CIPWG Workshop on Invasive Species Risk Assessment

June 15, 2017

Workshop Objectives

- develop and assess a quantitative means of evaluating invasive plant species in CT, using a numeric scoring system for the nine criteria mandated by the state, while also incorporating uncertainty in the scoring.
- review the full list of species with designations of "invasive“, "potentially invasive“, “watch list”, and other designations including “insufficient information”, not only for CT but also looking at what our surrounding states are doing.

CT State Statutes mandate a two component process in listing invasive or potentially invasive plant species, and any prohibition thereof

- “Invasive” species must meet 9 criteria to be so listed.
- “potentially Invasive” species must meet the first 5 criteria and one of the remaining 4 to be so listed.
- The listing of these species as invasive or potentially invasive is based on a majority vote of members of the Invasive Plants Council.
- Invasive or potentially invasive species may subsequently be designated as prohibited (import, export, sale or purchase) by two-thirds vote of the Council, but also taking into account: sales value of the plant, costs of eradication, environmental costs, and property value costs.

Voting Membership of the IPC

(1) Commissioner of Agriculture, or designee;
(2) Commissioner of DEEP, or designee;
(3) Director of the Connecticut Agricultural Experiment Station, or designee;
(4) the dean of the College of Agriculture and Natural Resources at UCONN, or designee;
(5) a representative of IPANE;
(6) a representative of a nonprofit environment association with knowledge of invasive plants;
(7) a representative of a nonprofit association concerned with growers and retailers of plants;
(8) one representative of a nonprofit association concerned with oceans, lakes and rivers.
(9) one representative from a company that grows or sells flowers and plants.

Note that the IPC no longer receives any funding from the State or other sources

The 9 criteria for IPC listing of invasive species

1. The plant is nonindigenous to the state;

2. the plant is naturalized or has the potential to become naturalized or occurring without the aid and benefit of cultivation in an area where the plant is nonindigenous;

3. under average conditions, the plant has the biological potential for rapid and widespread dispersion and establishment in the state or region within the state;

4. under average conditions, the plant has the biological potential for excessive dispersion over habitats of varying sizes that are similar or dissimilar to the site of the plant's introduction into the state;

5. under average conditions, the plant has the biological potential for existing in high numbers outside of habitats that are intensely managed;

6. the plant occurs widely in a region of the state or a particular habitat within the state;

7. the plant has numerous individuals within many populations;

8. the plant is able to out-compete other species in the same natural plant community;

- and -

9. the plant has the potential for rapid growth, high seed production and dissemination and establishment in natural plant communities.

One of these criteria is needed for listing a species as “potentially invasive” in addition to the above 5 criteria

Current IPC invasive species listing protocol versus those used elsewhere:

- Simply a majority vote by voting member of CT-IPC of yes or no as to whether or not a species is to be listed.
- A two-thirds vote by CT-IPC members as to whether or not a listed species should be prohibited.
- There has been a move by some other states and by the USDA to develop a quantitative scoring system using similar criteria to those of IPC, along with uncertainty in the scoring or listing, that provides an integrated, quantitative risk assessment for invasive species.
- Can IPC develop a similar protocol within the constraints of the State Statutes mandating the use of 9 criteria for listing invasive species.

Motivation for this workshop supported by a small grant for the UCONN Institute for Biological Risk Analysis

- To gather the necessary data that permits the development of a quantitative model of risk assessment of invasive or potentially invasive species and the uncertainty of designating species as such.
- A subset of 21 diverse species were chosen as a demonstration/feasibility data set.
- Scoring on scale of 1-5 for the likelihood that each species under consideration is likely to satisfy each of the 9 criteria: 1 = very low likelihood to 5 = very high likelihood.
- Scoring uncertainty on a scale of 1-5 associated with the scores for each of the 9 criteria: 1 = very low certainty about the score to 5 = very high certainty about the score.

Sources of uncertainty in the scoring

- Knowledge or expertise of the scorer.
- Availability of relevant information about the species being scored (based on knowledge from field observations, knowledge from other sources, etc.), or lack thereof.
- Conflicting information relevant to the criteria scoring that might be available (e.g. does the species produce seeds, can it overwinter, does it spread beyond disturbed or heavily managed areas, etc.)
- Ambiguities in the existing wording of the 9 criteria.
- Uncertainty in taxonomic identification.

Each state as well as the USDA has a different protocol and set of regulation for listing species as invasive or not, and prohibiting their sale and use or not. The only exception being the federally listed noxious weeds listing.

New York Scoring system

Species are ranked at the New York State level by a series of questions in four broad categories:

Points	
40	Ecological impact
25	Biological characteristic & dispersal
25	Ecological abundance and distribution*
10	Difficulty of control
100	TOTAL

*NYS, Northeastern USA and Canada) climate similar to NYS

Questions can be answered based on a species' behavior in areas beyond the borders of New York. Without this provision it would be impossible to assess the potential invasiveness of species that are new arrivals or not yet present

New York Scoring system

Points are assigned to answers to each question. The maximum possible total if all questions can be answered is 100 points. At least 70 points are needed to assess.

New York Invasiveness Rank	Relative Maximum Score
Very High Invasive Nature	> 80
High Invasive Nature	70-80
Moderate Invasive Nature	50-69
Low Invasive Nature	40-49
Insignificant Invasive Nature	<40

Not assessable (not persistent in NY's climate, or species does not occur outside of cultivation).

