty about results:
- *Asclepias meadii*
- *Dalea foliosa*
- *Fagus grandifolia*
- *Minuartia patula*
- *Pinus echinata*
- *Pinus strobus*
- *Potamogeton illinoensis*
- *Trillium grandiflorum*
- *Zizania aquatica*

Most vulnerable species:
- *Apios priceana*
- *Cirsium pitcheri*
- *Cypripedium candidum*
- *Dalea foliosa*
- *Drosera intermedia*
- *Isotria medeoloides*
- *Minuartia patula*
- *Pinus strobus*
- *Platanthera leucophaea*
- *Sarracenia purpurea*
- *Tetraneuris herbacea*
- *Trillium grandiflorum*

Foundational/keystone species:
- *Andropogon gerardii*
- *Acer saccharum*
- *Carya ovata*
- *Eryngium yuccifolium*
- *Prunus serotina*
- *Quercus alba*
- *Quercus rubra*

Rare plants are not effectively monitored with the CTAP protocols. Illinois would greatly benefit from a rigorous, state funded monitoring program that specifically targeted Threatened, Endangered and other rare plants. One existing program, the Plants of Concern (POC) monitoring program is run by the Chicago Botanic Garden and has been monitoring over 280 species of threatened, endangered and rare plants in Northeastern Illinois for fifteen years. The program is largely possible due to the participation of over 800 volunteer citizen scientists. POC is funded by IDNR, in addition to USFS, NFWF, USEPA and other public and private entities. Expanding this program to operate across the entire state may be a viable way to increase our understanding of how populations of rare plants in Illinois change in the coming decades. We would also advocate for additional funding to support general research on the biology and ecology of rare plants and would strongly support including rare plants in the State Wildlife Action Plan
(SWAP).

Fourth, it will continue to be very important to monitor invasive species' impacts on native habitats and species populations in Illinois. All seventeen non-native species investigated for this report will either be stable in the face of predicted climate changes or are predicted to see an increase in range or population size. It may be worthwhile to assess the climate change vulnerabilities of all invasive plants in Illinois in order to best understand how to prioritize management of these invasions. Given that the NatureServe CCVI tool is not designed to be used on non-native species, another assessment method may prove more appropriate.

Fifth, we would advocate for more natural areas and higher connectivity between natural areas in Illinois. The three factors most often ranked by experts as increasing a plant's vulnerability to climate change all had to do with the species' movements across the landscape: Distribution relative to anthropogenic barriers, Dispersal and movement, and Distribution relative to natural barriers. The ability to track favorable climate niches will be very important to the continued survival of all species in the face of climate change. Relative to many members of other kingdoms, plants are generally poor dispersers and the plants in this study were found to be vulnerable due to their dispersal abilities. Increasing habitat connectivity could make Illinois plants more able to adjust to changes in climate.

Considering the three factors most often ranked by experts as increasing a plant's vulnerability to climate change all related to the movement of species across the landscape, it will be important for managers, policymakers, researchers and the public to work together to fully consider the role that assisted migration should or should not play in Illinois plant conservation. Assisted migration (managed relocation, assisted colonization, managed translocation, etc.) is the movement of species, populations or genotypes to locations where they have not existed previously with a goal of conservation in the face of climate change (Schwartz et al. 2012). This practice is considered highly controversial in the conservation community. At the very least, the practice is associated with a vast number of unknown consequences and uncertainties regarding best practices. A unified set of decision frameworks and policies should be explored and developed on the state or regional scale before assisted migration of a species is undertaken. Most experts advocate for pursuing other conservation directions unless the species is under critical threat. Even then, not all would advocate for moving the species/population/genotype. The following articles will provide some further information that will be critical in informing these types of decisions: Guerrant et al. 2014; Haase, D.L., Pinto, J.R., Wilkinson 2013; Neff & Larson 2014; Rout et al. 2013; Sansilvestri et al. 2015; Schwartz et al. 2012

Lastly, we suggest bringing together the results from this report with other vulnerability studies on plants, ecosystems and other species in Illinois. Ecological niche models are another common method for making vulnerability assessments and have been found to provide information that is complementary to vulnerability indices (Hameed et al., 2013, Still et al., 2015). Some ecological niche modeling on Illinois plants is being conducted by researchers at the Chicago Botanic Garden. In addition, the US Forest Service has completed a report on the ecosystem vulnerability of nine natural community types within the Central Hardwoods Region of Illinois, Indiana and Missouri. Researchers at the Missouri Botanical Garden have developed a system for assessing vulnerability to climate change based ecological niche models which assesses current levels of threat and future threats. They are using this system to conduct a climate change vulnerability assessment of around 100 rare plants in the Central Hardwoods, including Illinois. The Illinois Department of Natural Resources, together with the Illinois Chapter of the Nature Conservancy has put together a report on the climate change vulnerability of the 162 animal Species in Greatest Need of Conservation in Illinois using NatureServe's CCVI tool (Walk, et al., 2011). In concert, results from these and other reports will provide researchers, managers and poicymakers with a more complete picture of the future of natural communities in Illinois, and enable them to make the most appropriate research, management, and policy decisions.

The plants in this study were found to be most vulnerable due to limitations in their abilities to move around the fragmented Illinois landscape as well as their interactions with other species. Managers of natural systems in Illinois will need to understand the specifics of how systems under their care are affected by these factors in order to best prepare for a climate change future. Management decisions regarding species movement and species interactions as well as ecosystem processes that may change with climate (flooding, fires, droughts, nutrient cycling, etc.) should be based on hard scientific evidence.

We advocate that managers use an adaptive approach to manage natural areas, testing and measuring the effectiveness of each management decision. While this strategy is generally advisable in conservation management, it is especially crucial in dynamic situations with many unknowns, such as in an environment with a changing climate (Tompkins & Adger 2006; McCarthy & Possingham 2007; Walters & Holling 1990; Irwin & Wigley 1993). Clearly defined conservation goals and measures of success are absolutely critical to effective management in these situations.

LITERATURE CITED

Anacker, B.L. et al., 2013. Climate Change Vulnerability Assessment of Rare Plants in California. *Madroño*, 60(3), pp.193–210.

Bova, B. et al., 2012. *Climate Change Vulnerability Assessments for Terrestrial and Freshwater Vertebrates in the Mediterranean Coast Network of National Parks*,

Byers, E. & Norris, S., 2011. *Climate Change Vulnerability Assessment of Species of Concern in West Virginia*, Elkins, WV.

Carroll, C. et al., 2002. Plant sampling protocols. In B. Molano-Flores, ed. *Critical Trends Assessment Program Monitoring Protocols*. Champaign, IL: Illinois Natural History Survey, Office of the Chief Technical Report 2002-2, p. 38.

Dubois, N. et al., 2011. *Integrating climate change vulnerability assessments into adaptation planning: A case study using the NatureServe Climate Change Vulnerability Index to inform conservation planning for species in Florida*, Washington, D.C.

Guerrant, E.O.J., Havens, K. & Vitt, P., 2014. Sampling for Effective Ex Situ Plant Conservation. *International Journal of Plant Sciences*, 175(1), pp.11–20. Available at: http://www.jstor.org/stable/info/10.1086/674131.

Haase, D.L., Pinto, J.R., Wilkinson, K.M., 2013. National Proceedings : Forest and Conservation Nursery Associations – 2012. , (December), p.124.

Hoving, C.L. et al., 2013. Changing Climate , Changing Wildlife A Vulnerability Assessment of 400 Species of Greatest Conservation Need and Game Species in Michigan. , (3564), pp.1–82.

Irwin, L.L. & Wigley, T.B., 1993. Toward an Experimental Basis for Protecting Forest Wildlife. *Ecological Applications*, 3(2), pp.213–217.

Iverson, L.R., Ketzner, D. & Karnes, J., 1999. Illinois Plant Information Network. *Illinois Natural History Survey and USDA Forest Service*. Available at: Database at http://www.nrs.fs.fed.us/data/il/ilpin/ [Accessed September 1, 2014].

McCarthy, M. a. & Possingham, H.P., 2007. Active adaptive management for conservation. *Conservation Biology*, 21(4), pp.956–963.

Mohlenbrock, R.H., 2014. *Vascular flora of Illinois: a field guide*, Southern Illinois University Press.

Neff, M.W. & Larson, B.M.H., 2014. Scientists, managers, and assisted colonization: Four contrasting perspectives entangle science and policy. *Biological Conservation*, 172, pp.1–7. Available at: http://dx.doi.org/10.1016/j.biocon.2014.02.001.

Pearse, I.S. et al., 2015. Illinois Plants: a web-based database for the flora of Illinois. Available at: http://www.inhs.illinois.edu/data/plantdb [Accessed May 20, 2007].

Resources, I.D. of E. and N., 1994. *The Changing Illinois Environment: Critical Trends*,

Ring, R.M., Spencer, E.A. & Walz, K.S., 2013. Vulnerability of 70 Plant Species of Greatest Conservation Need to Climate Change in New Jersey. , (June).

Rout, T.M. et al., 2013. How to Decide Whether to Move Species Threatened by Climate Change. *PLoS ONE*, 8(10).

Sansilvestri, R., Frascaria-Lacoste, N. & Fernández-Manjarrés, J.F., 2015. Reconstructing a deconstructed concept: Policy tools for implementing assisted migration for species and ecosystem management. *Environmental Science & Policy*, 51, pp.192–201.

Schwartz, M.W. et al., 2012. Managed Relocation: Integrating the Scientific, Regulatory, and Ethical Challenges. *BioScience*, 62(8), pp.732–743.

Tompkins, E.L. & Adger, W.N., 2006. Does Adaptive Management of Natural Resources Enhance Resilience to Climate Change? *Ecology and Society*, 9(2), p.10. Available at: http://www.ecologyandsociety.org/vol9/iss2/art10.

Walk, J., Hagen, S. & Lange, A., 2011. Adapting Conservation to a Changing Climate: An Update to the Illinois Wildlife Action Plan, Report to the Illinois Department of Natural Resources. , (February), p.120 p.

Walters, C.J. & Holling, C.S., 1990. Large-Scale Management Experiments and Learnign by Doing. *Ecology*, 71(6), pp.2060–2068.

White, J. & Madany, M.H., 1978. Classification of natural communities in Illinois. In *Illinois Natural Areas Inventory Technical Report*. Urbana, Illinois: Illinois Natural Areas Inventory, pp. 309–405.

Young, B. et al., 2011. Guidelines for Using the NatureServe Climate Change Vulnerability Index. NatureServe.

Young, B. et al., 2012. Rapid assessment of plant and animal vulnerability to climate change. In J. F. Brodie, E. S. Post, & D. F. Doak, eds. *Wildlife Conservation in a Changing Climate*. University of Chicago Press, pp. 129–152.

APPENDIX A: SPECIES SPECIFIC RESULTS

Acer rubrum L.

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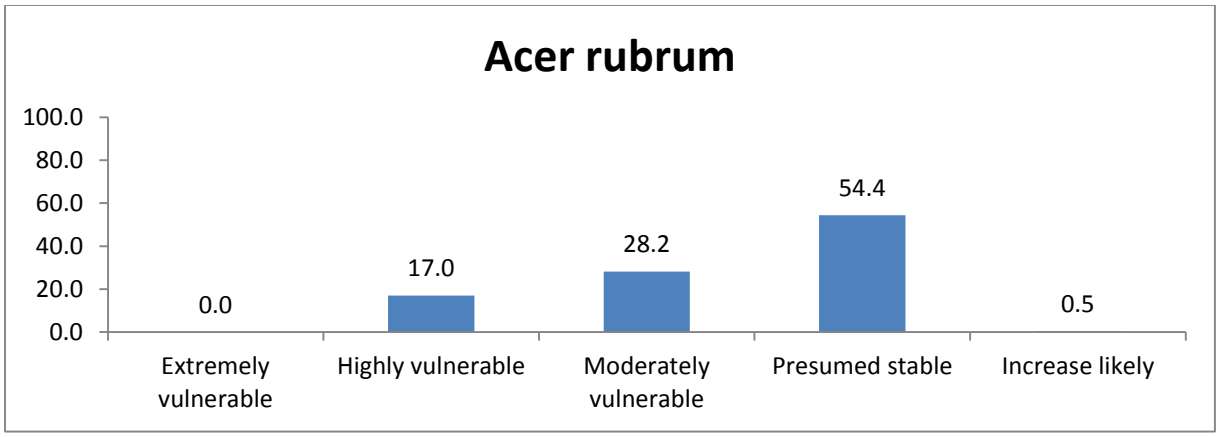

Figure 7: Experts predict that Acer rubrum will be Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N		
Historical thermal niche				N		
Physiological thermal niche				N		
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils			SI	N	SD	
Other spp. for habitat				N		
Other spp. for pollination				N		
Other spp. for dispersal				N		
Other spp. interactions				N		
Genetic variation			SI	N	SD	
Genetic bottlenecks				N		
Phenological response				N		

Table 5: Acer rubrum may be vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers.

Little is known about the ability of this plant to cross anthropogenic barriers.

Insights from experts

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General

Red maple is a common and widely distributed species with several named varieties and probably significant local adaptation. With high germination rates and high shade tolerance, red maple is a fairly successful species across the eastern US, including Illinois. Within the state, red maple is distributed primarily in the southern unglaciated portion of the state and the oldest portions of the Illinoisan till plan, as well as the far north eastern counties. This distribution seems to be based on the historic range of the tallgrass prairie peninsula across central and northern Illinois and not the tree's actual climatic tolerances: red maple grows just fine as a landscape tree across much of the state.

The tree occurs on a fairly wide range of sites in Illinois, from swamps in southern Illinois and bogs in northern Illinois to mesic forests and drier upland forests and rocky outcrops. In addition, red maple can be found in some habitats which themselves might be vulnerable to climate change, including forested bogs, acidic gravelly seeps, sandy dune areas, swamps and wet woodlands.

Climate conditions & phenology

Red maple could be sensitive to changes in temperature, precipitation and wind. However, most experts do not believe that either an increase or decrease in temperature will affect the species. Flowering seems to be dependent on temperature, coming after a period of cold. The timing of flowering may vary from year to year.

This tree is generally considered to be one of the most broadly hydrologically tolerant trees, and does well in dry and moist habitats. However, the tree might be sensitive to increased extreme precipitation events (both drought and flooding). Red maple seems to prefer but is not limited to sites with better year-round soil moisture. However it does not prefer floodplain soil conditions. There was a general consensus among the experts that red maple also does not prefer dry conditions. Some evidence suggests that red maple seedlings are able to survive drought by ceasing growth until conditions improve.

Dispersal, movement & genetics

As the ice sheets receded north after recent glacial periods, red maple followed them.
In the future, it is likely that warmer temperatures and increased precipitation will "move" the most suitable climate for red maple northward. Within Illinois, extensive areas of agriculture and urban development could prevent northward migration of the species. Experts disagree on red maple's ability to cross those barriers. In addition, Mollisols of the central prairie could prove to be a natural barrier to the plant's migration, as it does not compete well on these soils.

Experts agree that the fruits are easily dispersed by wind and water. The plant has not historically been limited by its dispersal abilities.

High genetic has been reported, and is to be expected with this wind-pollinated species. The tree's relatively short generation time may facilitate adaptation to new local conditions.

Abiotic conditions: disturbance, soils, geology

Red maple is generally considered to be a disturbance adapted tree and can be at home in both early successional and mature natural communities. It is readily able to invade many sites following disturbance. With increased frequency of intense storms and with increased flooding under future climate conditions, populations of red maple could increase. On the other hand, if dry conditions in the future lead to more frequent fires, red maple populations could be negatively affected. As a relatively thin-barked species, red maple is susceptible to fire, but young trees readily resprout.

Red maple is described as thriving on a wider range of soil types, textures, moistures, pH, and elevation than any other forest species in North America. However, some experts point out that the species prefers acidic soils, but that this preference decreases with cold temperatures. Additionally, the tree may be restricted in its range today because it prefers not to grow in limestone, high pH or xeric soils. Planted specimens on calcareous clay loams appear stressed and show greater incidence of fungal pathogens and chlorosis (mineral deficiency symptoms).

Biotic interactions

Interactions with other species do not seem to be particularly important for red maple. It is pollinated by both the wind and insect pollinators. It is not reliant on animals for dispersal. It is at home in a variety of habitats, including early successional ones and more mature communities. However, the tree is browsed by deer and other animals. In addition, some studies have shown that mycorrhizae improve the growth of red maple.

Bibliography

Abrams, Marc D. "The red maple paradox." BioScience (1998): 355-364.

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Table_of_contents.htm

Gugger, Paul F., et al. "Inferring long-distance dispersal and topographic barriers during post-glacial colonization from the genetic structure of red maple (Acer rubrum L.) in New England." Journal of Biogeography 35.9 (2008): 1665-1673.

Kovach, Katherine E. Assessment of genetic variation of Acer rubrum L. and Liriodendron tulipifera L. populations in unmanaged forests of the Southeast United States. Diss. Virginia Polytechnic Institute and State University, 2009.

Landscape Change Research Group. 2014. Climate change atlas. Northern Research Station, U. S. Forest Service, Delaware, OH. http://www.nrs.fs.fed.us/atlas.

Saeki, Ikuyo, et al. "Comparative phylogeography of red maple (Acer rubrum L.) and silver maple (Acer saccharinum L.): impacts of habitat specialization, hybridization and glacial history." Journal of Biogeography 38.5 (2011): 992-1005.

Acer saccharum Marsh.

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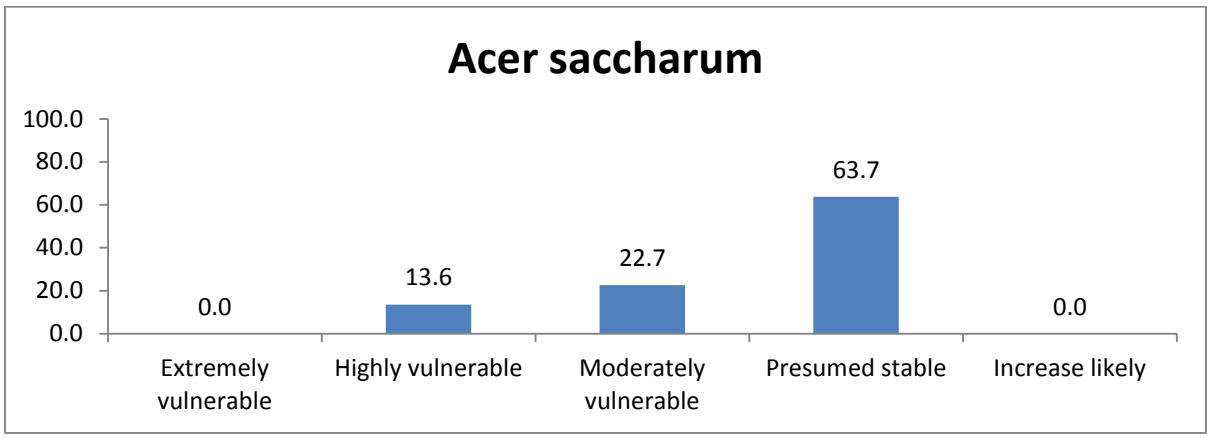

Figure 8: Experts predict that Acer rubrum will be Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N		
Historical thermal niche				N		
Physiological thermal niche	GI		SI	N		
Historical hydrological niche			SI			
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence			SI	N		
Ice/snow				N		
Geology/soils				N	SD	D
Other spp. for habitat				N		
Other spp. for pollination			SI	N		
Other spp. for dispersal				N		
Other spp. interactions				N		
Genetic variation				N	SD	
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 6: Acer saccharum may be vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers, its physiological thermal niche and its physiological hydrological niche.

Little is known about the physiological thermal niche of this plant or its physiological hydrological niche.

Insights from experts

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General

Acer saccharum is a shade-loving forest species found in every county in Illinois. It is commonly seen in remnant forests as well as new ones and decreases only in areas in the far south part of the state. Models of the distribution of sugar maple by 2100 indicate that this species' preferred climate conditions will be absent from most of Illinois and be concentrated in the northern most states of northeastern United States and the Great Lakes region.

Climate conditions & phenology

The species is sensitive to drought and increases in temperature and higher temperatures and greater aridity could depress population in some areas. The plant is probably most sensitive to prolonged droughts. As is the case with most temperate trees, *Acer saccharum* needs a seasonal cold dormancy period.

This tree prefers habitats that are moist at least seasonally, but is not very specific about the timing of that moisture. The tree is intolerant of inundation or prolonged saturation. *Acer saccharum* is sensitive to prolonged droughts. Although the tree can grow on shallow soils over bedrock, such trees are prone to dieback or death during droughts.

Experts point out that the seedlings of this tree germinate and grow before the tree canopy closes in the spring. They generate most of their photosynthetic energy at this time so if springtime precipitation became more limited or if the tree canopy were to begin developing earlier than under current conditions, this could greatly reduce seedling growth.

Dispersal, movement & genetics

Seeds of *Acer saccharum* are dispersed by the wind and therefore, natural barriers in Illinois (e.g. large rivers) do not present much of an obstacle for it. Seeds of this species typically move between 15 and 100 meters. Anthropogenic barriers (e.g., agriculture, urban areas) may provide greater obstacles to the species' dispersal, but it generally tolerates human habitats fairly well.

Genetic diversity is thought not to be much of an issue for this species as it is wind pollinated (and insect pollinated). Published studies verify this.

Abiotic conditions: disturbance, soils, geology

We generally think that sugar maple was once limited in Midwestern upland forests by frequent fires. The geographic range of this species may be increasing due to fire suppression. The tree is relatively thin-barked and is susceptible to fire, but young trees readily resprout. In the fragmented landscape of Illinois it is unlikely that a change in climate would lead to a change in the current fire frequency.

Acer saccharum grows on mesic to dry-mesic sites with a wide range of soil types. This species tends to prefer "better" soils and tolerates human habitats fairly well. It can grow on shallow soils over bedrock, but only in protected locations. Such trees are prone to dieback or death during droughts.

Acer saccharum grows on mesic to dry-mesic sites with a wide range of soil types; intolerant of inundation or prolonged saturation. Grows on shallow soils over bedrock, but in protected locations, such trees are prone to

dieback or death during droughts. Has a wide geographic range, probably increasing because of fire suppression. This is a relatively thin-barked species that is susceptible to fire, but young trees readily resprout. Shade tolerant, often dense recruitment under closed canopy, but recruitment can be low where deer browsing pressure is high.

Biotic interactions

Acer saccharum may be moderately dependent on other species. While sugar maple is wind pollinated, it also is pollinated by various insects, including bees. It does form mycorrhizal associations. However, it does not depend on animals to disperse its seeds.

Shade is important for this plant; the species often recruits heavily under closed canopy. Because of its shade requirement for recruitment, if forests disappear, *Acer saccharum* could also disappear. The plant is often found right in the middle of mesic forests that could be partially buffered from climate extremes. In the more xeric areas where it is found today, the tree could start to lose ground to oaks.

Recruitment can be low where deer browsing pressure is high. Interestingly, deer browse on sugar maple and competition from paw-paw, which are not browsed by deer, are both causing a decline in sugar maple reproduction in our area. If global climate change increases deer abundance or favors paw-paw (which is one of the tree species in our area that is of tropical origin) sugar maple may suffer an indirect negative effect of global climate change.

Bibliography

Graignic, Noémie, Francine Tremblay, and Yves Bergeron. "Development of polymorphic nuclear microsatellite markers in sugar maple (Acer saccharum Marsh.) using cross-species transfer and SSR-enriched shotgun pyrosequencing." Conservation Genetics Resources 5.3 (2013): 845-848.

Gunter, L. E. E. E., et al. "Genetic variation and spatial structure in sugar maple (Acer saccharum Marsh.) and implications for predicted global-scale environmental change." Global Change Biology 6.3 (2000): 335-344.

Ailanthus altissima (Mill.) Swingle

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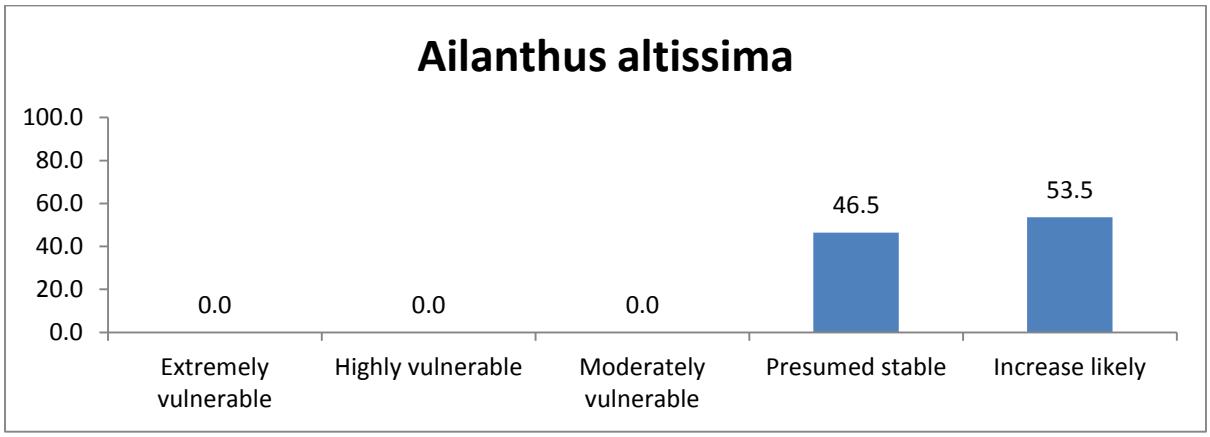

Figure 9: Ailanthus altissima falls into the Increase Likely category with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	D
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation				N		
Genetic bottlenecks				N		
Phenological response			SI	N	SD	

Table 7: Ailanthus altissima not be particularly vulnerable to changes in climate based on its biology and ecology.

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General

Ailanthus altissima is a drought-tolerant tree that spreads via sprouting from underground lateral root system. The tree can flower at small sizes, less than 2 meters in height. It is capable of rapid growth.

Climate conditions & phenology

As a primarily urban species in Illinois, the average habitat of *Ailanthus altissima* may already be around 5 degrees warmer than the rest of the state. The plant experiences extensive damage to leaves and new growth by late and early frosts. It needs winter dormancy. This plant could become more prominent if early frost and harsh winters become less common.

Tree-of-heaven is known to be drought tolerant. It tolerates a wide range of soil moisture conditions, but there is conflicting information regarding whether it is intolerant or tolerant of flooding. It can grow over a wide variety of climatic conditions

Dispersal, movement & genetics

Fruit of *Ailanthus altissima* often disperses as a cluster rather than individual schizocarps. This reduces the dispersal distance. Dispersal distance is around 100 meters. Tree-of-heaven is a wind-dispersed and is a highly prolific seed producer; it can reproduce vegetatively as well. Trees are either male or female.

Little is known about the genetic diversity of this species in Illinois. Studies indicate low diversity in Japan, where it is also invasive, but there is no clear information on North America. It was introduced to this state multiple times.

Abiotic conditions: Disturbance, soils, geology

Based on its ability to occur in concrete-dominated urban environments, this plant may have a high ability to tolerate stressful environments. The seedlings of tree-of-heaven germinate on exposed mineral soil.

This plant can tolerate disturbance, varying hydrology, varying nutrients, and varying pH.

Biotic interactions

Ailanthus altissima generally does not persist in undisturbed or mature plant communities.

The tree may be pollinated by a broad host of insects given its small and generic open-pollinated flowers. Tree-of-heaven is biochemically complex, which may reduce its palatability to herbivores and fungal pathogens. It is perhaps allelopathic, reducing competition for light, water, nutrients. It is the sole food plant of non-native Ailanthus Silkmoth (*Samia cynthia*).

Bibliography

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Table_of_contents.htm

Dallas, John F., Malcolm JB Leitch, and Philip E. Hulme. "Microsatellites for tree of heaven (Ailanthus altissima)." Molecular Ecology Notes 5.2 (2005): 340-342.

Fryer, Janet L. 2010. Ailanthus altissima. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 22]. Kurokochi et al. 2013 Botany.

Alliaria petiolata (M. Bieb.) Cavara & Grande

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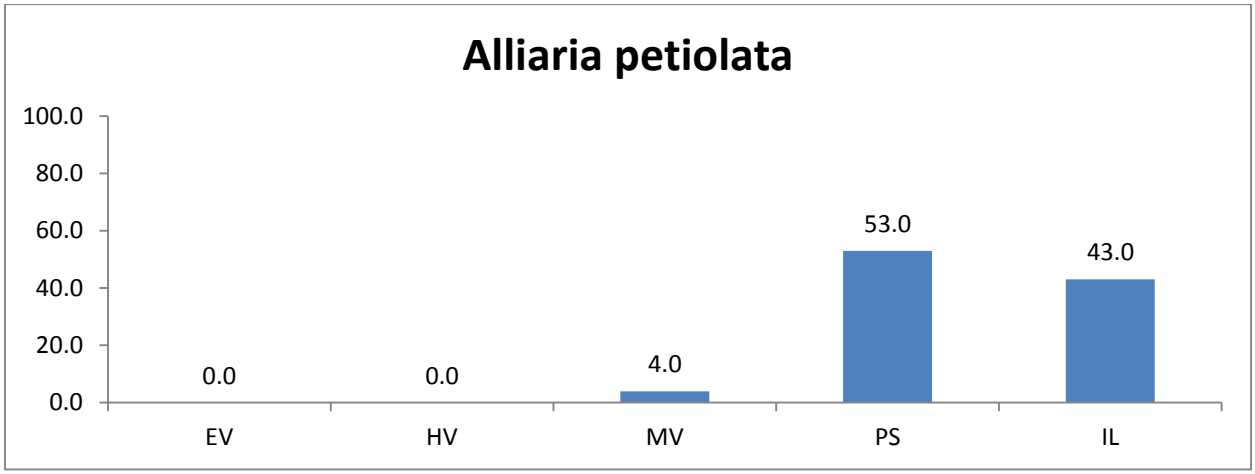

Figure 10: Experts predict that Alliaria petiolate will be Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence				N	SD	D
Ice/snow			SI	N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions			SI	N		
Genetic variation				N	SD	
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 8: Alliaria petiolata may not be particularly vulnerable to changes in climate based on its biology and ecology.

Little is known about the dispersal abilities of this plant.

Insights from experts

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General

Garlic mustard is a widely distributed generalist biennial herb, introduced in eastern North America and occurs under a wide range of climatic conditions. The plant is successional, displaces native species, and is highly competitive.

Climate conditions & phenology

Garlic mustard may not do well under a warmer temperature regime. It needs winter cooling. Seeds require cold-moist stratification for germination. First-year plants require the winter cooling to bolt and transition into second-year plants. However, some experts contend that, as a generalist, this plant could increase its growth and reproduction with an increase in temperature, and that it would only disappear if temperatures increase far more than currently projected. Late spring frosts may be more detrimental to native species than to garlic mustard.

Garlic mustard is sensitive to drought. An increase in precipitation could increase the growth and reproduction of the plant, with the exception of extreme conditions like flooding. During years of very heavy precipitation, this species may be susceptible to mold. One expert witness this phenomenon during the 1993 flood: large populations were covered in white, powdery mildew over acres and acres of forest habitat.

Given a longer growing season, garlic mustard might more successfully outcompete native plants that leaf out later in the spring.

Dispersal, movement & genetics

Alliaria petiolata does not disperse far, with most seeds being ballistically dispersed within one meter of the parent. However, there are also many documented cases of seed being dispersed by deer, raccoons (with home ranges as large as 30km) and other mammals. The seeds may also be dispersed by water.

Garlic mustard has been introduced to North America multiple times. The genetics of this species in Illinois have been studied to some extent. However, the genetic diversity of the species has not been compared to that of similar species, so it is difficult to fully understand how the genetic diversity of Illinois populations rates. One study found low diversity in both the introduced and native ranges and there is evidence that garlic mustard has experienced genetic bottlenecks in Europe when some deleterious genes may have been purged. The plant does not display inbreeding depression in Illinois. However, the greatest amount of genetic diversity occurs among populations rather than within populations and isolated populations are influenced by genetic drift. Because this species is self-compatible, single individuals can establish new populations with low genetic diversity.

Abiotic conditions: disturbance, soils, geology

Alliaria petiolata is a calciphile. While it can occur in somewhat sandy or peaty acidic soils, it is most commonly found on rich soils. It grows poorly in soils with a pH of 4 to 5 than in more neutral soils.

This species does well in disturbed habitats. It generally responds well to fire and could be helped by increased storm disturbance in forests.

Biotic interactions

Garlic mustard is not dependent on other species to generate its habitat. It is competitive against other species in similar habitat conditions. Garlic mustard eliminates some native soil biota, but this effect wanes over time, presumably as the soil community adjusts to the new chemical composition of the soil.

Garlic mustard disperses ballistically and is dispersed by mammals, water and humans. Often, the plant is seen in dense stands under tree dens of mammals. There is strong evidence that deer selectively avoid garlic mustard and browse preferentially on native vegetation.

Bibliography

Durka, Walter, et al. "Molecular evidence for multiple introductions of garlic mustard (Alliaria petiolata, Brassicaceae) to North America." Molecular ecology14.6 (2005): 1697-1706.

Engelhardt, Megan Jean, and Roger C. Anderson. "Phenological niche separation from native species increases reproductive success of an invasive species: Alliaria petiolata (Brassicaceae)-garlic mustard." The Journal of the Torrey Botanical Society (2011): 418-433.

Mullarkey, Alicia A., Diane L. Byers, and Roger C. Anderson. "Inbreeding depression and partitioning of genetic load in the invasive biennial Alliaria petiolata (Brassicaceae)." American journal of botany 100.3 (2013): 509-518.

Munger, Gregory T. 2001. Alliaria petiolata. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 22].

Ambrosia artemisiifolia L.

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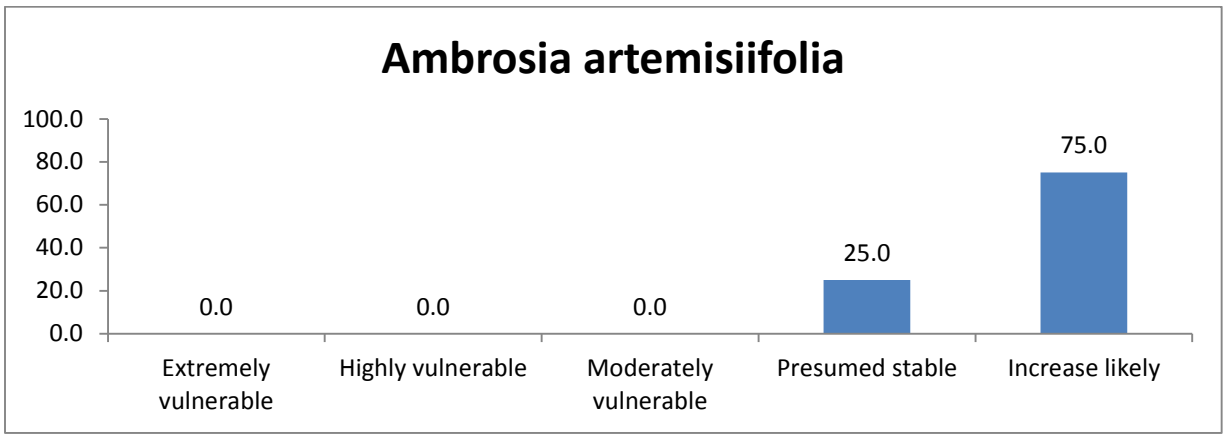

Figure 11: Ambrosia artemisiifolia falls into the Increase Likely category.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence			SI	N	SD	
Ice/snow				N		
Geology/soils						D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 9: Ambrosia artemisiifolia may be vulnerable to changes in climate due to its dispersal abilities.

Little is known about the dispersal abilities of this plant or about its genetic diversity in Illinois.

Insights from experts

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General

Ambrosia artemisiifolia is a native, annual, weed. Its long-lived seedbanks contribute to the plant's success. The plant is widespread and occurs as an agricultural weed throughout the state.

Climate conditions & phenology

This species may not be very sensitive to different temperature regimes. However, it does need cold stratification to break seed dormancy. It may be damaged to early or late frosts.

Under wetter climate conditions, common ragweed might not fare well; under drier conditions, it may or may not fare well.

Early and mid-summer dry spells can facilitate late summer-dominance by A. artemisiifolia in pastures by creating better conditions for germination and establishment, reducing competition from established pasture grasses.

Dispersal, movement & genetics

Dispersal of individual seeds from individual plants is likely not very far, but the seeds are small and light and likely to be carried by animals and water movement. The barbs on the seeds indicate that it may be animal-dispersed. It is also eaten by birds, including the Bob White quail. Common ragweed is very common and widespread filling almost every suitable habitat.

Little is known about the genetic diversity of this plant in Illinois. One expert speculates that the genetic diversity could be high, based on the fact that the species is widespread and wind-pollinated. The plant is wind-pollinated and autogamous so that single individuals could establish populations of the plant.

Abiotic conditions: disturbance, soils, geology

This species is early successional and does well in disturbed habitats. It responds well to the disturbance regimes (plowing, mowing, herbicide drift) of modern agriculture.

Biotic interactions

Common ragweed is a not a competitive species and requires disturbed and open habitats with little competition for maximum success. Seed germination and establishment are tied to sun exposure.

Bibliography

Bassett, I. John, and Clifford W. Crompton. "THE BIOLOGY OF CANADIAN WEEDS.: 11. Ambrosia artemisiifolia L. and A. psilostachya DC." Canadian Journal of Plant Science 55.2 (1975): 463-476.

Baskin, Jerry M., and Carol C. Baskin. "Dormancy and germination in seeds of common ragweed with reference to Beal's buried seed experiment." American Journal of Botany (1977): 1174-1176.

Andropogon gerardii Vitman

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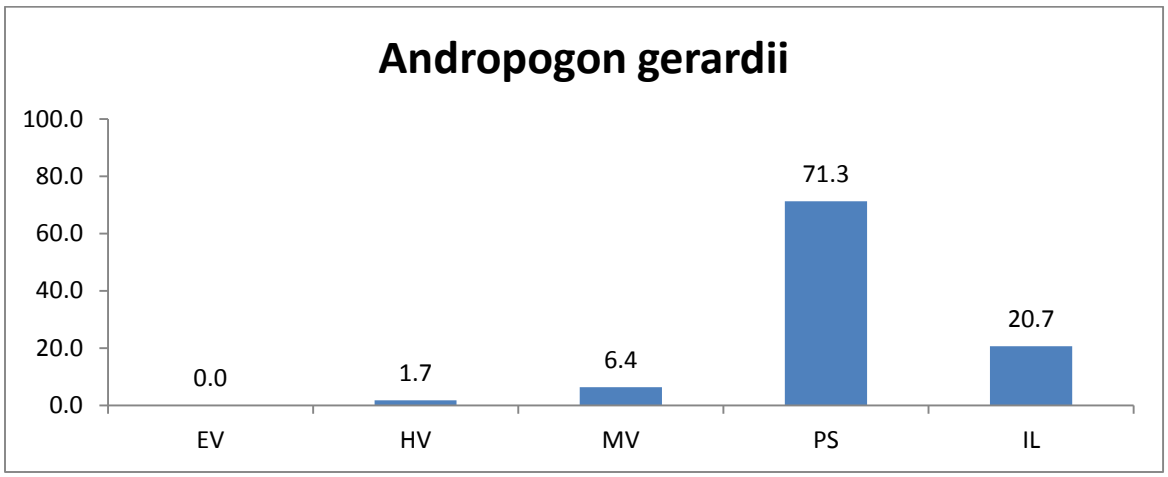

Figure 12: Andropogon gerardii will be Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation					SD	
Genetic bottlenecks			SI	N		
Phenological response			SI	N	SD	

Table 10: Andropogon gerardii may be vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers and its dispersal abilities.

Little is known about the ability of this plant to cross anthropogenic barriers or about its dispersal abilities.

Insights from experts

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General

Andropogon gerardii is a long-lived perennial grass, which is widespread in and beyond Illinois. It starts out as a bunch grass, slowly spreads and intercalates with other grasses to form a sod. It is commonly seen as a dominant in tall grass prairie remnants and is hearty in restoring disturbed prairie sites.

Climate conditions & phenology

Andropogon gerardii may be able to do quite well in warmer climate conditions due to its C4 photosynthetic carbon fixation. New growth on this plant can be damaged by late frosts.

The plant can tolerate drought conditions and one expert speculates that big bluestem would be fine unless conditions became extremely dry. On the other hand, seed set is vulnerable to mid- to late-summer moisture and precipitation. One expert points out that the grass could be replaced by shorter grasses in xeric conditions. However, there are many local ecotypes of the species that are adapted to a wide range of habitat conditions from sand prairies and dry-mesic prairies to mesic and wet prairies. It is possible that, given any changes in moisture, this species would be able to thrive.

Dispersal, movement & genetics

It is unclear how big bluestem disperses; wind and animals are the most likely dispersers. The plant is wind pollinated and is self-incompatible. Populations of this plant and patches of suitable habitat are isolated from one another by urban or agricultural areas. In order for a new population to become established, several individuals would likely be required due to the plant's self-incompatibility (depending on how far the pollen can travel). Vegetative reproduction is important for this species.

Andropogon gerardii has high genetic diversity. The plant has primarily two chromosome races [hexaploid (60 chromosomes) and enneaploids (90 chromosomes)] throughout most of it geographic distribution. The two chromosome races have different characteristic in terms of seed production and vigor of offspring. Big bluestem has local ecotypes adapted to a broad range of habitat conditions. As it is now a staple of prairie restorations, there is some concern that using non-local seed could affect local genotypes.

Abiotic conditions: disturbance, soils, geology

This species grows on a diversity of substrates and moisture conditions. It tends to do best on deep, fine-textured, loamy soils. In Illinois, these soils tend to be dominated by corn and soybeans. Big bluestem is capable of colonizing and becoming dominant on disturbed sites, successional fields and abandoned pastures.

The grass is not very tolerant of soil disturbances. It would decline if forests spread. It thrives with fire.

Biotic interactions

Big bluestem grows in full sun and would decline with increasing forest cover. It is unclear whether the seed was or is dispersed by animals. Some experts speculate that bison may have been important for its dispersal; others point out that it has no adaptation for seed dispersal by animals.

Bibliography

Gray, Miranda M., et al. "Ecotypes of an ecologically dominant prairie grass (Andropogon gerardii) exhibit genetic divergence across the US Midwest grasslands' environmental gradient." Molecular ecology 23.24 (2014): 6011-6028.

Keeler, Kathleen H. "Impact of intraspecific polyploidy in Andropogon gerardii (Poaceae) populations." The American midland naturalist 152.1 (2004): 63-74.

Tompkins, Robert D., et al. "Genetic Variation within and among Remnant Big Bluestem (Andropogon gerardii, Poaceae) Populations in the Carolinas."Southeastern Naturalist 11.3 (2012): 455-468.

Apios priceana B. L. Rob.

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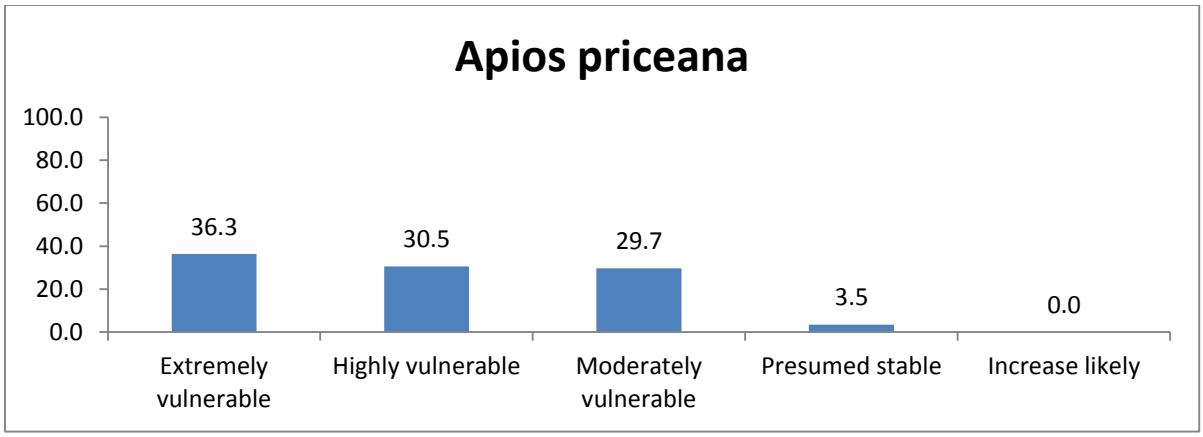

Figure 13: Experts predict Apios priceana to be Extremely Vulnerable to predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI			
Historical thermal niche				N		
Physiological thermal niche		I	SI	N	SD	
Historical hydrological niche	GI					
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence		I	SI	N	SD	
Ice/snow				N		
Geology/soils			SI	N	SD	
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks		I	SI	N		
Phenological response	UNKNOWN					

Table 11: Apios priceana might be vulnerable to predicted climate changes due to its inability to cross natural or anthropogenic barriers, its dispersal abilities, its physiological thermal niche, its historical and physiological hydrological niches, and its dependence on disturbance and genetic bottlenecks in its recent evolutionary past.

Little is known about the ability of this plant to cross anthropogenic barriers, its physiological thermal niche, its physiological hydrological niche, its dependence on disturbance or its ability to track changes in seasonality.

Insights from experts

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General

Apios priceana has not been seen in Illinois for a number of years, and is probably extirpated from the state. This long-lived perennial grows from a tuberous root. It is not aggressive or competitive and does not reproduce well.

Climate conditions & phenology

Little is known about the climate preferences of this plant. It is at the northern extent of its range in southern Illinois.

Dispersal, movement & genetics

Apios priceana has low seed set and short dispersal distances.

It is federally endangered and probably extirpated from Illinois, making genetic diversity in this state impossible to measure. Range-wide, it is possible that it is not genetically diverse, as it is extremely rare and has been greatly reduced in the last century.

Abiotic conditions: disturbance, soils, geology

Price's potato bean can grow on rocky (limestone) substrates, but may prefer rich loamy soils. It responds to canopy opening with increased flowering. It will regrow and flower after mid-summer mowing.

Biotic interactions

Apios priceana likes edges of woodlands. It is pollinated by the long-tailed skipper (*Urbanus proteus*) and by honey bees (*Apis mellifera*). Bees may have difficulty pollinating this species. Pollination is required for seed set.

Bibliography

United States Forest Service. 1993. Recovery plan for Apios priceana. U.S. Fish and Wildlife Service, Jackson, Mississippi.

Arnoglossum atriplicifolium (L.) H. Rob.

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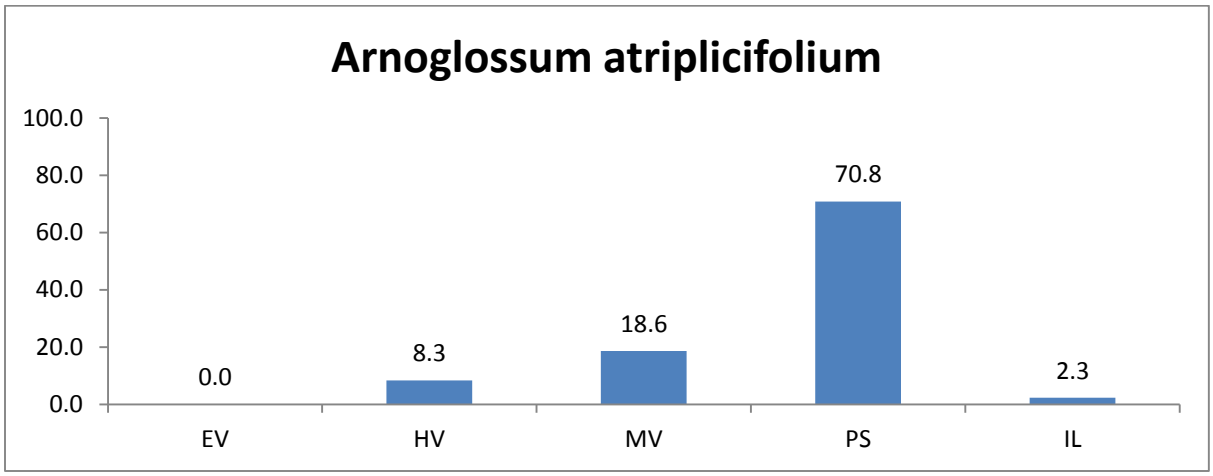

Figure 14: Arnoglossum atriplicifolium is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	
Other spp for habitat			SI	N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 12: Arnoglossum atriplicifolium may be vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers and its dispersal abilities.

Little is known about the ability of this plant to cross anthropogenic barriers, its dispersal abilities or its genetic diversity in Illinois.

Insights from experts

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General

Arnoglossum atriplicifolium is a widely-distributed, cespitose, perennial forb of prairies, savannas, and open woodlands, often with sandy soils. Reproduction is by seed; rosettes begin producing flowering shoots during second or third growing season, often not flowering during prolonged droughts.

Climate conditions & phenology

This plant could be sensitive to an increase in temperature. *Arnoglossum atriplicifolium* requires a summer and a winter. However, experts point out that, based on its distribution from cool northern Illinois to the foothills of South Carolina, this plant may be able to handle a range of temperatures.

Arnoglossum atriplicifolium appears to require moisture and is often found in mesic to wet-mesic sites. During prolonged droughts, it often does not flower.

Dispersal, movement & genetics

Arnoglossum atriplicifolium generally occurs in fragmented natural habitats that are separated by extensive areas of agriculture or urban development. Its seeds are very small and are probably wind-dispersed.

Little is known about the genetics of this plant in Illinois. One expert speculates that genetic diversity could be low because individual populations are small; another says that it could be genetically diverse across its large range.

Abiotic conditions: disturbance, soils, geology

This plant does not have strong soil preferences; it only requires that the soils are mesic to wet.

One expert has seen this plant come in to communities long after significant disturbance. *Arnoglossum atriplicifolium* may be able to tolerate some disturbance and could increase with an increase in fire frequency.

Biotic interactions

Arnoglossum atriplicifolium occurs in prairies, open woodlands, and forest edges. Experts seem to know little about the pollination of this flower, although one indicates that at least ten pollinators are known.

Bibliography

Landis, D., A. Fiedler, R. Isaacs. Pale Indian plantain. Native Plants Facts. Michigan State University. www.nativeplants.msu.edu
Hilty, John. Pale Indian plantain. Illinois Wildflowers Website. www.illinoiswildflowers.info

Asclepias amplexicaulis Sm.

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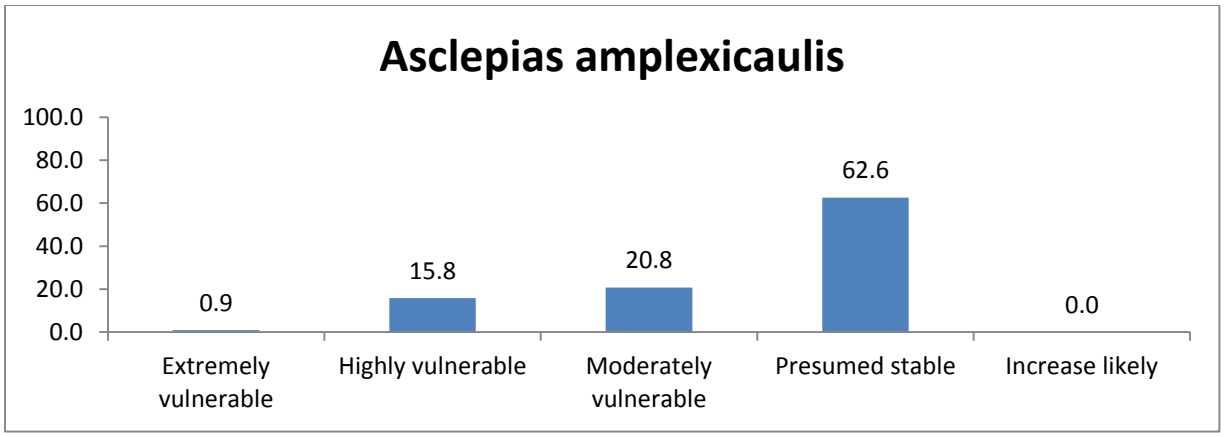

Figure 15: Asclepias amplexicaulis is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils		I	SI	N	SD	
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks			SI	N		
Phenological response			SI	N		

Table 13: Asclepias amplexicaulis may be vulnerable to predicted climate changes due to its inability to cross natural or anthropogenic barriers its dispersal abilities, its physiological hydrological niche, and its dependence on certain soil types.

Little is known about the ability of this plant to cross anthropogenic barriers, its dispersal abilities, its physiological hydrological niche, its soil preferences or its genetic diversity in Illinois.

Insights from experts

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General

Clasping milkweed is very widespread across the eastern and Midwestern US. It seems to be habitat limited, preferring to grow in sandy and well-drained soils in prairies, glades, and dry openings in forests.

Climate conditions & phenology

Clasping milkweed prefers dry, hot, habitats, indicating that an increase in temperature might not bother this wind-dispersed plant. It is possible that the plant's pollinators could be more sensitive to temperatures than clasping milkweed itself.

This species has extremely deep roots. It is often found in deep, well-drained soils. It is unclear how this plant would respond to a change in moisture.

Dispersal, movement & genetics

Asclepias amplexicaulis is wind-dispersed and typically travels between 8 and 18 meters. The plants are not found in large populations; typical of many milkweeds, individuals are widely scattered. Suitable habitat may be limiting for clasping milkweed. The plant is rhizomatous and populations may consist of one or a few genets.

Little is known about the genetic diversity of *Asclepias amplexicaulis* in Illinois.

Abiotic conditions: disturbance, soils, geology

Clasping milkweed is largely confined to sandy soils with little water holding capacity, including sand prairies and even disturbed areas like sandy pastures and roadsides.

The plant has a very deep root which helps make it resistant to drought and fire and possibly other types of disturbance.

Biotic interactions

Like most of its congeners, *Asclepias amplexicaulis* is an obligate out-crosser and needs insects to transport pollen from one plant to another. This plant is pollinated by large butterflies, predatory wasps and long-tongued bees.

Bibliography

Sacchi, Christopher F. "Variability in dispersal ability of common milkweed, Asclepias syriaca, seeds." Oikos (1987): 191-198.

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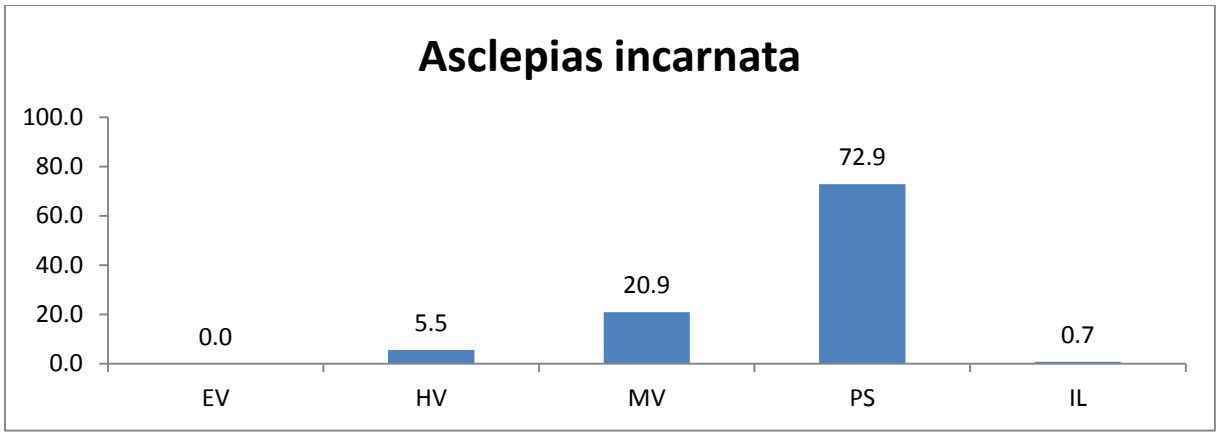

Figure 16: Asclepias incarnata is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence			SI	N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation				N		
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 14: Asclepias incarnata may be vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers and its physiological hydrological niche.

Little is known about the dispersal abilities of this plant or its physiological hydrological niche.

Insights from experts

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General

In Illinois this short-lived perennial herb is locally common in all areas of the state. It is found in open wetland habitats.

Climate conditions & phenology

Temperature may not be a major consideration for *Asclepias incarnata*. Based on its range, it may have a preference for cooler temperatures.

Swamp milkweed is somewhat dependent on wetland habitats (moist to saturated soils) to thrive and survive. If there are periodic conditions that are too wet or too dry, then individuals and populations of swamp milkweed might not do well. If changes in climate and weather patterns affect the seasonality or flashiness of precipitation patterns swamp milkweed may be impacted.

Dispersal, movement & genetics

Swamp milkweed is wind dispersed and has the ability to disperse tens, if not hundreds of meters. The seeds may also be water-dispersed. Suitable habitat (e.g. wetland) for swamp milkweed occurs in somewhat isolated patches across Illinois with unsuitable habitat in between.

Little is known about the genetic diversity of *Asclepias incarnata* in Illinois. One expert speculates that, due to its wide-ranging and common populations, this species could have high genetic diversity. Swamp milkweed seems to more self-compatible (e.g. rates of fertile seeds up to 25%) than other milkweeds (generally less than 10%).

Abiotic conditions: disturbance, soils, geology

This plant does well in a diversity of soil and open wetland types. It can grow with roots in inundated or saturated soils. It is unclear whether plants can tolerate prolonged, complete immersion during the growing season.

Biotic interactions

Although to a lesser degree than other Asclepias, this species is dependent on insects to pollinate it. Swamp milkweed is only found in sunny, open wetlands.

Bibliography

Ivey, Christopher T., Pocholo Martinez, and Robert Wyatt. "Variation in pollinator effectiveness in swamp milkweed, Asclepias incarnata (Apocynaceae)." American Journal of Botany 90.2 (2003): 214-225.

Lemoine, Nathan P. "Climate Change May Alter Breeding Ground Distributions of Eastern Migratory Monarchs (Danaus plexippus) via Range Expansion of Asclepias Host Plants." PloS one 10.2 (2015): e0118614.

Asclepias meadii Torr. ex A. Gray

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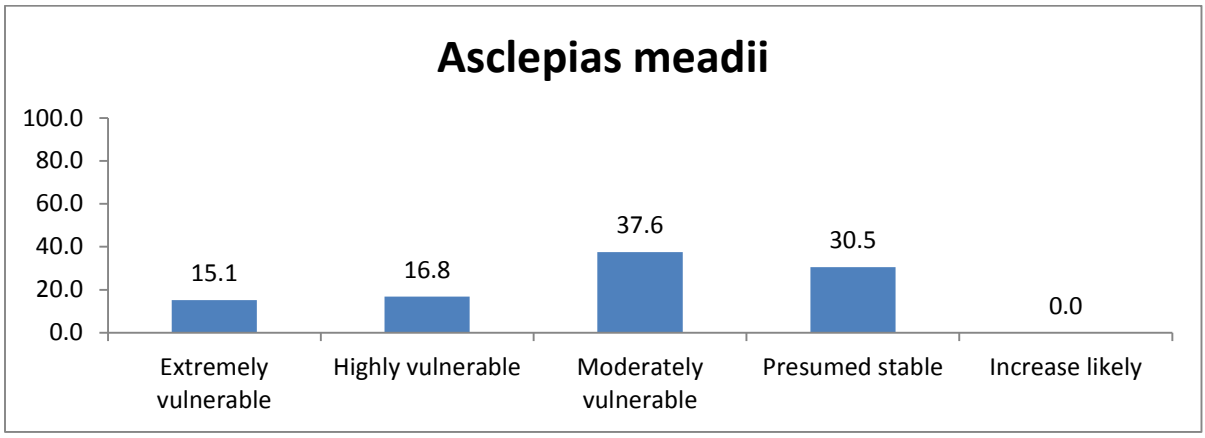

Figure 17: Asclepias meadii is categorized as Moderately Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence		I	SI	N	SD	
Ice/snow				N		
Geology/soils		I	SI	N	SD	
Other spp for habitat			SI	N		
Other spp for pollination		I	SI	N		
Other spp for dispersal			SI	N		
Other spp interactions			SI	N		
Genetic variation		I	SI	N	SD	
Genetic bottlenecks		I	SI	N		
Phenological response				N	SD	

Table 15: Asclepias meadii may be vulnerable to predicted climate changes due to its inability to cross natural or anthropogenic barriers, its dispersal abilities, and its physiological hydrological niche, its dependence on disturbance, its soil preferences, its low genetic diversity and its dependence on other species for pollination.

Little is known about the ability of this plant to cross anthropogenic barriers, its dispersal abilities, and its physiological hydrological niche, its dependence on disturbance, its soil preferences or its genetic diversity in Illinois.

Insights from experts

Contributing experts:
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General

Asclepias meadii is an extremely rare plant that has greatly declined in Illinois in the last century. Seedling recruitment is very rare, plants can take decades to reach maturity, it probably does not have a seed bank, and pollination is apparently poor.

Climate conditions & phenology

Little is known about the temperature preferences of this plant; it does occur to the south of Illinois and so may be tolerant of warmer climate conditions. Breaking of bud dormancy may be dependent upon the timing of winter cold conditions.

Seeds of *Asclepias meadii* require moist stratification for germination. Cultivated plants recover from drought-induced dieback rapidly following supplemental watering. An increase in drought events or drought length could damage populations in southern Illinois that occur on very thin soil over bedrock.

Dispersal, movement & genetics

Asclepias meadia is wind dispersed, although individuals rarely produce seed. Many populations are clonal. Prairies where this species occurs are highly fragmented and isolated due to agriculture.

Sexual reproduction is limited due to the lack of diversity of S-alleles. The species has comparable genetic diversity to other *Asclepias* (allozyme diversity) across its range, but individual populations often lack diversity. This range-wide diversity may make it an excellent candidate for restorations.

Abiotic conditions: disturbance, soils, geology

This species is dependent upon a narrow range of habitat drainage conditions. It appears to be restricted to dry-mesic soils. It is also dormant-season fire dependent.

Biotic interactions

Mead's milkweed is endemic to tallgrass prairie and barrens. This prairie was once continuous but has been fragmented by agriculture.

The species requires pollinators to produce viable seed. These include a narrow range of pollinator bee species, primarily Anthophera.

Bibliography

Betz, R.F. 1989. Ecology of Mead's milkweed (Asclepias meadii Torrey), p. 187-191. In: T.B. Bragg & J.Stubbendieck (eds.). Proceedings of the Eleventh North American Prairie Conference: Prairie pioneers: Ecology, history and culture. Lincoln, Neb.: University of Nebraska.

Hayworth, D., A., K. E. Shingleton. "Clonal population structure of the federal threatened Mead's milkweed, as determined by RAPD analysis, and its conservation implications." Proc. 17th NA Prairie Conference. Vol. 182. 2001.

Tecic, Diane L., et al. "Genetic variability in the federal threatened Mead's milkweed, Asclepias meadii Torrey (Asclepiadaceae), as determined by allozyme electrophoresis." Annals of the Missouri Botanical Garden (1998): 97-109.

Asclepias syriaca L.

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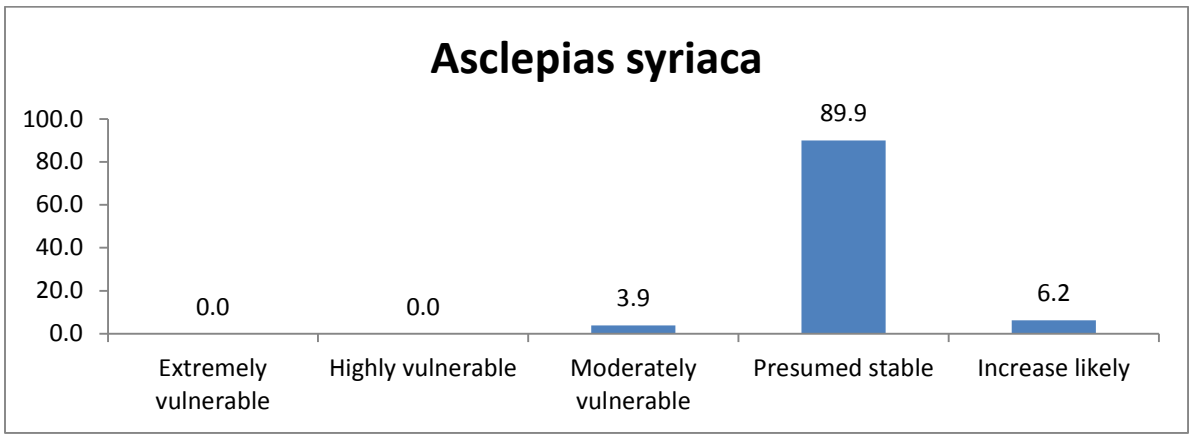

Figure 18: Asclepias syriaca is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers			SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N		
Disturbance dependence				N	SD	D
Ice/snow				N		
Geology/soils					SD	D
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 16: Asclepias syriaca may not be vulnerable to predicted climate changes, based on its biology and ecology.

Little is known about the dispersal abilities of this plant or about its genetic diversity in Illinois.

Insights from experts

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General

Common milkweed is widespread in Illinois and beyond. It grows under a wide variety of conditions, from partial shade to full sun, relatively dry to margins of wetlands. The most common milkweed, forms many fruits, many pollinators, forms colonies, likes disturbance, and is very flexible north to south.

Climate conditions & phenology

Based on its range, some experts speculate that this plant may be sensitive to increased temperatures. One study shows that populations vary in the temperatures required for germination and the length of stratification for breaking dormancy. This experiment suggests that *Asclepias syriaca* could germinate too early, during short winter warm spells, in the future.

Dispersal, movement & genetics

This plant is easily dispersed by wind. In addition, it is rhizomatous and can form large colonies.

Little is known about the genetic diversity of *Asclepias syriaca* in Illinois, one expert suggests that, based on its widespread distribution and its large population sizes, it may be genetically diverse.

Abiotic conditions: disturbance, soils, geology

This species is very flexible about where it grows. It is a strong colonizer and increases with many kinds of disturbance, including fire.

Biotic interactions

Butterfly milkweed requires insects to pollinate its flowers. It has a diverse fauna of associated, specialized phytophagous insects.

Bibliography

Dekker, J., T. DeGooyer. Milkweed. Iowa State University Weed Biology Library. http://agron-www.agron.iastate.edu/~weeds/weedbiollibrary/u4milkw1.html

Lemoine, Nathan P. "Climate Change May Alter Breeding Ground Distributions of Eastern Migratory Monarchs (Danaus plexippus) via Range Expansion of Asclepias Host Plants." PloS one 10.2 (2015): e0118614.

Asclepias tuberosa L.

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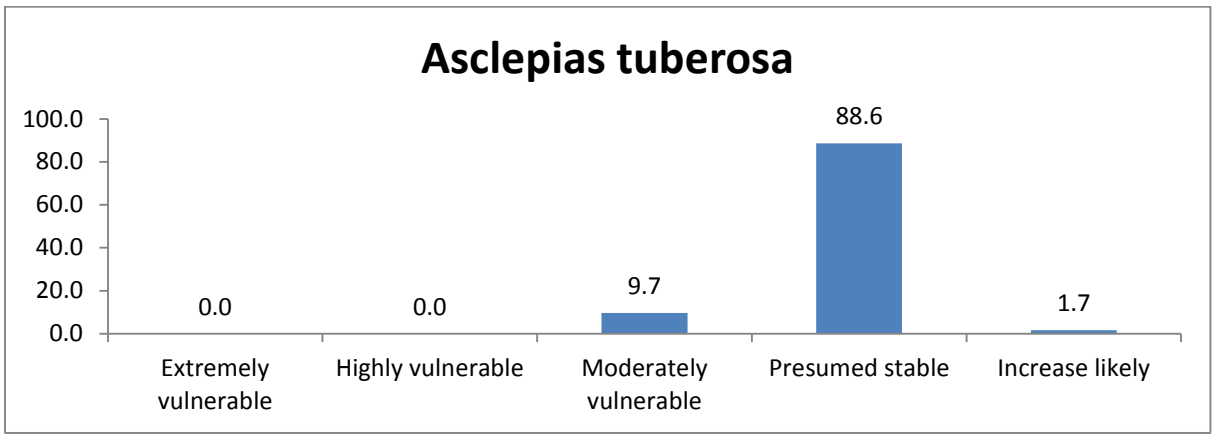

Figure 19: Asclepias tuberosa is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers		I		N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils			SI	N	SD	D
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation				N		
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 17: Asclepias tuberosa may be vulnerable to predicted climate changes due to its inability to cross natural and anthropogenic barriers.

Little is known about the dispersal abilities of this plant or its soil preferences.

Insights from experts

Contributing experts:

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General

Butterfly milkweed is a widespread, perennial forb of well-drained habitats, from open woodlands to prairies; occurs on a range of well-drained soils, from clay to sandy or rocky. It is commonly added to prairie reconstructions.

Climate conditions & phenology

Asclepias tuberosa is tolerant of hot dry weather. Temperature may be more important to its pollinators than it is to the plant itself. The plant is intolerant of flooding and saturated soils, and it seems likely that it would not be bothered by a drier climate in Illinois.

Dispersal, movement & genetics

This plant is wind-dispersed and can move easily across the landscape.

Butterfly milkweed is completely dependent on insects for pollination and does not self-pollinate. Little is known about the genetic diversity of this species in Illinois. One expert speculates that it is quite diverse, with flower color variations and several named varieties.

Abiotic conditions: disturbance, soils, geology

This species is commonly found in disturbed areas yet species can also be found in habitats that, in themselves, might be vulnerable to climate change which include sand prairies, hill prairies, shale and sandstone glades, sandy savannas. It prefers to grow on shallow, well-drained soils.

This species can colonize open areas but it is not weedy or successional. It does not need disturbance, but is fire-adapted with a large storage root underground.

Biotic interactions

Asclepias tuberosa does not do well with competition from tall plants, and requires open unshaded areas.

It does not self-pollinate and is entirely dependent on a diversity of insects for pollination. Its seeds are wind-dispersed.

Bibliography

Lemoine, Nathan P. "Climate Change May Alter Breeding Ground Distributions of Eastern Migratory Monarchs (Danaus plexippus) via Range Expansion of Asclepias Host Plants." PloS one 10.2 (2015): e0118614.

Besseya bullii (Eaton) Rydb.

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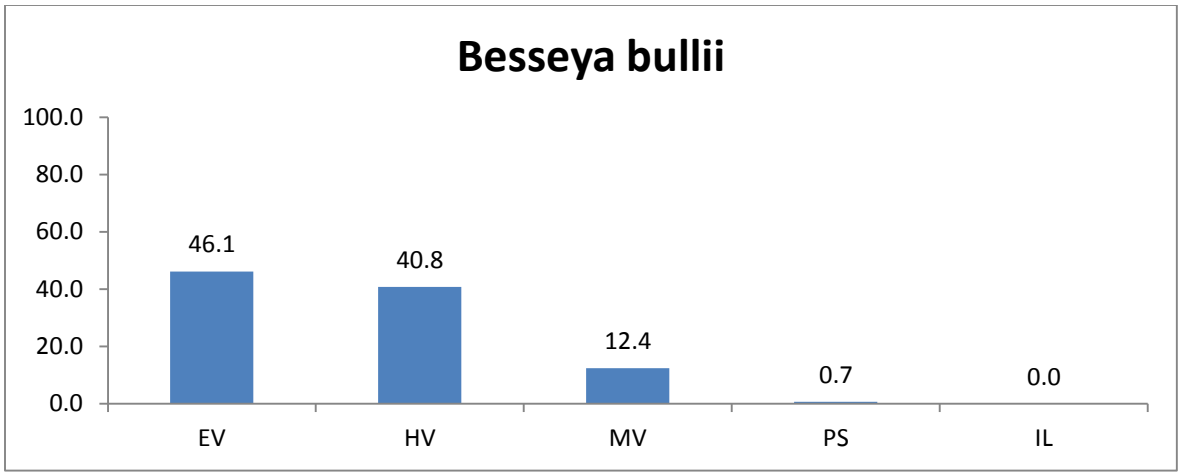

Figure 20: Besseya bullii is categorized as Highly Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers	GI	I		N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI			
Historical thermal niche				N		
Physiological thermal niche		I	SI	N		
Historical hydrological niche		I				
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence		I	SI	N	SD	
Ice/snow			SI	N		
Geology/soils		I	SI	N	SD	D
Other spp for habitat			SI	N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks			SI	N		
Phenological response			SI	N		

Table 18: Besseya bullii may be vulnerable to predicted climate changes due to its inability to cross natural and anthropogenic barriers, its dispersal abilities, its physiological thermal niche, its historical and physiological hydrological niche and its soil preferences.

Little is known about this plant's ability to cross natural or anthropogenic barriers, its physiological hydrological niche, its soil preferences or its genetic diversity in Illinois.

Insights from experts

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General

Besseya bullii is a perennial herb of well-drained savannas and prairies, often found on older (per-Wisconsin glaciation) soils derived from till, bedrock or loess. The species is state-threatened in Illinois and is only found in high quality habitats in natural areas; occurrences tend to be small, local relicts.

Climate conditions & phenology

Little is known about the temperature preferences of *Besseya bullii*. It appears to prefer cool climates, based on its distribution. However, it thrives on very dry, arid, well-drained soils which suggests to one expert that heat may not be the limiting factor for the distribution of the species. The basal leaves attempt to be evergreen and one expert speculates that winter survival of the plants could be greater with snow cover. Although some believe that changes in snow cover seem unlikely to change the vulnerability of this species.

Besseya bullii is likely restricted to dry, gravelly, sandy sites because it is a poor competitor. An increase in moisture could benefit the species in the short term, but would ultimately increase competition on its soils and extirpate it.

Besseya bullii blooms late enough and is pollinated by enough insects that a change in the timing of seasons should not be a problem for the plant.

Dispersal, movement & genetics

Besseya bullii may be dispersed solely by gravity. Fruits are capsules and seeds shake out of them. Most new individuals are recruited from seed but there is also minimal vegetative reproduction: offsets from older rosettes. One expert has seen areas of similar microhabitat in a larger prairie reserve that were located around 100m from a population of *Besseya bullii* which did not have the species present. Populations tend to be relatively small and isolated; many are surrounded by intensive agriculture.

Although no population genetic work has been conducted with this species, unpublished data by Zeng, Zaya, & Molano-Flores have shown that genome size is greater for plants in shaded habitat than in open habitat.

Abiotic conditions: disturbance, soils, geology

Besseya bullii is found on well-drained, gravelly or sandy soils, possibly because these areas present little competition.

This plant is dependent on disturbance. It responds well to increases in bare soil in its vicinity, which can be achieved through a number of disturbances. Lack of fire will result in woody encroachment and there is evidence that this woody encroachment will affect reproduction.

Biotic interactions

This plant benefits from situations with low competition—it is found in open prairies and savannas. It has been hypothesized that *Besseya bullii* once had a positive association with bison wallows. With the addition of bison at sites like Nachusa, this association could be tested.

This plant blooms late in the season and is pollinated, a number of halictid flies and bumblebees. There are concerns regarding the decline of bumblebees. The seeds of *Besseya bullii* are tiny and could be dispersed by ants. In addition, pre-dispersal seed predators have been detected, but it is unclear how this particular interaction will change with climate change.

Bibliography

Hilty, John. Kittentails. Illinois Wildflowers Website. www.illinoiswildflowers.info

Minnesota Department of Natural Resources, Division of Ecological Resources. 2008. Rare Species Guide: An online encyclopedia of Minnesota's rare native plants and animals [Web Application]. Minnesota Department of Natural Resources, St. Paul, Minnesota.www.dnr.state.mn.us/rsg. Accessed July 2015.

Chi, Katherine, and Brenda Molano-Flores. "Can floral display size compensate for Allee effects caused by low population abundance and density in Synthyris bullii (Plantaginaceae), a rare species?." American Journal of Botany 101.3 (2014): 428-436.

Chi, K., and B. Molano-Flores. Habitat degradation disrupts plant-pollinator interactions for a rare, self-compatible prairie species. Plant Ecology accepted.

Chi, K. and B. Molano-Flores. Reproductive morphology of a rare endemic Midwestern species in association with habitat degradation. The Journal of the Torrey Botanical Society accepted.

Curtis, Marnelle, Katherine Chi, and Brenda Molano-Flores. "Seed ecology of Synthyris bullii (Plantaginaceae), a rare endemic of the midwestern USA."Botany 91.12 (2013): 884-889.

Leja, M., K. Chi, and B. Molano-Flores. 2015. Presence and intensity of pre-dispersal seed predation in a rare plant in response to habitat quality and population metrics. Natural Areas Journal.

McKone, Mark J., et al. "An exception to Darwin's syndrome: floral position, protogyny, and insect visitation in Besseya bullii (Scrophulariaceae)."Oecologia 101.1 (1995): 68-74.

Betula nigra L.

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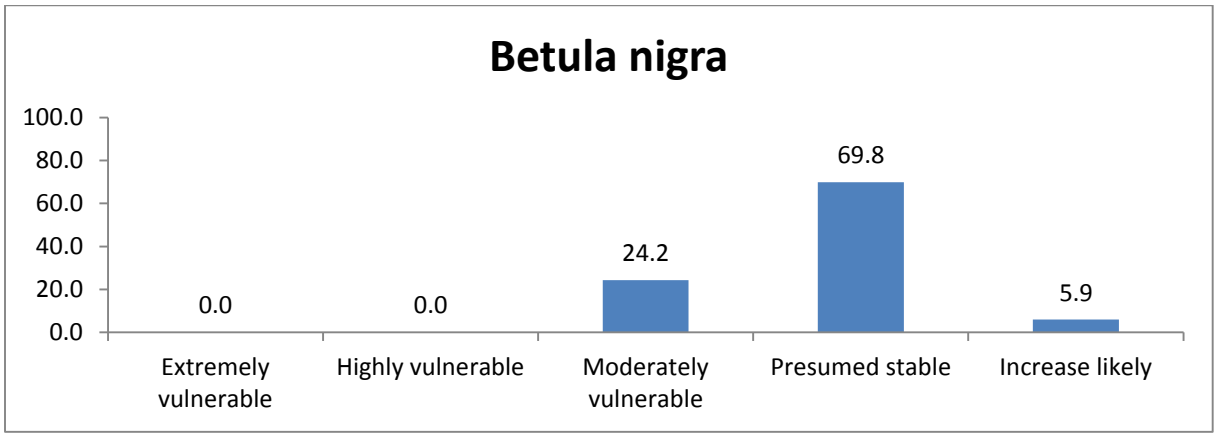

Figure 21: Betula nigra is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence			SI	N	SD	
Ice/snow				N		
Geology/soils				N	SD	
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation				N		
Genetic bottlenecks				N		
Phenological response			SI	N		

Table 19: Betula nigra may be vulnerable to predicted climate changes due to its inability to cross natural and anthropogenic barriers.

Insights from experts

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General

This species is the most southern of the birches, it is from southern Illinois to central Illinois, sometimes further north, and may be expanding its range. *Betula nigra*'s seeds have relatively short period of viability. When planted as ornamental tree, it does well on soils and situations it would not occur on nature; may seed from these sites into nearby suitable situations (along ditches).

Climate conditions & phenology

With warmer temperatures, this tree may increase in Illinois and may allow the tree's range to move northward. If temperature increases are not accompanied by increases in precipitation, conditions may be too dry for *Betula nigra*.

This tree prefers wet conditions, but does some tolerance for fluctuations in moisture regimes. Increases in flooding could help this birch expand its range.

Dispersal, movement & genetics

Betula nigra's seeds are dispersed by wind and water and the flowers are wind-pollinated.

Little is known about the genetic diversity of this tree in Illinois. Experts speculate that since it is widespread, common and wind pollinated, it may have high levels of genetic diversity.

Abiotic conditions: disturbance, soils, geology

Betula nigra grows on floodplains, usually those with somewhat acidic soils. Also grows in moist sandy soils and in association with seeps. Generally this species is absent from calcareous soils (glacial till). It also likes high organic matter soil or clayey soils.

Some amount of disturbance, such as river scour associated with flooding, is needed to maintain open habitats for this species. This tree is generally thought of as fire intolerant. However prescribed burns on barrens in southern Illinois can kill seedlings but not mature trees.

Biotic interactions

Betula nigra is shade intolerant and disturbances are needed to maintain open habitat for this species. In southern Illinois it occurs in barrens.

Bibliography

Adams, Dwight E., and Roger C. Anderson. "Species response to a moisture gradient in central Illinois forests." American Journal of Botany (1980): 381-392.

Anderson, Roger C., and John E. Schwegman. "Twenty years of vegetational change on a southern Illinois barren." Natural Areas Journal 11.2 (1991): 100-107.

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Table_of_contents.htm

Boltonia decurrens (Torr. & A. Gray) Alph. Wood

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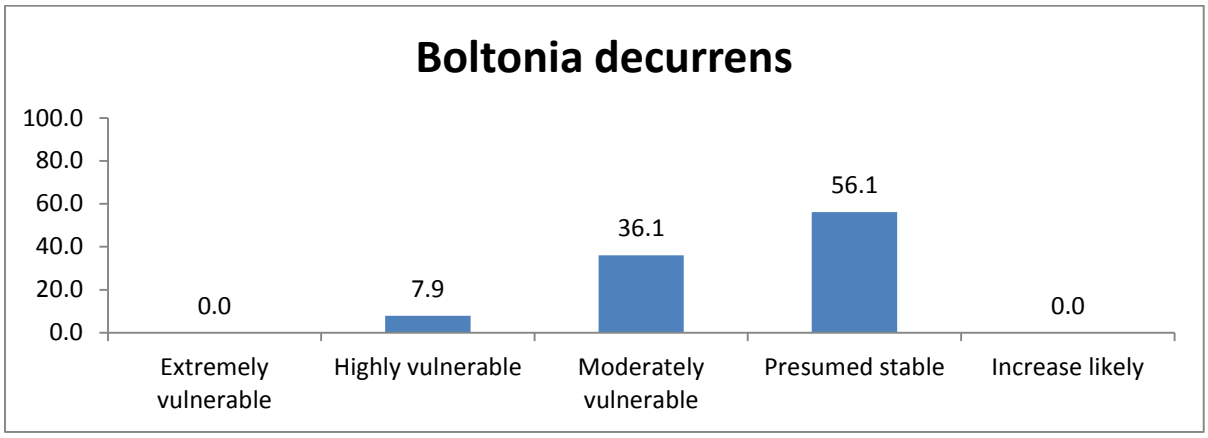

Figure 22: Boltonia decurrens is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers	GI	I	SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche		I	SI	N	SD	
Historical hydrological niche		I				
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence		I	SI	N	SD	D
Ice/snow				N		
Geology/soils		I	SI	N	SD	
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation			SI	N		
Genetic bottlenecks			SI	N		
Phenological response			SI	N		

Table 20: Boltonia decurrens may be vulnerable to climate changes due to its inability to cross natural and anthropogenic barriers. In addition, the plant may be vulnerable due to its dispersal abilities, its physiological thermal niche, its historical and physiological hydrological niches, its dependence on disturbance and its soil preferences.

Little is known about this plant's ability to cross natural or anthropogenic barriers, its dispersal abilities, its physiological thermal niche, its physiological hydrological niche, its dependence on disturbance or its soil preferences.

Insights from experts

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General

Boltonia decurrens is a well-studied species that is endemic to the floodplains and shores of the Illinois River from LaSalle County (historical) southwards to the Mississippi River; its presence southwards along the Mississippi River extends (historically) to Cape Girardeau MO. Populations have declined in the last century because of levees and other flood control on the Illinois River, but extensive flooding in the 1990s have allowed some populations to rebound and new populations to expand. Some populations have persisted in place for decades, for example at the McCluggage Bridge in Peoria County, on the shoreline of the Illinois River. Other habitats include natural wetlands, wet crop fields, and along drainage ditches.
The plant is an herbaceous perennial, usually flowering during its second year. Individual plants can be long-lived. *Boltonia decurrens* has been unintentionally (and intentionally) planted outside its natural range, one expert has seen four sites in NE Illinois (two in Will, two in Cook). Plants have persisted at all sites and there is recruitment and expansion of populations. Habitats are mostly restored/ reconstructed wet prairie and sedge meadow wetlands; managers have acted to control populations.

Climate conditions & phenology

The temperature preferences of this plant are unclear. Experts cite that its range extends to the south as reason to believe that the plant could do fine under a warmer climate in Illinois.

Populations of this species appear to be maintained by the flooding pulses along rivers to minimize vegetative competitors. Depending on the consequence of predicted increased precipitation, the species could benefit if flooding pulses remain fairly consistent with those we see currently, but if precipitation increases enough to cause more maintained higher water levels, habitat may be lost. In addition, if a lot of siltation is associated with flooding, that could effectively block germination. Flashy floods and then prolonged drought without more consistent water may be highly deleterious.

Dispersal, movement & genetics

This species can disperse fairly long distances by being washed downstream in the Illinois River, although the direction of the river flow (southwest) is the wrong way for species to move to cooler climes. Levees along the Illinois River significantly affect dispersal and colonization. Individual plants form clumps with relatively short rhizomes; new plants are the result of recruitment from seed. The plant is restricted to lowlands along rivers and cannot seem to migrate to other watersheds.

The genetic diversity of this plant in Illinois is not well understood. One paper did find that diversity may have been lower than in a congener, but no significance tests were done. The species does have very large fluctuations in population size. It can produce thousands of seeds per year.

Abiotic conditions: disturbance, soils, geology

Apparently not adapted to very acidic soils – but can grow in somewhat dry soils if there is no competition – but will not persist long. Its soils are sand and limestone-based.

Boltonia decurrens recruitment is dependent upon soil scouring caused by overbank flooding of rivers and streams. A decrease in severe flood events caused by reduced precipitation could adversely affect recruitment. Prolonged

flooding or flooding at the wrong time of year could be detrimental to the species. Excessive siltation could effectively block germination.

Biotic interactions

Boltonia decurrens needs periodic severe flooding that cuts down competition from other plants.

Seed set is typically very high, indicating sufficient pollination or the ability to self. Morphology and experts' observations suggest that it is visited by many species of generalists. Pollinators include syrphid flies, solitary bees, honeybees, various Lepidoptera including monarch butterflies on fall migration; timing of flowering suggests that the pulse of migrating monarchs may be important.

Bibliography

Boltonia decurrens. Center for Plant Conservation. National Plant Collection Profile. Website accessed July 2015. http://www.centerforplantconservation.org/collection/cpc_viewprofile.asp?CPCNum=8090

Checklist of endangered and threatened animals and plants of Illinois. Springfield, Illinois: Illinois Endangered Species Protection Board, 2011.

DeWoody, Jennifer, John D. Nason, and Marian Smith. "Hybridization between the threatened herb Boltonia decurrens (Asteraceae) and its widespread congener, B. asteroides." Botany 89.3 (2011): 191-201.

Ketzner, David, Allen Piocher, and Paul Marcum. "Recovery and monitoring plan for Boltonia decurrens, FAP 999 (New Mississippi River Crossing, Relocated 1-70 and 1-64 Connector) and FAP 14 (IL Route 3 Relocation), Madison and St." Clair Counties, Illinois. Report submitted to the Illinois Department of Transportation by the Illinois Natural History Survey, Champaign (2002).

Schwegman, John E., and Randy W. Nyboer. "The taxonomic and population status of Boltonia decurrens (Torr. & Gray) Wood." Castanea (1985): 112-115.

Smith, Marian, Hal Caswell, and Paige Mettler-Cherry. "Stochastic flood and precipitation regimes and the population dynamics of a threatened floodplain plant." Ecological Applications 15.3 (2005): 1036-1052.

United States Fish and Wildlife Service. 2012. Decurrent False Aster (Boltonia decurrens) 5-year Review: Summary and Evaluation. USFWS. Midwest Region. Rock Island Ecological Services Field Office. Moline, IL

Butomus umbellatus L.

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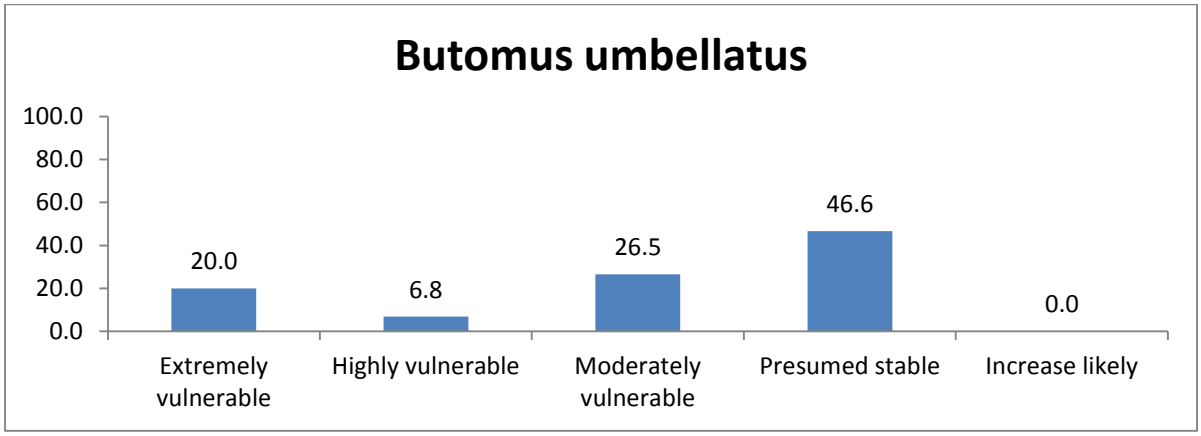

Figure 23: Butomus umbellatus is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers	GI	I		N		
Anthropogenic barriers		I		N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI		SD	D
Historical thermal niche				N		
Physiological thermal niche	GI	I	SI	N		
Historical hydrological niche		I				
Physiological hydrological niche	GI	I	SI	N	SD	
Disturbance dependence			SI	N	SD	
Ice/snow				N		
Geology/soils			SI		SD	
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response			SI	N		

Table 21: Butomus umbellatus may be vulnerable to climate changes due to its inability to cross natural or anthropogenic barriers, its dispersal abilities, its physiological thermal niche and its historical and physiological hydrological niches.

Little is known about the abilities of this plant to cross natural or anthropogenic barriers, its dispersal abilities, its physiological thermal niche, its physiological hydrological niche, its soil preferences or its genetic diversity in Illinois.

Insights from experts

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General

Butomus umbellatus is a perennial emergent in wetlands; plants grow on shore or in standing water; also along low gradient streams. Flowering rush is an obligate wetland hydrophyte, that is non-native, and currently is found only in a few Illinois counties. There are numerous state management plans for controlling the spread of this non-native species in the northern states and Canada where this species has been found.

Climate conditions & phenology

This plant may be sensitive to warmer temperatures, based on its current distribution in North America. However it may also be able to survive in a wide range of hardiness zones. Late summer dormancy after flowering may be part of the plant's phenological avoidance of stress.

Dispersal, movement & genetics

Seems to spread slowly although it has many methods for dispersal (bulbils produced in the inflorescence and off the rhizome) in addition to spreading by seed. Bulbils and rhizomes are water dispersed.

Little is known about the genetic diversity of this species in Illinois.

Abiotic conditions: disturbance, soils, geology

Apparently, *Butomus umbellatus* prefers alkaline or calcareous disturbed open wetlands with no competition. This species does well in disturbed wet habitats – pond margins, ditches, and canals. The plant is adapted to human disturbance, but extremely sensitive to heat and drying. One expert notes that it seems to thrive where nutrient runoff is common.

Biotic interactions

This plant does not tolerate competition. Flowers are hermaphroditic and pollinated by bees, flies, and Lepidoptera. Muskrats may move rhizomes.

Bibliography

Flowering Rush, Butomus umbellatus. New Invasive Plants of the Midwest Fact Sheet. Midwest Invasive Plant Network. Website accessed July 2015. http://www.mipn.org/Midwest%20Invasives%20Fact%20Sheets/PDF/floweringrush.pdf

Global Invasive Species Database. Website accessed July 2015. http://www.issg.org/database/species/ecology.asp?si=610&

Mohlenbrock, Robert H. Vascular flora of Illinois: a field guide. Southern Illinois University Press, 2014.

Carya illinoinensis (Wangenh.) K. Koch

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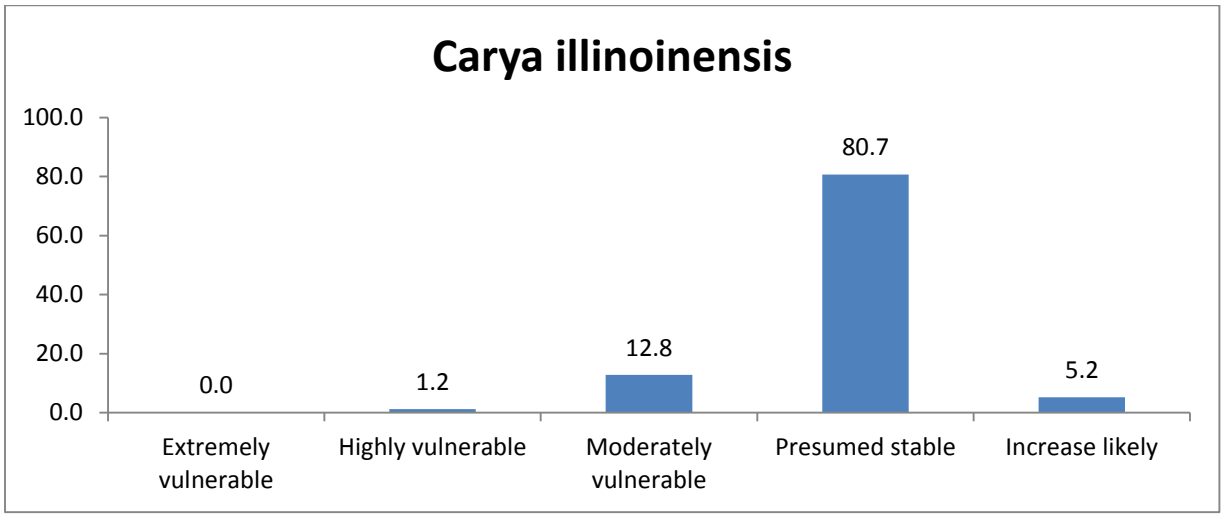

Figure 24: Carya illinoinensis is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence			SI	N	SD	
Ice/snow				N		
Geology/soils				N	SD	
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions				N		
Genetic variation			SI	N	SD	
Genetic bottlenecks				N		
Phenological response			SI	N		

Table 22: Carya illinoinensis may be vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers and its dispersal abilities.

Little is known about this plant's dispersal abilities.

Insights from experts

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General

Carya illinoinensis is a tree of floodplains, rarely found outside river floodplains or wet terraces. This tree is commercially grown (with supplemental irrigation) in Arizona and New Mexico, largely to avoid diseases and pests present in native range. It is commonly seen in southern Illinois along rivers and near cypress swamps, it was once more common.

Climate conditions & phenology

This plant would not likely be bothered by warmer temperatures in Illinois; it may be affected badly by extreme cold. Late and early frosts can kill or damage young growth and can even damage ripening seeds.

Carya illinoinensis is dependent on river floodplain environments in the wild, so aridity could affect it negatively. One expert contends, however, that this is a surprisingly drought-tolerant, it follows riparian corridors well into the southern Great Plains nearly to New Mexico.

Dispersal, movement & genetics

Pecan has heavy fruits that do not disperse far on their own from parent plants, but the seeds are dispersed by water and animals, and probably humans. Urban areas and intensive industrial agriculture pose barriers to this species. However, it can disperse along bottomland wooded areas along stream corridors.

Little is known about the genetics of this species in Illinois. Studies of variation in natural pecan stands throughout Louisiana indicated a large genetic diversity within populations. Also, there was a high degree of variation between breeding populations, indicating a close relationship (inbreeding) among trees in small stands.

Abiotic conditions: disturbance, soils, geology

Carya illinoinensis is not especially substrate dependent, but it is hydrologically dependent. If river floodplain moisture decreases, this tree might also. It might not fare well with changes of extreme flood or dry weather events.

Biotic interactions

This tree can grow with many other species adapted to the same warm moist habitat. It is dispersed by several animals and water, and is wind pollinated.

Bibliography

Adams, J. C. 1976. A study of genetic variability in wild populations of pecan *(Carya illinoensis* (Wangenh.) K. Koch). Thesis (Ph.D.), Louisiana State University, Baton Rouge.

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Table_of_contents.htm

Carya ovata (Mill.) K. Koch

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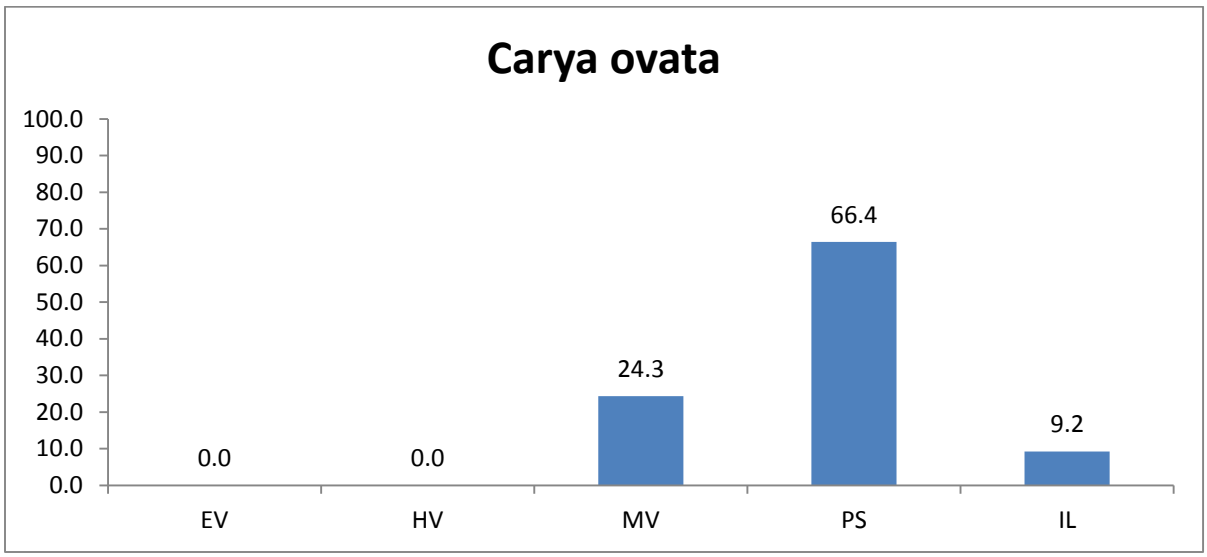

Figure 25: Carya ovata is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence			SI	N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat			SI	N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response			SI	N		

Table 23: Carya ovata may be vulnerable to predicted climate changes due to its inability to cross natural and anthropogenic barriers and its dispersal abilities.