Unknown (insufficient information to assess; <70 points)

New York Scoring system

	Maximum Points
1. ECOLOGICAL IMPACT	
1.1. Impact on Natural Ecosystem Processes and System-Wide Parameters	10
1.2. Impact on Natural Community Structure	10
1.3. Impact on Natural Community Composition	10
1.4. Impact on other species or species groups	10
Subtotal:	40
2. BIOLOGICAL CHARACTERISTICS AND DISPERSAL ABILITY	
2.1. Mode and rate of reproduction	4
2.2. Innate potential for long-distance dispersal	4
2.3. Potential to be spread by human activities (both directly and indirectly...)	3
2.4. Characteristics that increase competitive advantage, such as ….	6
2.5. Growth vigor	2
2.6. Germination/Regeneration	3
2.7. Other species in the genus invasive in New York or elsewhere	3
Subtotal:	25

New York Scoring system

3. ECOLOGICAL AMPLITUDE AND DISTRIBUTION	
3.1. Density of stands in natural areas in the northeastern USA and eastern Canada (use same definition as Gleason & Cronquist …)	4
3.2. Number of habitats the species may invade	6
3.3. Role of disturbance in establishment	4
3.4. Climate in native range	3
3.5. Current introduced distribution in the northeastern USA and eastern Canada	4
3.6. Current introduced distribution of the species in natural areas in the eight New York State PRISMs	4
Subtotal:	25
4. DIFFICULTY OF CONTROL	
4.1. Seed banks	3
4.2. Vegetative regeneration	3
4.3. Level of effort required	4
Subtotal:	10
Total:	100

Examples of NY Rankings of Invasive species vs. IPC

PLANTS				LISTS								
Genus	Species	Common Name	Growth Form or Habit	CT IPC & CIPWG Lists	CT Prohibited List	MA MIPAG List	MA Prohibited List	NYIS Ranking	NY Prohibited/ Regulated List	NJISST Do Not Plant List	NH Prohibited and Watch Lists	ME Natural Areas Program List
Phleum	*pratense*	Timothy	Grass or Grass-like	N	N	N	N	Moderate - 63.75	N	N	N	N
Photinia	*villosa*	Oriental Photinia	Shrub	N	N	N	N	N	N	Target	N	N
Phragmites	*australis*	Common Reed	Grass or Grass-like	Invasive	Y	Invasive	Y	Very High - 92.00	Prohibited	Widespread	N	Invasive
Phyllostachys	*spp.*	Bamboo species	Grass or Grass-like	Research	N	N	N	Not Assessable	Prohibited (*P. aurea and P. aureosulcata*)	N	N	N
Pinellia	*ternata*	Crowdipper	Herbaceous	N	N	N	N	Insignificant - 39.73	N	N	N	N
Pinus	*thunbergii*	Japanese Black Pine	Tree	N	N	N	N	Moderate - 58.62	N	N	N	N
Pistia	*stratiotes*	Water Lettuce	Aquatic & Wetland	Potentially Invasive	N	N	N	Not Assessable	N	N	N	N
Poa	*bulbosa*	Bulbous Bluegrass	Grass or Grass-like	N	N	N	N	Low - 48.75	N	N	N	N
Poa	*compressa*	Canada Bluegrass	Grass or Grass-like	Potentially Invasive	Y	N	N	Moderate - 68.75	N	N	N	N
Poa	*nemoralis*	Wood Bluegrass	Grass or Grass-like	N	N	N	N	N	N	N	N	Invasive
Poa	*pratensis*	Kentucky Bluegrass	Grass or Grass-like	N	N	N	N	Moderate - 67.78	N	N	N	N
Polygonum	*caespitosum; Persicaria longiseta*	Bristled Knotweed	Herbaceous	Invasive	Y	N	N	Moderate - 60.27	N	N	N	N
Polygonum	*cuspidatum; Fallopia japonica*	Japanese Knotweed	Herbaceous	Invasive	Y	Invasive	Y	Very High - 97.94	Prohibited	Widespread	Prohibited	Invasive

USDA quantitative WRA ranking protocol and associated risk assessment of invasive species

Biol Invasions (2012) 14:273–294
DOI 10.1007/s10530-011-0061-4

ORIGINAL PAPER

Development and validation of a weed screening tool for the United States

Anthony L. Koop · Larry Fowler ·
Leslie P. Newton · Barney P. Caton

The latest iteration of the USDA quantitative WRA Invasive Risk Assessment protocol

United States Department of Agriculture

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

September 29, 2016

Version 2.2

Guidelines for the USDA-APHIS-PPQ Weed Risk Assessment Process

https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/wra-guidelines.pdf

USDA's two component system risk assessment protocol

- Establishment/spread risk: likelihood species will become naturalized and spread to other areas (23 associated questions).
- Impact: capacity to cause direct or indirect damage to natural anthropogenic and production systems (18 associated questions).
- Scores range from negative to positive values:
  - likelihood of Establishment/Spread total scores range in value from -25 to 32 (negative = low risk to positive = high risk).
  - Likelihood of Impact total scores range from 1 to 5.1 (1 = low impact 5.1 = high impact).

USDA WRA Demonstration Study

- The Koop et al. 2012 study comprised 200+ species with a broad representation of species that *a priori*: 1) non-invaders, 2) minor-invaders, and 3) major invaders, 68 species each. Non-invaders were defined as not naturalized (using the plants.usda.gov listing and other souces), but were present in the US for 75+ yrs (from Bailey's *Hortus*).
  - "Naturalized" "…follows Richardson et al.'s (2000) definition as alien plants that reproduce consistently and sustain populations over many life cycles without direct human intervention in natural or human-made ecosystems. This definition is consistent with the IPPC's (2009) definition of ''established.''"
- "Several sources were used to determine…" the categorization of species as minor or major invaders.

Questions regarding USDA Establishment/Spread Potential

Table 6 Questions and scoring used in the final PPQ weed risk assessment

Establishment/spread potential	
ES-1	Select one: (A) Introduced elsewhere long ago (>75 years) but not escaped (−5). (B) Introduced recently (<75 years) but not escaped (−2). (C) Never introduced elsewhere (0). (D) Escaped/Casual (0). (E) Naturalized (2). (F) Invader (5)
ES-2	Is the species highly domesticated (y = −3, n = 0, or ? = 0)
ES-3	Congeneric weed (y = 1, n = 0, or ? = 0)
ES-4	Shade tolerant at some stage of life cycle (y = 1, n = 0, or ? = 0)
ES-5	Climbing or smothering growth habit (y = 1, n = 0, or ? = 0)
ES-6	Forms dense thickets (y = 2, n = 0, or ? = 0)
ES-7	Aquatic (y = 1, n = 0, or ? = 0)
ES-8	Grass (y = 1, n = 0, or ? = 0)
ES-9	Nitrogen-fixing woody plant (y = 1, n = 0, or ? = 0)
ES-10	Produces viable seed or spores (y = 1, n = −1, or ? = 0)
ES-11	Self-compatible or apomictic (y = 1, n = −1, or ? = 0)
ES-12	Requires specialist pollinators (y = −1, n = 0, or ? = 0)
ES-13	Minimum generative time: (A) Less than 1 (multiple generations per year) (2). (B) 1 Year (annual-1 gen per year) (1). (C) 2 or 3 years (0). (D) >3 Years (−1). ? = 0
ES-14	Prolific seed/spore production (see scoring guide) (y = 1, n = −1, or ? = 0)
ES-15	Propagules likely to be dispersed unintentionally by people (y = 1, n = −1, or ? = 0)
ES-16	Propagules likely to disperse in trade as contaminants and hitchhikers (y = 2, n = −1, or ? = 0)
ES-17[a]	No. natural dispersal vectors (none = −4, one = −2, two = 0, three = 2, four or five = 4)
ES-18	Evidence that a persistent (>1 year) propagule bank (seed bank) is formed (y = 1, n = −1, or ? = 0)
ES-19	Tolerates/benefits from mutilation, cultivation or fire (y = 1, n = −1, or ? = 0)
ES-20	Is resistant to some herbicides or has potential to acquire herbicide resistance (y = 1, n = 0, or ? = 0)
ES-21	Number of USDA cold hardiness zones suitable for survival (out of 13) (zero-three = −1, four-nine = 0, ten-thirteen = 1)
ES-22	Number of climate types suitable for survival (out of 12) (zero-two = −2, three = 0, four-twelve = 2)
ES-23	Number of precipitation bands suitable for survival (out of 11) (zero-four = −1, five-seven = 0, eight-eleven = 1)

23 questions to address

Questions regarding USDA Impact Potential

Impact potential

Imp-G1	Allelopathic (y = 0.1, n = 0, or ? = 0)
Imp-G2	Parasitic (y = 0.1, n = 0, or ? = 0)
Imp-N1	Change ecosystem processes and parameters that affect other species? (y = 0.4, n = 0, or ? = 0)
Imp-N2	Change community structure? (y = 0.2, n = 0, or ? = 0)
Imp-N3	Change community composition? (y = 0.2, n = 0, or ? = 0)
Imp-N4	Likely to affect any federal Threatened and Endangered plant species? (y = 0.1, n = 0, or ? = 0)
Imp-N5	Likely to affect any globally outstanding ecoregions? (y = 0.1, n = 0, or ? = 0)
Imp-N6	For conservation/natural areas, choose the best answer. (A) Plant not a weed (0); (B) Plant a weed but no evidence of control efforts (0.2); (C) Plant a weed and evidence of control efforts (0.6)
Imp-A1	Impacts human property, processes, civilization, or safety? (y = 0.1, n = 0, or ? = 0)
Imp-A2	Changes or limits recreational use of an area? (y = 0.1, n = 0, or ? = 0)
Imp-A3	Outcompetes, replaces or otherwise affects desirable plants and vegetation? (y = 0.1, n = 0, or ? = 0)
Imp-A4	For urban/suburban areas, choose the best answer. (A) Plant not a weed (0); (B) Plant a weed but no evidence of control efforts (0.1); (C) Plant a weed and evidence of control efforts (0.4)
Imp-P1	Reduces crop/product yield? (y = 0.4, n = 0, or ? = 0)
Imp-P2	Lowers commodity value? (y = 0.2, n = 0, or ? = 0)
Imp-P3	Is it likely to impact trade? (y = 0.2, n = 0, or ? = 0)
Imp-P4	Reduces the quality or availability of irrigation, or strongly competes with plants for water? (y = 0.1, n = 0, or ? = 0)
Imp-P5	Toxic to animals, including livestock/range animals and poultry (y = 0.1, n = 0, or ? = 0)
Imp-P6	For production systems, choose the best answer. (A) Plant not a weed (0); (B) Plant a weed but no evidence of control efforts (0.2); (C) Plant a weed and evidence of control efforts (0.6)