Little is known about this plant's dispersal abilities or its genetic diversity in Illinois.

Insights from experts

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General

Shagbark hickory is an upland tree, very common in Illinois. It may flower and fruit on relatively young root sprouts and develops a deep root system early in life. Its wood has many uses, including smoking food.

Climate conditions & phenology

Experts feel that, given this species' range, predicted climate changes may not affect this species. It has some cold restrictions and perhaps some heat restrictions as well, but they are well outside of the current climate in Illinois. New growth can be damaged by late spring frosts, effectively preventing flowering.

The tree is found in upland and mesic forests and can tolerate a range of hydrological conditions, with the exception of regular flooding.

Dispersal, movement & genetics

Shagbark hickory has heavy fruits that drop mainly below the parent; if there is a slope, they could role a bit farther. They rely on birds and mammals such as squirrels (Sciurus spp) and chipmunks for longer distance dispersal (at least within habitat patches), up to 50 meters. Squirrels seem to prefer the sweet nuts of shagbark hickory over other nuts (like bitter tasting acorns) even though it requires more effort to extract the "meat." Hickory nuts have an extremely hard, thick shell. The plant is not rhizomatous. Its flowers are cross-pollinated by wind.

Historically patches of prairie presented barriers to movement of shagbark hickory between habitat patches. Now the barriers are row-crop agriculture. If this species is to move north, these would still be the greatest barriers along with wetland, lakes, and the great lakes.

Little is known about the genetic diversity of this plant in Illinois. Experts speculate that given its widespread distribution and wind pollination, that this plant could have high genetic diversity.

Abiotic conditions: disturbance, soils, geology

Carya ovata prefers neutral or calcareous soils, but is otherwise fairly tolerant of various soil types. It can grow in upland and mesic sites and sometimes in well-drained floodplains, but is not tolerant of regular flooding.

The thin-barked tree is not heartily fire-tolerant, especially the young trees. Young trees can be killed to the ground by even relatively cool prescribed burns. Established trees can be drought-tolerant.

Biotic interactions

Carya ovata is a long-lived tree of upland forests, woodlands, and savannas. It is comfortable in both young and old forests. It is not a plant of prairies.

Shagbark hickory is wind pollinated and dispersed by birds and mammals. During poor seed years, seed predation eliminates most of the crop.

The tree can be more sensitive to insect infestations during drought.

Bibliography

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Table_of_contents.htm

Hilty, John. Shagbark Hickory. Illinois Wildflowers Website. www.illinoiswildflowers.info

Tirmenstein, D. A. 1991. Carya ovata. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 23].

Ceanothus americanus L.

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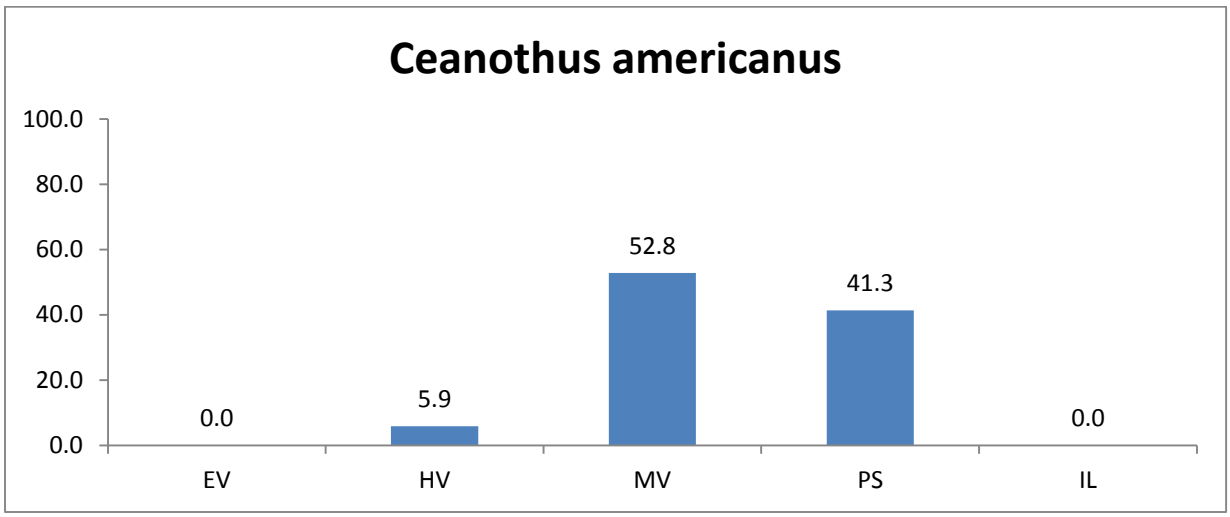

Figure 26: Ceanothus americanus is categorized as Moderately Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I		N		
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence		I		N	SD	
Ice/snow				N		
Geology/soils				N	SD	
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions			SI	N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 24: Ceanothus americanus may be vulnerable to predicted climate changes due to its inability to cross natural or anthropogenic barriers, its dispersal abilities and its dependence on disturbances.

Little is known about this plant's ability to cross anthropogenic barriers, its dependence on disturbance or its genetic diversity in Illinois.

Insights from experts

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General

Ceanothus americanus is a long-lived perennial shrub. It is broadly distributed throughout eastern North America, is occasional throughout Illinois, but is locally common in high quality habitats.

This is a widespread species of the tallgrass prairie as well as open woods and savannas of the eastern US. It does well on many soil types (not saturated soils). It's in almost every black-soil prairie remnant that one expert has visited in IL, and before the demise of the prairie, was probably a very common species. Since unplowed prairie remnants are uncommon, this species is now uncommon.

The hard little seeds have physical and physiological dormancy. They are able to persist in the seed bank, but it is unclear for how long.

Climate conditions & phenology

The temperature preferences of *Ceanothus americanus* are unclear. Some experts say it could be cold sensitive and could fare well with warmer temperatures. Heat treatment increases germination of seeds, which may be long-lived in the seedbank.

Ceanothus americanus is a deep-rooted plant that does well in dry soils. However, the species is favored by drier conditions in prairies and savannas. An increase in droughts could be detrimental to this species, although it currently seems to do just fine with periods of dry weather or short droughts. However, sandy rocky substrates may be more negatively affected by drying despite prediction of increased precipitation because coarse-textured soils tend to be excessively drained.

Dispersal, movement & genetics

New Jersey tea has ballistic fruits that dehisce explosively when ripe. Seeds probably do not move more than a meter or two from the parent plant and are not known to be eaten or be otherwise specialized for dispersal. This plant produces tillers which aid in limited vegetative spread.

Due to its widespread distribution, it seems unlikely that significant natural barriers exist. However, anthropogenic barriers are a major limitation for the dispersal of the plant.

Little is known about the genetic diversity of this plant in Illinois. A few experts feel that it could be genetically diverse across its wide distribution.

Abiotic conditions: disturbance, soils, geology

Ceanothus americanus does well on many dry- to mesic-soil types, but does not tolerate saturation. Its relationship with nitrogen-fixing *Frankia* spp. bacteria allows this plant to grow and thrive in nutrient-poor soils.

This species benefits from fire, which decreases canopy cover. The plant will vigorously resprout from the roots following a fire. On the other hand, once anthropogenic disturbances (plowing, grazing, frequent mowing, herbicide) eliminate it from an area, it does not persist or recolonize. Although *Ceanothus americanus* is an actinorhizal species, it does not seem to be a pioneer following disturbance, but rather seems to be modal to natural areas. Brief exposure to heat, such as that from fire, apparently stimulates both seed germination and possibly the germination of symbiotic *Frankia* spores in the soil.

Biotic interactions

New Jersey tea is a widespread shrub of well-drained prairie, savanna, barren, and woodland habitats. It requires open, sunny areas. It is not generally seen in severely disturbed plant communities and is harmed by overgrazing. This plant has been shown structure tallgrass prairie communities.

The flowers of this plant are visited by a wide array of potential pollinators, including beetles, flies, bees and small butterflies. While one expert feels that the seeds are not known to be eaten or distributed by any animals, another contends that it is eaten by many animals, including turkeys.

Ceanothus americanus is actinorhizal, forming a relationship with *Frankia* spp. soil bacteria, which are capable of fixing atmospheric nitrogen in root nodules on the plant. It is entirely unclear what the climatic or habitat preferences of this/these *Frankia* is/are, but *Ceanothus americanus* becomes nodulated readily in its widespread native prairie and savanna soils. Nodulating *Frankia* strains are likewise broadly distributed in nature with many strains capable of surviving in the soil in the absence of host plants. Brief exposure to heat, such as that from fire, apparently stimulates both seed germination and possibly the germination of symbiotic *Frankia* spores in the soil.

Bibliography

Hilty, John. New Jersey Tea. Illinois Wildflowers Website. www.illinoiswildflowers.info

Taft, John B., and Jeffrey O. Dawson. "Evidence for community structuring associated with the actinorhizal shrub Ceanothus americanus in tallgrass prairies in Illinois, USA." Functional Plant Biology 38.9 (2011): 711-719.

Cirsium arvense (L.) Scop.

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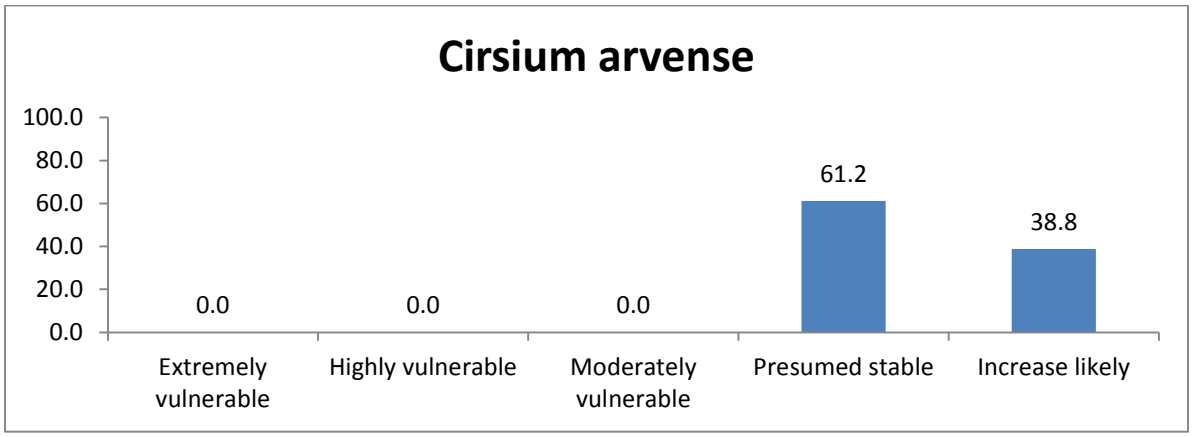

Figure 27: Cirsium arvense is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement				N	SD	D
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence				N	SD	D
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat			SI	N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation				N	SD	
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 25: Cirsium arvense may not be vulnerable to changes in climate, based on its biology and ecology.

Insights of experts

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General

Cirsium arvense is a non-native, invasive perennial herb widespread across North America. The plant is dioecious and spreads by rhizomes.

Climate conditions & phenology

Based on its range across North America, experts feel that *Cirsium arvense* is sensitive to warm conditions and could decrease if Illinois temperatures increase.

The plant prefers wetter habitats and does not thrive in dry conditions or under periods of dry weather or drought. It is wind-dispersed.

Canada thistle flowers in early summer, but will re-flower if mowed, sprayed, or if developing inflorescences killed by prolonged drought. The species is insect pollinated, but there are so many pollinators that any changes in bloom phenology are unlikely to change its reproductive success.

Dispersal, movement & genetics

Canada thistle's seeds are light and wind dispersed with good potential to move tens to hundreds of meters from parent plants. It is a weed of human disturbed areas, so dispersal is likely further facilitated by movement on mowing machinery, stuck to clothes and shoes, contaminated crop seed, etc. The plant can also grow from root fragments.

Little is known about the genetic diversity of this plant in Illinois. It may have been introduced to the state multiple times, increasing its chance of having higher genetic diversity.

Abiotic conditions: disturbance, soils, geology

Cirsium arvense is a soils generalist, with some preference for more nutrient-rich, loamy soils. It is salt-tolerant and can survive in areas with periodic flooding. It does well with disturbances of any kind.

Biotic interactions

This plant is able to invade natural communities including sedge meadow, prairie, even marsh. It requires full sun. It tends to be less common in high quality plant communities.

The species is insect pollinated by a very wide range of pollinators from multiple orders. This plant is functionally dioecious and the rate of self-pollination is likely to be low to almost-nonexistent.

Cirsium arvense can be infected with the rust fungus, *Puccinia punctiformis*, that may slightly decrease the species' performance, but because of the clonal, long-lived nature of the species, this rust is unlikely to make much of an impact unless the plants are really stressed.

Bibliography

Slotta, Tracey A., Michael E. Foley, and David Horvath. "Development of polymorphic markers for Cirsium arvense, Canada thistle, and their amplification in closely related taxa." Molecular Ecology Notes 5.4 (2005): 917-919.

Solé, Magali, et al. "Genotypic and genetic diversity of the common weed Cirsium arvense (Asteraceae)." International Journal of Plant Sciences 165.3 (2004): 437-444.
Zouhar, Kris 2001. Cirsium arvense. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 23].

Cirsium pitcheri (Torr. ex Eaton) Torr. & A. Gray

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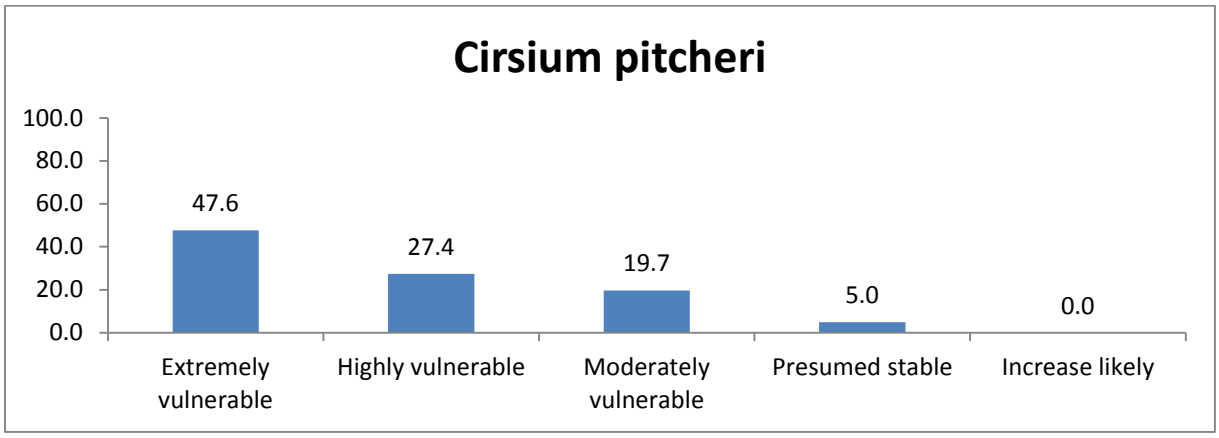

Figure 28: Cirsium pitcheri is categorized as Extremely Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers	GI	I	SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche	GI	I	SI	N		
Historical hydrological niche		I				
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence		I	SI	N	SD	
Ice/snow			SI	N		
Geology/soils		I	SI	N		
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions			SI	N		
Genetic variation		I	SI			
Genetic bottlenecks			SI	N		
Phenological response			SI	N		

Table 26: Cirsium pitcheri may be vulnerable to predicted climate changes due to its inabilities to cross natural and anthropogenic barriers, its dispersal abilities, and its physiological thermal niche. In addition, it may be vulnerable due to its historical and physiological hydrological niches, its dependence on disturbance, its soil preferences, and its low genetic diversity.

Little is known about the abilities of this plant to cross natural or anthropogenic barriers, its dispersal abilities, its physiological thermal niche, its physiological hydrological niche or its disturbance dependence.

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General

Cirsium pitcheri is a federally threatened monocarpic perennial that is endemic to Great Lakes sand dunes. It is a rare species adapted to deep sands along the Great lakes. It was extirpated and reintroduced in Illinois. Introduced weevils drastically decrease the seed production of this plant.

Climate conditions & phenology

Climate envelope modeling suggests that populations in Illinois, Indiana and southernmost Wisconsin and Michigan will not persist to the end of this century.

Some experts do not feel that changes in temperature will be problematic for *Cirsium pitcheri*, given that it experiences large swings in temperature on a daily basis. However, seedling establishment and early growth are negatively impacted by high temperatures. The plant tracks average daily temperature (or a correlate), flowering much later in years with average cold days than average warm days. Researchers used approximately twenty years of demographic data to determine that *Cirsium pitcheri* survival significantly decreases with average growing season temperature.

Using twenty years of demographic data, researchers have determined that *Cirsium pitcheri* survival was not significantly affected by average growing season precipitation. In drought years, according to this dataset, there is reduced or no recruitment. Most of the seedlings germinated in a given year will die if rains are rare in June through September. However, one expert speculates that during wet years, the plant may experience more negative effects of competition. Seedlings are very vulnerable to late season drought. Another expert feels that, given that the plant occurs on the driest and best-drained sand dunes, the plant may not be affected by changes to precipitation.

Predictions exist forecasting increasing wind speeds on Lake Superior; it is unclear whether the same will be true on Lake Michigan. Increases in wind may decrease survival through desiccation. On the other hand, in areas where the dunes are primarily kept open by wind, *Cirsium pitcheri* may have a better chance of long-term survival, excluding other climatic factors. In addition, the seeds of this plant are wind-dispersed.

Changes in lake water levels could also affect this species. If lake levels were to fall, they could allow for slight range expansion as more exposed sand is made available. This may help the plant migrate north, though it might leave Illinois. In some portions of its range, ice heaves are a way that dunes are set back, in terms of succession, which benefits *Cirsium pitcheri*.

Dispersal, movement & genetics

The seeds of this plant are large and median dispersal distance for the seeds is around 1.5 meters; they may be dispersed many meters when wind blows and rolls entire seed heads. Barriers between sand dune areas essentially preclude any dispersal attempt that the plants may try. The dunes are pollinator-poor and *Cirsium pitcheri* does not self well. It will self under some conditions, but the resulting seed is smaller and less likely to successfully germinate.

Cirsium pitcheri in Illinois has very low genetic diversity. Many populations are suffering from inbreeding depression. Southern populations of this plant will experience founder effects.

Abiotic conditions: disturbance, soils, geology

This plant is dependent on the natural disturbance of shifting sand dunes. Increases in wind speed and greater intensity storms could aid *C. pitcheri* because it is an early-successional dune species. However, greater wind speeds could desiccate seedlings of this plant.

Biotic interactions

Cirsium pitcheri is not competitive in dense vegetation and requires 70% open sand for establishment. This could be particularly problematic if climate changes benefit dune invasives more than they benefit *Cirsium pitcheri*. This plant colonizes disturbed habitat on foredunes and decreases slowly with increasing succession. Since *Schizachyrium scoparium*, the dominant late successional grass, is a C4 plant, it may grow faster at higher temperatures projected for Illinois and increase the rate of succession.

Cirsium pitcheri is very much a generalist in terms of pollination. It has a wide variety of pollinators (>10 species). However, the dunes are very pollinator poor. Many florets end up without successful development simply because of insufficient pollination. Therefore, while there are many species that can pollinate the plant, missing any of them would potentially cause decreases in seed set. Halictid and bumble bees are the most effective pollinators.

In addition, the species faces threats from an assortment of introduced insects that decrease seed production limiting the ability of *C. pitcheri* to disperse and to adapt to potential changes.

The interactions with the non-native weevils really decrease seed production which makes the species more vulnerable to many other threats, including climate change. Goldfinches also prey on the seeds of this plant.

Bibliography

Bell, T. J., M. L. Bowles, and A. K. McEachern. "Projecting the success of plant population restoration with viability analysis." Population viability in plants. Springer Berlin Heidelberg, 2003. 313-348.

Cirsium pitcheri Restoration Project website: http://www.pitchersthistle.org/research/mol_gens.php

Fant, Jeremie B., et al. "Genetics of reintroduced populations of the narrowly endemic thistle, Cirsium pitcheri (Asteraceae) 1." Botany 91.5 (2013): 301-308.

Fant, J.B., K. Havens, J.M. Keller, A. Radosavljevic and E.D. Yates. 2014. Glacial migration, biogeography and genetics of a narrow endemic thistle, Cirsium pitcheri (Asteraceae). Heredity. Available online doi: 10.1038/hdy.2013.134.

Gauthier, Martha, et al. "Conservation genetics of Pitcher's thistle (Cirsium pitcheri), an endangered Great Lakes endemic." Botany 88.3 (2010): 250-257.

Havens, Kayri, et al. "Effects of a non-native biocontrol weevil, Larinus planus, and other emerging threats on populations of the federally threatened Pitcher's thistle, Cirsium pitcheri." Biological Conservation 155 (2012): 202-211.

Staehlin, Benjamin M., and Jeremie B. Fant. "Climate Change Impacts on Seedling Establishment for a Threatened Endemic Thistle, Cirsium pitcheri."The American Midland Naturalist 173.1 (2015): 47-60.

Vitt, Pati, et al. "Assisted migration of plants: changes in latitudes, changes in attitudes." Biological conservation 143.1 (2010): 18-27.

Corylus americana Walter

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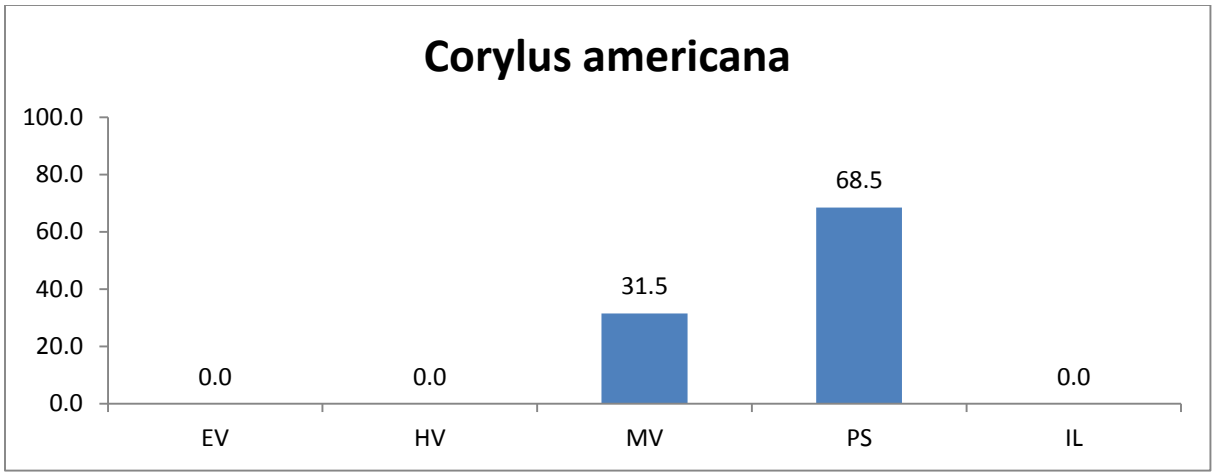

Figure 29: Corylus americana is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N		
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N		
Disturbance dependence			SI	N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat			SI	N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 27: Corylus americana may be vulnerable to predicted changes in climate due to its inability to cross anthropogenic barriers and its dispersal abilities.

Little is known about the genetic diversity of this plant in Illinois.

Insights from experts

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General

Corylus americana is a very widespread species that likely was very common prior to conversion of our landscape to row-crop agriculture. It seems to have done well from forests to savannas to open prairies, but now exists in fragmented patches of habitat on the landscape. The tree is also rather wide ranging also outside of the state.

Climate conditions & phenology

While American hazelnut's distribution across North American does extend to the south of Illinois, it does not extend all the way to the Gulf of Mexico. Based on this distribution, experts feel that the plant may survive warmer temperatures, but that if it gets very much warmer, the shrub may not do well.

This species grows best on rich, moist, well-drained soils but it can also be found along streams and on the open prairie. Occasionally it is found on drier sites. It is not often seen if very wet areas. It might not fare well with periods of dry weather or drought.

Dispersal, movement & genetics

Flowers of *Corylus americana* are wind pollinated, but both staminate and pistillate flowers are often on the same plant; but shaded plants tend to produce only staminate flowers. Fruit set seems to have declined – possibly due to small populations or blight or insect larva; some historical data seems to indicate that hazelnut at one time produced an abundance of viable seed. Present day populations seem to be spread by vegetative reproduction and can form extensive stands through root-sprouting. The seeds of this shrub are dispersed by rodents, jays and other animals.

American hazelnut seems to have done well from forests to savannas to open prairies, but now exists in fragmented patches of habitat on the landscape. Natural barriers are probably not a problem for this species. Anthropogenic barriers that might limit movement of hazelnut; it cannot migrate through forests or agricultural lands. A loss of dispersal agents could be partially responsible for the decline in this shrub.

Little is known about the genetics of this plant in Illinois. It is widespread but is not a fast reproducer.

Abiotic conditions: disturbance, soils, geology

This species grows best on rich, moist, well-drained soils but it can also be found on a wide range of soil types that are moist to well-drained.

The species readily sprouts from roots if woody stems are killed or removed by browsing, fire, or mechanical means. It can tolerate some flooding, but prolonged and regular flooding will result in eventual death. It does well with disturbances in forests, so greater storm intensity and tree blowdowns could help it by opening the forest canopy.

Biotic interactions

Corylus americana is a shrub of woodlands, savannas, and forms thickets on prairies and in fence lines and edge habitats; it will persist in deep shade under closed canopies.
It is likely that seeds of American hazelnut are dispersed by several species of mammals and birds, but there is no observational or experimental evidence showing how far. The heavy seeds likely fall close (a meter or less) to the parent plant. One expert has observed that it is difficult to find ripe seeds on hazelnut likely because animals have already eaten or carried them away. This species has high and low years for fruit production. The loss of prairie and forest rodents may contribute to a loss of this shrub.

Bibliography

Coladonato, Milo. 1993. Corylus americana. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 23].

Cypripedium candidum Muhl. ex Willd.

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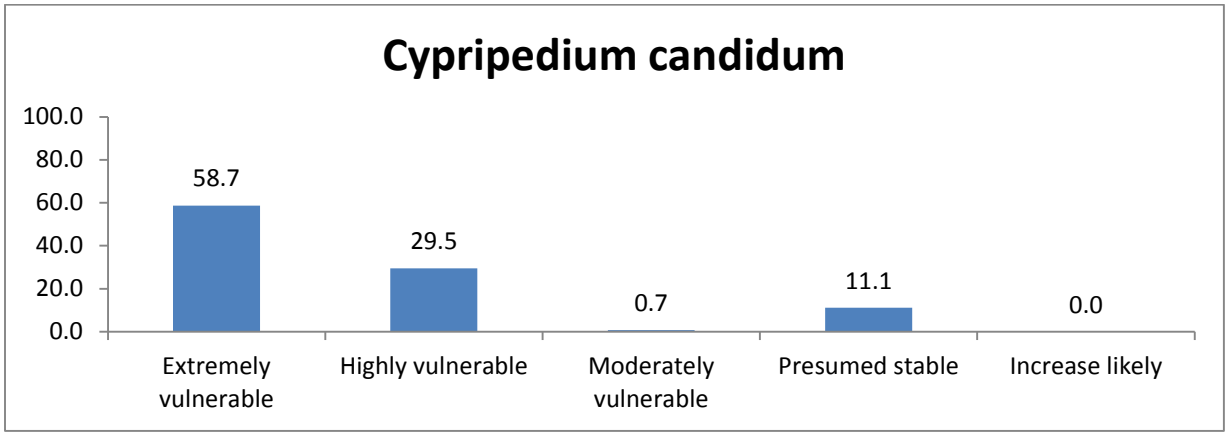

Figure 30: Cypripedium candidum is categorized as Extremely Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers	GI	I	SI			
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche		I	SI	N		
Historical hydrological niche		I				
Physiological hydrological niche	GI	I	SI	N	SD	
Disturbance dependence		I	SI	N	SD	D
Ice/snow			SI	N		
Geology/soils		I	SI	N	SD	D
Other spp for habitat		I	SI	N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions		I	SI	N		
Genetic variation			SI			
Genetic bottlenecks			SI	N		
Phenological response			SI	N	SD	

Table 28: Cypripedium candidum may be vulnerable to predicted climate changes due to its inability to cross natural or anthropogenic barriers, its physiological thermal niche, and its historical and physiological hydrological niche, its dependence on disturbance, its soil preferences, its dependence on other species to create its habitat and its dependence on other interspecific interactions.

Little is known about this plant's dispersal abilities, its physiological hydrological niche, and its dependence on disturbance or its soil preferences.

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General

Cypripedium candidum is a long-lived herbaceous perennial. In Illinois it is found in prairies and fens; elsewhere, it is reported from bogs. Most populations are extirpated, especially historic localities in central Illinois; most of remaining populations are protected; many are managed. The species now occurs primarily in the northwestern areas of its historic range. It's unclear whether this is the result of temperature conditions or occurrence of appropriate habitat.

Climate conditions & phenology

This plant may be sensitive to increasing temperatures. It does exhibit some temporal adaptations to mitigating drought stress—by leafing out and flowering early in the year and senescing during hot summer months.

Cypripedium candidum is also sensitive about its hydrology. Where this species occurs in non-groundwater fed wet prairies, it is vulnerable to increased drought. Where the species occurs in ground-water fed fen communities, it may be buffered from increased drought. The plant does form mycorrhizal associations, which may increase its water use efficiency.

POC's 14 year dataset for the Chicago region shows that we are tending to find plants in flower past the end bloom date listed in the literature and anecdotally it looks like this is happening more frequently than it did in the early 2000's, but this is not statistically significant. (Start bloom dates from POC's dataset are not a reliable indicator since monitors often do not visit populations until at least the literature-derived bloom date.) Project BudBurst has found that plants are accelerating their bloom dates in the Chicago region, but they do not track *Cypripedium* in particular. POC's data may indicate a longer bloom window if plants are also blooming earlier.

Dispersal, movement & genetics

Dust-like seeds can be wind dispersed, but must find suitable habitat. There is no evidence that this plant establishes outside of its remnant population sites. In Illinois this orchid is most often found in calcareous groundwater-influenced wetlands and prairies and such areas are not common across the landscape. The availability of the plant's fungal partner may also limit successful establishment of plants. The plant can also spread vegetatively through relatively short rhizomes.

Little is known about the genetic diversity of *Cypripedium candidum* in Illinois. According to Case (1994), *C. candidum* (sampled in Michigan) had low heterozygosity at a large number of polymorphic loci. Overall *Cypripedium* were found to have more gene flow among populations than was expected. Results suggest that a genetic bottleneck occurred at some point, and that populations may be vulnerable to climatic change, but note that no Illinois plants were sampled in the study.

Abiotic conditions: disturbance, soils, geology

This plant most often occurs in Illinois in calcareous ground water influenced wetlands and prairies. Fire would help eliminate competition which could benefit this species.

Biotic interactions

Plants rely on open prairie habitat with little competition; they are not reliant on a specific nurse plant to establish. Individual plants can persist in the shade of invading shrubs or non-native grasses, reappearing after management.

The plant requires a mycorrhizal soil fungus to germinate. One study found that some individuals were associated with fungi in the family Tulasnellaceae. Mycorrhizal associations may also increase the plant's water use efficiency. Mycorrhizae may be affected by excess nutrients in the soil; under more droughty conditions, this could render *Cypripedium candidum* more vulnerable.

Cypripedium candidum seems to depend on small andrenid and halictine bees for pollination, but perhaps many species in these groups.

Bibliography

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(4), 14-37.

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, 175-184.

Catling, P. M., & Knerer, G. (1980). Pollination of the small white lady's-slipper (Cypripedium candidum) in Lambton County, Southern Ontario. Canadian Field-Naturalist, 94(4), 435-438.

Klier, K., M. J. Leoschke, and J. F. Wendel. "Hybridization and introgression in white and yellow ladyslipper orchids (Cypripedium candidum and C. pubescens)." Journal of Heredity 82.4 (1991): 305-318.

Nies, A. (2014). Excess and Limitation of Soil Resources in Illinois Communities of Cypripedium candidum (Orchidaceae), the Unexpected Relationship Between Soil Character, Mycorrhizal Colonization and Photosynthesis (Doctoral dissertation, CHICAGO BOTANIC GARDEN).

Shefferson, R. P., WEIß, M., Kull, T., & Taylor, D. (2005). High specificity generally characterizes mycorrhizal association in rare lady's slipper orchids, genus Cypripedium. Molecular Ecology, 14(2), 613-626.

Dalea foliosa (A. Gray) Barneby

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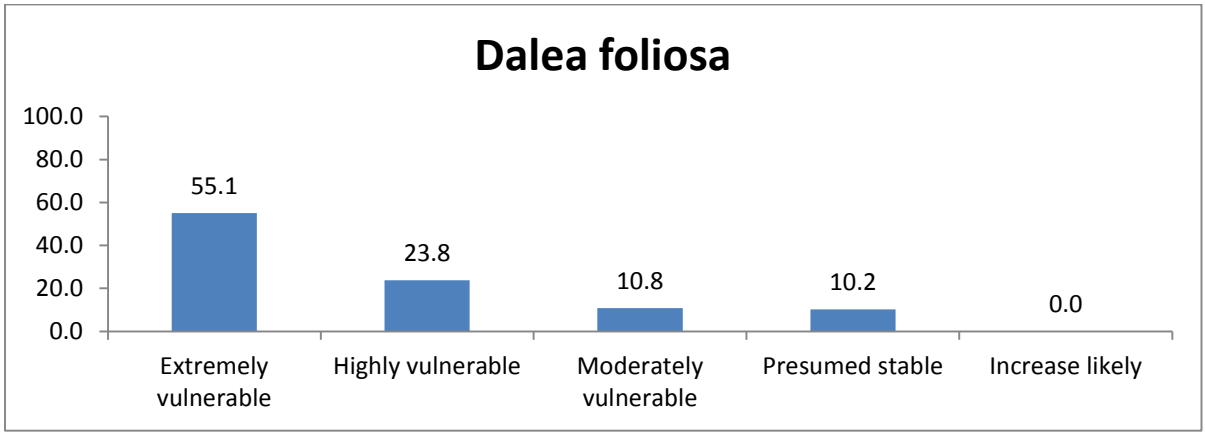

Figure 31: Dalea foliosa is categorized as Extremely Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers	GI	I	SI	N		
Anthropogenic barriers	GI	I	SI			
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI	N		
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche		I				
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence		I	SI	N	SD	
Ice/snow	GI	I	SI	N		
Geology/soils		I	SI	N		
Other spp for habitat		I	SI	N		
Other spp for pollination			SI	N		
Other spp for dispersal			SI	N		
Other spp interactions			SI	N		
Genetic variation		I	SI	N		
Genetic bottlenecks		I	SI	N		
Phenological response			SI	N	SD	

Table 29: Dalea foliosa may be vulnerable to predicted climate changes due to its inability to cross natural and anthropogenic barriers as well as its dispersal abilities, its historical and physiological hydrological niches, its dependence on disturbance, and ice and snow, its soil preferences, its dependence on other species to create its habitat and its low genetic diversity.

Little is known about the ability of this plant to cross natural barriers, its dispersal abilities, its physiological hydrological niche, its dependence on disturbance or on its dependence on ice, snow or snow-covered habitats.

Insights from experts

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General

Dalea foliosa is a short-lived perennial, individual plants rarely persist more than 5-7 years, though the plant does have a seedbank. Apparently, this plant arrived after glaciation when habitat opened up for it and migrated from the south to its current populations. *Dalea foliosa* is very habitat dependent, has greatly declined in the last century, both as a result of habitat loss as well as increased foraging by deer and other browsers.

Climate conditions & phenology

The temperatures in Illinois may need to change quite a bit to have much of an effect on *Dalea foliosa* in Illinois. However, high temperatures could affect the establishment of seedlings due to mortality. Several studies have shown that this is the most vulnerable stage for this species.

An increase in precipitation may cause an increase in competition from other plant species and may increase the plant's dependence on fire. In addition, *Dalea foliosa* does not tolerate prolonged inundation. During late-summer droughts this plant still grows when other species have gone dead or dormant. On the other hand, drought could affect the establishment of seedlings due to mortality. Several studies have shown that this is the most vulnerable stage for this species. One expert speculates that with a decrease in growing-season rainfall, this plant might become extinct in Illinois. Recruitment of seedlings appears highest when populations are subject to heavy mid- and late summer downpours (with protection from deer).

Under excellent conditions seedlings may flower late in its first growing season.

Dispersal, movement & genetics

Dalea foliosa is dispersed by wind, gravity, birds, and small mammals. However, it is restricted to rare dolomite prairie which is surrounded by non-habitat or agriculture and is presently probably unable to increase its range or migration patterns in Illinois.

Populations of *Dalea foliosa* in Illinois do not have much genetic variation.

Abiotic conditions: disturbance, soils, geology

In northeastern Illinois, *Dalea foliosa* is largely restricted to dolomite prairie communities, sometimes growing where soil is <6 cm deep above bedrock. Populations also occur southeast of Illinois in limestone & dolomite glades in Tennessee and northern Alabama. It is unclear whether this plant depends on the soil itself or the lack of competition that occurs on these soil types.

Due to its need for reduced competition, this species does well with fire or grazing. An increase in precipitation may cause an increase in competition from other plant species, leaving *Dalea foliosa* even more dependent on fire or grazing.

Biotic interactions

Dalea foliosa is capable of self-pollination and is pollinated by many different insects. It may be most successfully pollinated by bumblebees. Dispersal is done by wind and gravity and possibly also birds, small mammals, rabbits and deer. This plant forms root associations with mycorrhizal fungi and nitrogen-fixing rhizobium.

Browsing by deer or rabbits is a big issue with this species. If the population of these herbivores goes up, could result in too much browsing and the species may not be able to compensate. Currently, many plants are caged in the wild to prevent animals from eating them.

It requires full sun and is easily outcompeted by shading.

Bibliography

Edwards, A. L., Wiltshire, B., & Nickrent, D. L. (2004). Genetic diversity in Astragalus tennesseensis and the federal endangered Dalea foliosa (Fabaceae). Journal of the Torrey Botanical Society, 279-291.

Molano-Flores, B. (2004). Reproductive success of the federally endangered leafy prairie clover, Dalea foliosa (A. Gray) Barneby (Fabaceae) in Illinois: a third year of data. Castanea, 69(1), 9-14.

Molano-Flores, B., & Bell, T. J. (2012). Projected population dynamics for a federally endangered plant under different climate change emission scenarios.Biological Conservation, 145(1), 130-138.

U.S. Fish and Wildlife Service. (1996). Leafy prairie clover recovery plan.US Fish and Wildlife Service, Atlanta, Georgia.

Desmanthus illinoensis (Michx.) MacMill. ex B. L. Rob. & Fernald

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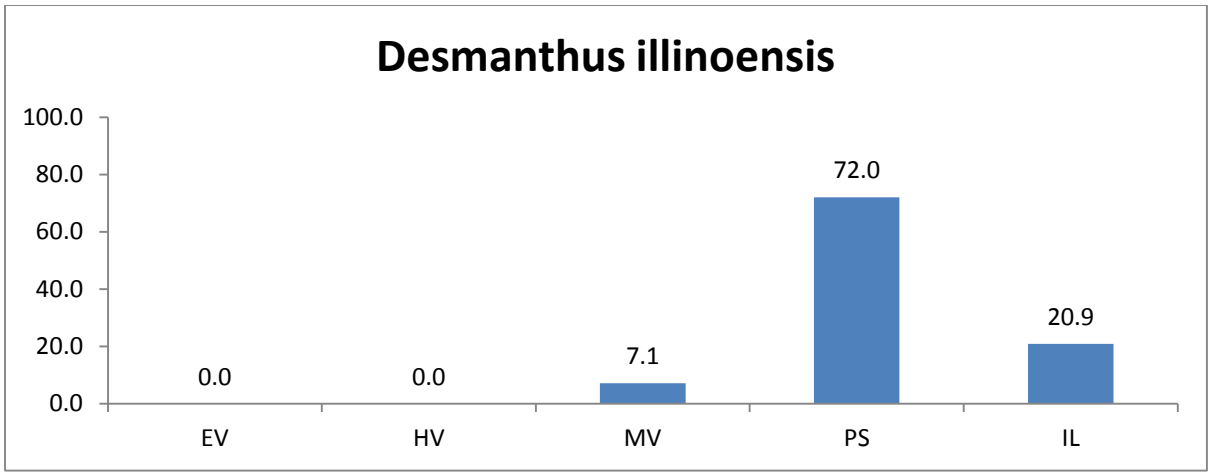

Figure 32: Desmanthus illinoensis is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers	GI		SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence			SI	N	SD	D
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation				N		
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 30: Desmanthus illinoensis may be vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers and its dispersal abilities.

Little is known about the ability of this plant to cross anthropogenic barriers, the dispersal abilities of this plant, or its dependence on disturbance.

Insights from experts

Contributing experts:
James Ellis, Illinois Natural History Survey
William C. Handel, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

Desmanthus illinoensis is a scattered and locally common perennial forb of well-drained prairies and savannas, which becomes weedy in southern Illinois. It is used in restoration plantings as food for quail and turkey so its distribution in Illinois has increased greatly over the last 30 years. It has become very common on interstate rights-of-way in southern Illinois.

Illinois bundleflower was used by several native tribes to treat eye infections. It was also used as a toy (rattle). This plant seems to be very common in areas of possible large settlements such as the American Bottoms near East St Louis.

Climate conditions & phenology

Desmanthus illinoensis seems to like warmer climates and would probably benefit from warmer, longer seasons. It is a summer bloomer and flowers abundantly until conditions become too cold or dry.

While this plant seems to do equally well in dry and moist environments, it does also show a preference for well-drained to dry soils.

Dispersal, movement & genetics

Seed of this plant are small, smooth, relatively heavy beans. That likely fall a few meters from the parent plant as it is knocked about in the wind. However, the plant seems to have no problem dispersing. It seems to be well-adapted to moving along railroad and highway corridors. It may be distributed by roadbuilding and maintenance machinery and in hay. However, Illinois bundleflower is widely planted and it is difficult to tell exactly how it disperses outside of human influences.

The genetic variation in this species is sufficient and compares favorably to other members of its subfamily.

Abiotic conditions: disturbance, soils, geology

Illinois bundleflower is often found on sandy soils, and sometimes on rocky or gravelly soils. It is intolerant of poor drainage and is susceptible to pathogens in saturated soils.

This plant seems to thrive in areas with low levels of soil disturbance or does well a year or two after a disturbance event. It tolerates low levels of mowing or grazing but does not persist under high levels of either.

Biotic interactions

This plant can be found in well-drained prairies and savannas and will sometimes persist in pastures and roadsides. It needs full sun, usually with no plants around which are taller than it is.

Flowers of Illinois bundleflower are visited by a variety of generalist insect pollinators, especially bees. Self-pollination is also likely. At least one author has observed successful seed set from self-pollination. Fruits (loments) of this plant are dispersed by animals, probably including birds.

The plant is often subjected to considerably herbivory from Japanese beetles, which may prevent seed production. Many authors have noted that this species is preferred by grazing animals like cattle; the plant does not persist under heavy grazing.

Bibliography

Kulakow, P. A. (1999). Variation in Illinois bundleflower (Desmanthus illinoensis (Michaux) MacMillan): a potential perennial grain legume. Euphytica, 110(1), 7-20.

Latting, J. (1961). The biology of Desmanthus illinoensis. Ecology, 487-493.

Desmodium illinoense A. Gray

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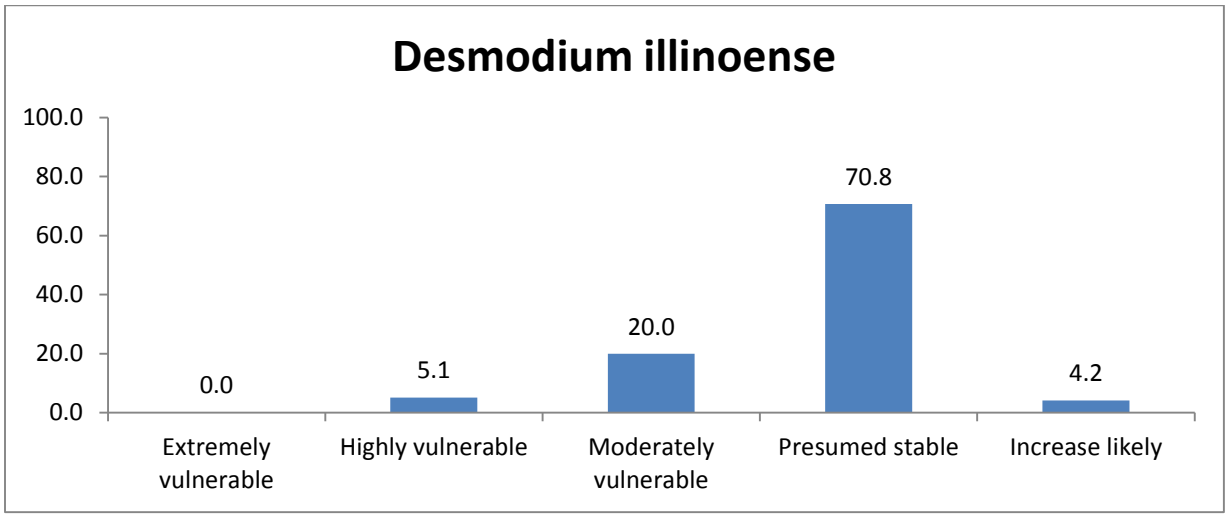

Figure 33: Desmodium illinoense is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal			SI	N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 31: Desmodium illinoense may be more vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers.

Little is known about the genetic diversity of this plant in Illinois.

Insights from experts

Contributing experts:
James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey

General

Desmodium illinoense is a true tallgrass prairie species. Today it can be found in both high-quality and degraded prairie remnants. It is at the northern edge of its range in Illinois. The plant is a perennial herb that may be long-lived.

Climate conditions & phenology

This plant does not like extreme cold or extremely hot conditions. It has relatively good drought tolerance and would likely do well under conditions with periodic dry weather or drought.

The plant flowers over a long period.

Dispersal, movement & genetics

Illinois tick trefoil has small fruits covered in hooked hairs—the original Velcro. While this plant is potentially a good disperser, the fragmented state of Illinois' landscape may prevent much actual long-distance dispersal. It may be dispersed with mowing as well.

Little is known about the genetic diversity of this plant in Illinois. Experts speculate that since it is common and widespread, it may be genetically diverse.

Abiotic conditions: disturbance, soils, geology

Desmodium illinoense occurs on a wide variety of soils, but not poorly drained or wet soils. The plant has relatively good drought tolerance.

Illinois tick trefoil is adapted to disturbance, but may decrease with annual prescribed fire. Plants that are browsed or mowed will resprout and flower again.

Biotic interactions

Illinois tick trefoil occurs in natural habitats, usually 'non-typical' prairie remnants growing over bedrock (dolomite, limestone, sandstone) or in floodplains. It is also able to colonize and spread in roadsides and pastures. It is a nitrogen fixer so it can grow in very poor soils.

This plant is animal dispersed. It depends on several species of long-tongued pees for pollination.

Bibliography

Towne, E. G., & Knapp, A. K. (1996). Biomass and density responses in tallgrass prairie legumes to annual fire and topographic position. American Journal of Botany, 175-179.

Dioscorea polystachya Turcz.

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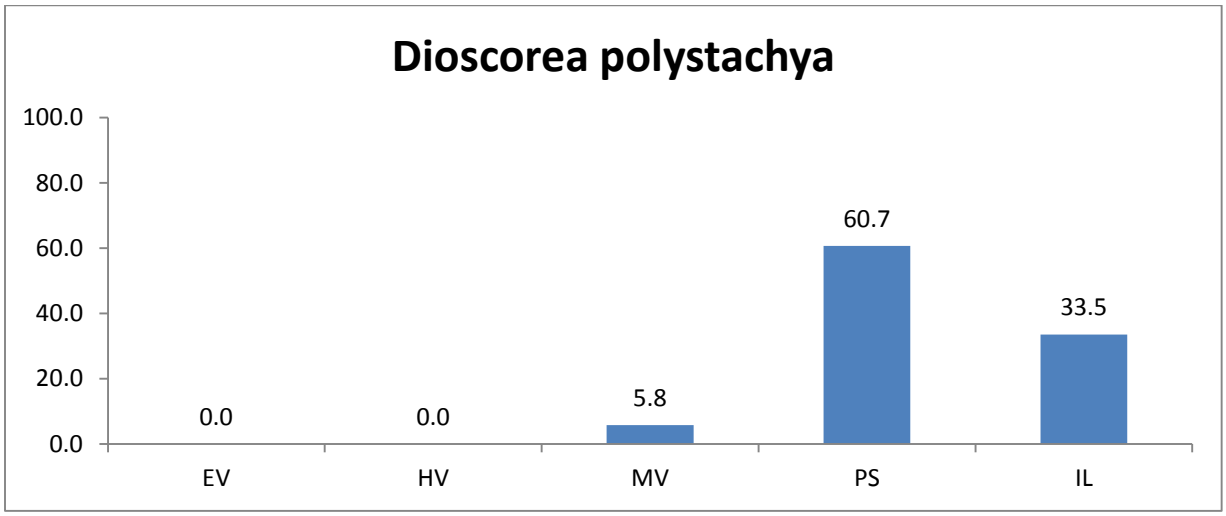

Figure 34: Dioscorea polystachya is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N		D
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation				N		
Genetic bottlenecks		I	SI	N		
Phenological response				N	SD	

Table 32: Dioscorea polystachya may be vulnerable to predicted changes in climate due to its having experienced genetic bottlenecks.

Little is known about the dispersal abilities of this plant.

Insights from experts

Contributing experts:
Connie Cunningham, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey

General

Dioscorea polystachya is a non-native herbaceous perennial vine. It can be a vigorous invader, effectively climbing and shading vegetation beneath.

Climate conditions & phenology

This plant prefers warm conditions and is sensitive to late or early frost, which can kill an entire stand back to the ground.

Dioscorea polystachya shows some preference towards the wetter end of the soil moisture spectrum.

Dispersal, movement & genetics

This plant is dispersed vegetatively, through underground and aerial tubers, or bulbils. In a study in southern Illinois, most bulbils fell within 10 meters for the source population. The bulbils are water dispersed and may also be dispersed by humans and rodents.

Little is known about the genetic diversity of this species in Illinois. Given that all of its reproduction in Illinois is vegetative, experts expect low diversity. This would depend on the number of times individuals were introduced to the state.

Abiotic conditions: disturbance, soils, geology

Chinese yam is found on a variety of soil types. It is well-adapted to disturbance, and increases in flood events could help this species spread. It may do well with fire too.

Biotic interactions

Dioscorea polystachya likes open areas along hedgerows; it generally climbs on something and is associated plants or fences. It is not pollinated or fertile in Illinois. This plant may be spread by rodents, but those rodents may also reduce bulbil viability, based on research done in Japan.

Bibliography

US Department of Agriculture. Fire Effects Information System. Accessed July 2015. http://www.feis-crs.org/beta/

Dipsacus laciniatus L.

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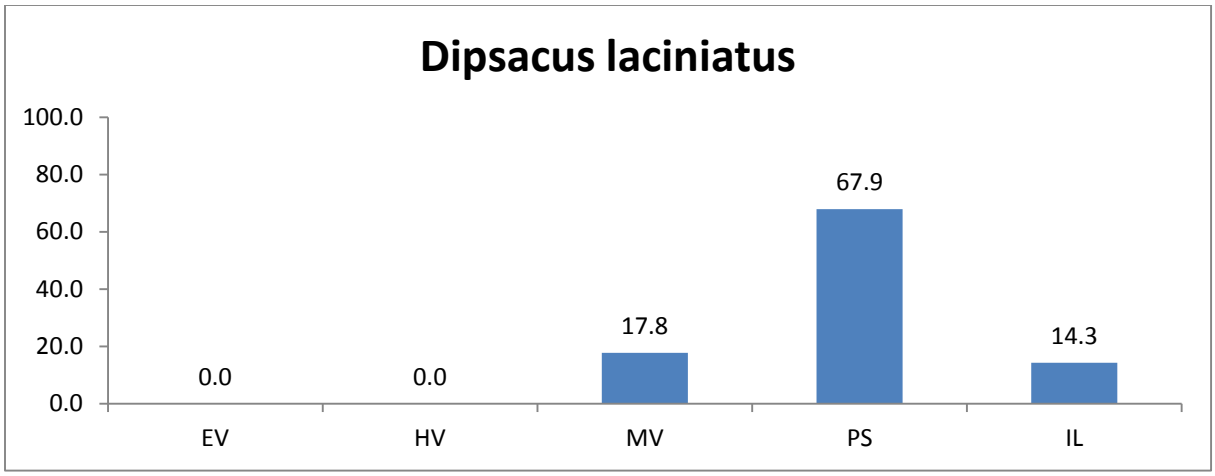

Figure 35: Dipsacus laciniatus is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers		I		N		
Anthropogenic barriers			SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI		SD	D
Historical thermal niche				N		
Physiological thermal niche			SI	N		
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	D
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat			SI	N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 33: Dipsacus laciniatus may be made vulnerable to predicted climate changes due its inability to cross natural barriers and its dispersal abilities.

Little is known about the dispersal abilities of this plant, or its genetic diversity in Illinois.

Insights from experts

Contributing experts:
James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Paul Marcum, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Eric Ulaszek, Illinois Natural History Survey

General

Dipsacus laciniatus is an extremely common non-native invasive biennial herb that reproduces by seed and has a persistent seedbank.

Climate conditions & phenology

Cutleaf teasel is tolerant of late and early frosts and may be tolerant to a wide range of temperatures, possibly with a slight preference for cooler rather than warmer conditions. It can tolerate dry and moist soil conditions. It can grow in wetlands but rarely becomes dominant as it will in upland habitats; rosettes tolerate short-term inundation.

This plant blooms in mid-summer.

Dispersal, movement & genetics

Morphological features and field studies show that the seeds of teasel generally disperse less than 2 meters from parent plants. However, teasel may be best dispersed on mowing equipment. Its dispersal may be limited by row-crop agriculture, highways and urban areas.

Little is known about the genetic diversity of this plant in Illinois.

Abiotic conditions: disturbance, soils, geology

This plant likes neutral and calcareous soils, which are very common in Illinois. It prefers moist conditions and can grow in wetlands.

Frequent mowing prevents flowering, although rosettes may persist for several years. Plants mowed just before or during flowering readily resprout, flower and set seed before the end of the growing season. It can increase with fire.

Biotic interactions

This plant is highly invasive in open habitats, especially prairies and savannas.

The plant is pollinated by butterflies, flies and bees, including bumblebees. It requires cross pollination.

Bibliography

Gucker, Corey L. 2009. Dipsacus fullonum, D. laciniatus. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 24].

Dodecatheon meadia L.

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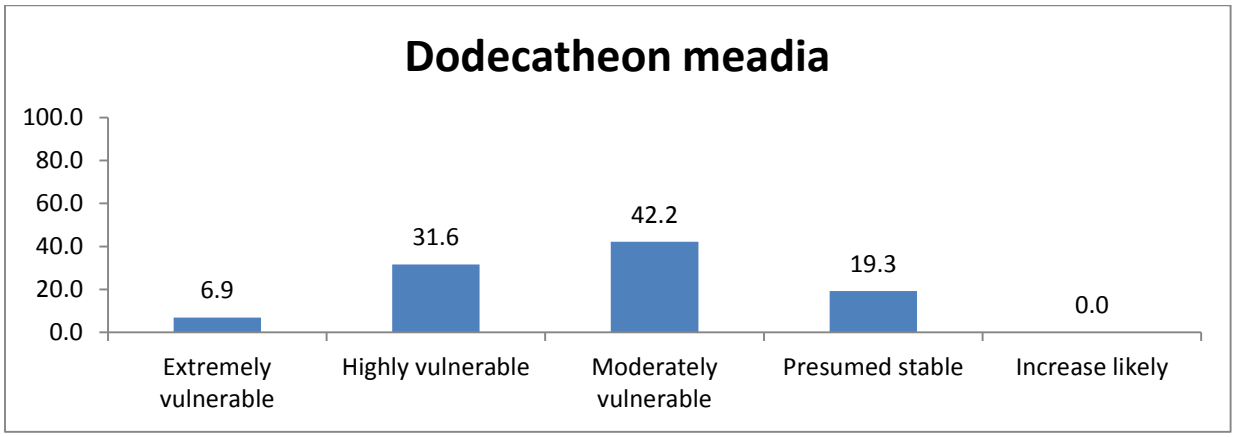

Figure 36: Dodecatheon meadia is categorized as Moderately Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers	GI	I	SI			
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI			
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N		
Disturbance dependence			SI	N	SD	
Ice/snow				N		
Geology/soils				N	SD	
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal			SI	N		
Other spp interactions			SI	N		
Genetic variation				N	SD	
Genetic bottlenecks				N		
Phenological response			SI	N	SD	

Table 34: Dodecatheon meadia may be vulnerable to predicted changes in climate due to its inability to cross natural and anthropogenic barriers and its dispersal abilities.

Insights from experts

Contributing experts:

Connie Cunningham, Illinois Natural History Survey
James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
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Eric Ulaszek, Illinois Natural History Survey
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General

Dodecatheon meadia is a long-lived, cespitose forb that is widespread in Illinois and beyond. It occupies a diverse range of habitats from moist sheltered cliffs in Minnesota to exposed glades in central Texas. Some varieties are associated with particular geographic features. The seedling stage may be the most vulnerable for this species, perhaps requiring reliable water. During the first growing season aboveground, the plant produces two cotyledons, and small rosette of true leaves following year. Individual plants rarely flower before fifth growing season, although they can flower earlier in optimum conditions in culture.

Climate conditions & phenology

The range of climatic conditions across this plant's distribution is very broad and it is unlikely to be sensitive to any particular changes in climate condition within Illinois. However, late frosts (especially following mild winters and early springs) can damage developing flower buds. This kind of climate event would be the most detrimental to this species. Plants will go dormant when temperatures are hot, but have masses of tuberous roots for food and water storage.

Dodecatheon meadia has a fairly broad range in moisture tolerance. This plant is found in mesic to dry-mesic prairies and forests and may do well on the drier end of the soil moisture spectrum. It requires spring rains.

Dodecatheon meadia is a spring ephemeral. This habit is defined by seasonal growth and sensitivity to climatic cues. Herbarium records demonstrate variation in the timing of development, flowering and senescence within sites and across its range, but no formal studies have been conducted. One expert has made observations leading him to conclude that this species may adjust its phenology with climate change, but that may not be true of its bumblebee pollinators. The plant flowers in spring (late April-May), goes dormant by early July, and fruits ripen July-early August. Its seeds have cold dormancy and germinate in the spring, following dispersal.

Dispersal, movement & genetics

These plants lack any apparent adaptation for dispersal, but their seeds are small and colonies grow in far-flung places. The contemporary distribution suggests that under favorable conditions this species can disperse well. Seeds are tiny and plants are usually found in local patches or colonies which are widely separated and isolated from one another.

In Illinois and elsewhere there is little population subdivision and abundant opportunities for gene flow to promote the spread of warm-adapted alleles as the climate changes. *Dodecatheon meadia* in Illinois exhibit high levels of within-population variation in AFLPs and very little population structure in the sense of between-population variation. Chloroplast DNA sequence variations from southern Illinois populations exhibit a similar pattern. These data suggest that genetic connectivity between populations was high and that apparent fragmentation today has not resulted in substantial drift.

This species is restricted to natural habitat fragments within the mostly agricultural landscape of Illinois. For instance it occurs in several prairie fragments in central Illinois. It also grows on cliffs and in open forests in some of the more contiguous areas of natural habitat in the Shawnee Hills and along the Mississippi and Illinois Rivers. The fact that populations have remained in some small and isolated patches and have maintained high within-population genetic variation suggests that D. meadia can persist for long periods of time. However, because its propagules are small and gravity dispersed, it is unlikely to recolonize patches once they go extinct. One expert would expect that climate change may extirpate D. meadia from some fragments but not from the corridors along major waterways.

Regarding genetic diversity, the one cited study did not explicitly test the difference in variation between this species and congeners. However, it did find very low differentiation, and generally the diversity within D. meadia is greater than or equal to the other two congeners in the study.

Abiotic conditions: disturbance, soils, geology

Dodecatheon meadia is often found on calcareous soils, often thin, over limestone and dolomite. Additionally, many populations occur in deep, intact prairie soils. It rarely persists in extremely degraded conditions. Occasional fires can reduce litter which helps spring emergence and reduces competition from taller plants. However, it also grows in habitats that never burn, such as cliffs.

Biotic interactions

Midland shooting star habitats include prairies (many types), savannas, woodlands, glades/barrens, clifftops or bluff tops, and margins of fens. It may have once been a fairly common species of the tallgrass prairie found in both prairies as well as open woodlands. Based on one expert's observations, one finds this species more often in open oak forest rather than prairie simply because there are more patches of extant forest than prairie in Illinois. This plant often occurs in close proximity (30-100 ft.) to localized congeners *D. pulchellum* and *D. frenchii*.

Dodecatheon is buzz-pollinated by bumblebees. While these bees are abundant and diverse in Illinois, climate change may disrupt the timing of bee foraging relative to flowering. However, *Dodecatheon* inflorescences have flowers that open sequentially. The largest plants can present fertile flowers over a period of weeks. Unless late frosts destroy most inflorescences, or bumblebees are driven extinct, *Dodecatheon* should not be pollen-limited.

Belowground mutualisms have not been studied in this species. It is likely that *Dodecatheon meadia* host symbiotic arbuscular mycorrhizal fungi, which are ubiquitous.

The plants are browsed by deer, rabbits; root crowns eaten by voles and other rodents.

Bibliography

Macior, L. W. (1964). An experimental study of the floral ecology of Dodecatheon meadia. American Journal of Botany, 96-108.

Macior, L. W. (1968). Pollination adaptation in Pedicularis canadensis.American Journal of Botany, 1031-1035.

Macior, L. W. (1970). Pollination ecology of Dodecatheon amethystinum (Primulaceae). Bulletin of the Torrey Botanical Club, 150-153.

Oberle, B., & Esselman, E. J. (2011). Fruit and seed characters help distinguish southern Illinois Dodecatheon (Primulaceae) species and highlight unusual intergrading populations. Rhodora, 113(955), 280-299.

Oberle, B., & Schaal, B. A. (2011). Responses to historical climate change identify contemporary threats to diversity in Dodecatheon. Proceedings of the National Academy of Sciences, 108(14), 5655-5660.

Drosera intermedia Hayne

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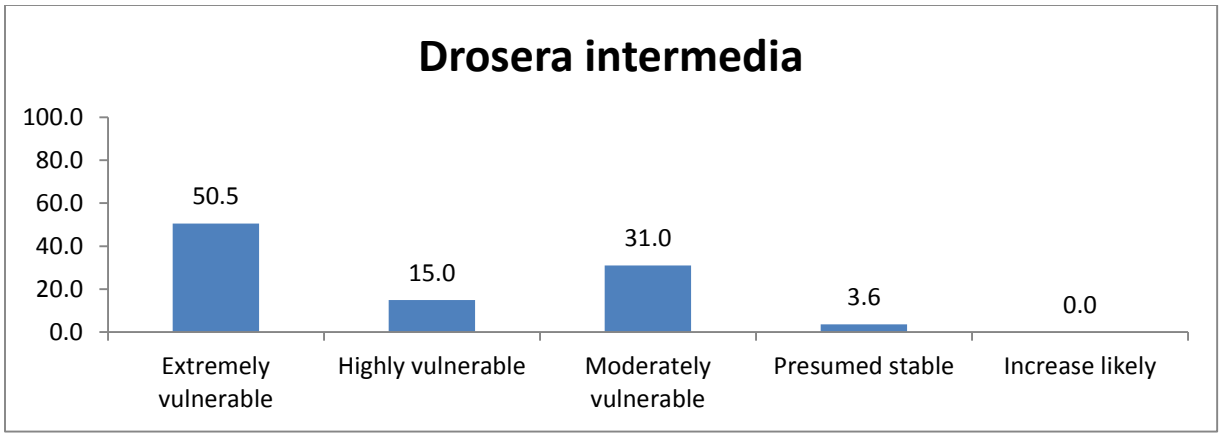

Figure 37: Drosera intermedia is categorized as Extremely Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers	GI	I	SI	N		
Anthropogenic barriers	GI	I	SI			
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI	N		
Historical thermal niche				N		
Physiological thermal niche		I	SI	N		
Historical hydrological niche		I				
Physiological hydrological niche	GI	I	SI	N	SD	
Disturbance dependence		I	SI	N	SD	
Ice/snow				N		
Geology/soils		I	SI	N	SD	D
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions			SI	N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N		

Table 35: Predicted climate changes may make Drosera intermedia vulnerable due to its inability to cross natural and anthropogenic barrier, its dispersal abilities, and its physiological hydrological niche. In addition, it may be vulnerable due to its physiological thermal niche, its historical hydrological niche, its dependence on disturbance and its soil preferences.

Little is known about this plant's ability to cross natural barriers, its dispersal abilities, its physiological hydrological niche, its dependence on disturbance, its soil preferences or its genetic diversity in Illinois.

Insights from experts

Contributing experts:
Connie Cunningham, Illinois Natural History Survey
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Steven R. Hill, Illinois Natural History Survey
Paul Marcum, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
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Greg Spyreas, Illinois Natural History Survey

General

Drosera intermedia is a carnivorous plant found along the Gulf and Atlantic Coast, northeast US and Upper Midwest, and in Appalachian bogs. In Illinois, it is a very localized species that may have always been rare or uncommon due to the lack of suitable habitat—bogs and fens. These habitats themselves may be vulnerable to changes in climate. In addition, bogs and fens are rare in Illinois due to extreme human-caused losses in wetlands.

Climate conditions & phenology

Spoonleaf sundew is adapted to both heat and cold and has winter dormancy. This species is found in areas with peaty soils. If warmer summers and warmer winters allow the peat to decompose, this substrate would no longer be available. The seeds of this plant may need a dormant period (3 months) and cold stratification for germination and warm winters in Illinois might disrupt this cycle.

The plant needs a fairly moist and constant soil hydrology. It is not clear how flashier precipitation with increased incidents of drought and floods could affect this species, which relies on water table in sandy habitats. It is unclear how periods of drought would affect individuals of this species: they may go dormant or simply die.

Dispersal, movement & genetics

Drosera intermedia reproduces by seed and vegetatively. The seeds of this plant are often not dispersed until the capsules rot. Its seeds can float for several months and can be dispersed by water. Wind and the feet of birds may also be important dispersal agents. Its tiny flowers may be wind or insect pollinated and often self-pollinate.

Little is known about the genetic diversity of this plant in Illinois. One expert speculates that small populations in Illinois are subject to genetic drift; but since it is a widespread species overall, genetic variation may be present.

Abiotic conditions: disturbance, soils, geology

Drosera intermedia is found in sandy or peaty, nutrient poor areas—bogs and fens—which are rare in Illinois. It requires acidic soils with a pH of greater than 6.8. If warmer summers and winters allow wetlands to dry and peat to decompose, this plant might be imperiled.

Fires can open habitat and reduce competition for spoonleaf sundew. However, drying and burning of acidic bogs could cause a decline in the amount of habitat available for this species.

Biotic interactions

This plant is pollinated by a wind and small insects; it can also self-pollinate. It can disperse through water, but also possibly on the feet of birds.

Spoonleaf sundew digests tiny insects (flies, gnats, small wasps) to obtain nutrients. In experimental settings it does well without consuming insects. However, it is out-competed by other plants when the nutrient levels in its habitat increase.

Bibliography

Crowder, A. A., Pearson, M. C., Grubb, P. J., & Langlois, P. H. (1990). Drosera L. The Journal of Ecology, 233-267.

Franco, V. (2000). The Distribution of Drosera rotundifolia and Drosera intermedia. Website. Accessed July 2015. http://www.unc.edu/~franco/writings/drosera.html
Thum, M. (1986). Segregation of habitat and prey in two sympatric carnivorous plant species, Drosera rotundifolia and Drosera intermedia. Oecologia, 70(4), 601-605.
Thum, M. (1988). The significance of carnivory for the fitness of Drosera in its natural habitat. Oecologia, 75(3), 472-480.
Thum, M. (1989). The significance of carnivory for the fitness of Drosera in its natural habitat. 2. The amount of captured prey and its effect on Drosera intermedia and Drosera rotundifolia. Oecologia, 401-411.
Thum, M. (1989). The significance of opportunistic predators for the sympatric carnivorous plant species Drosera intermedia and Drosera rotundifolia.Oecologia, 81(3), 397-400.
Wilson, S. D. (1985). The growth of Drosera intermedia in nutrient-rich habitats: the role of insectivory and interspecific competition. Canadian Journal of Botany,63(12), 2468-2469.

Echinacea purpurea (L.) Moench

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Steven R. Hill, Illinois Natural History Survey
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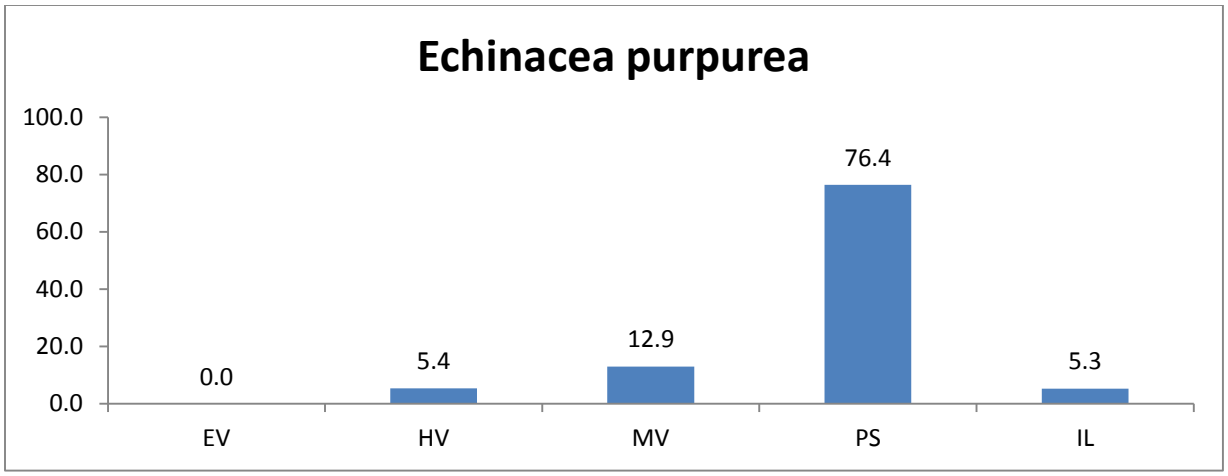

Figure 38: Echinacea purpurea is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N		
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N		

Table 36: Echinacea purpurea may be vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers and its dispersal abilities.

Little is known about this plant's ability to cross anthropogenic barriers or its genetic diversity in Illinois.

Insights from experts

Contributing experts:

Connie Cunningham, Illinois Natural History Survey
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General

The horticultural popularity of purple coneflower makes it difficult to assess how this species might respond to climate change in its natural habitat. Questions regarding things like substrate preferences, and native range are particularly difficult.

Climate conditions & phenology

This plant may be cold-sensitive and may not be bothered by increases in temperatures, based on its distribution in North America.

Echinacea purpurea may not be bothered by increased aridity, but one expert points out that the species is not deep-rooted and may not be able to survive dry weather or droughts.

Dispersal, movement & genetics

Seeds from *Echinacea purpurea* may disperse from the parent plant around one meter, but may also be dispersed by mice.

While quite a bit of genetic work has been done on this species, it has never been clearly compared to similar taxa, making the level of genetic diversity difficult to assess objectively. Since this plant is widely cultivated in Illinois, the gene pool is probably mixed and variable. This and other species of Echinacea are obligate out-crossers so distances between unrelated individuals is important.

Abiotic conditions: disturbance, soils, geology

While purple coneflower does not seem to be picky about soil types, it may have a preference for neutral or alkaline, calcium-rich soils.

Since the plant needs some sunlight, it could benefit from greater storm intensity and tree blow-downs in forests. It does not tolerate severely disturbed human habitats well. It is fairly shallow-rooted. *Echinacea purpurea* can respond well (e.g. an increase in flowering stems) to clearing of non-native shrubs and prescribed fire in dry-mesic upland forests.

Biotic interactions

Purple coneflower is a plant of forest edges. Its native populations seem to tolerate shade rather well, but not deep shade.

As this species is an obligate out-crosser, insect pollinators are important to it. It apparently has many possible pollinators. A series of experiments confirmed that the seeds of this plant are eaten by rodents; it is unclear whether the seeds might be carried away intact.

Bibliography

Baskauf, C. J., McCauley, D. E., & Eickmeier, W. G. (1994). Genetic analysis of a rare and a widespread species of Echinacea (Asteraceae). Evolution, 180-188.

Howe, H. F., & Brown, J. S. (2001). The ghost of granivory past. Ecology Letters, 4(4), 371-378.

Eryngium yuccifolium Michx.

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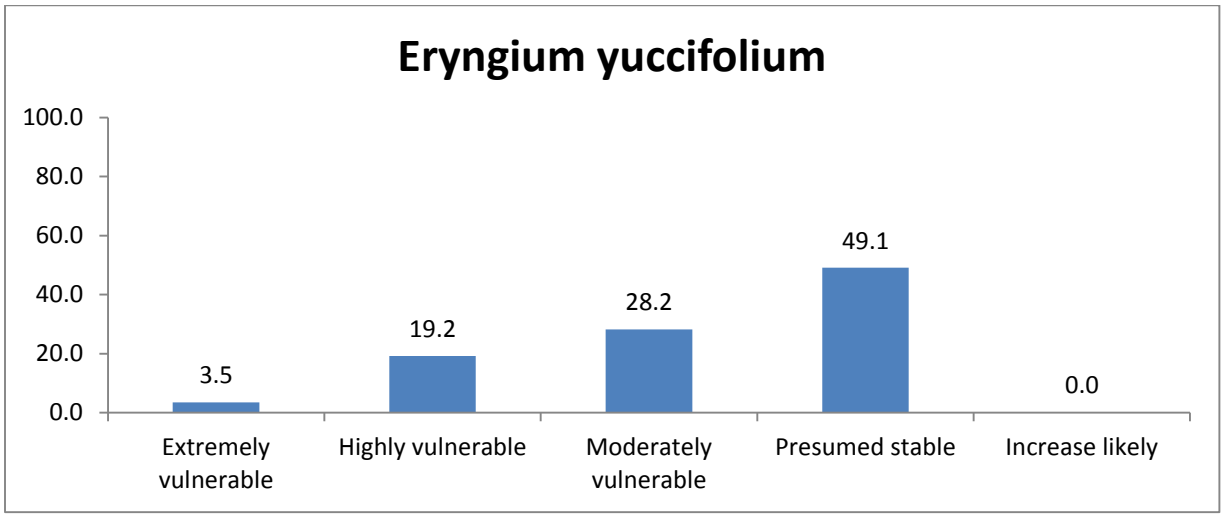

Figure 39: Eryngium yuccifolium is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers	GI	I	SI			
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N		
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence		I	SI	N	SD	
Ice/snow				N		
Geology/soils			SI	N	SD	
Other spp for habitat			SI	N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions			SI	N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response			SI	N	SD	

Table 37: Eryngium yuccifolium may be vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers, its dispersal abilities and its dependence on disturbance.

Little is known about this plant's dependence on disturbance or on its genetic diversity in Illinois.

Insights from experts

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General

Eryngium yuccifolium, a long-lived perennial forb, is a diagnostic species of the tallgrass prairie that persists in high-quality and degraded remnants but doesn't seem to tolerate much disturbance (frequent mowing, etc.). Once widespread, it is now restricted to prairie remnants and plantings. The seeds of this plant have a dormancy requirement. Seedlings will flower during their second year under optimum conditions.

Climate conditions & phenology

Plants in warmer climates have evergreen basal leaves. In general, this species is very flexible regarding temperature. It may have a slight preference for warmer temperatures.

Eryngium yuccifolium is not found on the driest or the wettest sites. Individuals do seem able to survive periods of dry weather and drought. While the plant is tolerant of a broad range of soil moisture levels, it does not persist under frequent soil saturation or inundation.

The plant has a long flowering season, from early July through late August. In Illinois this is one of the last prairie forbs to retain green rosettes and one of earliest to put out new green growth; new growth is sometimes damaged by spring fires, but regrowth is often rapid.

Dispersal, movement & genetics

Seeds are shaken from this plant over time. Some dispersal by wind or gravity is possible. Intensive urban development is a major issue for the dispersal of this species.

Little is known about the genetic diversity of this plant in Illinois. Experts speculate that the diversity could be high, citing several named varieties.

Abiotic conditions: disturbance, soils, geology

This plant is tolerant of a broad range of soils types.

Fire helps to reduce the competition this plant experiences in prairies. It can increase with various types of disturbance, including fire, forest removal and mowed areas under power lines, to name a few. If the inflorescences are lost, they will resprout and flower later in the growing season. One expert notes that rattlesnake master seems to do well in the growing season following prescribed fire.

Biotic interactions

Rattlesnake master grows in open areas including prairies, fen margins, savannas, glades, barrens, and flat woods. It colonizes stable grassland sites that are successional (i.e., not remnants).

Flowers are visited by a broad range of insects, including flies, beetles (especially Cantheridae), bees, moths, and butterflies (including Monarch). It may be dispersed to some extent by small mammals.

Deer will browse the inflorescences of this species; rodents will dig and eat the crowns and roots. This species is the host of Rattlesnake Master Borer moth (*Papaipema eryngii*), which has been proposed to be listed at the federal level.

A micro-lepidoptera is currently attacking seed heads of *Eryngium yuccifolium*, which may be acting as a bio-control agent. If this moth benefits from climatic changes, then it is possible that overall seed production of this plant will decline.

Bibliography

Danderson, C. A., Molano-Flores, B., & Raghu, S. (2008). Impact of floral herbivory by Coleotechnites eryngiella Bottimer (Lepidoptera: Gelechiidae) on the reproductive output of Eryngium yuccifolium Michaux (Apiaceae): a test of the reserve ovary model. Plant Ecology, 197(2), 277-284.

Danderson, C. A., & Molano-Flores, B. (2010). Effects of herbivory and inflorescence size on insect visitation to Eryngium yuccifolium (Apiaceae) a prairie plant. The American Midland Naturalist, 163(1), 234-246.

Molano-Flores, Brenda. "Biological Assessment: Rattlesnake Master, Eryngium yuccifolium." INHS Center for Biodiversity 1999 (4) (1999).

Molano-Flores, B. (2001). Reproductive biology of Eryngium yuccifolium (Apiaceae), a prairie species. Journal of the Torrey Botanical Society, 1-6.

Molano-Flores, B. (2009). Insect Herbivory of Ovules and Seeds in Native and Restored Prairies. Restoration Ecology, 17(2), 187-191.

Fagus grandifolia Ehrh.

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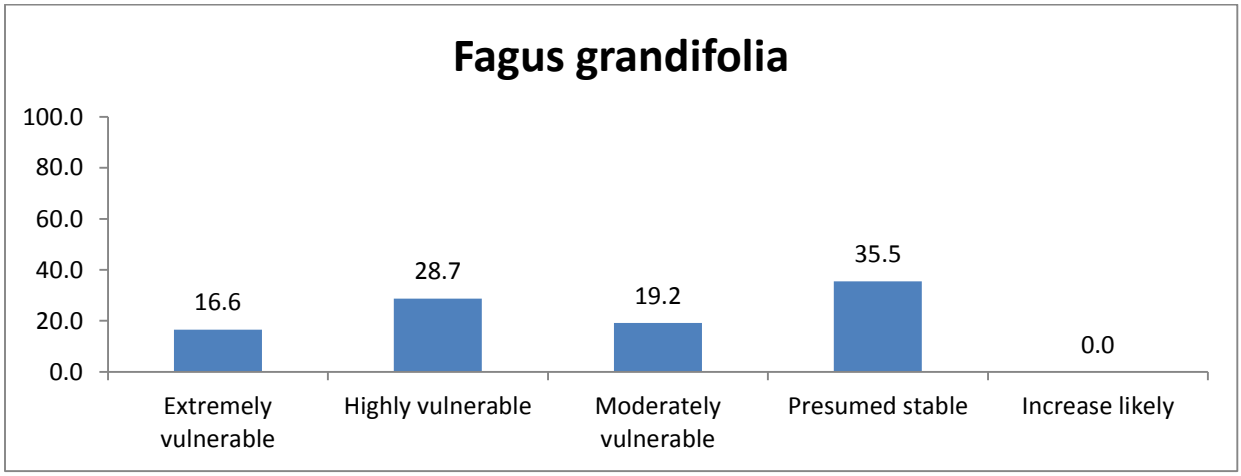

Figure 40: Fagus grandifolia is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche			SI	N		
Historical hydrological niche			SI			
Physiological hydrological niche		I	SI	N		
Disturbance dependence				N		
Ice/snow				N		
Geology/soils				N	SD	
Other spp for habitat			SI	N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions			SI	N		
Genetic variation					SD	
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 38: Fagus grandifolia may be vulnerable to climate changes due to its inability to cross natural and anthropogenic barriers, its dispersal abilities and its physiological hydrological niche.

Little is known about the dispersal abilities of this plant.

Insights from experts

Contributing experts:
James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Eric Ulaszek, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

Fagus grandifolia is a large, potentially long-lived tree of mesic forests, at the western edge of its natural range in Illinois.

Climate conditions & phenology

Experts do not believe that American beech would be particularly sensitive to a change in temperatures. However, the species has high evapotranspiration rates and could be susceptible to extended periods of dry weather or drought. Seedlings and saplings grow better where shade from other trees help to regulate soil moisture levels. This tree would also be susceptible to flooding.

Dispersal, movement & genetics

Production of viable seeds by American beech is uncommon in Illinois; most understory recruitment is by sprouting from extensive root systems. Natural seed dispersal is also limited.

This species is very widespread and genetically variable overall, but some colonies are clonal.

Abiotic conditions: disturbance, soils, geology

This species prefers neutral or acidic soils over calcareous ones. It may be dependent on fire.

Biotic interactions

Fagus grandifolia is dependent on mesic forest habitats and shade from other trees helps to regulate soil moisture levels for seedlings and saplings.

The fruits of this tree are relatively large and may limit dispersal. Seeds may be dispersed by birds and small mammals.

Seeds may be infested with a cottony aphid. At least one major pathogen, Beech Bark Disease, caused by the interaction between a non-native insect and a fungal pathogen, is spreading westward to Illinois.

Bibliography

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Table_of_contents.htm

Fallopia japonica var. *japonica* (Houtt.) Ronse Decr.

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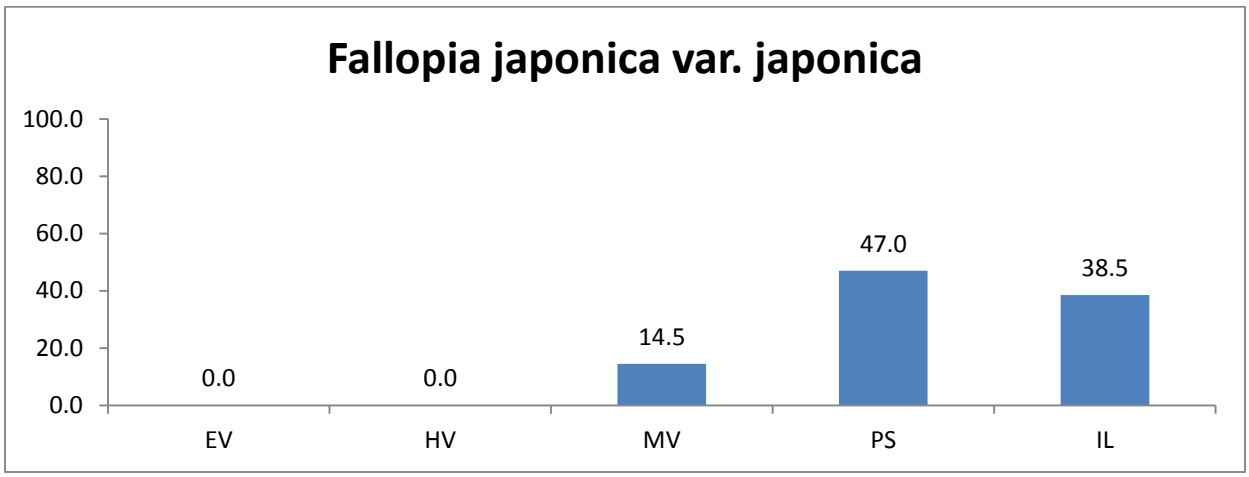

Figure 41: Fallopia japonica var. *japonica is categorized as Presumed Stable with predicted climate changes.*

Sea level				N		
Natural barriers				N		
Anthropogenic barriers			SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	D
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation		I		N	SD	
Genetic bottlenecks		I	SI	N		
Phenological response				N	SD	

Table 39: Under predicted climate changes, Fallopia japonica var. *japonica may be more vulnerable due to its dispersal abilities and its low genetic variation.*

Little is known about this plant's dispersal abilities.

Insights from experts:

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General

Fallopia japonica var. *japonica* is a large, rhizomatous perennial introduced to Illinois (and North America). It is often planted as an ornamental and for erosion control in barren land and in reclaimed soils in coal mining regions. Patches can be thick and extensive (quarter to half acre or more), growing to the exclusion of other plant species.

Climate conditions & phenology

Japanese knotweed does not grow well in relatively warm and dry areas. It is often observed growing in deep, rich soils with plenty of moisture, sometimes in wetlands. A drying climate would probably hurt this species in Illinois, but it can also grow in drier soils, such as along parking lot edges and in alleyways.

Increased heavy rainfall and flooding events may facilitate the spread of this species.

Dispersal, movement & genetics

The most common way for *Fallopia japonica* var. *japonica* to reproduce in Illinois is through dispersal of root and stem fragments, which can float and are water dispersed. Seed production is rare, and it is unknown whether seeds produced in Illinois are viable. It appears that in some locations in the U.S. knotweed was spread by seed initially and then began to spread vegetatively.

While the genetic diversity of *Fallopia japonica* var. *japonica* has not been studied in Illinois, populations may have quite low genetic diversity. Since the plant reproduces primarily (if not exclusively) by vegetative means, and since it was introduced to the state somewhat recently, there may be very low diversity.

Abiotic conditions: disturbance, soils, geology

Japanese knotweed is well-known for growing in disturbed areas, especially roadsides and road banks. It seems to do well in many different soil types with several pH regimes, but does prefer moist soils.

The species thrives on disturbance and an increase in heavy rainfall and flooding events could facilitate the spread of this species.

Biotic interactions

This plant forms large stands in riparian areas, woodlands, floodplains, and old fields. Its flowers are pollinated by generalist insects.

Bibliography

Bailey, J. P., Bímová, K., & Mandák, B. (2009). Asexual spread versus sexual reproduction and evolution in Japanese Knotweed sl sets the stage for the "Battle of the Clones". Biological Invasions, 11(5), 1189-1203.

Bram, M. R., & McNair, J. N. (2004). Seed germinability and its seasonal onset of Japanese knotweed (Polygonum cuspidatum). Weed Science, 52(5), 759-767.

Bailey, J. (2005). The history of Japanese knotweed. Ecos-British Association of Nature Conservationists, 26(3/4), 55.

Baker, R. M. (1988). Mechanical control of Japanese knotweed in an SSSI.Aspects of Applied Biology, (16), 189-192.

Barney, J. N. (2006). North American history of two invasive plant species: phytogeographic distribution, dispersal vectors, and multiple introductions.Biological Invasions, 8(4), 703-717.

Forman, J., & Kesseli, R. V. (2003). Sexual reproduction in the invasive species Fallopia japonica (Polygonaceae). American Journal of Botany, 90(4), 586-592.
Gaskin, J. F., Schwarzländer, M., Grevstad, F. S., Haverhals, M. A., Bourchier, R. S., & Miller, T. W. (2014). Extreme differences in population structure and genetic diversity for three invasive congeners: knotweeds in western North America. Biological Invasions, 16(10), 2127-2136.
Grimsby, J. L., & Kesseli, R. (2010). Genetic composition of invasive Japanese knotweed sl in the United States. Biological Invasions, 12(7), 1943-1946.
Stone, Katharine R. 2010. Polygonum sachalinense, P. cuspidatum, P. × bohemicum. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 24].

Fragaria virginiana Duchesne

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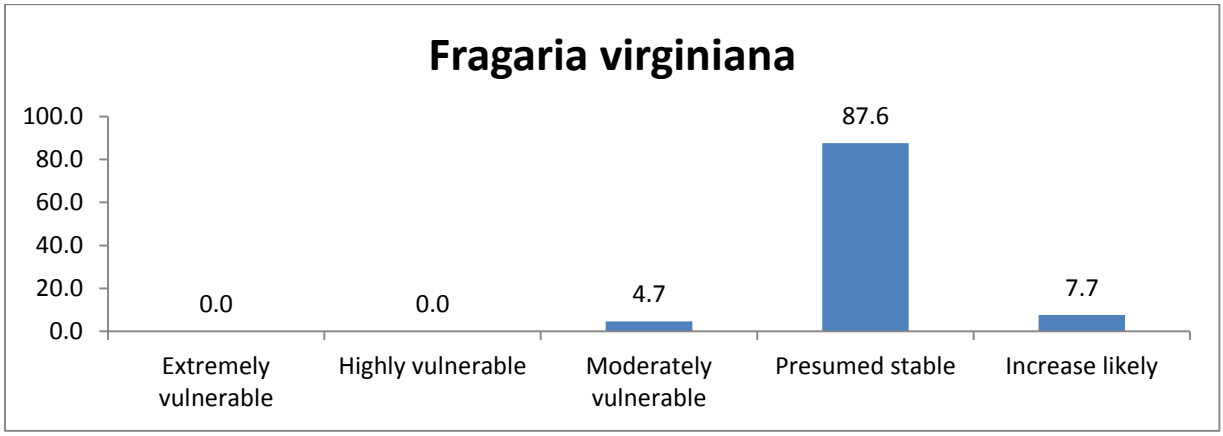

Figure 42: Fragaria virginiana is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement				N	SD	
Historical thermal niche				N		
Physiological thermal niche				N		
Historical hydrological niche			SI			
Physiological hydrological niche				N		
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation					SD	
Genetic bottlenecks				N		
Phenological response			SI	N		

Table 40: With predicted climate changes, Fragaria virginiana may be more vulnerable due to its inability to cross natural and anthropogenic barriers, its historical hydrological niche and its inability to track changes in seasonality.

Insights from experts

Contributing experts:
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General

Fragaria virginiana is an extremely widespread, perennial plant that spreads by stolons (runners). Rosettes are short-lived, usually flowering (and fruiting) the year after establishment.

Climate conditions & phenology

Wild strawberry seems to have little preference in terms of temperature. Experts indicate that it prefers mesic conditions, but that conditions would need to become extremely dry for most of the year to cause a decline in this species. However, the plant experiences some amount of variation in fruit production during droughts.

Seeds of *Fragaria virginiana* have little dormancy and germinate shortly after reaching the soil in the summer.

Dispersal, movement & genetics

This plant disperses both by seed and by clonal growth forming patches of plants on stolons; individual plants only live a few years so new plants needed continuously. Fruits are highly edible by many species of mammals, and these animals may be important vectors for the seeds. Clones may not be self-fertile, requiring cross-pollination.

Little is known about the genetic diversity of this plant in Illinois. Experts speculate, due to its widespread nature, that wild strawberry may be genetically diverse.

Abiotic conditions: disturbance, soils, geology

Wild strawberry has a wide tolerance of soil types. It needs disturbance to keep down competition; disturbances include fire, soil disturbance, mowing, and removal of woody plants.

Biotic interactions

Fragaria virginiana's habitats include prairies, barrens, open woodlands, wetland margins, old fields, savannas, and roadsides; may be most abundant where surface competition and litter is low, but is also found in high-quality prairie communities with dense ground-cover. This plant will disappear if areas are taken over by shrubs and trees.

Seeds are dispersed by birds, mammals, ants and possibly other animals. A very wide range of bees and flies visit the flowers for pollen and nectar rewards.

Bibliography

Bishop, E. J., Spigler, R. B., & Ashman, T. L. (2010). Sex-allocation plasticity in hermaphrodites of sexually dimorphic Fragaria virginiana (Rosaceae).Botany, 88(3), 231-240.

Case, A. L., & Ashman, T. L. (2009). Resources and pollinators contribute to population sex-ratio bias and pollen limitation in Fragaria virginiana (Rosaceae).Oikos, 118(8), 1250-1260.

Hilty, John. Wild Strawberry. Illinois Wildflowers Website. www.illinoiswildflowers.info

Penet, L., Collin, C. L., & Ashman, T. L. (2009). Florivory increases selfing: an experimental study in the wild strawberry, Fragaria virginiana. Plant Biology,11(1), 38-45.

Rohde, A. S., & Ashman, T. L. (2010). Effects of florivory and inbreeding on reproduction in hermaphrodites of the wild strawberry Fragaria virginiana.International journal of plant sciences, 171(2), 175-184.

Spigler, R. B., & Ashman, T. L. (2011). Sex ratio and subdioecy in Fragaria virginiana: the roles of plasticity and gene flow examined. New Phytologist,190(4), 1058-1068.

Spigler, R. B., Lewers, K. S., Johnson, A. L., & Ashman, T. L. (2010). Comparative mapping reveals autosomal origin of sex chromosome in octoploid Fragaria virginiana. Journal of Heredity, 101(suppl 1), S107-S117.

Hordeum jubatum L.

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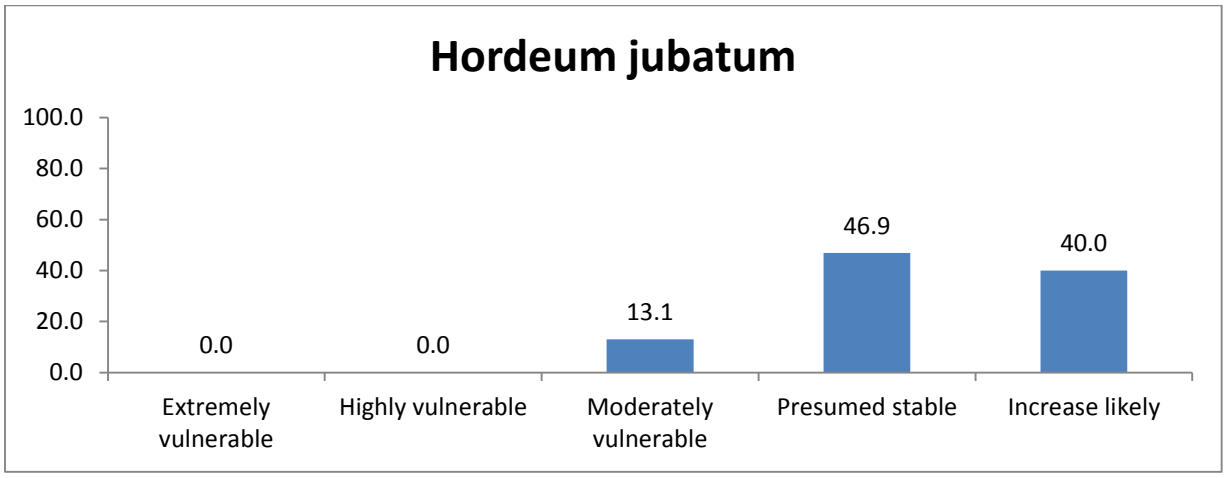

Figure 43: Hordeum jubatum is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers			SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement				N	SD	D
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils		I	SI	N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 41: Hordeum jubatum may be more vulnerable to climate change due to its soil preferences.

Little is known about the soil preferences of this plant or about its genetic diversity in Illinois.

Insights from experts

Contributing experts:
James Ellis, Illinois Natural History Survey
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General

Hordeum jubatum is a widespread, non-native grass introduced from the western US. It is rarely seen in natural plant communities.

Climate conditions & phenology

Hordeum jubatum could decrease with higher temperatures as it seems to prefer cooler weather. It is common from the arctic to the southwest, but is essentially missing from gulf coast southeastern states. The plant likes wet, disturbed areas and is common along roadside ditches.

Foxtail barley prefers or can withstand areas of high salinity. It is most likely to be found along highways that get mowed and receive high inputs of de-icing salts in the winter. It is unclear what a decrease in ice and snow might mean for the plant in this regard.

This plant is abundant in the spring along wet roadsides, vernal pools and temporarily wet meadows. It has a long flowering period which is mostly finished by mid-summer. Plants in late-drying depressions and on mowed sites flower later in the season.

Dispersal, movement & genetics

Dispersal of this plant is done primarily by humans. It is also likely that this species is dispersed by grazing animals, wind and vehicles. It moves easily along highways and ditches.

Little is known about the genetic diversity of this species in Illinois. It is a hybrid of an introduced species and a species that is native to the western U.S. Experts speculate that it has high genetic diversity due to its wide range and to the fact that several varieties have been named.

Abiotic conditions: disturbance, soils, geology

Foxtail barley can withstand areas of high salinity. It seems to thrive in hard, dry soils, especially those found along most interstate highways in Illinois. It is found on many substrates, but all are generally wet in the spring.

This plant responds well to disturbances, including close mowing and fire.

Biotic interactions

Animals graze the seed heads and may be an important disperser of the plant.

Although foxtail barley does invade some natural communities, including dolomite prairie, it is most commonly seen along roadsides. Saline conditions may encourage the plant by eliminating competition.

Bibliography

Tesky, Julie L. 1992. Hordeum jubatum. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 24].