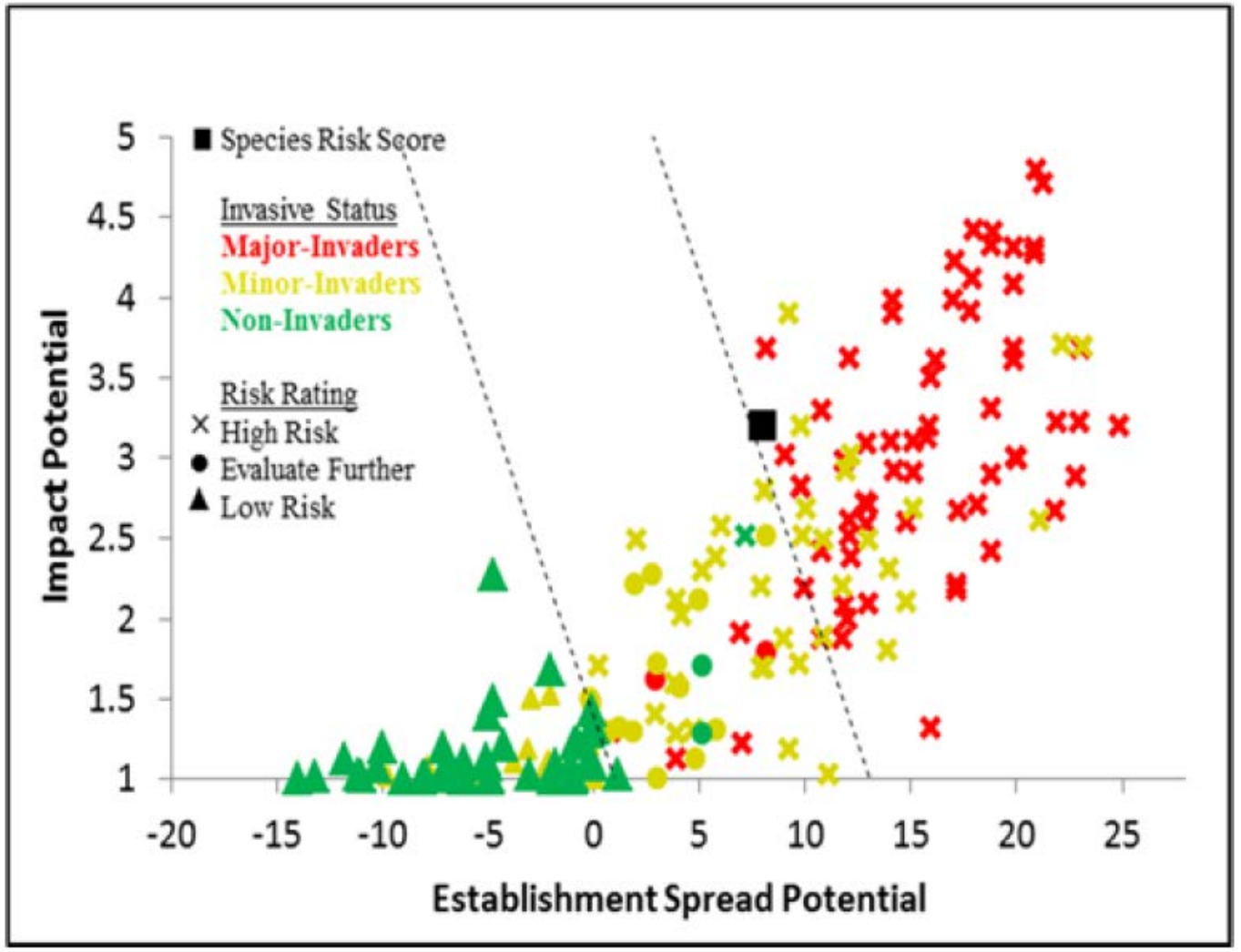
18 questions to address

The USDA scoring of the species for each of the 41 questions was done by:

"a small group of people with varying levels of botanical and invasive expertise…questions were discussed by the group regards interpretation and approaches…and every assessment was reviewed by a second team member." The focus was on biological information available on the web, not on other scoring systems available. If an answer to some question was unknown, it was listed as such. Scores were summed and then averaged. Total scores ranged for likelihood of Establishment/Spread from -25 to 32 (negative = low risk, positive = high risk) and for Impact from 1 to 5.1 (1= low impact 5= high impact).

USDA invasive risk assessment outcome:

a 2-D display of the total mean score for each of the 200+ species

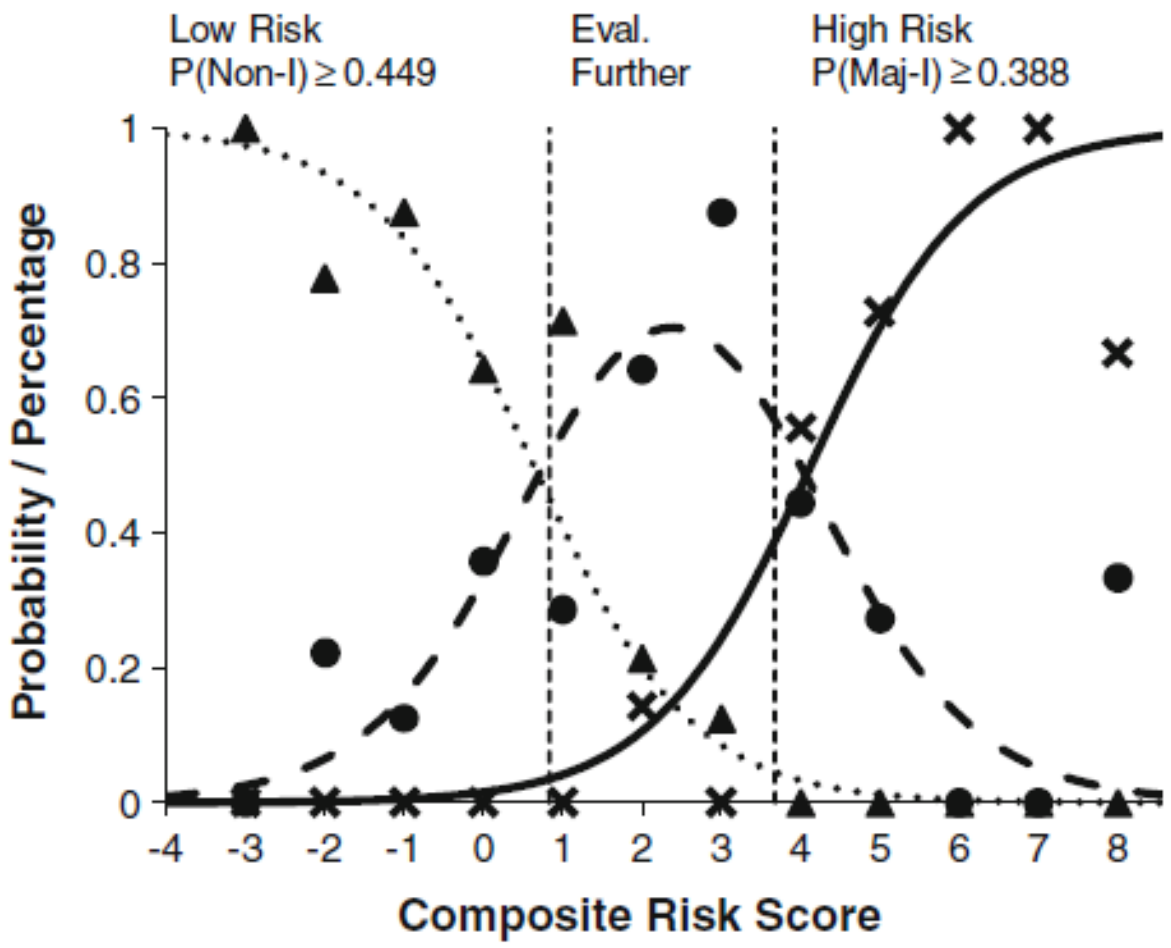


Note:

1) a priori categorization of species in red, tan and green.
2) The post hoc categorization of high risk and low risk species and those needing further evaluation
3) The differences between a priori and post hoc categorization

Statistical Modeling

(logistic regression of probability of invasive species class)



Composite risk score refers to a linear combination of the risk scores for establishment/spread and impact. Points show proportion for each risk category.

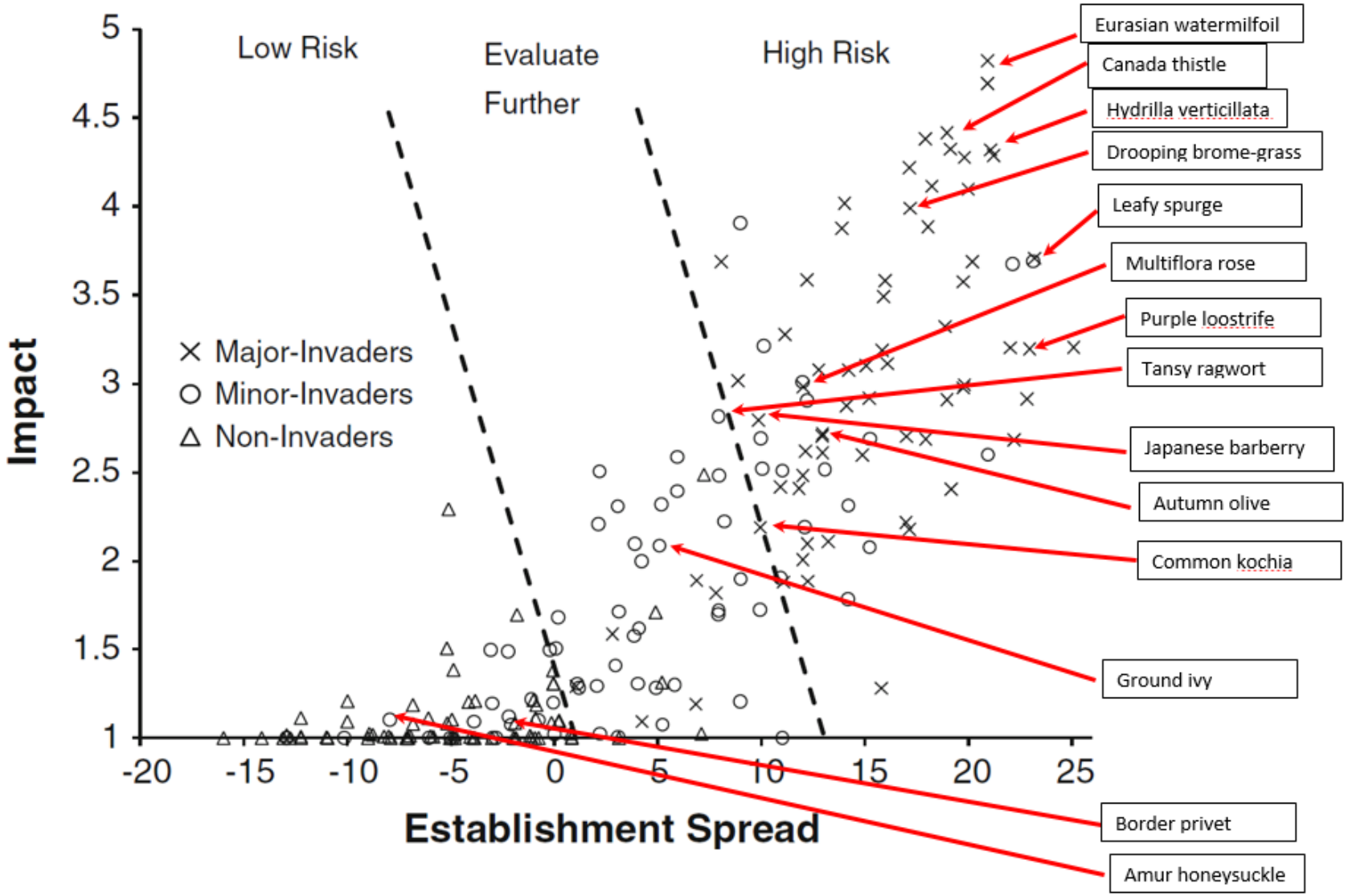
▲ = non-invaders ·····

● = minor invaders – – – ·

X = major invaders ——

Note cut points defining the model risk assessment results for each category and overlap among these: “Low Risk”, “High Risk” and “Evaluate Further”.