Iliamna remota Greene

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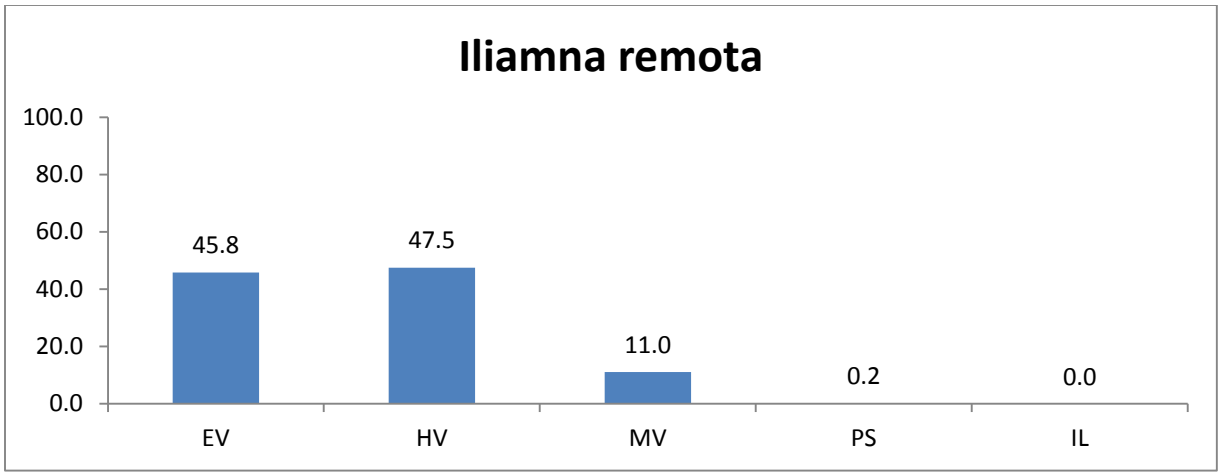

Figure 44: Iliamna remota is categorized as Highly Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers	GI	I	SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI	N		
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche	GI					
Physiological hydrological niche			SI	N		
Disturbance dependence		I		N	SD	
Ice/snow				N		
Geology/soils		I	SI	N	SD	
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal			SI	N		
Other spp interactions			SI	N		
Genetic variation					SD	
Genetic bottlenecks		I	SI	N		
Phenological response				N	SD	

Table 42: Iliamna remota may be vulnerable to predicted climate changes due to its inability to cross natural and anthropogenic barriers, its dispersal abilities, its historical hydrological niche, its dependence on disturbance, its soil preferences and its having been through genetic bottlenecks.

Little is known about the ability of this plant to cross natural or anthropogenic barriers, its dispersal abilities, its disturbance dependence, or its soil preferences.

Insights from experts

Contributing experts:

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Greg Spyreas, Illinois Natural History Survey
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David N. Zaya, Illinois Natural History Survey

General

This is a rare species currently found on a single island in the Kankakee River; it has, apparently, always been rare – at least since Europeans arrived. *Iliamna remota* is a potentially long-lived perennial forb, although some individual plants only live a few years. Under optimum conditions, seedlings can flower and set seed during their first year. There are some taxonomic questions regarding this species, but many botanists in the state support the concept that this is a distinct species with only a single population, and it was not known any other place since its discovery on Altorf Island. With a single population, its survival chances are not good.

Climate conditions & phenology

Experts disagree about whether this species prefers hot or cold conditions. Several believe that it is tolerant of heat and cold. Another says hot conditions could benefit the propagation of this species. Another points out that the plant's seeds respond to cold stratification, but that this condition is not always necessary. It is not damaged by late frosts.

This plant is intolerant of saturated soils and high nutrient levels. Dry conditions could benefit the propagation of this species, and it is tolerant of drought. One expert suggests that the species could survive with an increase or a decrease in precipitation. Some worry that increased flooding could harm the species, being that the only population is on an island in the middle of the Kankakee River.

Dispersal, movement & genetics

This species is restricted to the island it occurs on and it is not dispersing. There is a high density of seeds in the loose, gravelly soils on the island. Established plants can spread by rhizomes, but some never do. Experts consider, that since this species grows along a river, water could be a dispersing agent but there is no evidence as to whether the seeds float. The general consensus on this plant is that it's a fire/disturbance adapted long lived seed bank species that may not need to disperse much.

Abiotic conditions: disturbance, soils, geology

Iliamna remota seems to prefer limestone or dolomite substrate. It grows in dry gravelly soils.
The population on Altorf Island has been thought to have become extinct several times, only to start up again after clearing and fires. Seeds germinate in response to removal of shading and duff by fire or brush clearing. The plant's seeds seem to be very long-lived.

Biotic interactions

Habitat is degraded oak savanna/woodland over dolomite, but also grows in old fields. Seeds germinate in response to removal of shading and duff by fire or brush clearing. The plant does not like competition or shade. Various insects visit flowers, including honeybees, halictid bees, small bumblebees, flies, skippers, small butterflies, and soldier beetles.
Japanese beetles eat flowers, prevent seed set. Deer browse this plant and may prevent reproduction.

Bibliography

McDonnell, A., Grant, M., & Coons, J. M. (2012). Effects of Hot Water on Breaking Seed Dormancy of the Endangered Kankakee Mallow (Iliamna remota Greene (Malvaceae). Erigenia, 8.

McDonnell, A. L. (2006). A survey and developmental biology of Iliamna remota Greene (Malvaceae), an endangered species in Illinois. M.S. Thesis. Eastern Illinois University, Charlston, IL.

McDonnell, A. L., Owen, H. R., Jones, S. C., Gutowski, V. P., & Ebinger, J. E. (2006). Survey of the Illinois Endangered Kankakee Mallow, Iliamna remota, in Kankakee County. Erigenia, 32.
Schwegman, J. E. (1991). The Vascular Flora of Langham Island, Kankakee County, Illinois. Erigenia, 11, 1-8.
Swinehart, A. L., & Jacobs, M. E. (1998). Rediscovery, status, and preservation of the endangered Kankakee globe mallow (Iliamna remota) in Indiana. Rhodora, 82-87.

Isotria medeoloides (Pursh) Raf.

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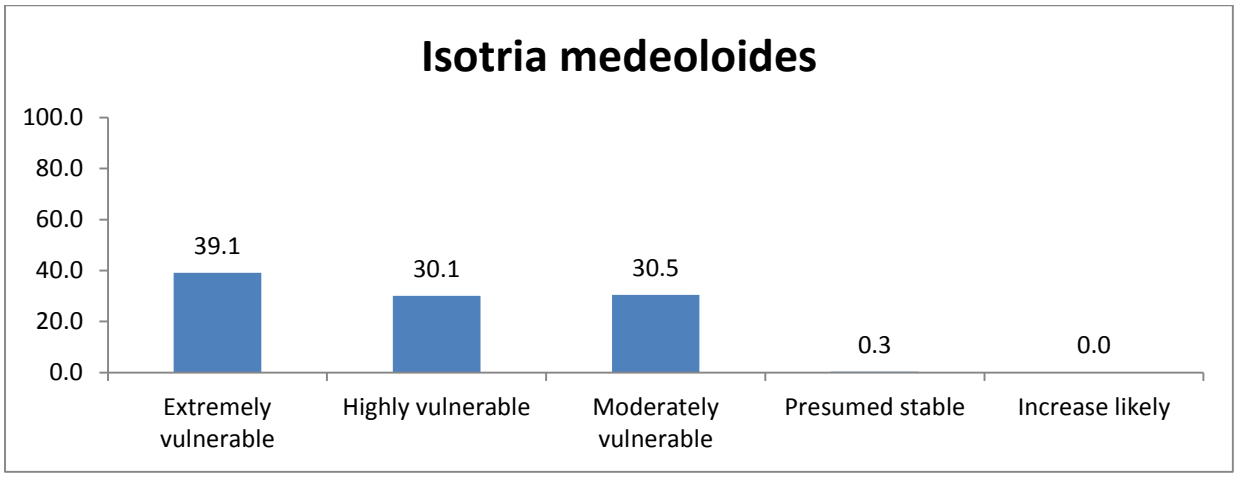

Figure 45: Isotria medeoloides is categorized as Extremely Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche	GI					
Physiological hydrological niche			SI	N		
Disturbance dependence		I	SI	N	SD	
Ice/snow				N		
Geology/soils		I	SI	N	SD	D
Other spp for habitat				N		
Other spp for pollination		I	SI	N		
Other spp for dispersal				N		
Other spp interactions		I	SI	N		
Genetic variation		I				
Genetic bottlenecks				N		
Phenological response				N		

Table 43: Isotria medeoloides may be vulnerable to predicted climate changes due to its inability to cross natural and anthropogenic barriers, its historical hydrological niche, its dependence on disturbance, its soil preferences, its dependence on other species for pollination and for other interspecific interactions, and due to its low genetic diversity.

Little is known about the ability of this plant to cross anthropogenic barriers, its disturbance dependence or its soil preferences.

Insights from experts

Contributing experts:
Christopher Benda, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Greg Spyreas, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

This is a very rare species of orchid, which is particularly sensitive to changes in the environment. *Isotria medeoloides* is extirpated in Illinois. It was once known from a single location in Randolph County, but it has not been observed for over 20 years. This plant is full of unknowns – it does not seem to come up every year or flower every year, it is fungus-dependent; it is so rare that there are no large populations, yet it is widespread, historically.

Climate conditions & phenology

This species shows a preference for warmer environments and is not dependent on a wetland or a seasonal hydrologic regime. *Isotria medeoloides* seeds are wind-dispersed; increases in wind at the right time of year will increase the ability of this species to disperse.

Dispersal, movement & genetics

Seeds are dust-like and they can disperse in the wind, though the plants are short, and so few fruit that producing seeds is a very rare event. There are not likely barriers to the movement of these seeds, but loss of suitable forest habitat has been an issue.

Due to small population sizes, genetic diversity in southern populations of this plant is low.

Abiotic conditions: disturbance, soils, geology

Some experts say that this plant generally needs acidic soils which are not common in Illinois, especially glaciated northern Illinois. Others believe that it is not dependent on a specific soil type.

Disturbances in forests could benefit this species.

Biotic interactions

Isotria medeoloides requires mesic forest, rich woods and moist soils. Orchid pollination is generally performed by species-specific pollinators. Obligately mycotrophic, but apparently can grow with a number of other species.

Bibliography

Stone, J. L., Crystal, P. A., Devlin, E. E., Downer, R. L., & Cameron, D. S. (2012). Highest genetic diversity at the northern range limit of the rare orchid Isotria medeoloides. Heredity, *109*(4), 215-221.

Juglans nigra L.

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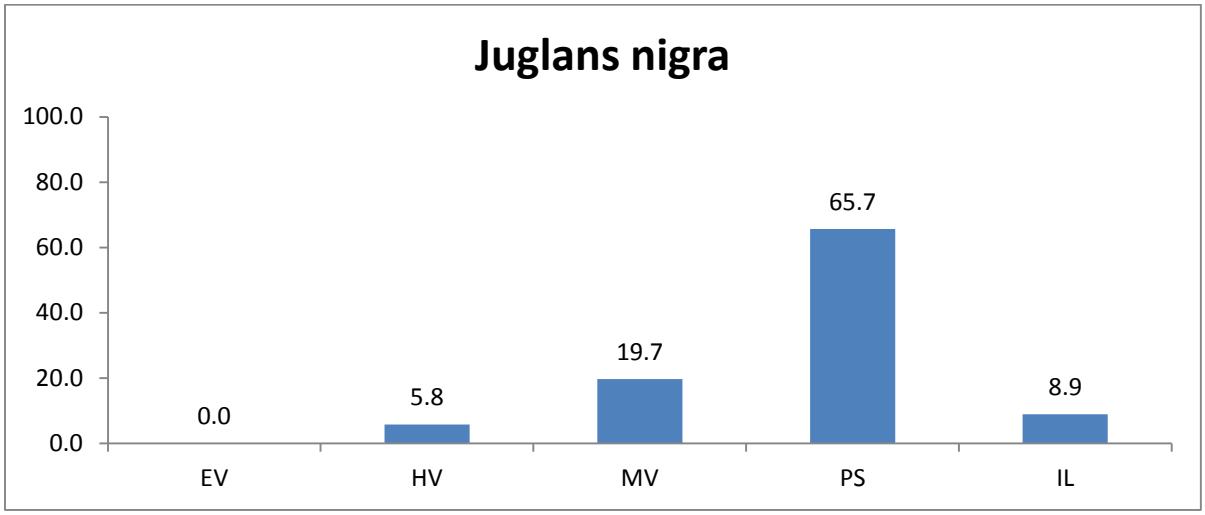

Figure 46: Juglans nigra is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence			SI	N		D
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions			SI	N		
Genetic variation				N		
Genetic bottlenecks				N		
Phenological response			SI	N		

Table 44: Juglans nigra may be vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers and its dispersal abilities.

Little is known about the dispersal abilities of this plant.

Insights from experts

Contributing experts:

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General

With a range extending from Florida to Canada, Black walnut is particularly common in Illinois; a common, mostly floodplain tree, formerly more abundant than now because of its valuable wood, yet still quite common despite this.

Climate conditions & phenology

Based on its range, experts do not believe that a change in temperature would affect *Juglans nigra* much. It may be most limited by cold or winter extreme temperatures. New growth is susceptible to damage from last frosts, which can kill catkins and prevent fruit set; however new growth to produce foliage usually appears. Seed germination is stimulated by freeze-thaw cycles.

This species grows best on deep, rich soils with adequate moisture, including those found in floodplain forests. Periodic dry or drought conditions could negatively impact this species.

Dispersal, movement & genetics

This is a widely planted species. Its seeds are moved by numerous wildlife and may float as well.

Little is known about the genetic diversity of this plant in Illinois.

Abiotic conditions: disturbance, soils, geology

Best growth of *Juglans nigra* is achieved on well-drained, moist, deep soils, as on floodplain terraces and natural levees, but this was also an occasional tree in savannas and other habitats.

Flooding is probably good for the species; extreme drought and fire are not good.

Biotic interactions

Many animals regularly eat and bury the seeds of this species. There are diseases present in North America which have the potential to devastate this tree. Black walnut has an alleopathic compound, juglone, which may give it a slight advantage in some ecological settings. This could be a factor in the establishment of walnut groves in some areas.

Bibliography

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Table_of_contents.htm

Lespedeza leptostachya Engelm.

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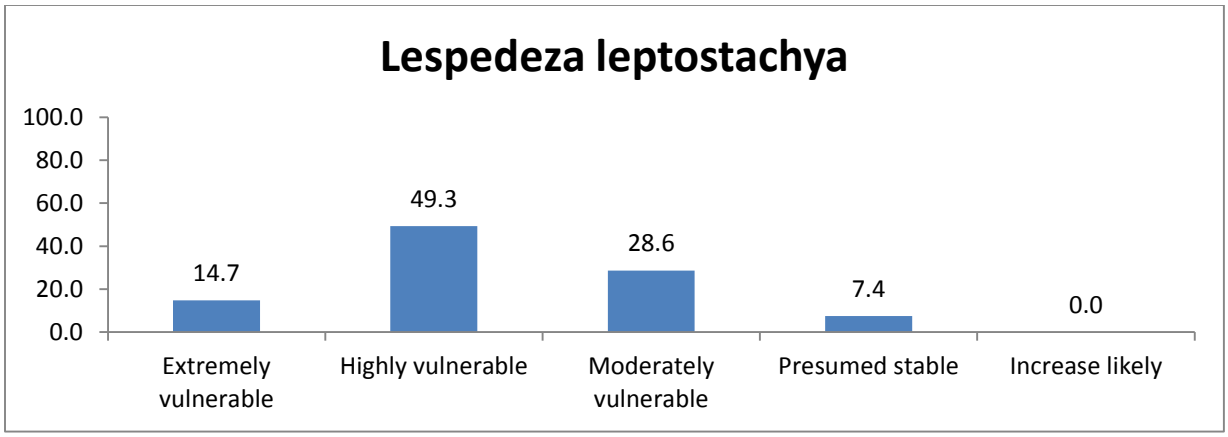

Figure 47: Lespedeza leptostachya is categorized as Highly Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche	GI	I	SI	N		
Historical hydrological niche		I				
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence		I	SI	N	SD	
Ice/snow				N		
Geology/soils		I	SI	N	SD	
Other spp for habitat		I	SI	N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions			SI	N		
Genetic variation		I				
Genetic bottlenecks			SI	N		
Phenological response				N		

Table 45: Lespedeza leptostachya may be vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers, its dispersal abilities, its physiological thermal niche, its historical and physiological hydrological niches, its dependence on disturbance, its soil preferences, its dependence on other species to generate habitat and its low genetic diversity.

Little is known about the ability of this plant to cross anthropogenic barriers, its dispersal abilities, its physiological thermal niche, its physiological hydrological niche, and its dependence on disturbance or its soil preferences.

Insights from experts

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General

This species is a long-lived perennial, living for more than twenty years. It is in decline mostly due to loss of habitat. Also, it appears to be restricted to uncommon habitats – especially gravel hill prairies, and seems to be limited to the upper 1/3 of IL, implying it likes cooler temperatures. It is federally threatened, and protected in IL, too. From a population perspective, seedling establishment is the limiting stage. Seed viability is low.

Climate conditions & phenology

Several changes to the current temperature regime across this species range could affect the species.
Increased temperature: *Lespedeza leptostachya* does not compete well with grasses, particularly warm season grasses such as *Schizachyrium scoparium*. Grows more slowly and has decreased fecundity with grass litter accumulation. Seed germination and recruitment lower under high competition with grasses. Lower spring temps: decreased seedling germination occurs under these conditions.

A decrease in precipitation may lead to decreased germination and seedling survivorship. Populations of this species are often observed on drier sites, which may have decreased competition due to decreased levels of moisture. This species may be vulnerable to changes in seasonality of precipitation due to germination and seedling establishment patterns.

There is some speculation that climate change is causing overlap in flowering period between *L. capitata* and this species, increasing the potential for hybridization and extinction by genetic swamping. *L. capitata* occurs sympatrically in very high numbers throughout the range.

Dispersal, movement & genetics

Most seeds do not disperse far beyond the area of the mother plant. It is difficult for the species to cross unfavorable habitats for this reason. There may be limited dispersal by ants which may help increase dispersal distance a bit, but not enough to overcome significant distances between populations.
Lespedeza leptostachya will have difficulty crossing rivers and other natural barriers. It is also not likely to cross the large agricultural matrix that surrounds prairie remnants. Fruits are small, nut-like legumes, perhaps dispersed mostly by birds in the past.

Lespedeza leptostachya reproduces mostly through cleistogamous flowers, with some chasmogamous flowers as well. Experts expect it to have low genetic diversity. There is some speculation that climate change is causing overlap in flowering period between *L. capitata* and this species, increasing the potential for hybridization and extinction by genetic swamping. *L. capitata* occurs sympatrically in very high numbers throughout the range.

Abiotic conditions: disturbance, soils, geology

Lespedeza leptostachya prefers somewhat drier soils, but is not as specific to sandy soils as some dry prairie species are. This species is restricted to gravel hill prairies, and it may be that a perched water table exists beneath the largest and/or more enduring populations.

This plant responds positively to fire and appears to do better under period or episodic grazing. It is a poor competitor, particularly with grasses.

Biotic interactions

This species is largely self-pollinated, but can be cross-pollinated as well. Ants and other animals may disperse this plant. It is a nitrogen fixer.

Lespedeza leptostachya does not compete well with grasses, particularly warm season grasses such as *Schizachyrium scoparium*. It grows more slowly and has decreased fecundity with grass litter accumulation. Seed germination and recruitment are lower under high competition with grasses. This species appears to do best with grazing, and may have evolved with bison grazing in particular, given its sensitivity to grass competition. Its relationship with bison will be studied at Nachusa Grasslands.

Bibliography

Fant, J. B., Banai, A., Havens, K., & Vitt, P. (2010). Hybridization between the threatened plant, Lespedeza leptostachya Englem. and its co-occurring congener Lespedeza capitata Michx.: morphological and molecular evidence.Conservation genetics, 11(6), 2195-2205.

Minnesota Department of Natural Resources, Division of Ecological Resources. 2008. Rare Species Guide: An online encyclopedia of Minnesota's rare native plants and animals [Web Application]. Minnesota Department of Natural Resources, St. Paul, Minnesota.www.dnr.state.mn.us/rsg. Accessed July 2015.

Medicago sativa L.

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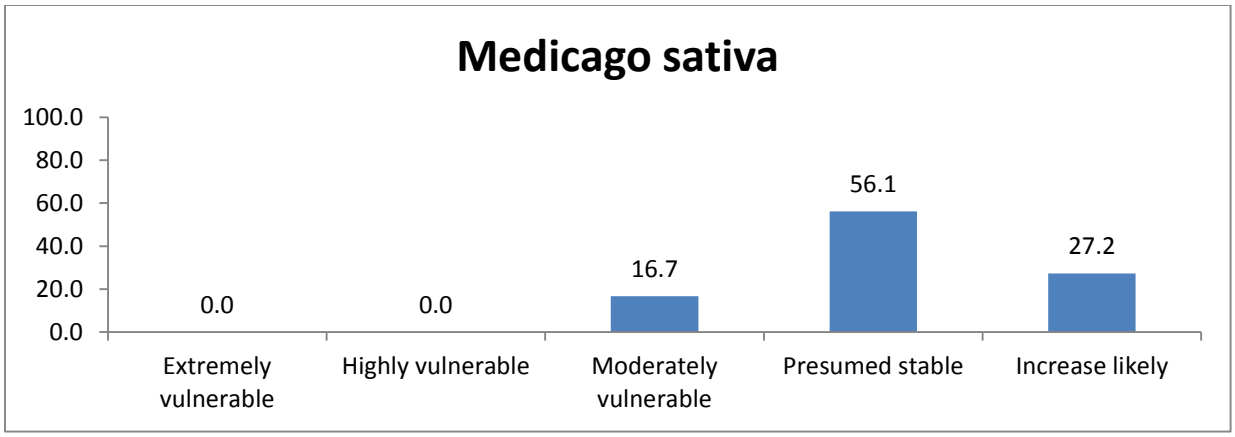

Figure 48: Medicago sativa is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N		D
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N		D
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions		I		N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 46: Medicago sativa may be more vulnerable to predicted climate changes due to its interactions with other species.

Little is known about the dispersal abilities of this plant, its dependence on disturbance, its interspecific interactions or its genetic diversity in Illinois.

Insights from experts

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General

Medicago sativa is a non-native perennial often planted for hay, less often for erosion control. It can and does invade open habitats (grasslands) although not to the degree of other invasive legumes. The plant is grown for commercial production of alfalfa hay over a wide region, even with irrigation in arid southwest USA.

Climate conditions & phenology

Alfalfa is very flexible, it is grown in both cool and warm, dry and moist areas around the globe. In arid regions, it does require irrigation.

Dispersal, movement & genetics

While most populations of this plant in Illinois have been planted by humans, it does spread on its own on occasion. Seeds may be dispersed by gravity, grazing animals, small mammals and birds.

The genetics of this plant in Illinois are likely quite complicated. Wild and cultivated varieties exist and there are various ploidy levels of the plant.

Abiotic conditions: disturbance, soils, geology

Medicago sativa grows well on a wide range of soil types and drainage classes. It does best on slightly calcareous, well-drained soils.

Biotic interactions

Escaped individuals are likely to be found in disturbed old fields or roadsides close to active or old hayfields. It can be a persistent problem in prairie reconstructions on land formerly in agriculture as it forms a long-lived seedbank.

The plant is dispersed by grazing animals, small mammals and birds. It is often planted to attract wildlife (whitetail deer) and game birds (grouse, pheasant), and may be an important part of the habitat for prairie chickens at the sanctuary in Jasper County.

Medicago sativa is pollinated by generalists. It forms associations with many strains of rhizobium bacteria.

Bibliography

Campbell, T. A. (2000). Molecular analysis of genetic variation among alfalfa (Medicago sativa L.) and Medicago ruthenica clones. Canadian Journal of Plant Science, *80*(4), 773-779.

Sullivan, Janet. 1992. Medicago sativa. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 24].

Microstegium vimineum (Trin.) A. Camus

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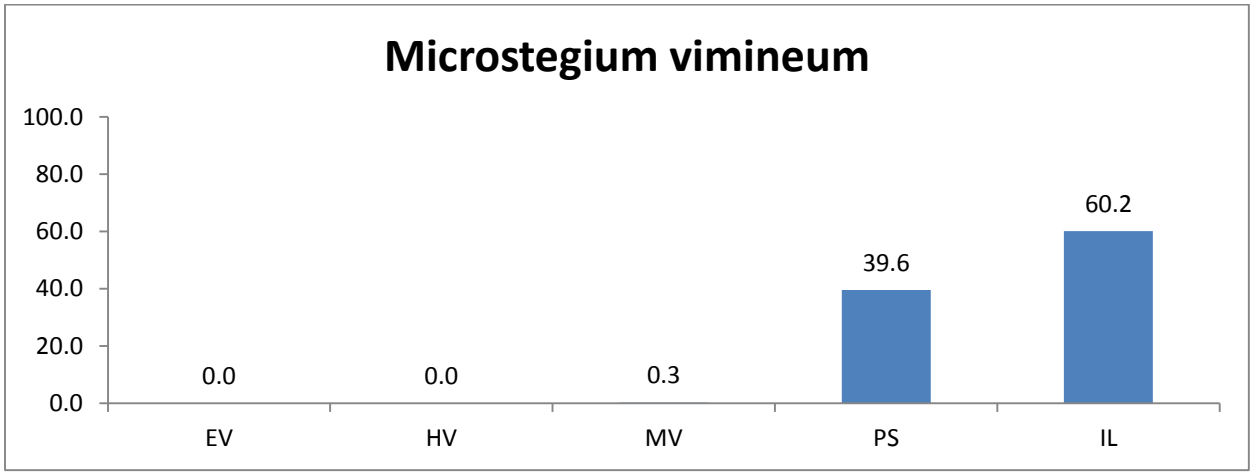

Figure 49: Microstegium vimineum is categorized as Increase Likely with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche					SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence				N	SD	D
Ice/snow				N		
Geology/soils			SI	N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation			SI	N		
Genetic bottlenecks				N		
Phenological response			SI	N	SD	

Table 47: Under predicted climate change, Microstegium vimineum may be more vulnerable due to its dispersal abilities.

Little is known about the dispersal abilities of this plant.

Insights from experts

Contributing experts:

Steven R. Hill, Illinois Natural History Survey
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General

Microstegium vimineum in an annual, non-native grass that it actively increasing and spreading in Illinois, primarily from south to north, with isolated infestations appearing in central and northern Illinois.

Climate conditions & phenology

This plant prefers warm areas and is currently restricted by cold. It prefers low wet areas, and moist floodplains. It is somewhat sensitive to dryness in forests. It is wind pollinated.

Flowers and seeds are set late in the growing season. If frost occurs too early, no seeds will be produced. After germination, seedlings grow fast.

Dispersal, movement & genetics

This plant is not a great disperser, but may get an occasional long distance event with flooding or being caught in animal fur. Seeds are dispersed by water, gravity, domestic animals, vehicles and people, as well as vegetatively.

Most populations of *Microstegium vimineum* in Illinois have low genetic diversity, but some do have high diversity.

Abiotic conditions: disturbance, soils, geology

Microstegium vimineum likes floodplains and has some preference for acidic soils. It could benefit from increased storm intensity and tree blowdown in forests. Heavy infestations of this plant in forests can change fire behavior in understory microhabitats.

Biotic interactions

This is a shade-adapted grass that often forms dense stands along riparian woodlands and shaded roadsides, but does invade native woodlands and forests. Its seed is dispersed by water, gravity, domestic animals, vehicles, and people.

Bibliography

Baker, S. A., & Dyer, R. J. (2011). Invasion genetics of Microstegium vimineum (Poaceae) within the James River Basin of Virginia, USA.Conservation Genetics, 12(3), 793-803.

Flory, S. L., & Clay, K. (2010). Non-native grass invasion suppresses forest succession. Oecologia, 164(4), 1029-1038.

Flory, S. L. (2010). Management of Microstegium vimineum invasions and recovery of resident plant communities. Restoration Ecology, 18(1), 103-112.

Flory, S. L., Long, F., & Clay, K. (2011). Invasive Microstegium populations consistently outperform native range populations across diverse environments.Ecology, 92(12), 2248-2257.

Gibson, D. J., Spyreas, G., & Benedict, J. (2002). Life history of Microstegium vimineum (Poaceae), an invasive grass in southern Illinois. Journal of the Torrey Botanical Society, 207-219.

Cheplick, G. P. (2010). Limits to local spatial spread in a highly invasive annual grass (Microstegium vimineum). Biological Invasions, 12(6), 1759-1771.

Minuartia patula (Michx.) Mattf.

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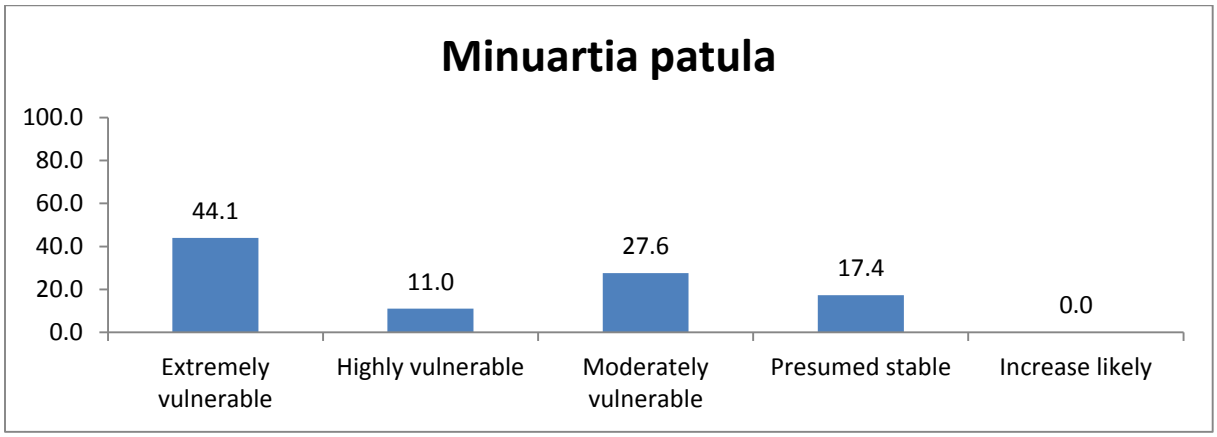

Figure 50: Minuartia patula is categorized as Extremely Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers	GI	I	SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI		SI	N		
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche		I				
Physiological hydrological niche			SI	N		
Disturbance dependence			SI	N		
Ice/snow				N		
Geology/soils		I	SI	N	SD	
Other spp for habitat			SI	N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions			SI	N		
Genetic variation	UNKNOWN					
Genetic bottlenecks			SI	N		
Phenological response			SI	N	SD	

Table 48: Minuartia patula may be more vulnerable to predicted climate changes due to its inability to cross natural or anthropogenic barriers, its dispersal abilities, its historical hydrological niche and its soil preferences.

Little is known about the abilities of this plant to cross natural or anthropogenic barriers, its dispersal abilities, its soil preferences or its genetic diversity in Illinois.

Insights from experts

Contributing experts:
Steven R. Hill, Illinois Natural History Survey
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Eric Ulaszek, Illinois Natural History Survey

General

Based on recent population counts, many populations are declining in size and at least in one location the population may be extirpated. This species is most common to the south in Tennessee, but is also common along the upper Illinois River.

Climate conditions & phenology

As an annual species, having the right temperature and moisture at the right time of year could be particularly important for seed germination and seedling establishment. This plant needs water early in the spring. Plants flower in the late spring, set seed in early summer and have died by mid-July. Seeds begin germination in the fall and throughout winter until early spring.

Dispersal, movement & genetics

Habitat for this species is rare; its numerous, dust-like seeds can get around in soil and wind. Ants may also disperse the seeds.

Little is known about the genetic diversity of this plant in Illinois.

Abiotic conditions: disturbance, soils, geology

Most of the species' population is restricted to dolomite prairies of northeastern Illinois; it can also be found in some gravel prairies and other calcareous, thin-soiled habitats. It is often found in places where flooding occurs, increasing dispersal capability within and away from the habitat.

Biotic interactions

Minuartia patula does not grow well with any competition from other plants and requires full sun. It is pollinated by ants and small flying and crawling insects. Seeds may be dispersed, in part, by ants.

An increase in herbivores (mammals or insects) could make this species more vulnerable as it only has one chance to generate any kind of offspring.

Bibliography

Fishman, L., & Wyatt, R. (1999). Pollinator-mediated competition, reproductive character displacement, and the evolution of selfing in Arenaria uniflora (Caryophyllaceae). Evolution, 1723-1733.

Molano-Flores, B. (2000). Population Viability Assessment for Pitcher's stitchwort (Minuartia patula (Michx.) Mattf.). INHS Center for Biodiversity 2000 (9).

USDA Forest Service Eastern Region. 2003. Conservation assessment for pitcher's stitchwort (Minuartia patula) (Michx.) Mattf. T and E Species Program, Milwaukee, WI. 11 p.

Phoradendron serotinum (Raf.) M. C. Johnst.

Contributing experts:
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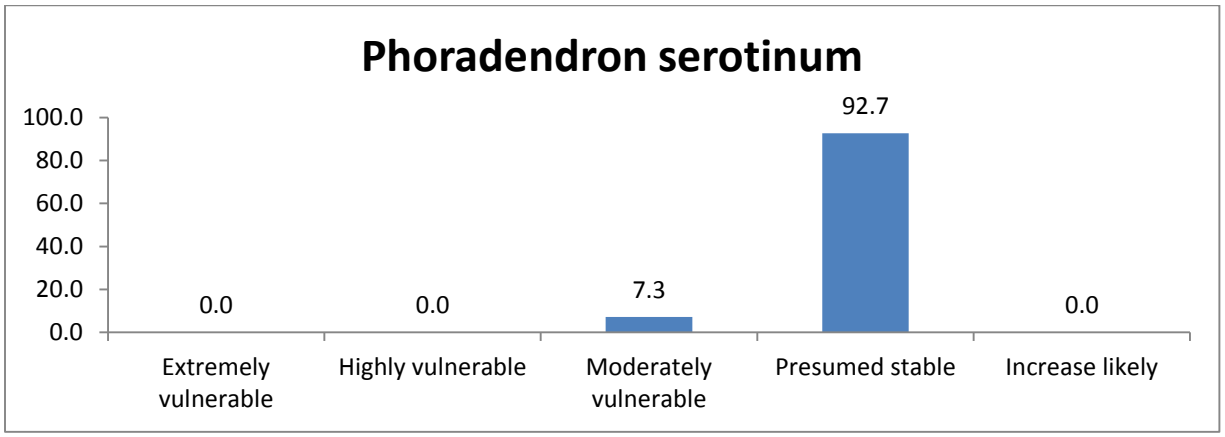

Figure 51: Phoradendron serotinum is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement				N	SD	
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche		I				
Physiological hydrological niche				N		
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N		D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions			SI	N		
Genetic variation	UNKNOWN					
Genetic bottlenecks			SI	N		
Phenological response			SI	N		

Table 49: Phoradendron serotinum may be made more vulnerable to predicted changes in climate due to its historical hydrological niche.

Little is known about the genetic diversity of this plant in Illinois.

Insights from experts

Contributing experts:
Steven R. Hill, Illinois Natural History Survey
Paul Marcum, Illinois Natural History Survey
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey

General

Phoradendron serotinum is a parasitic, evergreen shrub that grows on the branches of trees.
The range of this species retracted in Illinois during the late 1900s and may be recovering. This plant is common to the south of Illinois and is dioecious.

Climate conditions & phenology

This species is distributed to the south and in in southern Illinois, and is probably limited by prolonged periods of cold weather. It could increase under a warmer climate. Changes in precipitation would likely not affect this plant as long as its host tree stays alive.

Dispersal, movement & genetics

This species is common even on trees in yards, cities, farmlands, and widely dispersed by birds. Fruits are sticky and adhere to trees. The flowers may be wind- or self-pollinated; they are very tiny and not colorful.

Little is known about the genetic diversity of this species in Illinois. Within its range, it is common and widespread, leading one expert to conclude that it may be genetically diverse.

Abiotic conditions: disturbance, soils, geology

None noted.

Biotic interactions

Host species for this parasitic plant observed in Illinois include *Ulmus americana, Nyssa sylvatica, Nyssa aquatica, Celtis* spp., *Platanus occidentalis, Liquidambar styraciflua* (both floodplain and upland species). It is also common on oak trees.

Mistletoe's seeds are dispersed by birds.

Bibliography

No references noted.

Pinus echinata Mill.

Contributing experts:
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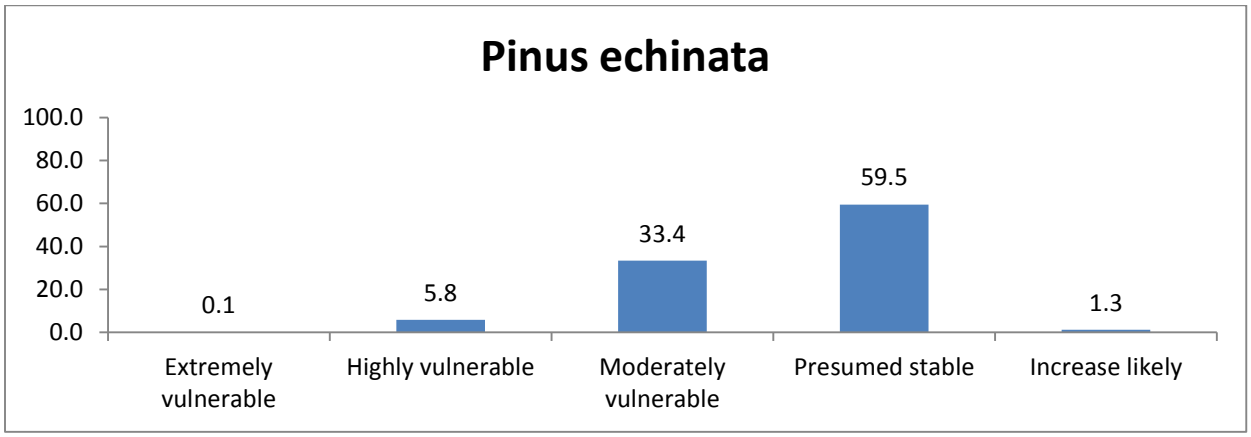

Figure 52: Pinus echinata is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche		I				
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils		I	SI	N	SD	
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions			SI	N		
Genetic variation					SD	
Genetic bottlenecks			SI	N		
Phenological response			SI	N		

Table 50: Pinus echinata may be vulnerable to predicted climate changes due to its inability to cross natural and anthropogenic barriers, its dispersal abilities, its historical hydrological niche and its soil preferences.

Little is known about the dispersal abilities of this plant or about its soil preferences.

Insights from experts:

Contributing experts:
Connie Cunningham, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey

General

Pinus echinata is at the northern edge of its range in Illinois, native populations known are from two extant sites: Union, where there are hundreds of trees (perhaps >1000); and a much smaller population in Randolph County. Historical accounts suggest former presence in other locations in adjacent counties.

This pine is widely planted for reforestation, escapes into old fields, open woodlands, and glade/barren communities. The tree is very common further south, often a co-dominant forest tree in the southern states.

Climate conditions & phenology

Pinus echinata occurs on some of the hottest, driest habit in Illinois and south of Illinois. This plant is limited by cold and individual trees planted far north of native range (northern Illinois) can be damaged or killed during severe winters or late spring freezes. Populations of this plant would likely increase with warmer temperatures. When the tree is planted in mesic soils, it grows well, but it is very drought-tolerant and is not vulnerable to variations in rainfall.

Dispersal, movement & genetics

Dispersal of *Pinus echinata* is probably done by squirrels and occasional blue jays who prize pine nuts. So a rare long-distance dispersal is not out of the question, especially because the seeds are small. This tree is not able to disperse across prairie or deep soil habitats like the Grand Prairie Region, as it needs bare mineral soil to germinate.

Little is known about the genetic diversity of this species in Illinois. Experts speculate that since it is open pollinated and widespread, it may be genetically diverse.

Abiotic conditions: disturbance, soils, geology

In Illinois this species is found on acidic shallow mineral soil and is unlikely to colonize the calcareous soils which are so common in Illinois. Exposure of mineral soil is important for this tree's seedling establishment.

Pinus echinata is tolerant of fire. This species could see a benefit from fires or storms that result in a more open canopy and reduced competition for light.

Biotic interactions

Habitats for *Pinus echinata* include dry and xeric woodlands and forests, also cliffs, barrens, and glades.

The tree's seeds are dispersed by squirrels and blue jays. It is obligate mycorrhizal. It is sensitive to pine bark beetle infestations. Many have been decimated in the south because of these insects.

Bibliography

No references noted.

Pinus strobus L.

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Connie Cunningham, Illinois Natural History Survey
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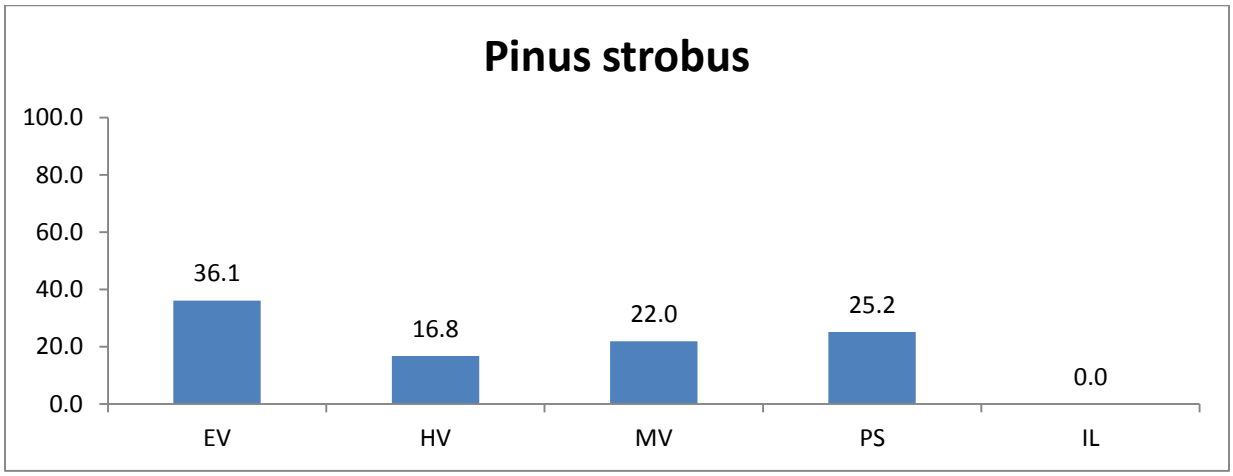

Figure 53: Pinus strobus is categorized as Extremely Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers	GI	I	SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche	GI	I	SI	N		
Historical hydrological niche			SI			
Physiological hydrological niche	GI	I	SI	N	SD	
Disturbance dependence			SI	N	SD	
Ice/snow			SI	N		
Geology/soils		I	SI	N	SD	
Other spp for habitat		I		N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions			SI	N		
Genetic variation				N		
Genetic bottlenecks				N		
Phenological response			SI	N		

Table 51: Pinus strobus may be more vulnerable to predicted climate changes due to its inability to cross natural and anthropogenic barriers its physiological thermal niche, its physiological hydrological niche, its soil preferences and its dependence on other species to generate its habitat.

Little is known about this plant's ability to cross natural or anthropogenic barriers, its physiological thermal niche, its physiological hydrological niche or its soil preferences.

Insights from experts

Contributing experts:

Connie Cunningham, Illinois Natural History Survey
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General

Economically, white pine is one of the most valuable trees in eastern North America. It has likely been slowly marching northward since the last glacier receded ca. 10,000 BP. There are very few places in IL where this species is considered "natural," though it grows fairly well where planted across much of the state.

Climate conditions & phenology

Naturally occurring populations of *Pinus strobus* in Illinois are generally restricted to cool climate areas, but the species is planted widely outside of cool climate areas and persists and reproduces. The tree can be damaged by late freezes.

White pine seems to grow in areas with a wide range of annual precipitation (20 to 80 inches/yr.) and does best on well-drained soils.

Dispersal, movement & genetics

This wind-pollinated tree is dispersed via gravity, wind and small mammals. Natural barriers may not be a problem for the dispersal of this species, but it may not be able to cross prairie or row crop agriculture systems. Like most pines, *Pinus strobus* needs bare mineral soil to reproduce.

Pinus strobus has moderate to high genetic diversity. A compatative genetics study has found its genetic diversity to be lower than (but similar to) that of *P. monticola*.

Abiotic conditions: disturbance, soils, geology

Across its range, white pine grows on a fairly wide range of soil types/geologic features, yet in IL, it seems to be somewhat restricted. It is found, for example, on the ridge and cliff tops at Starved Rock, in the sandy dunes and ravines in Lake County, and in a remnant stand of oaks and pines at White Pines State Park. The tree prefers well-drained soils in ravines and steep rock cliffs. It is found on soils derived from both sandstone and limestone. Seedlings establish on exposed mineral soil. *Pinus strobus* is intolerant of saline conditions.

Thin-barked, seedlings, saplings, and even mature trees can be killed by fire, although the tree may reseed prolifically into burned habitats.

Biotic interactions

This wind-pollinated tree has seeds that are dispersed by small mammals, especially squirrels. They are obligate mycorrhizal associates.

Bibliography

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Table_of_contents.htm

Mehes, M., Nkongolo, K. K., & Michael, P. (2009). Assessing genetic diversity and structure of fragmented populations of eastern white pine (Pinus strobus) and western white pine (P. monticola) for conservation management. Journal of Plant Ecology, rtp016.

Platanthera leucophaea (Nutt.) Lindl.

Contributing experts:
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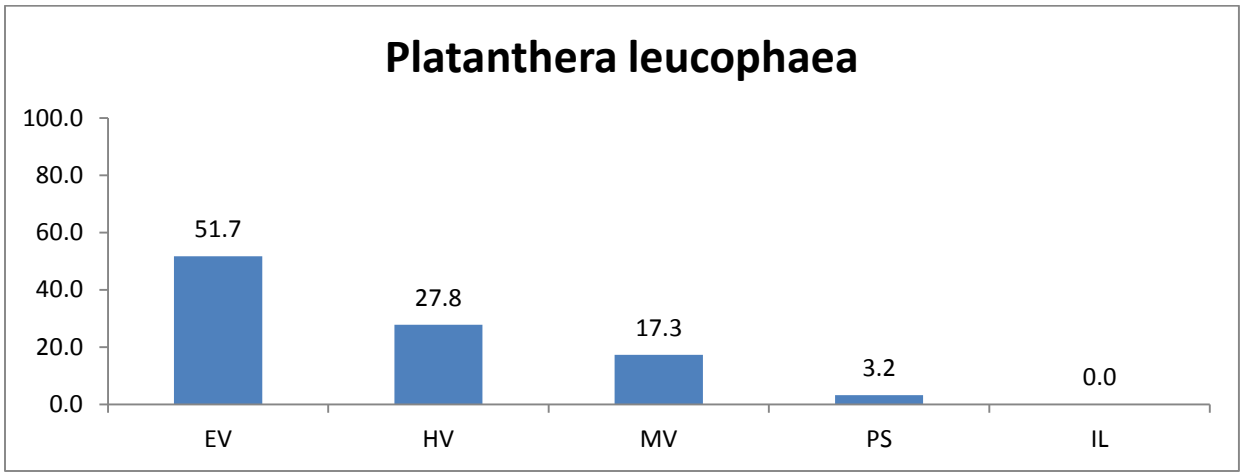

Figure 54: Platanthera leucophaea is categorized as Extremely Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers	GI	I	SI			
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche		I	SI	N		
Historical hydrological niche		I				
Physiological hydrological niche	GI	I	SI	N	SD	
Disturbance dependence		I	SI	N	SD	
Ice/snow				N		
Geology/soils			SI	N	SD	
Other spp for habitat		I	SI	N		
Other spp for pollination		I	SI	N		
Other spp for dispersal				N		
Other spp interactions		I	SI	N		
Genetic variation		I	SI			
Genetic bottlenecks			SI	N		
Phenological response		I	SI	N		

Table 52: Under predicted climate changes, Platanthera leucophaea may be vulnerable due to its inability to cross anthropogenic barriers, its dispersal abilities, its physiological thermal niche, its historical and physiological hydrological niches, its dependence on disturbance, its dependence on other species to generate its habitat and pollinate it, its dependence on other interspecific interactions, its low genetic variation and its inability to track changing seasonality.

Little is known about this plant's dispersal abilities, or its physiological hydrological niche.

Insights from experts

Contributing experts:

Timothy Bell, Chicago State University
Connie Cunningham, Illinois Natural History Survey
Kayri Havens, Chicago Botanic Garden
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
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David N. Zaya, Illinois Natural History Survey

General

Platanthera leucophaea is a federally threatened perennial monocot, growing from an underground tuberous stem. Plants apparently can go dormant for one or more years, and are able to survive off heterotrophic nutrition.

Records indicate that it was much more common in Illinois in previous centuries; now only a few populations remain due to the loss of prairie habitat. It is not always found in the highest quality remnants. Sometimes it survives considerable degradation and recolonizes sites with past disturbance history, for example, adjacent to the Grant Creek Nature Preserve the plant occurs in vegetated ruts on an abandoned county road. This species is widely planted and has several cultivars that are planted as well. *Platanthera leucophaea* was probably a true woodland savanna plant, but now it occurs in a wide range of habitats both natural and artificial.

Climate conditions & phenology

Experts are not clear as to whether warming, in and of itself, would be a detriment to this species. Warming without an increase in precipitation, however, would not benefit *Platanthera leucophaea*.

This plant requires moist conditions and late season drought could be a particular problem for *Platanthera leucophaea*. There is an apparent relationship between flowering and precipitation, with increased flowering and size of inflorescences following springs with higher-than-average precipitation. Conversely, extreme flood events at occupied sites seem to have a negative impact on plant survival and flowering during the following years.

Dispersal, movement & genetics

Seeds of *Platanthera leucophaea* are gravity and wind dispersed. The plant is rarely able to reproduce vegetatively. The plant's habitat, wet prairies, are highly fragmented due to agriculture.

Genetic variation of *Platanthera leucophaea* has been assessed and it is comparable to other similar species.

Abiotic conditions: disturbance, soils, geology

This orchid prefers wet boggy organic soils. It seems to be absent from sites with acidic, mostly sandy, or gravelly soils, and thin soils over bedrock. It is also absent from leached, more acidic soils in southern Illinois. Fire can keep this plant's habitats open and stimulate growth.

Biotic interactions

In Illinois, *Platanthera leucophaea* is primarily a plant of prairies and associated communities, such as sedge meadows and fens. In some locations, this plant occurs with *Phalaris arundinacea* or cattails. It is not in pannes along Lake Michigan, but in Lake Plain wet-mesic prairies just north of Illinois. *Platanthera leucophaea* likes sunny, open areas.

This wind-dispersed species is pollinated largely on one moth species, *Sphinx emeritus*, the hermit sphinx; larvae of this moth feed primarily on various members of the Lamiaceae, especially *Monarda fistulosa*, which is a fairly numerous plant in prairie and savanna remnants, old fields, and less intensively managed roadsides and utility ROWs. One expert has seen butterflies with polymnia on their heads, although this does not prove successful pollination.

Like most orchids it has obligate relationships with mycorrhizae for germination, and likely vigor in later life stages. The plants depend on the fungus for a considerable portion of their nutrition, although aboveground stems and leaves are photosynthetic.

Bibliography

Paul, J., Budd, C., & Freeland, J. R. (2013). Conservation genetics of an endangered orchid in eastern Canada. Conservation Genetics, 14(1), 195-204.

Pollack, C. (2009). Restoration of the Eastern Prairie Fringed Orchid (Platanthera Leucophaea): Natural Pollinators and the Abundance of Larval Host Plants: A Thesis Presented to the Faculty of the Department of Biology, Northeastern Illinois University in Partial Fulfillment of the Requirements for the Degree Master of Science in Biology (Doctoral dissertation, Northeastern Illinois University).

Wallace, L. E. (2003). The cost of inbreeding in Platanthera leucophaea (Orchidaceae). American Journal of Botany, 90(2), 235-242.

Poa pratensis L.

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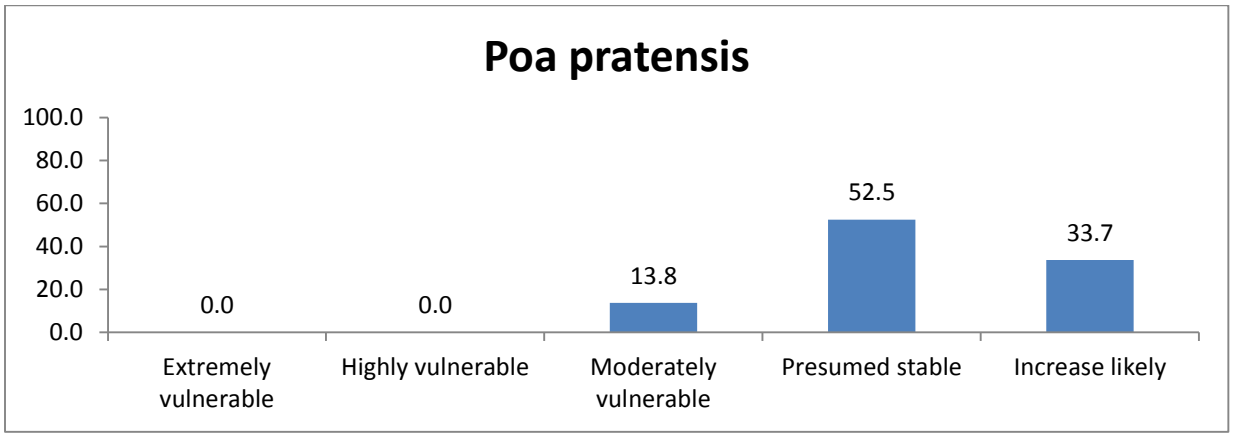

Figure 55: Poa pratensis is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers			SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche			SI	N		
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation				N	SD	
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 53: Poa pratensis may be more vulnerable to predicted climate changes due to its dispersal abilities.

Little is known about this plant's dispersal abilities.

Insights from experts

Contributing experts:

Connie Cunningham, Illinois Natural History Survey
James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Greg Spyreas, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

Poa pratensis is an abundant rhizomatous, perennial, meadow and lawn grass – adapted to many climates and habitats. The range in Illinois is entirely the result of deliberate planting for pasture, erosion control, and lawns. This is probably the most common plant species in IL.

Climate conditions & phenology

With its relatively shallow roots and preference to grow and flower best under cool conditions in the spring of the year, Kentucky bluegrass might not do well during periods of hot, dry weather. Indeed we observe many "brown" lawns during dry summers as Kentucky bluegrass goes dormant without regular water.

This wind-pollinated grass flowers in the late spring and tends to go dormant or semi-dormant in the summer. Its seeds have no dormancy and can germinate shortly after dropping, in the summer and fall. *Poa pratensis* can also seed through apomixis.

Dispersal, movement & genetics

Widespread planting of this species for lawns, livestock forage, and roadsides likely makes any evaluation of natural dispersal difficult. Seeds likely get caught in fur, folds of clothes, and in mowing equipment. If it were dependent upon natural dispersal, Kentucky bluegrass might be limited by a landscape of barriers—row crop agriculture, urban areas, etc. The plant can also spread vegetatively through rhizomes, stolons and tillers.

Genetic variation of *Poa pratensis* in Illinois is similar to that of the outbreeding grass, *Agrostis*. At 88 of the plant's loci, it has a high mean number of alleles.

Abiotic conditions: disturbance, soils, geology

Poa pratensis seems to be fairly adaptable to a wide variety of soil types but it has a high soil fertility requirement, and may do best on neutral to slightly alkaline soils.

This plant often occurs along trails or other disturbances in woodland and forests. Mowing helps the species. Fire may harm it, especially under a regular fire regime if burning occurs after flowering in mid-spring. This grass is intolerant of inundation.

Biotic interactions

This plant is a universal invasive into natural communities in Illinois. It responds positively to livestock grazing, with increased vegetative reproduction. It is a facultative mycorrhizal plant.

Bibliography

Helgadottir, A., & Snaydon, R. W. (1986). Patterns of genetic variation among populations of Poa pratensis L. and Agrostis capillaris L. from Britain and Iceland. Journal of applied ecology, 703-719.

Honig, J. A., Bonos, S. A., & Meyer, W. A. (2010). Isolation and characterization of 88 polymorphic microsatellite markers in Kentucky bluegrass (Poa pratensis L.). HortScience, 45(11), 1759-1763.

Uchytil, Ronald J. 1993. Poa pratensis. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 24].

Potamogeton illinoensis Morong

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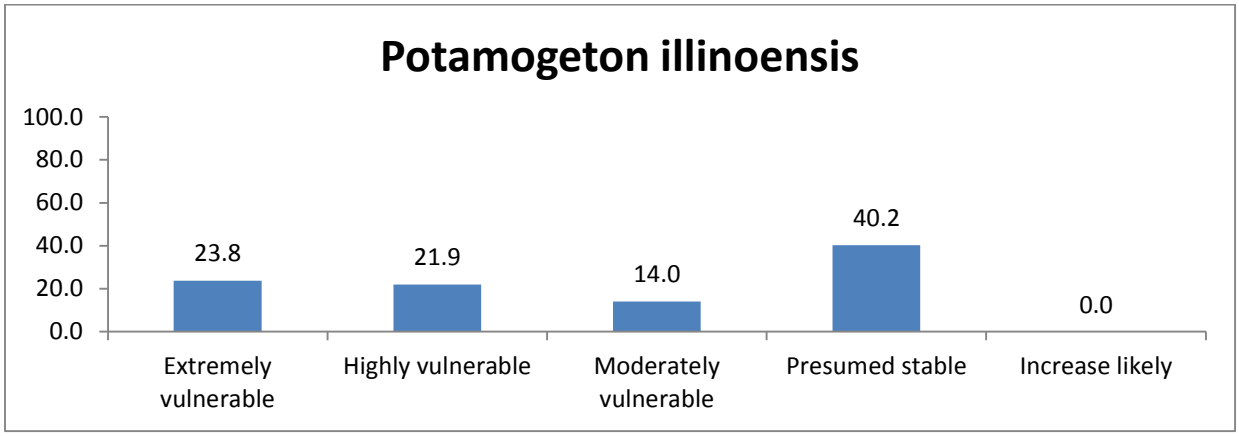

Figure 56: Potamogeton illinoensis is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers	GI		SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche			SI	N		
Historical hydrological niche			SI			
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence			SI	N		
Ice/snow				N		
Geology/soils		I	SI	N	SD	
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks			SI	N		
Phenological response			SI	N		

Table 54: Under predicted climate changes, Potamogeton illinoensis may be more vulnerable to climate change due to its inability to cross natural and anthropogenic barriers, its dispersal abilities, its physiological hydrological niche and its soil preferences.

Little is known about this plant's abilities to cross natural or anthropogenic barriers, its dispersal abilities, its physiological hydrological niche, its soil preferences or its genetic diversity in Illinois.

Insights from experts:

Contributing experts:

James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

This perennial aquatic macrophyte is found across the upper Midwest as well as across central Florida. *Potamogeton illinoensis* is rare, endangered or extirpated in several states where it formerly occurred; one expert has seen it only in undisturbed glacial ponds and lakes in northern IL – especially Lake County. Conditions for the establishment of this species are unknown, but it does need bodies of unpolluted water.

Climate conditions & phenology

Experts feel that this plant prefers cooler areas, but is somewhat tolerant of warm water as well. It requires quiet, relatively deep, alkaline waters. Some of its habitats could dry up with increased drawdown or with periodic dry spells or drought.

Dispersal, movement & genetics

Potamogeton illinoensis seeds are dispersed either very locally in the water next to the parent plant or many kilometers from the parent plant, if they have been carried in duck guts. Many Potamogetons are widely dispersed by waterfowl, but one expert notes a study that found Potamogeton seeds in wild duck feces unable to germinate. In addition, this plant can spread vegetatively.

Unsuitable habitat (i.e., dry land) between habitat patches is substantial in Illinois, but these may not prove to be a barrier to migration if the plant is dispersed by ducks. One expert feels that, due to the limited availability of this plant's habitat in Illinois, it may decrease with changes to climate.

Little is known about the genetic diversity of this plant in Illinois.

Abiotic conditions: disturbance, soils, geology

Potamogeton illinoensis is often found growing in calcareous/alkaline waters, but it may not be endemic to or completely dependent on these conditions. The plant prefers rather pure, clean water, and decreases with warming, siltation, pollution and draining of ponds. While it can grow in both lakes and streams, it seems to prefer some amount of current. Does grow in places where it may be rarely exposed by low water levels, but does not emergent phase like some other Potamogeton spp. The plant grows rooted in substrate, which can be gravel, sand, silt, or bedrock rubble.

Biotic interactions

Pollinators for this plant are not known, but may be small insects or perhaps water. Seeds are dispersed by water and probably water birds.

Bibliography

Lindqvist, C., De Laet, J., Haynes, R. R., Aagesen, L., Keener, B. R., & Albert, V. A. (2006). Molecular phylogenetics of an aquatic plant lineage, Potamogetonaceae. Cladistics, *22*(6), 568-588.

Mueller, M. H., & van der Valk, A. G. (2002). The potential role of ducks in wetland seed dispersal. Wetlands, *22*(1), 170-178.

Smits, A. J. M., Van Ruremonde, R., & Van der Velde, G. (1989). Seed dispersal of three nymphaeid macrophytes. Aquatic Botany, *35*(2), 167-180.

Prunus serotina Ehrh.

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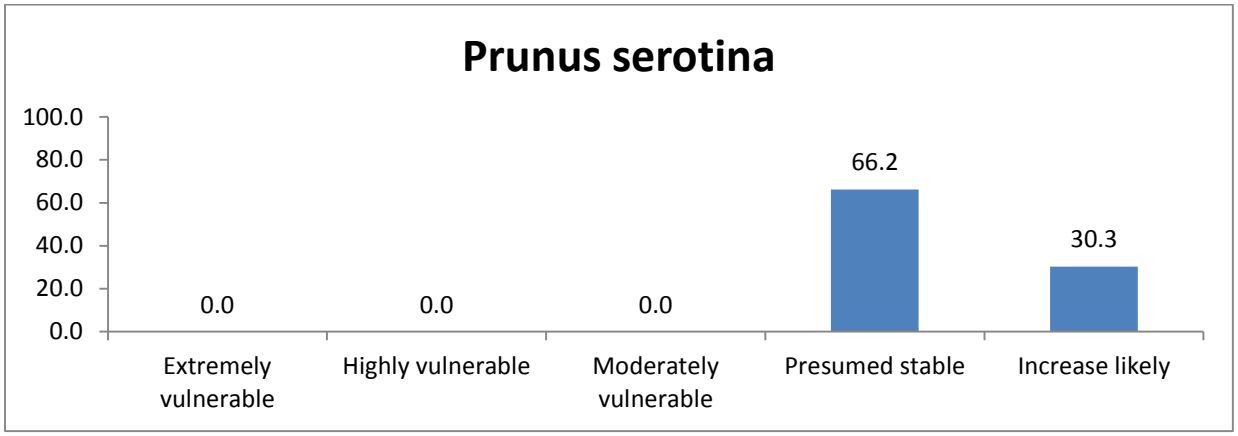

Figure 57: Prunus serotina is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers			SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche				N		
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions			SI	N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N		

Table 55: Prunus serotina may not be vulnerable to predicted climate changes based on its biology and ecology.

Little is known about the dispersal abilities of this plant or about its genetic diversity in Illinois.

Insights from experts

Contributing experts:

James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

Prunus serotina is a native tree of upland woodlands and forests in Illinois; it has a wide range beyond Illinois. The tree is widespread, variable and common, and may have been increasing in woodlands and forests. The wood of this tree is commercially valuable, but the tree is rarely planted.

Climate conditions & phenology

Experts feel that, since Illinois is more or less in the heart of this species' range, we may not notice any temperature or precipitation- related changes to *Prunus serotina* here. The seeds of this plant have a cold dormancy requirement. *Prunus serotina* does not typically dominate the hottest driest habitats in Illinois. It flowers in the late spring. If drought conditions killed larger mature canopy trees, this might open up opportunities for the relatively fast growing black cherry to fill the gaps.

Dispersal, movement & genetics

Most of the viable fruits drop from the parent tree and end up only a few meters or less away. However, many have observed birds and mammals that eat the seeds. They likely deposit the hard drupes at a distance.

While the genetic diversity of this plant in Illinois has been studied, it is difficult to say whether it is higher or lower than expected because the results are never compared to those of congeners. Experts believe the plant may be genetically diverse, citing the fact that there are several named varieties.

Abiotic conditions: disturbance, soils, geology

Black cherry is able to grow and thrive on a wide variety of substrates and soil types, except for the very wettest and the very driest.

While this species is sensitive to fire, it will respond quickly to damage of canopy trees in a forest. It will quickly grow to fill light openings that are left after canopy trees are killed by drought conditions or are damaged by storms, for example.

Biotic interactions

This species is just as happy in disturbed areas as in older forests – it is a common successional tree, matures early, and produces thousands of seeds. Although somewhat shade tolerant, it also readily colonizes old fields, prairie remnants, and along fencelines.

Black cherry is visited by a wide variety of insect pollinators. Many birds and mammals eat the fruits and disperse the seeds. Although somewhat resistant to browsing mammals, black cherry is a host plant for a broad range of insects including sesiid stem-borers and foliovorous caterpillars. It does have mycorrhizae on roots, but they may not specific or even facultative. Black cherry is allelopathic.

Bibliography

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Table_of_contents.htm

Pueraria montana var. *lobata* (Willd.) Maesen & S. M. Almeida ex Sanjappa & Predeep

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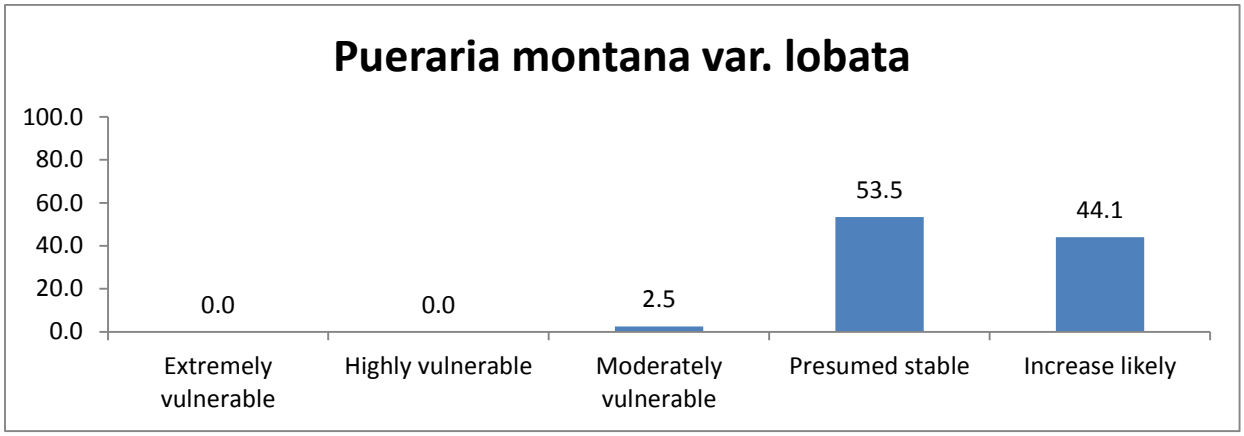

Figure 58: Pueraria montana var. *lobata is categorized as Presumed Stable with predicted climate changes.*

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI	N		D
Historical thermal niche				N		
Physiological thermal niche					SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence				N	SD	D
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation				N	SD	
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 56: Pueraria montana var. *lobata may be made more vulnerable to predicted climate changes due to its dispersal abilities.*

Little is known about the dispersal abilities of this plant in Illinois.

Insights from experts

Contributing experts:
Steven R. Hill, Illinois Natural History Survey
Cathy McGlynn, Northeast Illinois Invasive Plant Partnership
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey
Christopher Warneke, Chicago Botanic Garden

General

Pueraria montana var. *lobata* is extremely invasive; it forms dense canopy over other woody and herbaceous plants and can kill even competitive plants, including trees. It produces viable seeds in southern and central Illinois and at least one population in Cook County (in Evanston) produces viable seed as well.

Climate conditions & phenology

Kudzu is generally thought to be limited by cold and frost. However, populations of the plant persist as far north as Chicago. Although there is some aboveground damage to the plant in severe winters, it recovers rapidly and is extremely persistent. That being said, this plant is certainly much more widespread to the south, and experts expect that it would increase in Illinois if the climate warms.

In the experience of one expert, the moisture regime does not make much of a difference once the plant is established. However, a wetter climate will benefit the species. Kudzu is susceptible to extreme drought and flooding and will respond positively to increasing carbon levels which are predicted in the future.

Dispersal, movement & genetics

Kudzu is dispersed by gravity and wind. One expert regularly encounters seeds greater than 10 meters from their source due to pods being blown a decent distance by the wind. Seeds may also be dispersed by animals, humans and water. In addition, the plant reproduces vegetatively through underground rhizomes. Experts agree that as an aggressive habitat generalist, kudzu is unlikely to experience natural or anthropogenic barriers to migration in Illinois.

Little is known about the genetics of kudzu in Illinois.

Abiotic conditions: disturbance, soils, geology

Pueraria montana var. *lobata* grows on a diversity of soils and sites. It thrives with increased human disturbance and erosion.

Biotic interactions

The morphology of kudzu's flowers does not suggest pollinator limitation. Giant resin bee is one of the primary pollinators, but a number of bees and other insects also pollinate the plant. In addition, the plant is capable of self-pollination. The plant, in addition to vegetative spread, can be moved by wind, animals, humans and water.

Kudzu is a nitrogen fixer, with nodules of N-fixing bacteria on roots. In addition, it may have facultative mycorrhizal associates.

Bibliography

Dukes, J. S., & Mooney, H. A. (1999). Does global change increase the success of biological invaders?. Trends in Ecology & Evolution, 14(4), 135-139.

Heider, B., Fischer, E., Berndl, T., & Schultze-Kraft, R. (2007). Analysis of genetic variation among accessions of Pueraria montana (Lour.) Merr. var. lobata and Pueraria phaseoloides (Roxb.) Benth. based on RAPD markers.Genetic Resources and Crop Evolution, 54(3), 529-542.

McClain, W. E., Coons, J. M., Adler, E. T., & Ebinger, J. E. (2006). Distribution and reproductive potential of kudzu (Pueraria lobata, Fabaceae) in Illinois, USA.Trans Ill St Acad Sci, 99(1/2), 17-3O.

Sun, J. H., LI, Z. C., Jewett, D. K., Britton, K. O., Ye, W. H., & GE, X. J. (2005). Genetic diversity of Pueraria lobata (kudzu) and closely related taxa as revealed by inter-simple sequence repeat analysis. Weed Research, 45(4), 255-260.

Wilson, J. R., Dormontt, E. E., Prentis, P. J., Lowe, A. J., & Richardson, D. M. (2009). Something in the way you move: dispersal pathways affect invasion success. Trends in Ecology & Evolution, 24(3), 136-144.

Quercus alba L.

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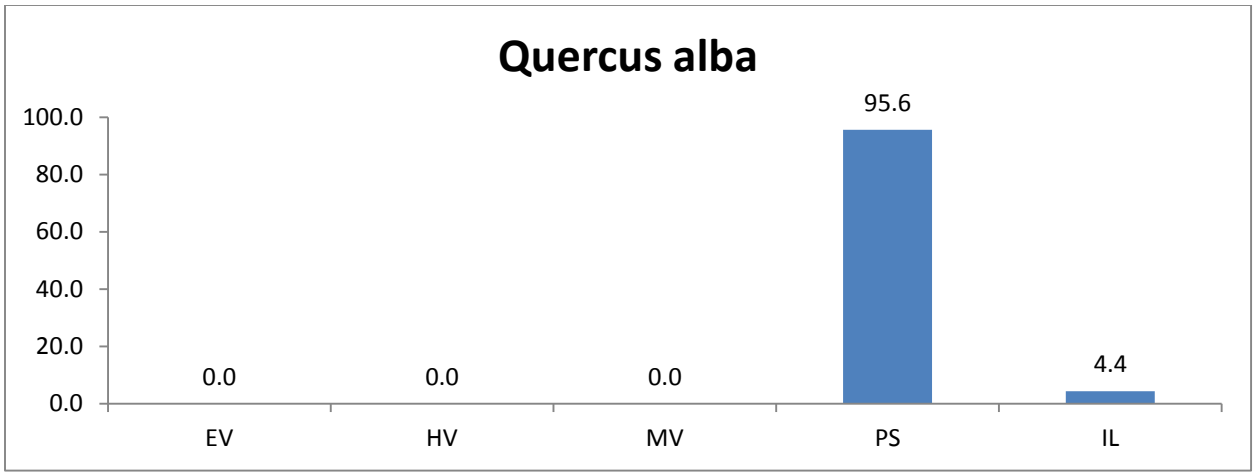

Figure 59: Quercus alba is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers			SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat			SI	N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation			SI	N	SD	
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 57: Quercus alba may be made more vulnerable to predicted climate changes due to its dispersal abilities.

Little is known about the dispersal abilities of this plant.

Insights from experts:

Contributing experts:

James Ellis, Illinois Natural History Survey
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Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

Quercus alba is the Illinois state tree. It is a large, long-lived species found throughout Illinois and beyond. It is an economically important timber species.

Climate conditions & phenology

Experts believe that this heat-tolerant oak could increase with higher temperatures. They point out that on the northern ends of the species' range, individuals prefer more southerly aspects and at the southern ends, they prefer more northerly aspects. Late frosts may damage or kill flowers.

These trees are not usually found in in wet soils and drier conditions could benefit white oak in Illinois. The tree is intolerant of prolonged flooding and saturation. When trees are found in floodplains, they are often growing on well-drained sites.

Dispersal, movement & genetics

White oak is dispersed by small mammals, especially squirrels. The heavy acorns of these trees may not be dispersed far and dispersal between forest patches may be limited or non-existent.

Quercus alba is wind pollinated, and monoecious, although there are staminate and pistillate flowers. Under certain stress conditions, individual trees may be functionally male or female. The tree hybridizes with other oak species (*Q. macrocarpa, Q. bicolor, Q. muhlenbergii, Q. stellata*, etc.); introgression may be an important means of capturing adaptive genes. Genetic diversity of this species may be low. One study found it to be a little lower than that of two other white oaks, but still relatively high. Another study found that the genetic diversity of this tree was somewhat low compared with other congeners.

Abiotic conditions: disturbance, soils, geology

When planted da a planted shade tree, *Quercus alba* is somewhat intolerant of highly modified, calcareous, high clay-content soils. It is more fire resistant than many other oaks, except as seedlings.
Sizeable trees can resprout after top damage.

Biotic interactions

White oak is a dominant canopy species in dry mesic forests, woodlands, barrens, and savannas, but it also grows in mesic and dry communities. It is relatively shade intolerant and seedlings/saplings grow better with full to almost full sunlight. If other forest tree species are affected by dry weather and die creating light gaps, then this might be beneficial to white oak.

Seeds of this species are dispersed by animals, including woodpeckers, blue jays and squirrels. One expert has observed seeds germinating on top of the ground in the early fall, indicating that the seeds do not require burial by animals to succeed.

Quercus alba is obligate mycorrhizal. It has a specialized cadre of fungal and invertebrate associates – deleterious, commensal, and perhaps some beneficial.

One way climate changes could affect white oak is through an increase in pestilence as with a potential increase in sudden oak syndrome or gypsy moths.

Bibliography

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Table_of_contents.htm

Craft, K. J., & Ashley, M. V. (2006). Population differentiation among three species of white oak in northeastern Illinois. *Canadian Journal of Forest Research*, *36*(1), 206-215.

Sork, V. L., Koop, A., De La Fuente, M. A., Foster, P., & Raveill, J. (1997). Patterns of genetic variation in woody plant species in the Missouri Ozark Forest Ecosystem Project. *UNITED STATES DEPARTMENT OF AGRICULTURE FOREST SERVICE GENERAL TECHNICAL REPORT NC*, 231-247.

Tirmenstein, D. A. 1991. Quercus alba. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 27].

Quercus rubra L.

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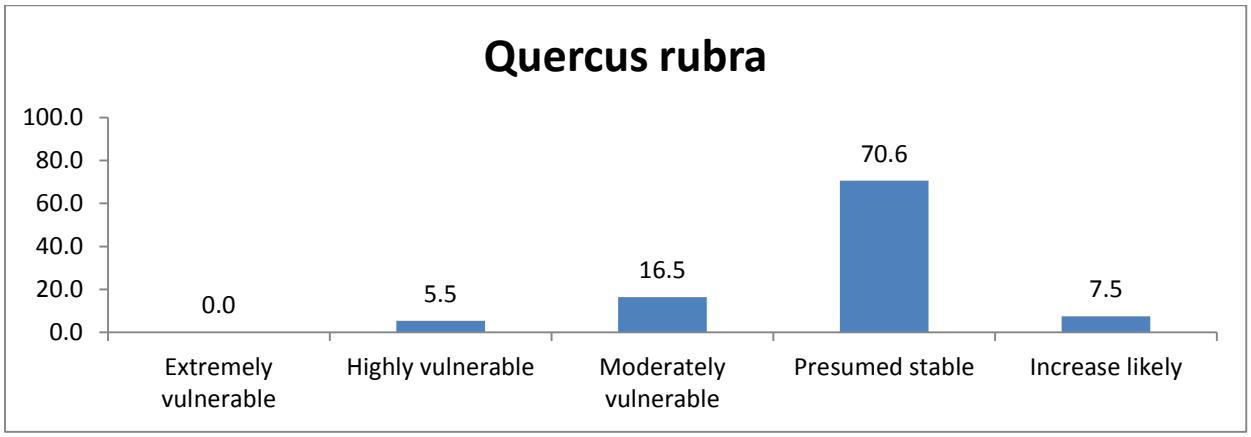

Figure 60: Quercus rubra is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation				N		
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 58: Quercus rubra may be made more vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers and its dispersal abilities.

Little is known about the dispersal abilities of this plant.

Insights from experts

Contributing experts:

James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

Quercus rubra is a large, long-lived tree, which occurs throughout Illinois and is widespread beyond, especially to the east.

Climate conditions & phenology

Red oak prefers cooler temperatures than many oaks. It is common in the northern part of the state and is replaced by other species to the south. However, the species is able to tolerate some heat.

This is the most mesophytic (i.e. more demanding of moisture) oak in the IL flora. Predicted periods of dry weather might impact red oak. While it is sometimes found in floodplains on mesic sites, it is not especially tolerant of flooding. The tree is somewhat drought tolerant.

Flowers of this oak can be damaged by late frosts.

Dispersal, movement & genetics

The acorns of red oak are primarily gravity, squirrel and mice dispersed. The plant is wind pollinated and monoecious, but does have separate staminate and pistillate flowers.

Little work has been done investigating the genetic diversity of this plant in Illinois. One expert suggests that the diversity could be relatively high because the species is widespread, old, and abundant and wind pollinated. *Quercus rubra* is known to hybridize with *Q. imbricaria*, *Q. velutina*, *Q. falcata*, *Q. ellipsoidalis*, *Q. coccinea*, and probably other red/black oaks.

Abiotic conditions: disturbance, soils, geology

At northern edge of range (ex. UP Michigan) *Quercus rubra* occurs on southerly aspects, while south of Illinois, it is more characteristic of northerly aspects. This tree is a generalist regarding soil types that it grows in. It has a wide pH range, similar to *Q. alba*.

Red oak is less tolerant of fire than many other oaks.

Biotic interactions

Quercus rubra is dominant canopy in mesic woodlands, also in mesic forest; it is present in many other mesic and dry-mesic forest, woodland, barrens, and savanna communities. It is classed as intermediate in shade tolerance.

Seeds dispersed by birds (long-distances) and rodents (short-distances). Deer browse can significantly impact regeneration. The tree is obligate mycorrhizal.

Bibliography

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Table_of_contents.htm

Forkner, R. E., & Hunter, M. D. (2000). What goes up must come down? Nutrient addition and predation pressure on oak herbivores. Ecology, *81*(6), 1588-1600.

Tirmenstein, D. A. 1991. Quercus rubra. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 27].

Ranunculus ficaria L.

Contributing experts:
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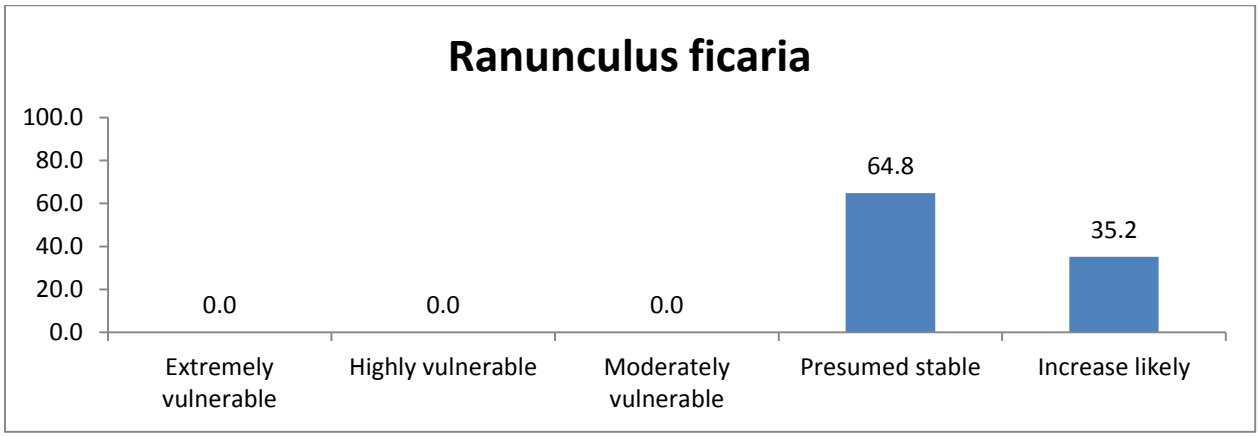

Figure 61: Ranunculus ficaria is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers			SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement				N	SD	D
Historical thermal niche				N		
Physiological thermal niche		I	SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N		
Disturbance dependence					SD	D
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 59: Under predicted changes, Ranunculus ficaria may be more vulnerable due to its physiological thermal niche.

Little is known about the physiological thermal niche of this plant or its genetic diversity in Illinois.

Insights from experts:

Contributing experts:
Steven R. Hill, Illinois Natural History Survey
Cathy McGlynn, Northeast Illinois Invasive Plant Partnership
Greg Spyreas, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

This is a rather recently introduced and spreading weed in Illinois. It has been in places such as the east coast, such as Maryland, for a long time and is now under consideration as a noxious weed in many states. It is sometimes confused with the similar *Caltha palustris*, a native, so reports must be checked carefully.

Climate conditions & phenology

In Europe lesser celandine's climate envelope is in pretty cool habitats, like the UK, but in the US it seems to be establishing pretty far south and it may not be all that sensitive to heat. One expert suggests that additional precipitation (excluding severe flooding or droughts) would increase the growth and reproduction of the species. Another expert says the plant is tolerant of flooding, and also tolerant of drought –as it is dormant during the warm months as tubers in the ground. Flooding might impact individual plants, but it could also help the species to disperse by carrying tubers and bulblets to new locations.

In Illinois today, this plant grows only in the spring then goes dormant. This is a real early bloomer that may be helped by warmer springs. Lesser celandine will leaf out and bloom earlier as the winters become milder and the growing season starts earlier. This species will have additional time to reproduce and spread during spring.

Dispersal, movement & genetics

Experts agree that this plant is spread by people, by soil movement, and by flooding. Bulblets or seed can be carried along waterways. In addition, the plant can be spread vegetatively by tubers.

The diploid (2n=16) and tetraploid (2n=32), the tetraploid types prefer more shady locations and frequently develop bulbils at the base of the stalk. These two variants are sometimes referred to as distinct sub-species, *R. ficaria ficaria* and *R. ficaria bulbifer* respectively. Both forms are likely present in the Chicago area, with ssp. Bulbifer being more common. Many authors do not recognize the subspecies as being distinct.

As an introduced species, its populations probably experience founder effects. Some genetic work has been done on this plant in Illinois but it is difficult to say how genetically diverse our populations are. No comparative studies have been conducted within taxonomic groups and one study measured diversity with RAPD, but only made intraspecific comparisons.

Abiotic conditions: disturbance, soils, geology

Ranunculus ficaria may prefer calcareous or high pH soils. It does well in disturbed floodplain forests.

Biotic interactions

This plant is pollinated by generalists: bees, flies and beetles. It needs forest habitat to survive.

Bibliography

Reisch, C., & Scheitler, S. (2009). Disturbance by mowing affects clonal diversity: The genetic structure of Ranunculus ficaria (Ranunculuaceae) in meadows and forests. Plant Ecology, 201(2), 699-707.
Swink, F., & Wilhelm, G. (1994, October). Plants of the Chicago region. Indianapolis: Indiana Academy of Science.

Rhamnus cathartica L.

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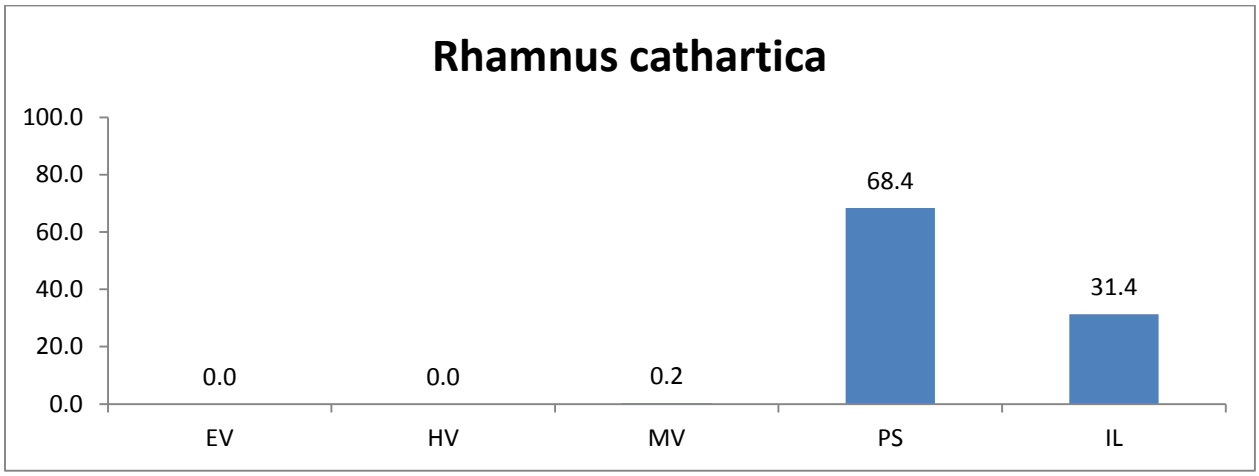

Figure 62: Rhamnus cathartica is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence			SI	N	SD	D
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat			SI	N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 60: Rhamnus cathartica may not be vulnerable to predicted climate changes based on its biology and ecology.

Little is known about this plant's dispersal abilities, its disturbance dependence or its genetic diversity in Illinois.

Insights from experts:

Contributing experts:
James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Jessica Kurylo, University of Melbourne
Cathy McGlynn, Northeast Illinois Invasive Plant Partnership
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Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

Rhamnus cathartica is a large shrub or small tree native to Europe. It is highly invasive in Illinois, especially northern Illinois. Although much less frequent farther south, there are localized pockets of invasion.

Climate conditions & phenology

Experts disagree about the temperature preferences of *Rhamnus cathartica*. Some contend that it prefers cool temperatures, and that it is sensitive to heat, based on its distribution throughout Illinois and the rest of North America, and that is resistant to unseasonal frosts and freezes. Others believe that the species is somewhat cold-sensitive. It may be that predicted temperature and moisture changes (warmer and wetter) will not have much of an effect on the species, its southern reaches being dictated more by soil type than by temperature. However, if current predictions prove wrong, and Illinois becomes warmer and drier, *Rhamnus cathartica* will likely not fare well.

Experts generally agree that buckthorn prefers wetter sites and is rarely seen to thrive on drier sites. Increased precipitation would likely produce increased growth with the exception of severe storm events involving long term severe flooding or torrential rains that could result in habitat loss and plant destruction in ravines. The plant can invade wetlands, although it is short-lived under these conditions.

In terms of changing seasonality and the plant's phenology, experts agree that this plant should do fine with an earlier onset of spring. *Rhamnus cathartica* already is able to leaf out earlier and outcompete native plants in the forested areas and roadside edges it often inhabits. The plant would likely benefit from a longer growing season. *Rhamnus cathartica* does and will continue to germinate throughout the year.

Increased wind along lake bluffs might result in some stunted growth, but only in extremely exposed locations.

Dispersal, movement & genetics

Rhamnus cathartica is spread by birds and other animals that eat the fruits and deposit seeds some distance from the source plant. The European starling may have been pivotal in this species' success in Illinois. There are no natural barriers to this species' range expansion in Illinois. However, row crop agriculture does pose as a barrier to the species; most other anthropogenically influenced habitats are not a barrier. Buckthorn does better and is more prolific in population centers in Illinois than in more rural settings.

Buckthorn likely has a "jack of all trades" type of genome, so it can thrive in new conditions. The species was probably introduced multiple times to Illinois, each time experiencing founder effects. Experts feel that this plant may be quite genetically diverse in Illinois, but no research has been done on this topic.

Abiotic conditions: disturbance, soils, geology

Rhamnus cathartica thrives after certain types of disturbances: moving of soil/litter to expose seeds through fire or mechanical means, but also a change or termination of a regular disturbance regime (e.g., stopping fire). In Illinois the plant invades all types of habitats but is most dense in former oak savannas and woodlands with a history of grazing and fire suppression.

The plant has a wide tolerance for a variety of different soil conditions, including acidic, basic, wet, dry, sandy, and clayey. *Rhamnus cathartica* can alter soil nutrient cycling.

Biotic interactions

In Illinois, buckthorn invades all types of habitats, though it becomes most dense in former oak savannas and woodlands with history of grazing and fire suppression.

Seeds of this plant are dispersed by mice, birds, humans, deer, dogs, cats, to name a few. The European starling may have been pivotal in this species' success in Illinois. However, it is hard to say how far animals are able to disperse the seed, as the fruit has a purgative effect on the things that eat it.

Buckthorn is pollinated by a variety of generalist insects including bees and flies.

There is some evidence in the Chicago area that buckthorn relies on forest soils that have been cleared of their surface organic matter in part by introduced worms, Lumbricus. However, one expert notes that, for every study showing a relationship between earthworms and *Rhamnus cathartica* there is another that shows none. The plant may be allelopathic and casts dense shade, preventing competition. It can be heavily browsed by deer in localized areas, and is sometimes affected (but not killed) by leaf rust diseases.

Bibliography

Culley, T. M., & Stewart, J. R. (2010). Microsatellite primers in Rhamnus cathartica (Rhamnaceae) and applicability in related taxa to assess hybridization events. American journal of botany, 97(3), e7-e9.

Harrington, R. A., Brown, B. J., & Reich, P. B. (1989). Ecophysiology of exotic and native shrubs in Southern Wisconsin. Oecologia, 80(3), 356-367.

Harrington, R. A., Brown, B. J., Reich, P. B., & Fownes, J. H. (1989). Ecophysiology of exotic and native shrubs in southern Wisconsin. II. Annual growth and carbon gain. Oecologia, 368-373.

Heimpel, G. E., Frelich, L. E., Landis, D. A., Hopper, K. R., Hoelmer, K. A., Sezen, Z., ... & Wu, K. (2010). European buckthorn and Asian soybean aphid as components of an extensive invasional meltdown in North America.Biological Invasions, 12(9), 2913-2931.

Knight, , K. S., Kurylo, J. S., Endress, A. G., Stewart, J. R., & Reich, P. B. (2007). Ecology and ecosystem impacts of common buckthorn (Rhamnus cathartica): a review. Biological Invasions, 9(8), 925-937.

Kurylo, J. S., Knight, K. S., Stewart, J. R., & Endress, A. G. (2007). Rhamnus cathartica: Native and naturalized distribution and habitat preferences 1. The Journal of the Torrey Botanical society, 134(3), 420-430.

Kurylo, J. S., & Endress, A. G. (2014). Effects of Scarification and Stratification on Germination of Common Buckthorn (Rhamnus cathartica L.) seeds. J Biodivers Manage Forestry 3: 4. of, 2, 2.

Qaderi, M. M., Clements, D. R., & Cavers, P. B. (2009). The biology of Canadian weeds. 139. Rhamnus cathartica L. Canadian Journal of Plant Science, 89(1), 169-189.

Reisch, C., & Scheitler, S. (2009). Disturbance by mowing affects clonal diversity: The genetic structure of Ranunculus ficaria (Ranunculuaceae) in meadows and forests. Plant Ecology, 201(2), 699-707.

Zouhar, Kris. 2011. Rhamnus cathartica, R. davurica. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 27].

Rosa carolina L.

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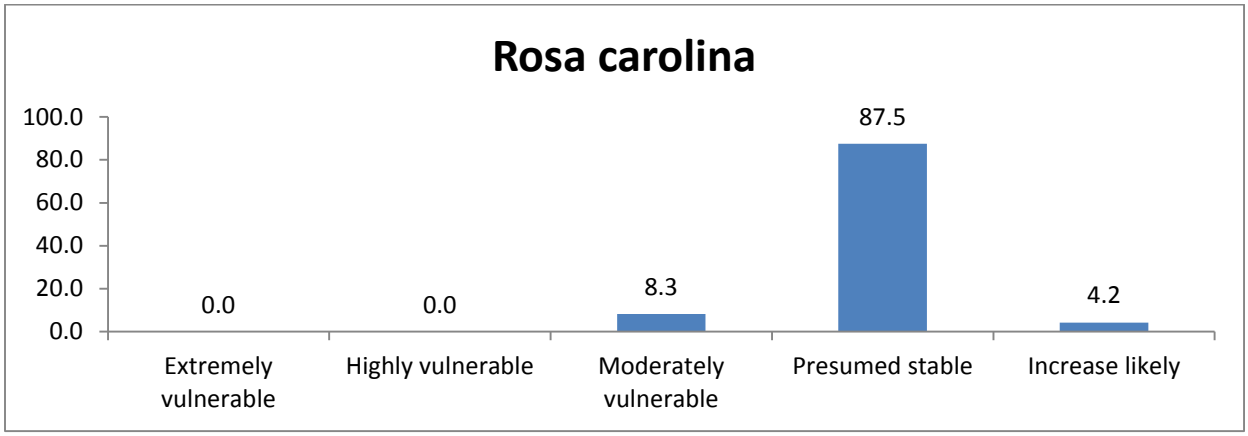

Figure 63: Rosa carolina is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche		I		N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 61: Rosa carolina may be more vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers, its dispersal abilities and its physiological hydrological niche.

Little is known about this plant's dispersal abilities or its genetic diversity in Illinois.

Insights from experts

Contributing experts:

James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Eric Ulaszek, Illinois Natural History Survey

General

Rosa carolina was likely once a common and ubiquitous plant of the tallgrass prairie as well as environs to the east of IL. The fruits or hips of pasture rose persist on plants into the fall and sometimes through the winter. Rose hips can be eaten in the late summer, but I'm not sure if the seeds are ripe at that time. I know seeds are ripe in the fall but by that time the hip is very hard and at least to me, unpalatable.
Rosa carolina is a long-lived, rhizomatous perennial with above ground woody stems.
Seeds have complex dormancy, often little or no germination until second spring after deposition, but little germination after third year.

Climate conditions & phenology

Pasture rose prefers or thrives on deep, well-drained to dry soils. Periods of very wet weather may be detrimental to the plant, but periods of dry weather might not affect pasture rose. If both of those type of weather events become more common, it is unclear what that means for pasture rose.

Dispersal, movement & genetics

Rosa carolina is a long-lived, rhizomatous perennial with above ground woody stems. Vegetative spread is important in this species' persistence and a single colony may be larger than acre. In addition, seeds may be spread by mammals and birds.

This plant is sometimes reported to be self-incompatible. The plant is variable, widespread, and will hybridize with similar species, including *R. arkansana*. Little is known about the genetic diversity of *Rosa carolina* in Illinois.

Abiotic conditions: disturbance, soils, geology

This plant does fine with fire, some disturbance, mesic or xeric sites, as well as in essentially pristine prairies. Flowers appear on the previous years' growth, so a hot fire that kills aboveground stems will effectively prevent flowering and seed production for the following year. However, the plant usually resprouts vigorously after fire.

Biotic interactions

Rosa carolina occurs in diverse upland habitat, including prairies (typic, sand, dolomite, gravel), woodlands, barrens, and savannas, and sometimes in wet-mesic prairies. The plant does invade old fields; survives degradation in pastures, roadsides, rights-of-ways. *Rosa carolina* would likely increase if prairies increased because it is shaded out in forests. In addition, it could increase with grazers, *Rosa carolina* is rather protected from grazers. Foragers avoid the plant because of prickles.

The flowers are visited by a wide range of generalist insects. One expert notes that he has seen its pollen being carried by bumblebees.

There is some amount of uncertainty about how the seeds of *Rosa carolina* are dispersed. Many believe that birds and small mammals eat the rosehips and disperse the seeds long distances. However, one study of bobwhite quail food habits in Missouri found seeds of many species of plant in the birds' crops during the fall, but no *Rosa*. The plant is mycorrhizal, but it is unclear if that relationship is obligatory.

Bibliography

Hilty, John. Pasture Rose. Illinois Wildflowers Website. www.illinoiswildflowers.info

Sarracenia purpurea L.

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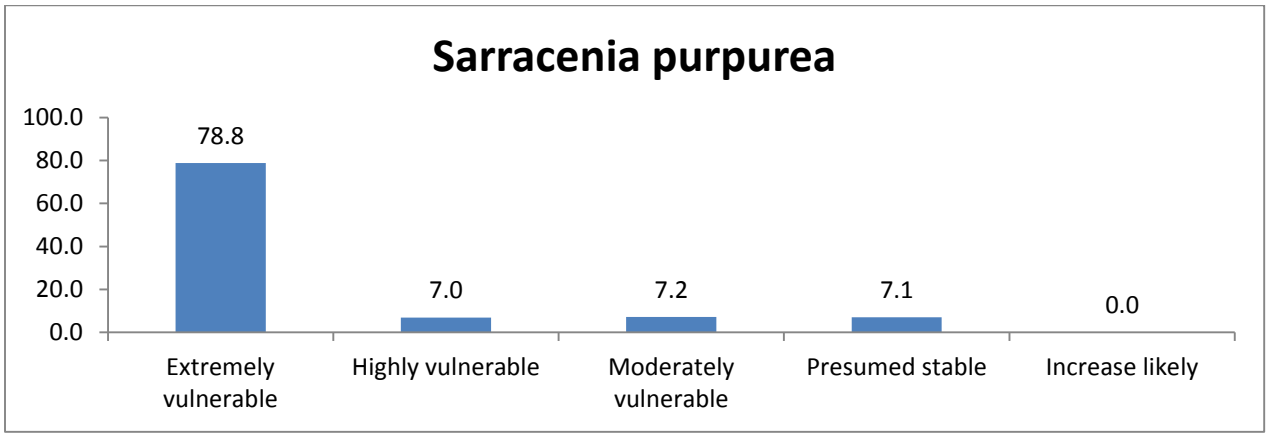

Figure 64: Sarracenia purpurea is categorized as Extremely Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers	GI	I	SI	N		
Anthropogenic barriers	GI	I	SI			
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI			
Historical thermal niche				N		
Physiological thermal niche	GI	I	SI	N		
Historical hydrological niche		I				
Physiological hydrological niche	GI	I	SI	N		
Disturbance dependence		I		N		
Ice/snow				N		
Geology/soils		I	SI	N	SD	
Other spp for habitat		I	SI	N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions			SI	N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response	UNKNOWN					

Table 62: Sarracenia purpurea may be made more vulnerable to predicted climate changes due to its inability to cross natural and anthropogenic barriers, its dispersal abilities, its physiological thermal niche, its historical and physiological hydrological niches, its dependence on disturbance, its soil preferences, and its dependence on other species to generate its habitat.