The USDA composite figure with IPC species listed



What about uncertainty in categorizations?

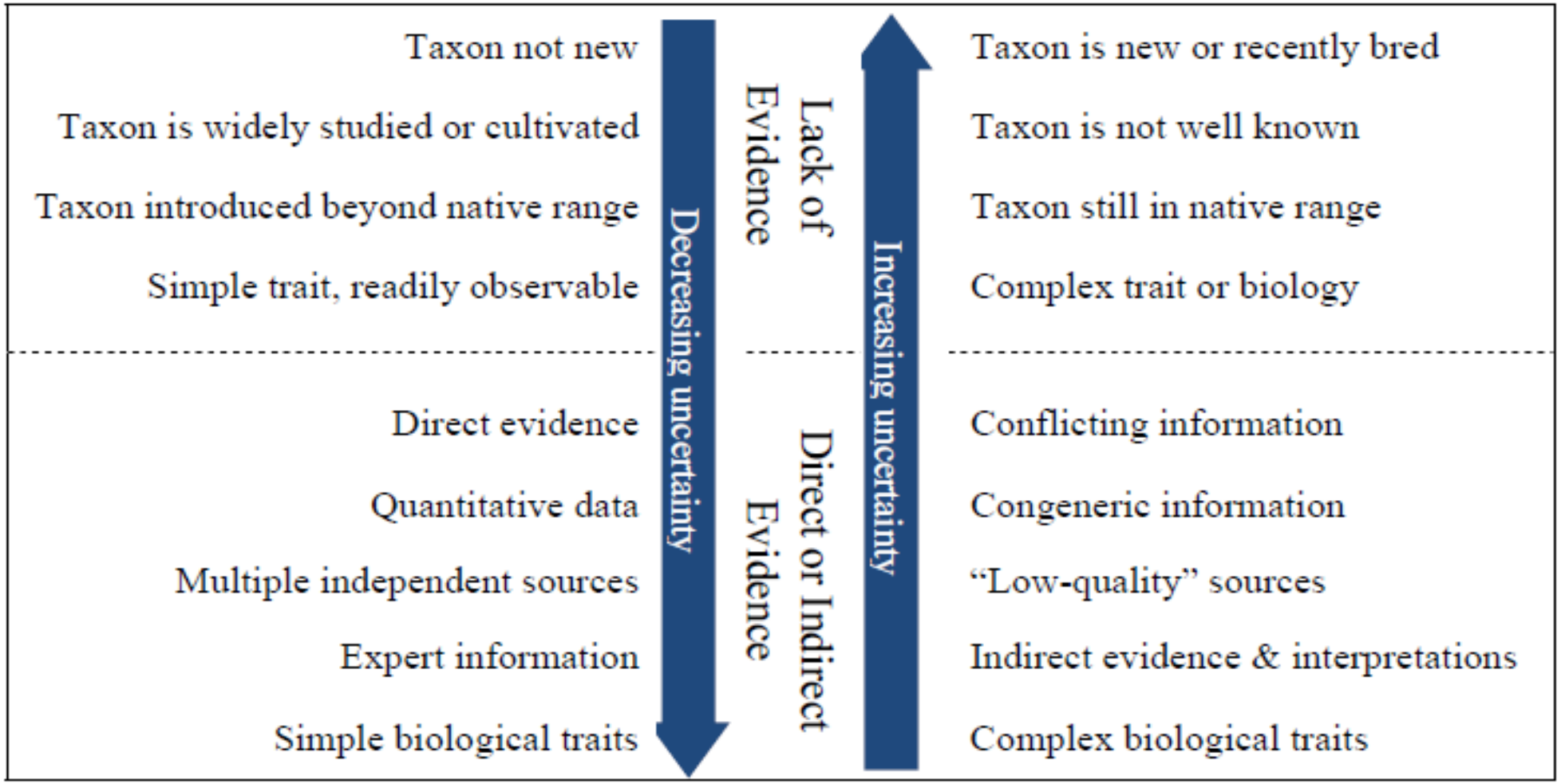
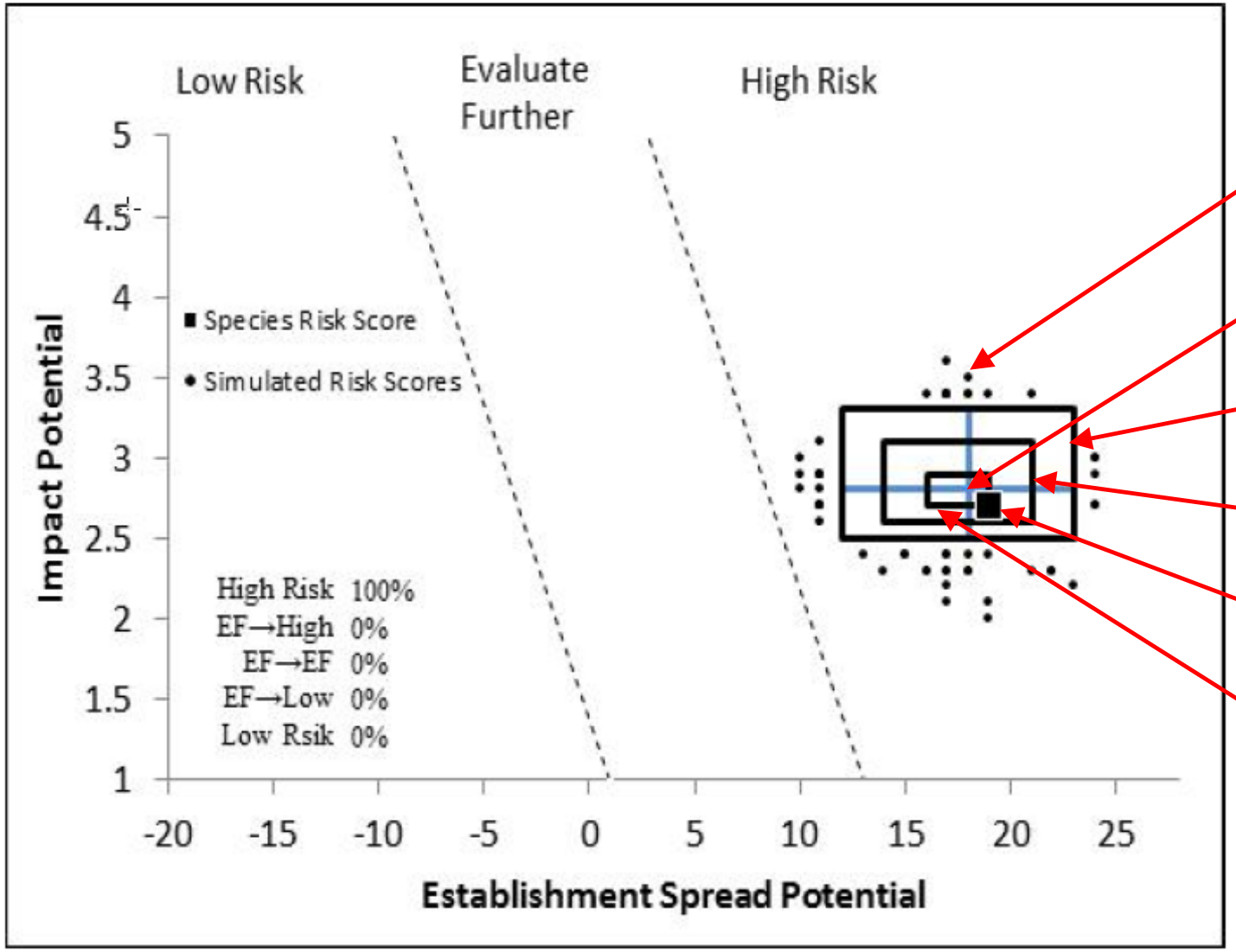


Figure 8. The general impact of factors on the level of uncertainty associated with an answer.

Assessment of uncertainty in the modeling of risk



1% outliers of simulated risk scores

Medians of simulated risk scores

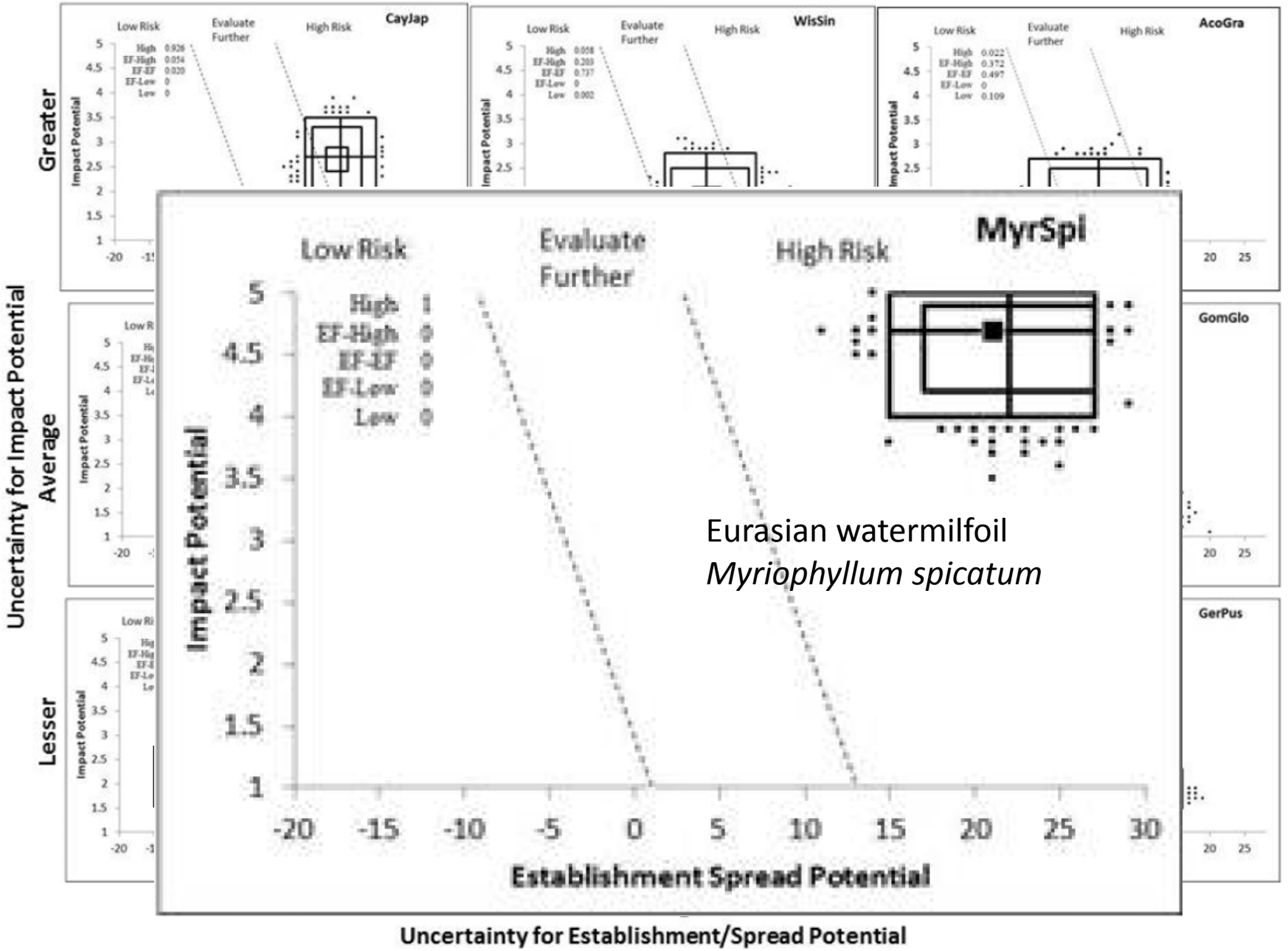
99% of simulated risk scores

95% of simulated risk scores

Overall observed risk score

50% of simulated risk scores

Risk analysis of species in USDA 2016 study