Little is known about this plant's ability to cross natural barriers, its physiological thermal niche, its physiological hydrological niche, its soil preferences, its genetic diversity in Illinois or its ability to track changing seasonality.

Insights from experts

Contributing experts:
James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Paul Marcum, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Rick Phillippe, Illinois Natural History Survey

General

The west and south boundaries of the range of this species in the upper Midwest seem to almost perfectly match the northeast boundary of the tallgrass prairie (prairie peninsula). This may indicate that climate and geography have played a strong role in determining the range of this species.

Climate conditions & phenology

There are several subspecies of *Sarracenia purpurea* adapted to either cold or warm conditions. The subspecies in Illinois is the northern one, sensitive to warming. It is very dependent on acidic bogs that are cool. At the species level, however, Purple pitcher plant has a wide latitudinal range from north to south which may indicate that this species is physiologically capable of both relatively hot and cold climates.

The plant is dependent on acidic bogs, which are Highly Vulnerable in Illinois to drying and warming. Periods of dry weather or drought would likely have an adverse effect on individuals or local populations.

Dispersal, movement & genetics

Current habitats in IL are few and separated by inhospitable land in between. These habitat types are unlikely to increase in numbers under predicted conditions. One expert notes that an ice age would probably help the plant. Barriers to the plant's migration certainly exist, but the seeds of the plant probably do float, helping with dispersal to some extent.

Little is known about the genetics of purple pitcher plant in Illinois. Colonies are small and quite local, possibly characteristics that could indicate low genetic diversity.

Abiotic conditions: disturbance, soils, geology

The occurrence of Sphagnum dominated wetlands usually coincides with geological features that are relicts of the last global glacial advance. The plant is extremely dependent on acid bogs, and cannot move to warmer high pH wetlands.

Biotic interactions

One expert notes that *Sarracenia purpurea* often co-occurs with Sphagnum but is uncertain as to whether this is correlation or a dependent relationship.

Bees, and possibly other generalists, pollinate this plant. Purple pitcher plant will consume most any small insect.

Bibliography

Cain, M. L., Damman, H., & Muir, A. (1998). Seed dispersal and the Holocene migration of woodland herbs. Ecological monographs, 68(3), 325-347.

Clark, J. S., Fastie, C., Hurtt, G., Jackson, S. T., Johnson, C., King, G. A., & Wyckoff, P. (1998). Reid's Paradox of Rapid Plant Migration Dispersal theory and interpretation of paleoecological records. BioScience, 48(1), 13-24.

Ellison, A. M., & Parker, J. N. (2002). Seed dispersal and seedling establishment of Sarracenia purpurea (Sarraceniaceae). American Journal of Botany, 89(6), 1024-1026.

Walkup, Crystal. Sarracenia purpurea. 1991. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 28].

Schedonorus arundineceus (Schreb.) Dumort., nom. Cons.

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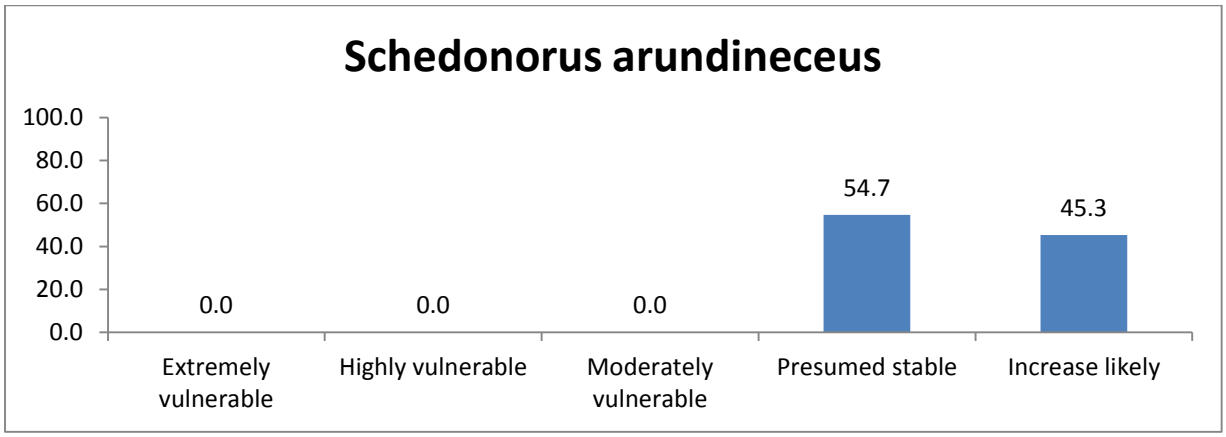

Figure 65: Schedonorus arundineceus is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N		D
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence			SI	N	SD	D
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 63: Schedonorus arundineceus may not be vulnerable to climate changes due to its biology and ecology.

Little is known about the plant's dispersal abilities, its dependence on disturbance or its genetic diversity in Illinois.

Insights from experts

Contributing experts:
James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
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General

Schedonorus arundineceus is a widespread, invasive, non-native, perennial grass. Plants are strongly cespitose, but it does produce longer rhizomes forming a sod. The grass is heavily planted along roadsides, ditches, airports, and waterways.

Climate conditions & phenology

Schedonorus arundineceus is quite flexible with its temperature requirements. It seems to have a slight preference for warmer temperatures. In Illinois, this grass attempts to remain evergreen, but foliage is killed by prolonged cold.

Soil moisture does seem to limit this species, and it is not usually found in dry, well-drained soils. Total rainfall seems to limit this species as well. While it grows best on soil with good moisture, it seems to survive a wide range of conditions.

Tall fescue grows best, flowers and sets seed in the cool parts of the spring and summer. A sward of fescue can go completely dormant in severe summer drought and will recover (with some losses) when cooler conditions return. Scattered inflorescences can emerge throughout the summer, especially if the plants have been mowed. Ripe seeds will drop in the summer and germinate in the fall or spring.

Dispersal, movement & genetics

Tall fescue inhabits mostly human disturbed, agricultural systems; dispersal on farm/mowing equipment as well as purposeful planting for forage is most likely how this species gets around. Naturally, it may not be a tremendous disperser. Research shows that seeds are capable of germination after passing through the gut of grazing animals such as cattle and sheep or horses. Seeds have been found to cling to wool of sheep. Rodents might carry viable seeds a fair distance.

Schedonorus arundineceus is a wind-pollinated, obligate out-crosser. Even though the overwhelming majority of Fescue planted has been the KY-31 agronomic variety developed in Kentucky, many other varieties exist so one expert speculates that it should have plenty of genetic variation

Abiotic conditions: disturbance, soils, geology

This grass is able to grow in about every little patch of periodically disturbed land in IL (not in deep shade or areas with little soil disturbance).

Biotic interactions

Tall fescue forms dense sward with heavy duff; many natives can colonize fescue-dominated grasslands if fall mowing or other disturbance regularly removes duff. The plant is considered invasive in prairies, glades, barrens, and savannas; can even colonize sedge tussocks in wetlands.

Research suggests that seeds are capable of germination after passing through the gut of grazing animals such as cattle and sheep or horses. Seeds have been found to cling to wool of sheep. Rodents might carry viable seeds a fair distance. Tall fescue has an endophytic fungus that causes health and reproductive issues in animals that graze exclusively on fescue.

Bibliography

Batcher, M. S. Schedonorus phoenix. Eds. J. M. Randall, B. Meyers-Rice, Global Invasive Species Team, The Nature Conservancy. Website accessed July, 2015. http://wiki.bugwood.org/Schedonorus_phoenix

Securigera varia (L.) Lassen

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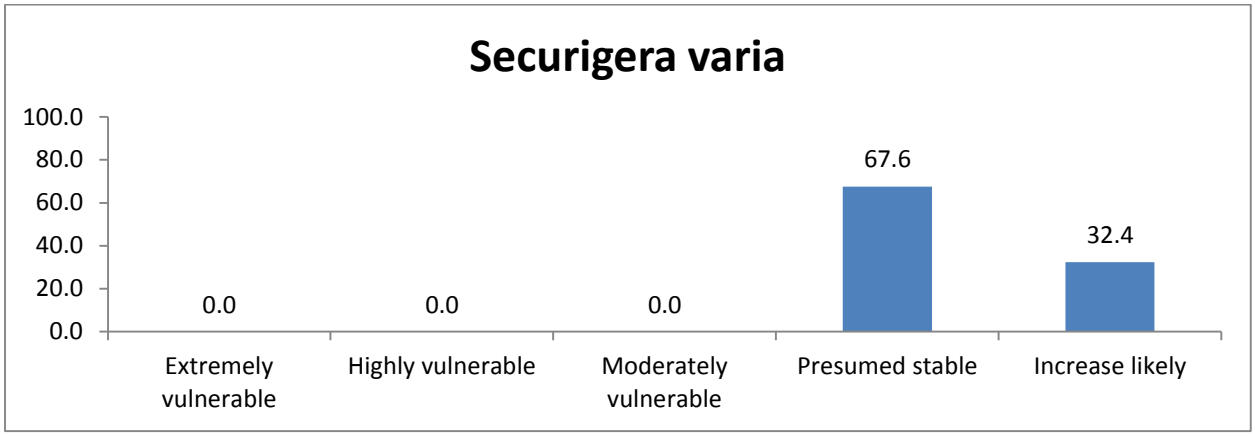

Figure 66: Securigera varia is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers			SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche				N		
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence				N	SD	D
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions			SI	N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response					SD	

Table 64: Securigera varia may be more vulnerable to predicted climate changes due to its dispersal abilities.

Little is known about this plant's dispersal abilities or its genetic diversity in Illinois.

Insights from experts:

Contributing experts:
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Eric Ulaszek, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

Securigera varia is invasive throughout Illinois; have seen as invader in Kentucky, Tennessee, Arkansas, and Oklahoma. It was introduced from Europe for erosion control throughout the US and Canada, but is most common in the Midwestern states – probably because of higher pH soils and adequate moisture and moderate temperatures. The plant forms dense ground-cover and excludes less competitive native forbs and grasses.

Climate conditions & phenology

Crown vetch grows across a wide north to south range, so it may not be adversely affected by changes in climate. Experts seem to have some disagreement about what types of temperatures the plant prefers—from preferring cool areas to not being common in the coolest sites. All agree, however that it has wide temperature tolerances. In addition, the plant does not show damage from unseasonal frosts or freezes.

On *Securigera varia*'s moisture preferences, experts likewise disagree. Some contend that the plant prefers moist areas and may decrease with less precipitation. Others believe that the plant does well in dry, disturbed soils and has excellent drought tolerance. In any case, the plant grows under considerable moisture conditions, although it is intolerant of prolonged inundation or saturation.

Dispersal, movement & genetics

Crown vetch fruits and seeds are not particularly designed for moderate or long distance dispersal. Seeds are probably carried on mowing equipment, moved with soil, vehicles, domestic animals and boots. Often the plant is dispersed by people into disturbed roadside areas. Some studies have shown viable seeds in deer feces, so long distance dispersal is feasible. On the other hand, one expert contends that it is not often seen in areas where it has not been planted, and that it does not spread much from its area of introduction. In any case, *Securigera varia* is a rhizomatous perennial legume, so it is not dependent exclusively on seeds to move around.

Little is known about the genetics of this plant in Illinois. It may be capable of self-pollination. The genetic diversity of the plant will depend, in part, on the number of introductions that were made in Illinois.

Abiotic conditions: disturbance, soils, geology

This plant is able to grow on a wide range of soils. Although it may prefer calcareous substrates, it is also successful on more neutral and slightly acidic soils. It responds positively to fire and is salt-tolerant.

Biotic interactions

Securigera varia is now locally abundant as invader of a most prairie types (typical, sand, dolomite, hill, gravel); also savannas, woodlands, barrens, glades, rock outcrops, and gravel bars in streams.

The plant is visited by a wide range of bees and other insect pollinators, including bees and butterflies (especially European Skipper); perhaps only bumblebees can effectively manipulate the flower. Humans, livestock and deer are likely the plant's main dispersal agents.

One expert speculates that the plant is toxic to non-ruminants, possibly including deer. However, others say that deer and rabbits often brows the green fruits, which apparently contain viable seed. Heavy grazing by livestock can reduce the vigor of a population but will not eliminate it. The plant is assumed to have rhizobium as a root associate.

Bibliography

Gucker, Corey L. 2009. Coronilla varia. In: Fire Effects Information System, [Online]. U.S. Department of agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 28].

Silphium laciniatum L.

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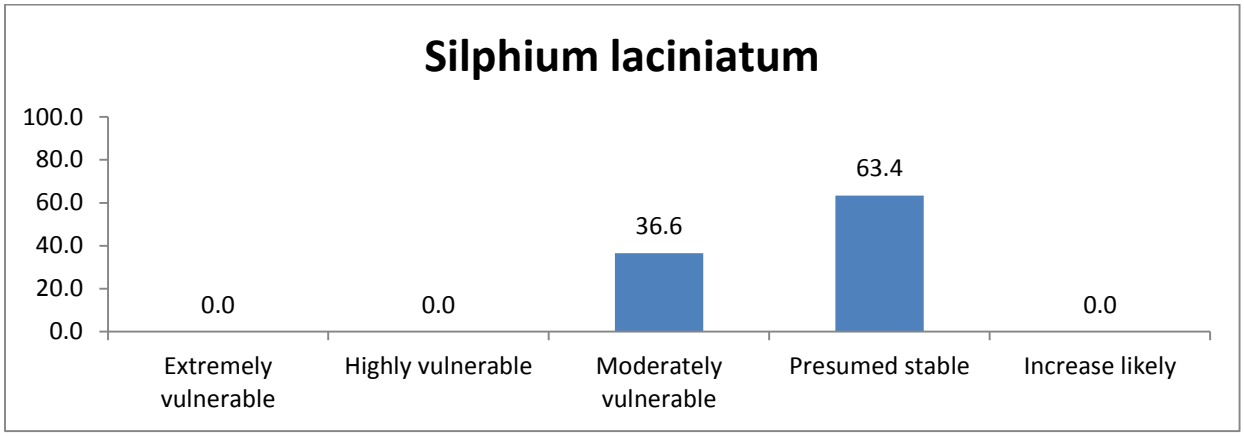

Figure 67: Silphium laciniatum is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers		I	SI			
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N		
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 65: Silphium laciniatum may be more vulnerable to predicted climate changes due to its inability to cross natural and anthropogenic barriers, as well as its dispersal abilities.

Little is known about the genetic diversity of this plant in Illinois.

Insights from Experts:

Contributing experts:
Steven R. Hill, Illinois Natural History Survey
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Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey

General

Silphium laciniatum is a large, perennial forb that grows from a taproot that may down 2-4m. It is quite common in IL and surrounding states in open prairie or savanna habitats. The seeds have a dormancy that is overcome by cold-moist treatment.

Climate conditions & phenology

Based on its range outside of Illinois, experts predict that this species will not be sensitive to increasing or decreasing temperatures. It has wide water preferences and can be found from wet prairies to rocky barrens, although it is not usually in loess hill prairies.
Silphium laciniatum flowers early-middle summer, seeds ripen in September and October.

Dispersal, movement & genetics

The seeds of *Silphium laciniatum* are mostly wind- and gravity-dispersed. Birds and mice may carry seed heads away from the plant too. Experts note that plants are usually seen within a relatively close distance, implying short distance dispersal. The plant is not likely to disperse across regions without prairie but it is so widespread across the state that natural barriers should not be a problem. Crossing non-prairie habitats, on the other hand, could be difficult, but the plant is able to spread along railroad rights-of-way and along highways if they are not mowed.

Little is known about the genetics of this species in Illinois. One expert points out that while there are many populations of this plant, they are often isolated because of habitat fragmentation. Another speculates that the genetic diversity might be acceptable due to the species being quite widespread.

Abiotic conditions: disturbance, soils, geology

It likes high pH soils, but is not restricted to them.
It survives prairie fires,
Does well in calcareous soils, but not restricted to them; best in prairie soils
Pretty much a deep soil species

Biotic interactions

Silphium laciniatum is widespread in Illinois, usually in prairie remnants but also in barrens and savannas. It occasionally colonizes successional sites and roadsides. The plant would not do well under the shade of trees.

Pollinators of this plant are generalists, including bees, beetles, butterflies and moths. In addition, *Silphium laciniatum* is host to a rich array arthropods—stem borers, leaf miners and seed predators. It can be heavily browsed by livestock and deer.

Bibliography

None noted.

Solidago sempervirens L.

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Greg Spyreas, Illinois Natural History Survey
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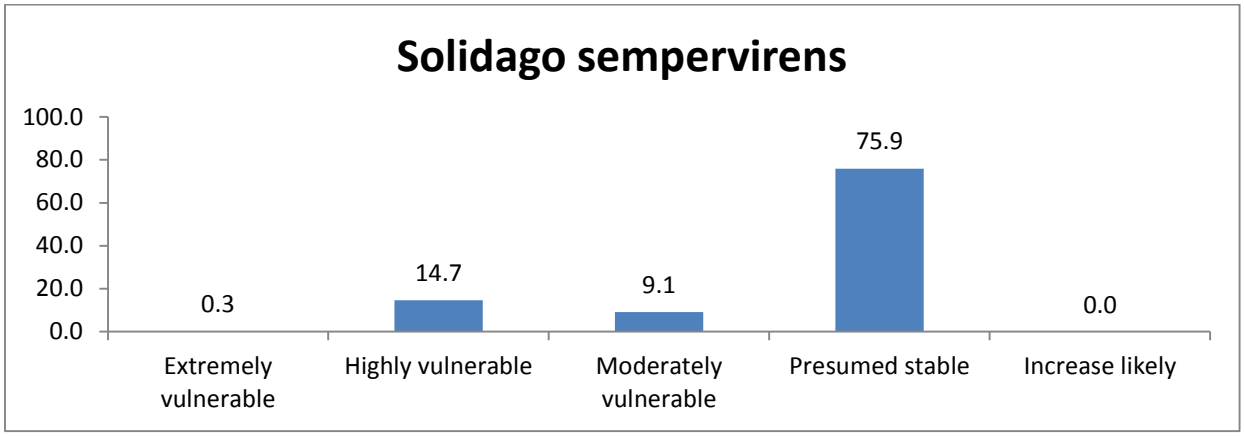

Figure 68: Solidago sempervirens is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers			SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche		I				
Physiological hydrological niche			SI	N	SD	
Disturbance dependence			SI	N	SD	
Ice/snow			SI	N		
Geology/soils		I	SI	N	SD	
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks		I	SI	N		
Phenological response				N		

Table 66: Under predicted climate changes, Solidago sempervirens may be more vulnerable due to its inability to cross natural barriers, its dispersal abilities, its historical hydrological niche, its soil preferences and its having experienced genetic bottlenecks.

Little is known about the dispersal abilities of this plant, its soil preferences or its genetic diversity in Illinois.

Insights from Experts:

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General

Solidago sempervirens is a non-native (native to Gulf and Atlantic coasts), cespitose perennial that reproduces largely by seeds. It is locally abundant in Illinois, mostly in the northeastern counties, where it is common along expressways and other roads that are frequently treated with de-icing products during the winter.

Climate conditions & phenology

Heat, in and of itself, would probably not pose a problem to this plant. However, with warmer winters reduced use of de-icing compounds on roads may reduce competitive edge this species has over other ruderal plants.
The plant requires a fair amount of soil moisture, but it must be salty.

Dispersal, movement & genetics

Like most Solidagos, this plant is probably not a great disperser. Its seeds may be dispersed by wind, water and vehicles.

Natural dispersal barriers should not stop this plant from migrating along roadsides, but around the Chicago area it many pops are limited by non-saline soil surrounding the habitats in which it is found.

While some work has been done finding microsatellite diversity of this plant in Illinois, those numbers have not been compared to those of similar taxa, making it difficult to say for sure how robust the genetic diversity of this plant is. Experts speculate that the genetic diversity in Illinois may be low, given that it is a recent immigrant to the state.

Abiotic conditions: disturbance, soils, geology

Solidago sempervirens is basically only found on alkaline or saline soils which are not common in Illinois except for along roadsides or along Lake Michigan. It sometimes colonizes empty urban lots, fields, and wetlands that receive runoff or salt mist from roads, but sometimes it is in similar areas with no road runoff.

Biotic interactions

Appears to be insect pollinated, but its morphology suggests that it is not specialized to a specific insect.

Bibliography

Wieczorek, A. M., & Geber, M. A. (2002). Microsatellite loci for studies of population differentiation and range expansion in Solidago sempervirens L. (Asteraceae). Molecular Ecology Notes, 2(4), 554-556.

Spergularia media (L.) C. Presl ex Griseb.

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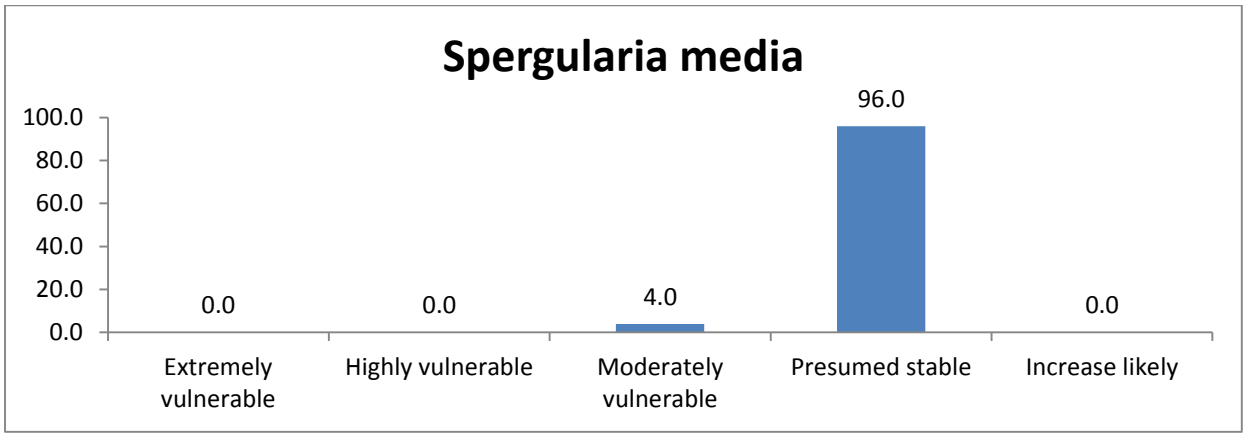

Figure 69: Spergularia media is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers		I		N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche			SI	N		
Historical hydrological niche		I				
Physiological hydrological niche			SI	N		
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils		I		N	SD	
Other spp for habitat		I	SI	N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N		

Table 67: Spergularia media may be made more vulnerable to predicted climate changes due to its inability to cross natural barriers, it dispersal abilities, its historical hydrological niche, its dependence on certain soil types and its dependence on other species to create its habitat.

Little is known about this plant's dispersal abilities, soil preferences or genetic diversity in Illinois.

Insights from Experts:

Contributing experts:
Steven R. Hill, Illinois Natural History Survey
Paul Marcum, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting

General

Spergularia media is an introduced species from salt marshes on the east coast that has been spreading in areas along highways where lots of salt has been used. It is not found in IL to the south – not enough salt used there on the roads.

Climate conditions & phenology

While the plant is flexible regarding heat conditions, if temperatures rise such that salt is not added to roadways, the plant could disappear in Illinois. *Spergularia media* requires wetlands, including roadside ditches.

Dispersal, movement & genetics

This plant is wind-dispersed. It does not have barriers to migration since it grows along roadsides, however it is restricted to the northern part of Illinois where salt is applied to roadways.

Little is known about the genetics of *Spergularia media* in Illinois. The genetic diversity would depend in part on how many introductions have been made from the plants traditional range.

Abiotic conditions: disturbance, soils, geology

This halophyte responds to salt addition along roads and cannot grow in areas with no salt.

Biotic interactions

None known.

Bibliography

Reznicek, A. A. (1980). Halophytes along a Michigan roadside with comments on the occurrence of halophytes in Michigan. Mich. Bot, 19(1), 23-30.
Cusick, A. W. (1983). Spergularia (Caryophyllaceae) in Ohio. Mich. Bot, 22(2), 69-71.

Sporobolus heterolepis (A. Gray) A. Gray

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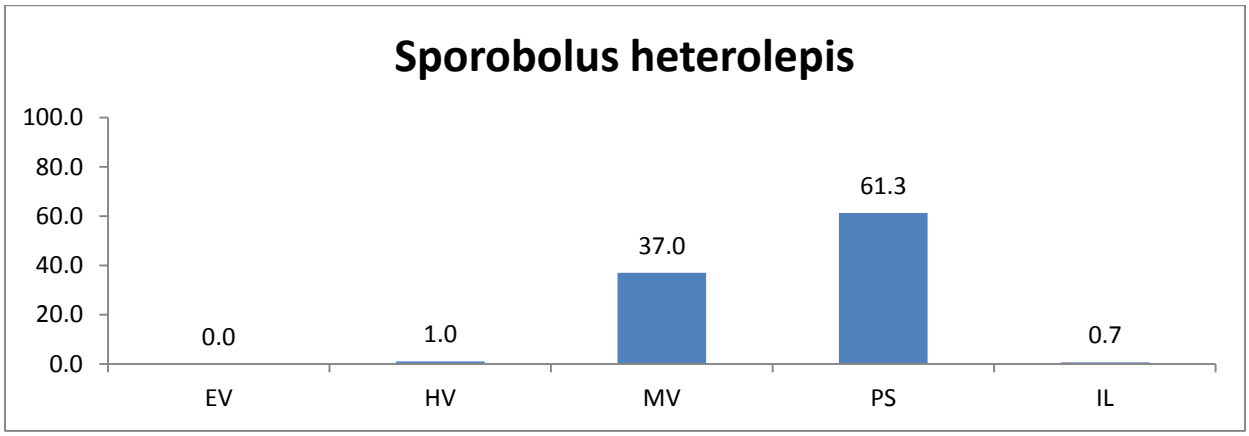

Figure 70: Sporobolus heterolepis is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers	GI	I	SI			
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N		
Historical thermal niche				N		
Physiological thermal niche			SI	N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils				N	SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 68: Under predicted climate changes, Sporobolus heterolepis may be vulnerable due to its inability to cross natural and anthropogenic barriers and its dispersal abilities.

Little is known about the genetic diversity of this plant in Illinois.

Insights from Experts:

Contributing experts:
James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey

General

Sporobolus heterolepis is a characteristic and almost ubiquitous species of the tallgrass prairie and prairie peninsula—a long-lived, deep rooted prairie perennial. It is a generally slow-growing grass; seedlings may not begin flowering until third or fourth year, but will flower in second year under optimum conditions. May be keystone species for structure and composition in late-successional prairie communities; established plants appear to suppress other grasses and forbs nearby.

Although seeds are often assumed to have dormancy, freshly planted seeds, kept warm and with an artificially longer day, will have a higher germination rate than stratified seeds. Probably not persisting in seed banks, seed can remain viable up to three years under constant temperature and moisture levels.
A strictly mesic prairie species usually indicating less disturbed prairies; has declined because of lack of habitat and grazing. *Sporobolus heterolepis* can be easily grown in cultivation, but it is slow to establish in prairie restorations.

Climate conditions & phenology

This is a deep rooted prairie perennial that readily survives periods of dry weather and drought. However, too much or too little moisture at critical times results in abundant and prolonged flowering with little seed set. The plant can tolerate some saturation and flooding, but is also killed by prolonged (>1 week) inundation.

Sporobolus heterolepis flowers mid-summer and seed ripens in early fall. Its root tips stop growing in late August.

Dispersal, movement & genetics

The seeds of prairie dropseed seem ill suited to dispersal via wind or picked up by animals or other vectors. Most seeds probably drop close to parent plants, though experts also speculate that there may be some short distance wind dispersal. This plant is adapted for large prairie acreages.

Natural barriers should not be a problem for this species' migration. In terms of anthropogenic barriers, on the other hand, while some natural corridors for movement may exist, the species cannot travel long distances or cross extensive areas of unsuitable habitat such as cities and cropland. Most populations are surrounded by urban areas and/or row-crop agriculture.

Little is known about the genetics of this species in Illinois. One expert speculates that since the species is widespread and open-pollinated, it should have good genetic diversity. Another points out that as populations get smaller, decreasing genetic diversity may pose a problem.

Abiotic conditions: disturbance, soils, geology

Sporobolus heterolepis is a large bunch grass of prairies, occurring mostly in fine-textured soils but also on dolomite and gravel prairies, and mesic sand prairie; also in barrens and glades. This species is usually considered indicator of unplowed prairie remnants, but can recolonize disturbed sites (slowly) from adjacent remnants.

Fire can stimulate flowering, but can also kill established clumps of S. heterolepis. While it is tolerant of fire, it is not tolerant of shade or habitat disturbance.

Biotic interactions

Probably mycorrhizal, but generalist;
Sporobolus heterolepis is not tolerant of shade. Ants may help to disperse the seeds. The plant may have mycorrhizal relationships, but is probably a generalist.

Bibliography

Snyder, S. A. 1992. Sporobolus heterolepis. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 28].

Taxodium distichum (L.) Rich.

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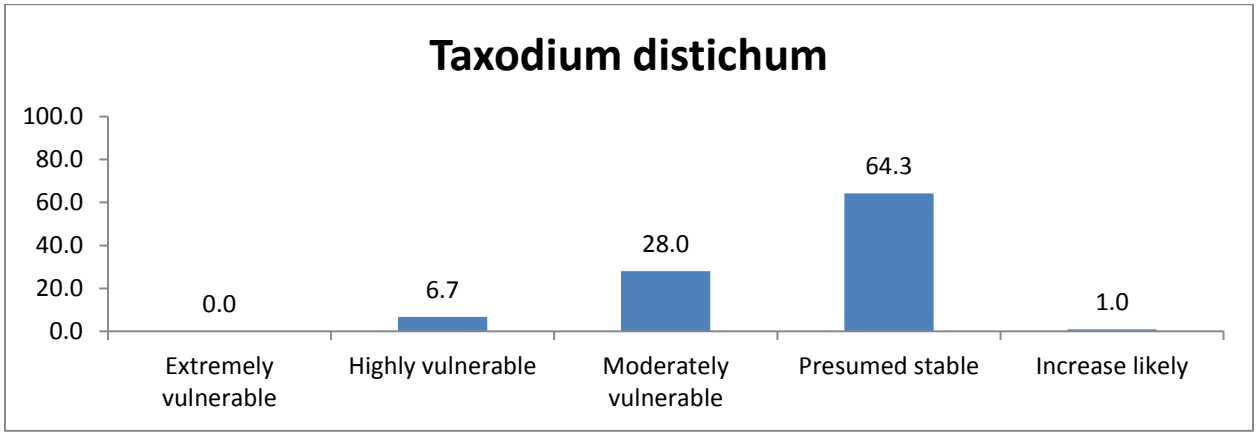

Figure 71: Taxodium distichum is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence			SI	N	SD	
Ice/snow				N		
Geology/soils		I	SI	N	SD	
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation				N		
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 69: Taxodium distichum may be more vulnerable to predicted climate changes due to its inability to cross anthropogenic barriers, its physiological hydrological niche and its soil preferences.

Little is known about this plant's physiological hydrological niche or its soil preferences.

Insights from Experts:

Contributing experts:

James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey

General

Bald cypress is a tree species with most of its range across the southern and southeastern US making its home in wetlands along the Atlantic and Gulf coastal plain as well as north into the Mississippi Delta and south into the Florida peninsula. A well-known tree of southern swamps, which is at the northern edge of its range in southern Illinois, *Taxodium distichum* can also survive in lawn-like conditions. Trees planted to the north of its natural range do produce viable seed and recruit on suitable sites. This species has experienced over-logging.

Climate conditions & phenology

Experts say that bald cypress is tolerant of heat and is more sensitive to cold, though possibly not as much as their natural range would indicate. The tree does not appear to be damaged by late frosts.

For reproduction, the tree seems to need pulses of flooding and water draw-down for successful seedling germination and recruitment. Periodic dry spells and droughts might impact individuals and populations.

Dispersal, movement & genetics

Taxodium distichum is wind pollinated and is dispersed by water, birds, mammals and humans. Its seeds can float and in swamps, that means that bald cypress can get around pretty well. In addition, floodwaters have the potential to carry cones and seeds long distances. However, the plant cannot cross significant upland barriers or habitats. It is limited in its northward expansion by a shortage of habitat and by row-crop agriculture.

Little is known about the genetics of this plant in Illinois. One expert speculates that since the plant is wide ranging and variable, it is probably genetically diverse.

Abiotic conditions: disturbance, soils, geology

Taxodium distichum is a tree of swamps, although it can and does grow in drier conditions (when planted); the plant is dependent on saturated soils in flat terrain—features that are not particularly rare. It is usually found in acidic waters but may be just as comfortable over limestone substrates.

These trees can survive even with fire if the swamp dries. Fire may even help establishment of seedlings, but conditions must get wet again for the best reproductive success.

Biotic interactions

Seeds of *Taxodium distichum* are dispersed by water, birds, and mammals. One experts doubt that anything eats the seeds.

Bibliography

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Table_of_contents.htm

Lickey, E. B., & Walker, G. L. (2002). Population genetic structure of bald cypress (Taxodium distichum [L.] Rich. var. distichum) and pond cypress (T. distichum var. imbricarium [Nuttall] Croom): Biogeographic and taxonomic implications. Southeastern Naturalist, 1(2), 131-148.

Tetraneuris herbacea Greene

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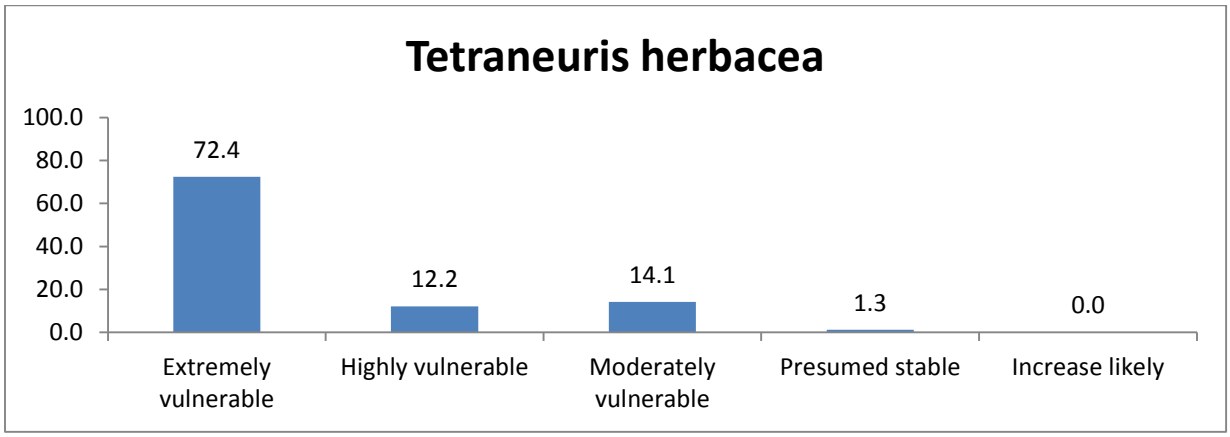

Figure 72: Tetraneuris herbacea is categorized as Extremely Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers	GI	I	SI	N		
Anthropogenic barriers	GI	I				
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche	GI	I	SI	N		
Historical hydrological niche		I				
Physiological hydrological niche			SI	N	SD	
Disturbance dependence		I	SI	N	SD	
Ice/snow				N		
Geology/soils			SI	N		
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal		I	SI	N	SD	
Other spp interactions				N		
Genetic variation		I	SI	N		
Genetic bottlenecks			SI			
Phenological response		I	SI			

Table 70: Given predicted changes to climate in Illinois, Tetraneuris herbacea may be particularly vulnerable due to natural and anthropogenic barriers to its dispersal, its dispersal abilities, its physiological thermal niche, and its historical hydrological niche, its dependence on disturbance and on other species for dispersal, its low genetic diversity and its inability to track changes in seasonality.

Little is known about the ability of this plant to cross natural barriers, its dispersal abilities, its physiological thermal niche, its dependence on disturbance or its dependence on other species for dispersal.

Insights from Experts:

Contributing experts:
Kayri Havens, Chicago Botanic Garden
Steven R. Hill, Illinois Natural History Survey
Paul Marcum, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey

General

Tetraneuris herbacea is an herbaceous perennial considered a Great Lakes endemic which has been restored in Illinois with the help of imports from other states. Plants are relatively long-lived rosettes and have a complex breeding system (see below: "Dispersal, movement & genetics").

Climate conditions & phenology

Appears, based on its historically northern distribution, to be vulnerable to warming. Populations in Michigan receive much more water than in Illinois. The plant can tolerate very dry conditions and wet springtime conditions.

Dispersal, movement & genetics

Seeds are dispersed by wind and gravity, and there is some spread by rhizome. Most seedlings are found within one meter of adult plants.

The species has a complex breeding system involving incompatibility alleles. In small, isolated populations, the reduction in diversity of these alleles from genetic drift and inbreeding results in a loss of sexual reproduction and recruitment of new individuals. No natural populations remain in Illinois; however, the species has been 'restored' by out-planting to at five locations in Illinois, perhaps more. These 'restored' populations do undergo recruitment; fertility was restored by breeding the last line of Illinois plants with plants from other populations.

Abiotic conditions: disturbance, soils, geology

Tetraneuris herbacea grows on well-drained alvars and dolomite prairies, marl flats, and gravel prairies.

Biotic interactions

The microhabitat of this plant appears to be sparsely vegetated patches where associated species are shorter prairie grasses and native annuals. It is pollinated by bumble bees, carpenter bees, halictid bees, flies, or pollen dispersed by wind.

Bibliography

DeMauro, M. M. (1993). Relationship of Breeding System to Rarity in the Lakeside Daisy (*Hymenoxys acaulis* var. *glabra*). Conservation Biology, 542-550.

Toxicodendron radicans (L.) Kuntze

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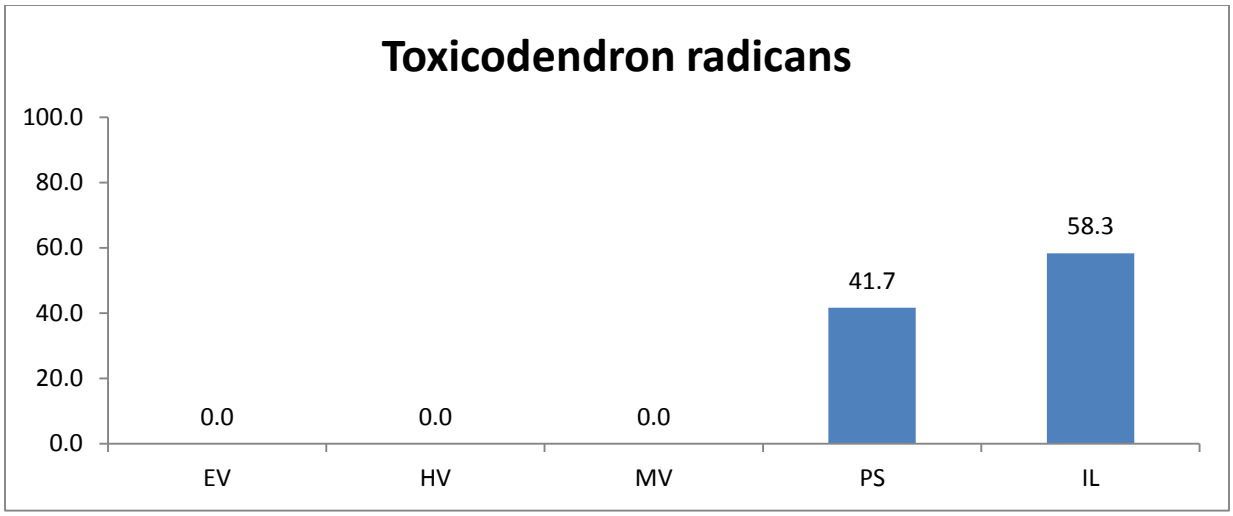

Figure 73: Toxicodendron radicans is categorized as Increase Likely with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	D
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence				N	SD	D
Ice/snow				N		
Geology/soils					SD	D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation				N	SD	
Genetic bottlenecks				N		
Phenological response				N	SD	

Table 71: Toxicodendron radicans may not be vulnerable to predicted changes in climate, based on its biology and ecology.

Little is known about the dispersal abilities of this plant.

Insights from experts:

Contributing experts:
James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Tim Rye, Illinois Natural History Survey
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

Toxicodendron radicans is a very common, widespread, woody species with variable growth forms and a wide amplitude of habitats; it can be a creeping shrub, free-standing shoot of a clonal shrub, or a climbing vine. This vine is capable of undetected movements to make contact with sensitive individuals.

Climate conditions & phenology

Generally, experts do not believe that poison ivy will be sensitive to changes in temperature or precipitation. Late season frosts and freezes sometimes damage new growth on the plant. It is found in dry, mesic, and sometimes even wet habitats.

Dispersal, movement & genetics

This plant is dispersed by birds and the small seeds are able to cross most barriers. In addition, seeds can fall some distance from the parent because the plant climbs and vines.

Taxonomically, this species is not well understood. It is genetically diverse.

Abiotic conditions: disturbance, soils, geology

Toxicodendron radicans is found on many, many soil types. The plant is considered fire sensitive. Its vegetative cover is reduced and its woody shoots are killed by ground fires. However, its importance may increase with periodic fires.

Biotic interactions

Poison ivy grows in fence lines, floodplain forests, sand prairies, old fields, ruins, dry upland woodlands and rock outcrops. The seeds of this species are eaten and dispersed by a variety of birds and mammals. Its male and female flowers are visited by a wide range of generalist insect pollinators.

Bibliography

Innes, Robin J. 2012. Toxicodendron radicans, T. rydbergii. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2015, July 28].

Londré, R. A., & Schnitzer, S. A. (2006). The distribution of lianas and their change in abundance in temperate forests over the past 45 years. Ecology, 87(12), 2973-2978.

Schnitzer, S. A., Londre, R. A., Klironomos, J., & Reich, P. B. (2008). Biomass and toxicity responses of poison ivy (Toxicodendron radicans) to elevated atmospheric CO2: Comment. Ecology, 89(2), 581-585.

Tradescantia virginiana L.

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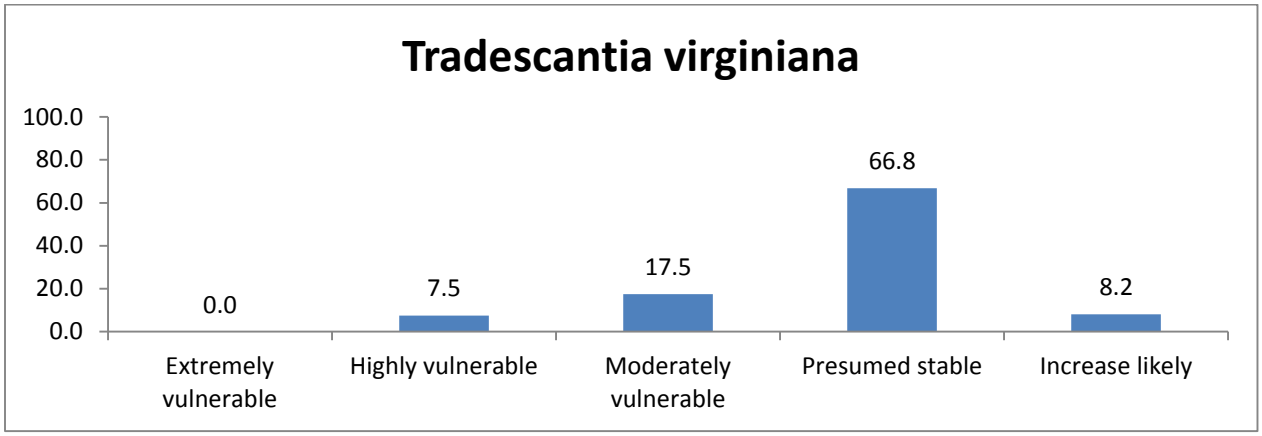

Figure 74: Tradescantia virginiana is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers			SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI		SI	N		
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche				N	SD	
Disturbance dependence				N		
Ice/snow				N		
Geology/soils				N	SD	
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response					SD	

Table 72: Tradescantia virginiana may be more vulnerable to predicted changes in climate due to its inability to cross anthropogenic barriers and its dispersal abilities.

Little is known about the dispersal abilities of this plant or its genetic diversity.

Insights from experts:

Contributing experts
James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey

General

This plant is at the northern edge of its range in southern Illinois. Its seeds can remain dormant for more than 1 year and germinate. Contributing experts did not know upwards limit of life in seed bank.

Climate conditions & phenology

This species tends to be a bit southern in our state, and so may be cold sensitive. The plant grows in both mesic and dry conditions. It readily goes dormant during dry weather or drought and has tuberous roots that can get it through dry seasons.

Tradescantia virginiana flowers in late spring, capsules ripen and plants enter dormancy in middle summer. The plant goes dormant earlier during droughts and flowers earlier during dry springs.

Dispersal, movement & genetics

Tradescantia virginiana is not rhizomatous; new plants are recruits from seed. Capsules dehisce with some force, spreading seeds, and plants are usually found in groups. Long range dispersal is also limited by the row-crop agriculture and urban areas that surround populations of this species.

Little is known about the genetic diversity of this species, but one expert speculates that, since it is range is large, and has probably not experienced significant reductions in population, it is likely to be genetically diverse.

Abiotic conditions: disturbance, soils, geology

This species occurs on rocky, well-drained soils, and may have a preference for high pH soils.

Biotic interactions

Tradescantia virginiana is a perennial forb of open woodlands, savannas, and dry forests and forest margins. Its flowers do not suggest a relationship with a specialist pollinator; visitors include bumblebees, other bees and flies. The plant's root structure implies a mycorrhizal relationship.

Bibliography

No references noted.

Trillium grandiflorum (Michx.) Salisb.

Contributing experts:
Connie Cunningham, Illinois Natural History Survey
James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

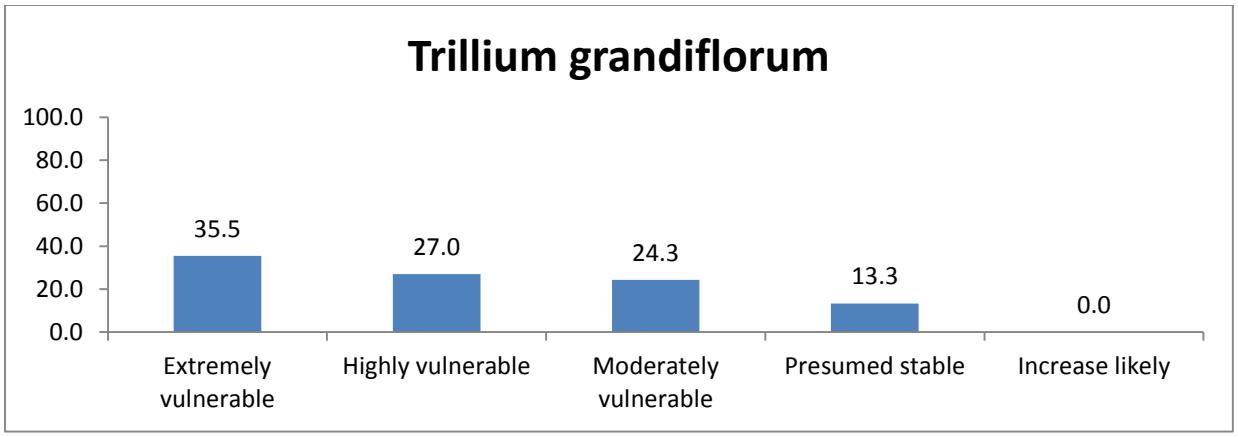

Figure 75: Trillium grandiflorum is categorized as Extremely Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers	GI	I	SI			
CC mitigation & land use			SI	N	SD	
Dispersal & movement	GI	I	SI			
Historical thermal niche				N		
Physiological thermal niche	GI	I	SI	N		
Historical hydrological niche			SI			
Physiological hydrological niche			SI	N	SD	
Disturbance dependence			SI	N		
Ice/snow				N		
Geology/soils			SI	N	SD	
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions				N		
Genetic variation			SI			
Genetic bottlenecks			SI	N		
Phenological response				N	SD	

Table 73: Under predicted climate changes, Trillium grandiflorum may be made more vulnerable due to its inability to cross natural and anthropogenic barriers, its dispersal abilities and its physiological thermal niche.

Little is known about the physiological thermal niche of this plant.

Insights from experts:

Contributing experts

James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey
David N. Zaya, Illinois Natural History Survey

General

In Illinois, *Trillium grandiflorum* is at the southwest extent of its range. Most populations are found in northeastern counties, but there are isolated populations in northwestern, central, and southern Illinois.
Plants take more than 3 years to grow from seed to flowering.

Climate conditions & phenology

This is a species that grows in forests that are generally cooler and moister than forest conditions across Illinois. Plants seem to prefer cooler temperatures, and so seem vulnerable if the temperatures increase significantly here. Its current range may be limited to places that are cool, with a wet spring. Fruits ripen mid- to late-summer.

Trillium grandiflorum is an early bloomer that generally requires quite a bit of moisture in the winter and spring. It apparently, it must get all growth and reproduction done before it gets hot. The plant therefore might not be able to reproduce well if precipitation and/or moisture decline, and this could easily happen if temperatures increase.

Dispersal, movement & genetics

The seeds of this plant are dispersed by gravity, ants, and wasps. Most often, the seeds fall around the plant so that the plants grow in groups. *Trillium grandiflorum* cannot easily cross habitats that are incompatible to it such as open areas, rivers or disturbed habitats.

This obligate out-crosser is visited by at least a few insect species. Illinois populations are small and isolated. Genetic diversity was found to be lower than in a congener, but higher than what is expected for selfing species.

Abiotic conditions: disturbance, soils, geology

Trillium grandiflorum prefers soils including sand, sandy loams, loams, glacial till, gravel or bedrock-derived soils. It is not adapted to much habitat disturbance, including fire. Destruction of bud or new growth may result in dormancy for more than a year.

Biotic interactions

This is characteristic forest herb of the upper Midwest and eastern deciduous forests (north and east of the prairie peninsula). It can be found in mesic forests, woodlands, and savannas, and shaded thickets of native woody plants in old fields.

Trillium grandiflorum is dependent on one taxonomic group for dispersal (ants!) but is likely sought after by any number of opportunistic species that might feed on the elaisomes. The fleshy fruits may be dispersed by small mammals or birds. Experts do not believe that the plant has a specialized pollinator. One expert has seen diptera and various bees visiting flowers. The plant may be obligate mycorrhizal.

Heavily browsed by deer, many stands in Illinois now consist of very ephemeral, stunted, non-flowering plants that rarely flower; flowering plants often restricted to deer exclosures. In addition, the plant may be susceptible to allelopathic compounds from garlic mustard.

Bibliography

Broyles, S. B., Sherman-Broyles, S. L., & Rogati, P. (1997). Evidence of outcrossing in Trillium erectum and Trillium grandiflorum (Liliaceae). Journal of Heredity, 88(4), 325-329.
Case Jr, F. W., & Case, R. B. (1997). Trilliums. Timber Press.

Kalisz, S., Hanzawa, F. M., Tonsor, S. J., Thiede, D. A., & Voigt, S. (1999). Ant-mediated seed dispersal alters pattern of relatedness in a population of Trillium grandiflorum. Ecology, 80(8), 2620-2634

Kalisz, S., Nason, J. D., Hanzawa, F. M., & Tonsor, S. J. (2001). Spatial population genetic structure in Trillium grandiflorum: the roles of dispersal, mating, history, and selection. Evolution, 55(8), 1560-1568.

Vincetoxicum nigrum (L.) Moench

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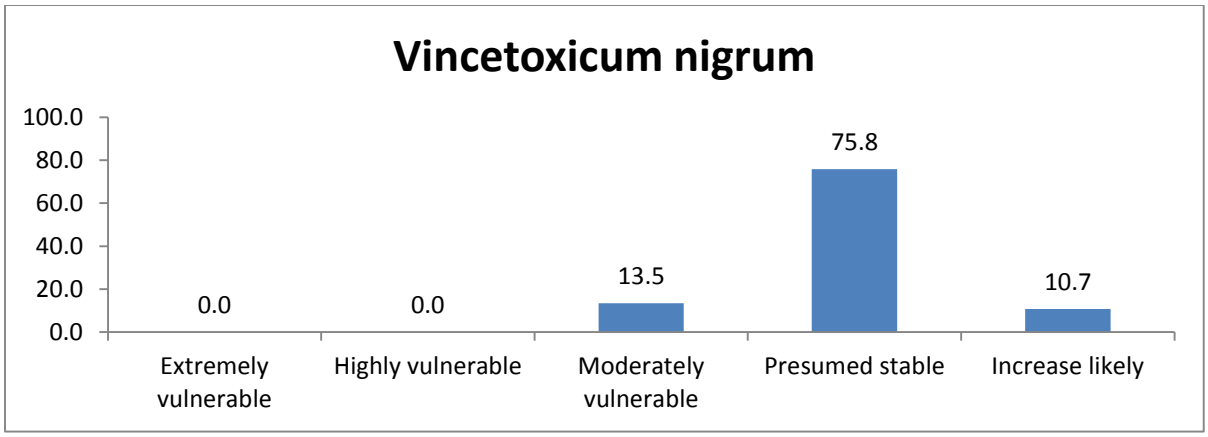

Figure 76: Vincetoxicum nigrum is categorized as Presumed Stable with predicted climate changes.

Sea level				N		
Natural barriers				N		
Anthropogenic barriers				N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement			SI	N	SD	
Historical thermal niche				N		
Physiological thermal niche		I	SI	N		
Historical hydrological niche		I				
Physiological hydrological niche				N		
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils					SD	D
Other spp for habitat				N		
Other spp for pollination			SI	N		
Other spp for dispersal				N		
Other spp interactions			SI	N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response				N		

Table 74: Vincetoxicum nigrum may be vulnerable to predicted climate changes due to physiological thermal niche and its historical hydrological niche.

Little is known about the genetic diversity of this plant in Illinois.

Insights from experts

Contributing experts:
Steven R. Hill, Illinois Natural History Survey
Paul Marcum, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey

General

Vincetoxicum nigrum is a non-native, perennial, rhizomatous, herbaceous vine.

Climate conditions & phenology

This species seems to prefer colder climates and probably does not range very far south. Many sites where this plant is found are uplands with well-drained soils.

Dispersal, movement & genetics

Vincetoxicum nigrum is wind and water dispersed. It may also be passively distributed by people.

Little is known about the genetic diversity of this species in Illinois. One expert speculates that with limited introductions to the state, the plant if probably limited in variability.

Abiotic conditions: disturbance, soils, geology

Many sites where this plant is found are uplands with well-drained soils. It can grow on edges of disturbed areas. It seems to like moist, disturbed areas.

Biotic interactions

This species has been found clambering over planted shrubs in cemeteries and invading remnant hill prairies in Illinois. It is self-pollinated and pollinated by flies and possibly other insects. Its seeds are wind-dispersed.

Bibliography

Cappuccino, N., Mackay, R., & Eisner, C. (2002). Spread of the invasive alien vine Vincetoxicum rossicum: tradeoffs between seed dispersability and seed quality. The American Midland Naturalist, 148(2), 263-270.

Viola pedata L.

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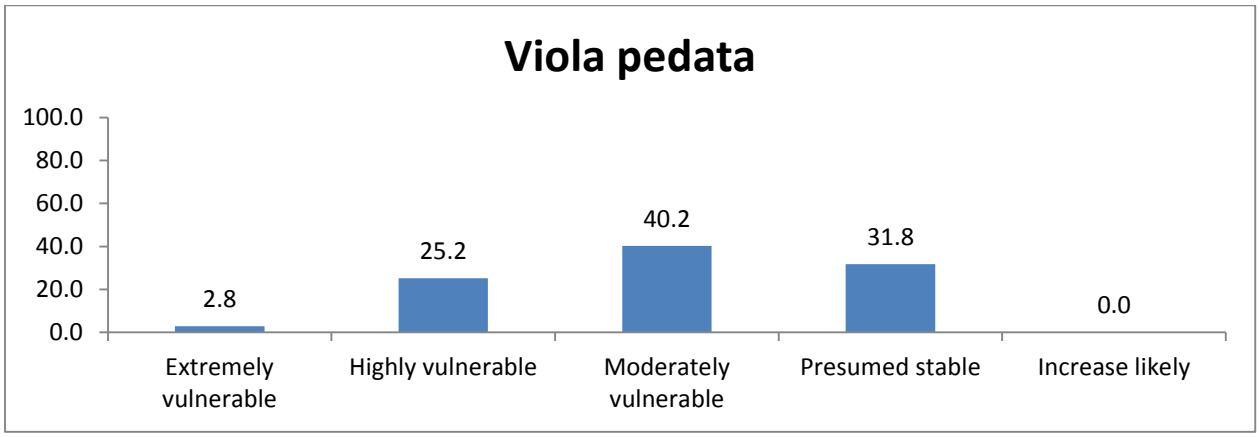

Figure 77: Viola pedata is categorized as Moderately Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers	GI	I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N		
Historical thermal niche				N		
Physiological thermal niche				N	SD	
Historical hydrological niche			SI			
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence				N	SD	
Ice/snow				N		
Geology/soils		I	SI	N		
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal			SI	N		
Other spp interactions				N		
Genetic variation	UNKNOWN					
Genetic bottlenecks				N		
Phenological response			SI	N	SD	

Table 75: Under predicted climate changes, Viola pedata may be more vulnerable due to its inability to cross natural and anthropogenic barriers, its dispersal abilities its physiological hydrological niche and its soil preferences.

Little is known about the abilities of this plant to cross anthropogenic barriers, its physiological hydrological niche or its genetic diversity.

Insights from experts:

Contributing experts

James Ellis, Illinois Natural History Survey
Steven R. Hill, Illinois Natural History Survey
Scott Namestnik, Orbis Environmental Consulting
Greg Spyreas, Illinois Natural History Survey
Eric Ulaszek, Illinois Natural History Survey

General

Viola pedata is a cespitose, perennial forb. This species is often misidentified and confused with *Viola pedatifida*; the difference must be seen under magnification. This species is unusual for a violet in never producing cleistogamous flowers in the wild and in being a functionally out-crossing species.

Climate conditions & phenology

Viola pedata requires abundant winter and spring rains because it flowers and fruits early in spring; less rain in its flowering season would probably lead to a decline. The plant seems tolerant of late frosts, meaning that its young leaves, flowers and flower buds will survive undamaged. In addition, *Viola pedata* is not very sensitive to heat. Its summer habitats are dry, often exposed to full sun, and hot. The most important climate factor for this plant will be rains that continue to come at the right time of year.

Dispersal, movement & genetics

Viola pedata is not a good disperser. Its capsules dehisce when ripe, scattering seed and are dispersed to some extent by ants, which are attracted to the sugary caruncle on the seed. Seeds tend to move 0.5 to 5 meters. Due to this limited dispersal, the plant is not easily able to cross barriers like inhospitable environments or rivers.

Experts believe it to be genetically diverse across its range, but perhaps less so in Illinois where its populations tend to be isolated. However, no studies have been found that look at the diversity of this species in Illinois.

Abiotic conditions: disturbance, soils, geology

Birdfoot violet is frequent in sandy black oak savannas, especially where there is a history of fire. It needs and prefers open, sunny habitats. If periods of dry weather and drought kill trees, opening canopies in some sites might benefit birdfoot violet.

Viola pedata tends to be found in dry, open, well-drained, uplands habitat. It prefers sandy soils or acidic, rocky soils, but can occur in dry, fine-textured, black prairie soil too.

Biotic interactions

Birdfoot violet needs and prefers open, sunny habitats, including sandy black oak savannas. It is often found in well-drained prairies, barrens, bluff tops openings, savannas, and open woodlands. The species colonizes road cuts running through suitable habitat and survives in pastured prairie communities.

Flowers are visited by a number of butterflies and skippers. One expert has seen many insects visiting flowers (Dipterans, bees, butterflies) but is not certain which are effective pollinators. Its seeds are sometimes dispersed by ants, which are attracted to the sugary caruncle on the seed.

Bibliography

Beattie, A. J., & Lyons, N. (1975). Seed dispersal in Viola (Violaceae): adaptations and strategies. American Journal of Botany, 714-722.
Swink, F., & Wilhelm, G. (1994). Plants of the Chicago region. Indianapolis: Indiana Academy of Science.

Zizania aquatica L.

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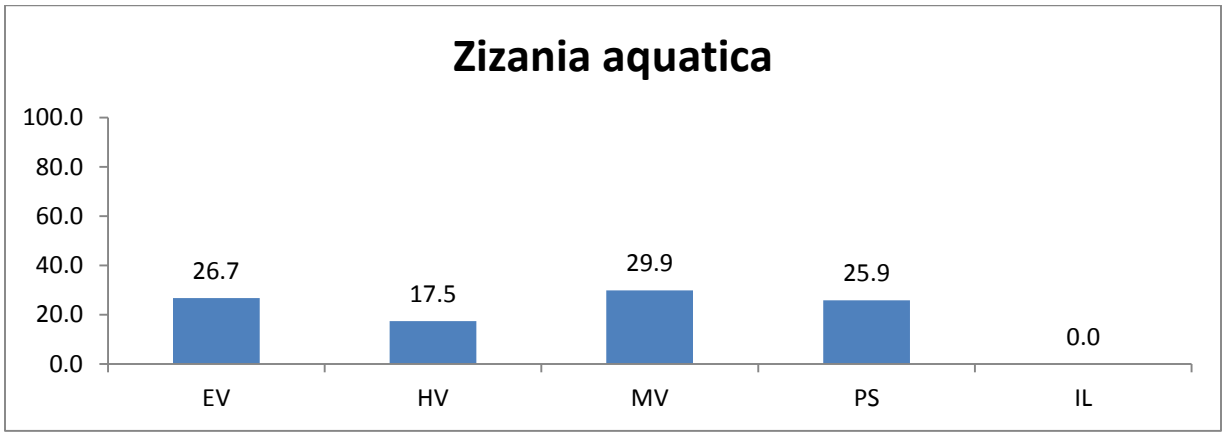

Figure 78: Zizania aquatica is categorized as Moderately Vulnerable with predicted climate changes.

Sea level				N		
Natural barriers		I	SI	N		
Anthropogenic barriers		I	SI	N		
CC mitigation & land use			SI	N	SD	
Dispersal & movement		I	SI	N		
Historical thermal niche				N		
Physiological thermal niche		I	SI	N		
Historical hydrological niche			SI			
Physiological hydrological niche		I	SI	N	SD	
Disturbance dependence		I	SI	N		
Ice/snow			SI	N		
Geology/soils			SI	N		D
Other spp for habitat				N		
Other spp for pollination				N		
Other spp for dispersal				N		
Other spp interactions			SI	N		
Genetic variation				N		
Genetic bottlenecks			SI	N		
Phenological response			SI	N	SD	

Table 76: Ziziana aquatic may be vulnerable to predicted climate changes due to its inability to cross natural and anthropogenic barriers, its dispersal abilities, its physiological thermal niche, its physiological hydrological niche and its dependence on disturbance.

Little is known about the physiological hydrological niche of this plant.

Insights from experts

Contributing experts:

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Steven R. Hill, Illinois Natural History Survey
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Greg Spyreas, Illinois Natural History Survey
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General

Zizania aquatica is an annual wetland grass that can grow as a submersed plant during a limited period early in its life history, and eventually becomes a tall emergent. Wild Rice has cultivated for food for 1,000 years and continues to be an important food plant. It is possible that the plant could be used more in the future as a food crop in some localized areas. Some populations of this species may be reintroductions to Illinois.

Climate conditions & phenology

Changes in both temperature and precipitation may be important to this species. The wetland habitat on which *Zizania aquatica* is dependent could decrease in a warmer climate. Seeds can be dispersed by water.

Dispersal, movement & genetics

Historically, this plant has been dispersed by humans. On its own, it is not a great disperser: seeds will float around a little, and move before they sink to the bottom.

This plant can occur all the way down to the Gulf of Mexico though those populations are disjunct with little chance of genetic material reaching IL. Since it was moved around by people so readily, the genetics of wild populations could be unusual. In terms of genetic diversity, one study found non-significant differences in heterozygosity with a congener.

Abiotic conditions: disturbance, soils, geology

Zizania aquatica prefers wet areas. More southerly populations in Illinois often occur in seeps, which should be somewhat buffered because of their association with water tables.

Biotic interactions

Sometimes this is planted as a wildlife food crop outside natural occurrences. It is also planted as a wetland crop.

Bibliography

Counts, R. L. (1993). Phenotypic plasticity and genetic variability in annual Zizania spp. along a latitudinal gradient. Canadian journal of botany, 71(1), 145-154.

APPENDIX B: QUESTIONNAIRE GIVEN TO THE EXPERTS

Page 1: Record keeping information

Name:	
Title:	
Organization:	
Address:	
City:	
State:	
Zip:	
Email address:	
Phone number:	
Date:	

Plant species being assessed:	

Any additional information you would like to include for our records:	

Open-ended questions:

1. This species may be sensitive to what climate changes? Consider all possible changes related to temperature, wind and precipitation, averages and extremes. For each climate condition, please explain why and in what ways the species is sensitive and how the species might respond.

2. Are there biotic or abiotic interactions that may make species more or less sensitive to climate changes? Explain how each interaction may affect the plant's sensitivity to climate changes.

Question 1: Please consider how this plant's dispersal abilities may influence its vulnerability to climate change, as described below. (Place an "X" in the appropriate gray box). Please select more than one category to indicate any uncertainty regarding your response.

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

Greatly increase vulnerability: Species is characterized by severely restricted dispersal or movement capability. This category includes species represented by **sessile organisms that almost never disperse more than a few meters per dispersal event**. Examples include: plants with large or heavy propagules for which the disperser is extinct or so rare as to be ineffective; species with dispersal limited to vegetative shoots, buds, or similar structures that do not survive (at least initially) if detached from the parent.

Increase vulnerability: Species is characterized by highly restricted dispersal or movement capability. This category includes species that **rarely disperse through unsuitable habitat more than about 10 meters** per dispersal event, and species in which dispersal beyond a very limited distance (or outside a small isolated patch of suitable habitat) periodically or irregularly occurs but is dependent on highly fortuitous or rare events. Examples include: plants dispersed ballisticly; plant or animal species with free-living propagules or individuals that may be carried more than 10 meters by a tornado or unusually strong hurricane or large flood but that otherwise rarely disperse more than 10 meters; plants that do not fit criteria for Greatly Increase but lack obvious dispersal adaptations (i.e., propagules lack any known method for moving more than 10 meters away from the source plant).

Somewhat increase vulnerability: Species is characterized by limited but not severely or highly restricted dispersal or movement capability**. A significant percentage (at least approximately 5%) of propagules or individuals disperse approximately 10-100 meters** per dispersal event (rarely farther), or dispersal capability likely is consistent with one of the following examples. Examples include species that exist in small isolated patches of suitable habitat but regularly disperse or move among patches that are up to 100 meters (rarely farther) apart; many ant-dispersed plant species; plants whose propagules are dispersed primarily by small animals (e.g., some rodents) that typically move propagules approximately 10-100 meters from the source (propagules may be cached or transported incidentally on fur or feathers); plants dispersed by wind with low efficiency (e.g., species with inefficiently plumed seeds and/or that occur predominantly in forests).

Neutral: Species is characterized by moderate dispersal or movement capability**. A significant percentage (at least approximately 5%) of propagules or individuals disperse approximately 100-1,000 meters** per dispersal event (rarely farther), or dispersal capability likely is consistent with one of the following examples. Examples include:

species whose individuals exist in small isolated patches of suitable habitat but regularly disperse or move among patches that are 100-1,000 meters (rarely farther) apart; many plant species dispersed by wind with high efficiency (e.g., species with efficiently plumed seeds or very small propagules that occur predominantly in open areas); plant and animal species whose propagules or individuals are dispersed by small animals (e.g., rodents, grouse) that regularly but perhaps infrequently move propagules approximately 100-1,000 meters from the source.

Somewhat decrease vulnerability: Species is characterized by good dispersal or movement capability. Species has **propagules that readily move 1-10 kilometers from natal or source areas** (rarely farther), or dispersal capability likely is consistent with one of the following examples. Examples include: plant species regularly dispersed up to 10 km (rarely farther) by large or mobile animals (e.g., plant has seeds that are cached, regurgitated, or defecated 1-10 kilometers from the source by birds [e.g., corvids, songbirds that eat small fleshy fruits] or mammals or that are transported on fur of large mobile animals such as most Carnivora or ungulates).

Decrease vulnerability: Species is characterized by excellent dispersal or movement capability. Species has propagules or dispersing individuals that readily move more than 10 kilometers from natal or source areas, or dispersal capability likely is consistent with one of the following examples: plant or animal species whose individuals often or regularly are dispersed more than 10 kilometers by migratory or otherwise highly mobile animals, air or ocean currents, or humans, including species that readily become established outside their native ranges as a result of intentional or unintentional translocations by humans. In essence, this category includes the species that tend to occupy all or most areas of suitable habitat or that readily or predictably colonize newly available habitat (e.g., recently restored areas, areas that become suitable as a result of fire, insect infestations, or other environmental changes, etc.). Note that these species are not necessarily "early successional" or "r-selected" species but also may include certain "late successional" or equilibrium ("K-selected") species that have excellent innate or vector-aided dispersal capability.

Any additional notes, caveats, citations, etc. you would like us to consider under Question 1:	

Question 2 (a-d): Please consider how this plant's predicted sensitivities to temperature, moisture and disturbance regimes may influence its vulnerability to climate change, as described below. (Place an "X" in the appropriate gray boxes). Please select more than one category to indicate any uncertainty regarding your response.

Question 2a: Physiological thermal niche

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

Greatly increase vulnerability: Species is completely or almost completely (> 90% of occurrences or range) restricted to relatively cool or cold environments that may be lost or reduced in the assessment area as a result of climate change.

Increase vulnerability: Species is moderately (50-90% of occurrences or range) restricted to relatively cool or cold environments that may be lost or reduced in the assessment area as a result of climate change.

Somewhat increase: Species is somewhat (10-50% of occurrences or range) restricted to relatively cool or cold environments that may be lost or reduced in the assessment area as a result of climate change.

Neutral: Species distribution is not significantly affected by thermal characteristics of the environment in the assessment area, or species occupies habitats that are thought to be not vulnerable to projected climate change.

Somewhat decrease vulnerability: Species shows a preference for environments toward the warmer end of the spectrum.

Any additional notes, caveats, citations, etc. you would like us to consider under Question 2a:	

Question 2b: Physiological hydrological niche

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

Greatly increase vulnerability: Completely or almost completely (>90% of occurrences or range) dependent on a specific aquatic/wetland habitat or localized moisture regime that is highly vulnerable to loss or reduction with climate change AND the expected direction of moisture change (drier or wetter) is likely to reduce the species' distribution, abundance, or habitat quality. If this second condition is not met (e.g., species dependent on springs tied to a regional aquifer that would not be expected to change significantly with climate change), the species should be scored as Neutral. Examples for Greatly Increase include certain spring-dependent fishes, ephemeral pool-dependent branchiopods, and plants that are exclusively or very strongly associated with localized moist microsites (e.g., "hanging gardens" in arid landscapes).

Increase vulnerability: Moderately (50-90% of occurrences or range) dependent on a strongly seasonal hydrologic regime and/or a specific aquatic/wetland habitat or localized moisture regime that is highly vulnerable to loss or reduction with climate change AND the expected direction of moisture change (drier or wetter) is likely to reduce the species' distribution, abundance, or habitat quality. If this second condition is not met, the species should be scored as Neutral. Examples for Increase include certain amphibians that often breed in vernal pools but also regularly use other aquatic or wetland habitats, and certain plants whose life cycles are highly synchronized with Mediterranean precipitation patterns in areas vulnerable to large changes in the amount and seasonal distribution of precipitation. Also included are desert or semi-desert plants that frequently occur in but are not restricted to or almost restricted to moisture-accumulating microsites, as well as plants (and animals that depend on these species) for which >50% of populations occur in areas such as sandy soils that are sensitive to changes in precipitation.

Somewhat increase vulnerability: Somewhat (10-50%) dependent on a strongly seasonal hydrologic regime and/or a specific aquatic/wetland habitat or localized moisture regime that is highly vulnerable to loss or reduction with climate change AND the expected direction of moisture change (drier or wetter) is likely to reduce the species' distribution, abundance, or habitat quality. If this second condition is not met, the species should be scored as Neutral. Examples for Somewhat Increase include plants (and animals that depend on these species) for which 10-50% of populations occur in areas such as sandy soils that are sensitive to changes in precipitation, and certain plants with ranges restricted to seasonal precipitation environments (e.g., summer rainfall deserts) and which have a moderate degree of adaptation to that seasonality.

Neutral: Species has little or no dependence on a strongly seasonal hydrologic regime and/or a specific aquatic/wetland habitat or localized moisture regime that is highly vulnerable to loss or reduction with climate change OR hydrological requirements are not likely to be significantly disrupted in major portion of the range.

Somewhat decrease vulnerability: Species has very broad moisture regime tolerances OR would benefit by the predicted change in hydrologic regime. Examples include water-limited species that could increase with increasing precipitation or arid-adapted species that could increase in areas with decreasing moisture availability.

Any additional notes, caveats, citations, etc. you would like us to consider under Question 2b:	

Question 2c: Dependence on a specific disturbance regime likely to be impacted by climate change

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

Increase vulnerability: Strongly affected by specific disturbance regime, and climate change is likely to change the frequency, severity, or extent of that disturbance regime in a way that reduces the species' distribution, abundance, or habitat quality. For example, many sagebrush-associated species in regions predicted to experience increased fire frequency/intensity would be scored here due to the anticipated deleterious effects of increased fire on their habitat.

Somewhat increase vulnerability: Moderately affected by specific disturbance regime, and climate change is likely to change the frequency, severity, or extent of that disturbance regime in a way that reduces the species' distribution, abundance, or habitat quality, OR strongly affected by specific disturbance regime, and climate change is likely to change that regime in a way that causes minor disruption to the species' distribution, abundance, or habitat quality. For example, plants in a riverscour community that are strongly tied to natural erosion and deposition flood cycles, which may shift position within the channel rather than disappear as a result of climate change.

Neutral: Little or no response to a specific disturbance regime, or climate change is unlikely to change the frequency, severity, or extent of that disturbance regime in a way that affects the range or abundance of the species.

Somewhat decrease vulnerability: Moderately affected by specific disturbance regime, and climate change is likely to change the frequency, severity, or extent of that disturbance regime in a way that increases the species' distribution, abundance, or habitat quality. For example, if climate change increases the frequency of fires, black-backed woodpeckers may benefit due to increased availability of foraging habitat (burned-over forests that become infested with beetles). Many fire-adapted plants can be scored here if a predicted increase in fire frequency/intensity is anticipated to be beneficial.

Decrease vulnerability: Strongly affected by specific disturbance regime, and climate change is likely to change the frequency, severity, or extent of that disturbance regime in a way that increases the species' distribution, abundance, or habitat quality. For example, in areas predicted to experience increased fire frequency, invasive grasses that have a strong positive response to fire (e.g., ecosystem function-altering) could be scored here.

Any additional notes, caveats, citations, etc. you would like us to consider under Question 2c:	

Question 2d: Dependence on ice, ice-edge, or snow-covered habitats

Greatly	Increase	Somewhat	Neutral	Somewhat	Decrease	Unknown

increase		**increase**		**decrease**		

Greatly increase vulnerability: Highly dependent (>80% of subpopulations or range) on ice- or snow-associated habitats; or found almost exclusively on or near ice or snow during at least one stage of the life cycle. For example, polar bear (*Ursus maritimus*) is strongly dependent on sea ice throughout its range.

Increase vulnerability: Moderately dependent (50-80% of subpopulations or range) on ice- or snow-associated habitats; or often found most abundantly on or near ice or snow but also regularly occurs away from such areas. For example, Kittlitz's murrelet (*Brachyramphus brevirostris*) feeding habitat is moderately to strongly associated with tidewater glaciers.

Somewhat increase vulnerability: Somewhat (10-49% of subpopulations or range) dependent on ice- or snow-associated habitats, or may respond positively to snow or ice but is not dependent on it. For example, certain alpine plants are often associated with long-lasting snowbeds but also commonly occur away from such areas; certain small mammals experience increased survival and may develop relatively large populations under winter snow cover but do not depend on snow cover. Species that benefit from a minimum thickness of ice or snowpack for winter insulation should also be scored here.

Neutral: Little dependence on ice- or snow-associated habitats (may be highly dependent in up to 10% of the range).

Any additional notes, caveats, citations, etc. you would like us to consider under Question 2d:	

Question 3: Please consider how this plant's dependence to uncommon geological features or their derivatives may influence its vulnerability to climate change, as described below. (Place an "X" in the appropriate gray boxes). Please select more than one category to indicate any uncertainty regarding your response.

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

Increase vulnerability: Very highly dependent upon, i.e., more or less endemic to (> 85% of occurrences found on) a particular highly uncommon geological feature or derivative (e.g., soil, water chemistry). Such features often have their own endemics. Examples include serpentine (broad and strict) endemic plants, plants of calcareous substrates where such substrates are uncommon (e.g., California, southeastern U.S.), plants restricted to one or a few specific rock strata, organisms more or less restricted to inland sand dunes or shale barrens, obligate cave-dwelling organisms, and springsnails restricted to springs with high dissolved CO2.

Somewhat increase vulnerability: Moderately to highly dependent upon a particular geological feature or derivative, i.e., (1) an indicator of but not an endemic to (65-85% of occurrences found on) the types of features described under Increase, OR (2) more or less restricted to a geological feature or derivative that is not highly uncommon within the species' range, but is not one of the dominant types. Examples of the latter include species more or less restricted to active coastal sand dunes, cliffs, salt flats, inland waters within a particular salinity range, and non-dominant rock types such as occasional igneous rock intrusions within a landscape mostly dominated by sedimentary and/or metamorphic rocks.

Neutral: Having a clear preference for (> 85% of occurrences found on) a certain geological feature or derivative, where the feature is among the dominant types within the species' range. For example, red spruce prefers acidic, organic soils (not uncommon within its range), although it is occasionally found on other soil types. Many species whose habitat descriptions specify one pH category (acidic, neutral, or basic) and/or one soil particle size (e.g., rocky, sandy, or loamy) will probably fall here, upon confirmation that the substrate type is not particularly uncommon within the species' range.

Somewhat decrease vulnerability: Somewhat flexible but not highly generalized in dependence upon geological features or derivatives, i.e., found on a subset of the dominant substrate/water chemistry types within its range. Most habitat descriptions that mention more than one type of relatively widespread geological feature should probably go here; however, if all types mentioned are uncommon within the species' range, Somewhat Increase may be appropriate. This category also encompasses species not strongly tied to any specific geological feature or derivative, such as many birds and mammals.

Decrease vulnerability: Highly generalized relative to dependence upon geological features or derivatives, i.e., the species is described as a generalist and/or a significant proportion of its occurrences have been documented on substrates or in waters that represent opposite ends of the spectrum of types within the assessment region (e.g., many occurrences known from both acidic and basic soils or waters, or from both sandy and clay soils). Species such as common yarrow (*Achillea millefolium*) should be assigned to this category.

Any additional notes, caveats, citations, etc. you would like us to consider under Question 2d:	

Question 4 (a-d): Please consider how this plants' interactions with other species may influence its vulnerability to climate change, as described below. (Place an "X" in the appropriate gray boxes). Please select more than one category to indicate any uncertainty regarding your response.

Question 4a: Dependence on other species to generate habitat

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

Creation of habitat conditions necessary for seedling establishment should be considered here; nutritional relationships necessary for seedling establishment (e.g., parasitic or obligately myco-heterotrophic plants) should be considered below, under Question 4d.

Greatly increase vulnerability: Required habitat generated primarily by one species, and that species is highly to extremely vulnerable to climate change within the assessment area. The following examples are cases in which species depend on others to generate habitat, although the species generating the habitat is not necessarily highly vulnerable to climate change throughout its range. In harsh environments, the presence of a single ecosystem engineer can create habitat for species for which abiotic conditions would otherwise be unsuitable (e.g., Spartina alterniflora in eastern North American salt marshes).

Increase vulnerability: Required habitat generated primarily by one species, and that species is at most moderately vulnerable to climate change within the assessment area. If the climate change vulnerability of the habitat-generating species is unknown, check both Greatly Increase and Increase Vulnerability.

Somewhat increase vulnerability: Required habitat generated primarily by one or more of not more than a few species. For example, a certain degree of specificity exists between particular cactus species and certain nurse plants; burrowing owls (*Athene cunicularia*) depend on excavations made by relatively few species of burrowing mammals; marbled murrelets (*Brachyramphus marmoratus*) strongly depend on a few species of large trees to provide suitable nesting platforms; certain plant species depend on large grazing animals to generate disturbance required for establishment and early growth.

Neutral: Required habitat generated by more than a few species, or does not involve species-specific processes.

Any additional notes, caveats, citations, etc. you would like us to consider under Question 4a:	

Question 4b: Dependence on other species for pollination

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

Increase vulnerability: Completely or almost completely dependent on one species for pollination (> 90% of effective pollination accomplished by 1 species) or, if no observations exist, morphology suggests very significant limitation of potential pollinators (e.g., very long corolla tube).

Somewhat increase vulnerability: Completely or almost completely dependent on 2-4 species for pollination (> 90% of effective pollination accomplished by 2-4 species) or, if no observations exist, morphology suggests conformation to a specific "pollination syndrome" (e.g., van der Pijl 1961, Evolution 15: 44-59, http://www.fs.fed.us/wildflowers/pollinators/syndromes.shtml).

Neutral: Pollination apparently flexible; five or more species make significant contributions to pollination or, if no observations exist, morphology does not suggest pollinator limitation or pollination syndrome. Score wind-pollinated species as Neutral.

Any additional notes, caveats, citations, etc. you would like us to consider under Question 4b:	

Question 4c: Dependence on other species for propagule dispersal

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

Increase vulnerability: Completely or almost completely (roughly > 90%) dependent on a single species for propagule dispersal. For example, whitebark pine would fit here because Clark's nutcracker is the primary dispersal agent.

Somewhat increase vulnerability: Completely or almost completely (roughly > 90%) dependent on a small number of species for propagule dispersal. For example, a freshwater mussel, for which only a few species of fish can disperse larvae.

Neutral: Disperses on its own (most animals) OR propagules can be dispersed by more than a few species.

Any additional notes, caveats, citations, etc. you would like us to consider under Question 4c:	

Question 4d: Other interspecific interactions

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

Refers to interactions unrelated to habitat, seedling establishment, diet, pollination, or propagule dispersal. For example, an acacia bush requires an ant colony for protection against herbivores. Here an interspecific interaction can include mutualism, parasitism, commensalism, or predator-prey relationship.

Increase vulnerability: Requires an interaction with a single other species for persistence.

Somewhat increase vulnerability: Requires an interaction with a one member of a small group of taxonomically related species for persistence. Could also include cases where specificity is not known for certain, but is suspected. Many Orchidaceae will be in this category because of their requirement for a specific fungal partner for germination (Tupac Otero and Flanagan 2006, TREE 21: 64-65).

Neutral: Does not require an interspecific interaction or, if it does, many potential candidates for partners are available.

Any additional notes, caveats, citations, etc. you would like us to consider under Question 4d:	

Question 5 (a & b): Please consider how this plants' genetics may influence its vulnerability to climate change, as described below. (Place an "X" in the appropriate gray boxes). Please select more than one category to indicate any uncertainty regarding your response.

Question 5a: Measured genetic variation

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

Species with less standing genetic variation will be less able to adapt because the appearance of beneficial mutations is not expected to keep pace with the rate of 21st century climate change. Throughout this question, "genetic variation" may refer to neutral marker variation, quantitative genetic variation, or both. To answer the question, genetic variation should have been assessed over a substantial proportion of a species' range.

Because measures of genetic variability vary across taxonomic groups, there cannot be specific threshold numbers to distinguish among the categories. The assessor should interpret genetic variation in a species relative to that measured in related species to determine if it is low, high, or in between.

Increase vulnerability: Genetic variation reported as "very low" compared to findings using similar techniques on related taxa, i.e., lack of genetic variation has been identified as a conservation issue for the species.

Somewhat increase vulnerability: Genetic variation reported as "low" compared to findings using similar techniques on related taxa.

Neutral: Genetic variation reported as "average" compared to findings using similar techniques on related taxa.

Somewhat decrease vulnerability: Genetic variation reported as "high" compared to findings using similar techniques on related taxa.

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Any additional notes, caveats, citations, etc. you would like us to consider under Question 5a	

Question 5b: Occurrence of bottlenecks in recent evolutionary history (***use only if 5a is "unknown")***

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

In the absence of range-wide genetic variation information (Question 5a), this factor can be used to infer whether reductions in species-level genetic variation that would potentially impede its adaptation to climate change may have occurred. Only species that suffered population reductions and then subsequently rebounded qualify for the "Somewhat increase" or "Increase" vulnerability categories.

Increase vulnerability: Evidence that total population was reduced to ≤ 250 mature individuals, to one occurrence, and/or that occupied area was reduced by >70% at some point in the past 500 years.

Somewhat increase vulnerability: Evidence that total population was reduced to 251-1000 mature individuals, to less than 10 occurrences, and/or that occupied area was reduced by 30-70% at some point in the past 500 years.

Neutral: No evidence that total population was reduced to ≤ 1000 mature individuals and/or that occupied area was reduced by > 30% at some point in the past 500 years.

Any additional notes, caveats, citations, etc. you would like us to consider under Question 5b	

Question 6: Please consider how this plant's phenological response to changing seasonal temperature or precipitation dynamics may influence its vulnerability to climate change, as described below. (Place an "X" in the appropriate gray boxes). Please select more than one category to indicate any uncertainty regarding your response.

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

Recent research suggests that some phylogenetic groups are declining due to lack of response to changing annual temperature dynamics (e.g., earlier onset of spring, longer growing season), including European bird species that have not advanced their migration times (Moller et al. 2008), and some temperate zone plants that are not moving their flowering times (Willis et al. 2008) to correspond to earlier spring onset. This may be assessed using either published multi-species studies such as those cited above or large databases such as that of the U.S. National Phenology Network.

Increase vulnerability: Seasonal temperature or precipitation dynamics within the species' range show detectable change, but phenological variables measured for the species show no detectable change.

Somewhat increase vulnerability: Seasonal temperature or precipitation dynamics within the species' range show detectable change, and phenological variables measured for the species show some detectable change, but the change is significantly less than that of other species in similar habitats or taxonomic groups.

Neutral: Seasonal temperature or precipitation dynamics within the species' range show detectable change, and phenological variables measured for the species show detectable change which is average compared to other species in similar habitats or taxonomic groups, OR seasonal dynamics within the species' range show no detectable change.

Somewhat decrease vulnerability: Seasonal temperature or precipitation dynamics within the species' range show detectable change, and phenological variables measured for the species show detectable change which is significantly greater than that of other species in similar habitats or taxonomic groups.

Any additional notes, caveats, citations, etc. you would like us to consider under Question 6	

Question 7: Plant's distribution relative to barriers

The degree to which a barrier may affect a species' ability to shift its range in response to climate change depends in part on the distance of the barrier from the species' current distribution. Barriers that are separated from a species' range by a long distance of relatively flat topography can nevertheless affect range shifts because in gentle terrain relatively small changes in climate can result in large shifts in the location of a particular climate envelope. If a species changed its range to track a particular climate envelope, it might encounter barriers that were far from its original range. In contrast, in landscapes in which climatic conditions change rapidly over small horizontal distances (e.g., mountainous areas, steep slopes) a species' distribution would have to shift a relatively small distance in order to track a particular climate envelope, so the species is less likely to encounter distant barriers.

To count as a barrier for the purposes of this factor, a feature can be up to 50 km from the species' current range when measured across areas where climate changes gradually over latitude or longitude (e.g., relatively flat terrain) and up to 10 km when measured across areas where climate changes abruptly over latitude or longitude (e.g., mountainous or steep terrain). Use 25 km for species that occur in intermediate topography, such as moderate hill country. These distances apply to both terrestrial and aquatic species. These distances are derived from Loarie et al. (2009, Nature 462:1052).

7a) Natural barriers: Examples of features that may function as natural barriers for various species include: high mountain ranges (especially those that extend west-east) are a barrier for many lowland plants; warm lowlands are a barrier for some alpine species such as American pika but not for elk or American pipit; large expanses of water are barriers for pocket gophers and many other small terrestrial animals (but not for many volant species, or for plant species that are dispersed by wide-ranging birds, or for species that readily swim between land areas if the distance is not too great).

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

Greatly increase vulnerability: Barriers completely OR almost completely surround the current distribution such that the species' range in the assessment area is unlikely to be able to shift significantly with climate change, or the direction of climate change-caused shift in the species' favorable climate envelope is fairly well understood and barriers prevent a range shift in that direction. See *Neutral* for species in habitats not vulnerable to climate change. *Examples:* lowland terrestrial species completely surrounded by high mountains (or bordered closely and completely on the north side by high mountains); most nonvolant species that exist only on the south side of a very large lake in an area where habitats are expected to shift northward with foreseeable climate change.

Increase vulnerability: Barriers border the current distribution such that climate change-caused distributional shifts in the assessment area are likely to be greatly but not completely or almost completely impaired. *Examples for natural barriers:* certain lowland plant or small mammal species whose ranges are mostly (50-90%) bordered by high mountains or a large lake.

Somewhat increase vulnerability: Barriers border the current distribution such that climate change-caused distributional shifts in the assessment area are likely to be significantly but not greatly or completely impaired. *Examples for natural barriers:* certain lowland plant or small mammal species whose ranges are partially but not mostly bordered by high mountains or a large lake.

Neutral: Significant barriers do not exist for this species, OR small barriers exist in the assessment area but likely would not significantly impair distributional shifts with climate change, OR substantial barriers exist but are not likely to contribute significantly to a reduction or loss of the species' habitat or area of occupancy with projected climate change in the assessment area. *Examples of species in this category:* most birds (for which barriers do not exist); a plant whose climate envelope is shifting northward and range is bordered on the west by a barrier but for which no barriers exist to the north.

7b) Anthropogenic barriers: Examples of features that may function as anthropogenic barriers include: large areas of intensive urban or agricultural development; dams without fish passage facilities and improperly installed culverts can be barriers for fishes and certain other strictly aquatic species; tortoise-proof fencing may be barrier for small reptiles and certain other nonvolant animals, but not for most plants, large mammals, or large snakes. See map on the next page for distribution of wildland in Illinois.

Greatly increase	Increase	Somewhat increase	Neutral	Somewhat decrease	Decrease	Unknown

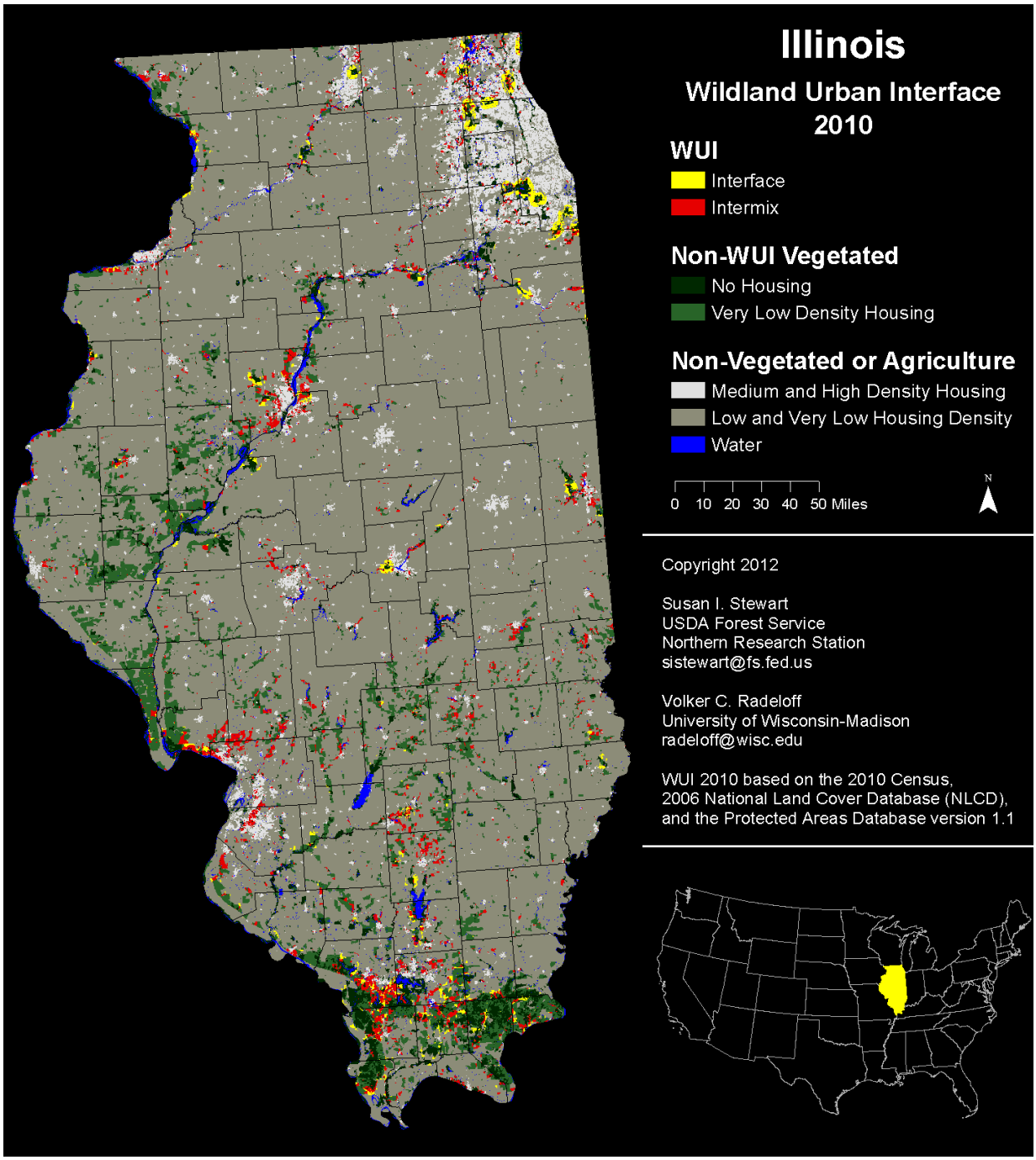
Greatly increase vulnerability: Barriers completely OR almost completely surround the current distribution such that the species' range in the assessment area is unlikely to be able to shift significantly with climate change, or the direction of climate change-caused shift in the species' favorable climate envelope is fairly well understood and barriers prevent a range shift in that direction. See *Neutral* for species in habitats not vulnerable to climate change. *Examples for anthropogenic barriers:* species limited to small habitats within intensively developed urban or agricultural landscapes through which the species cannot pass.

Increase vulnerability: Barriers border the current distribution such that climate change-caused distributional shifts in the assessment area are likely to be greatly but not completely or almost completely impaired. *Example for anthropogenic barriers:* intensive urbanization surrounds 75% of the range of a salamander species.

Somewhat increase vulnerability: Barriers border the current distribution such that climate change-caused distributional shifts in the assessment area are likely to be significantly but not greatly or completely impaired. *Example for anthropogenic barriers:* 10-50% of the margin of a plant species' range is bordered by intensive urban development.

Neutral: Significant barriers do not exist for this species, OR small barriers exist in the assessment area but likely would not significantly impair distributional shifts with climate change, OR substantial barriers exist but are not likely to contribute significantly to a reduction or loss of the species' habitat or area of occupancy with projected climate change in the assessment area. *Examples of species in this category:* most birds (for which barriers do not exist); a plant whose climate envelope is shifting northward and range is bordered on the west by a barrier but for which no barriers exist to the north.

Any additional notes, caveats, citations, etc. you would like us to consider under Question 7a or 7b	


Illinois
Wildland Urban Interface
2010
WUI
Interface
Intermix
Non-WUI Vegetated
No Housing
Very Low Density Housing
Non-Vegetated or Agriculture
Medium and High Density Housing
Low and Very Low Housing Density
Water
0 10 20 30 40 50 Miles
N
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WUI 2010 based on the 2010 Census,
2006 National Land Cover Database (NLCD),
and the Protected Areas Database version 1.1

CONGRATULATIONS!

You have finished the climate change sensitivity assessment for this species!

Your answers will be compiled together with those of other experts and the results of our literature reviews on this species. These sensitivity assessments will be combined with the species' expected exposure to climate change (how is the climate expected to change over the range of this species in Illinois?) and indirect exposure to climate change (assessment of natural and anthropogenic barriers to movement throughout the species' range within Illinois). Our result will be an assessment of the plant's vulnerability to predicted climate changes in Illinois! To put all of this information together, we are using NatureServe's Climate Change Vulnerability Index tool. You can read all about it here: https://connect.natureserve.org/science/climate-change/ccvi

Please consider sharing some additional information with us:

Do you have **any further questions or comments** regarding the biology or natural history of this plant that you feel is important for our assessment?	
Are there **others who are very familiar with this species** that we should be sure to interview? If so, please include their contact information if you have it, and indicate whether we can use your name when we do contact them.	
Do you have any **questions or concerns** regarding our process?	
Anything else?	
Time spent on evaluation:	