USDA invasive risk assessment (2016) taken a step further: model potential species distributions

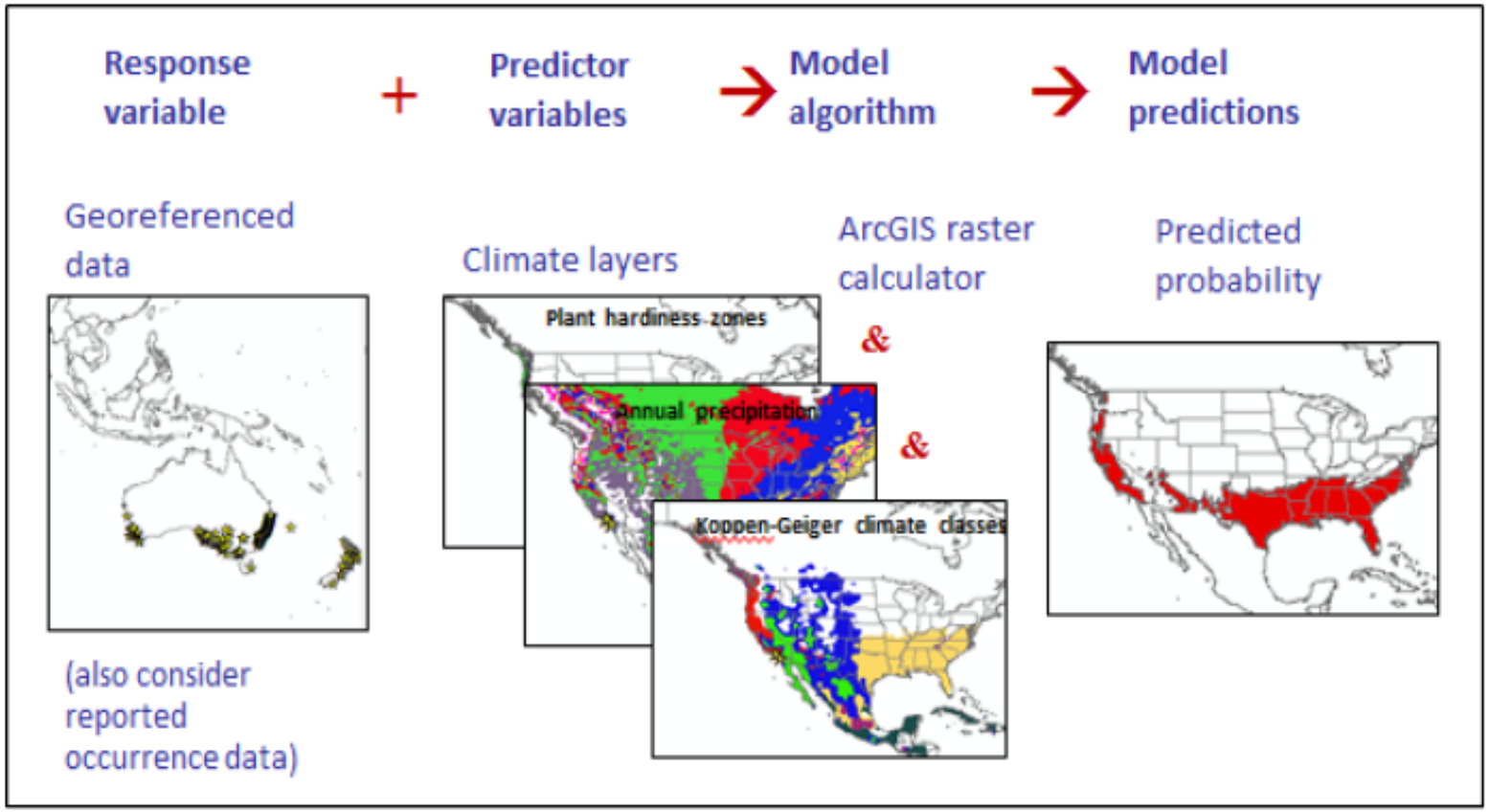


Figure 9. Overview of the PPQ Proto3 model for assessing the geographic potential of a plant taxon.

Example USDA WRA (2102) for one of the species on our list: *Phyllostachys sp*.

Figure 2. *Phyllostachys aurea* risk score (black box) relative to the risk scores of species used to develop and validate the WRA model (other symbols). See Appendix A for the complete assessment.

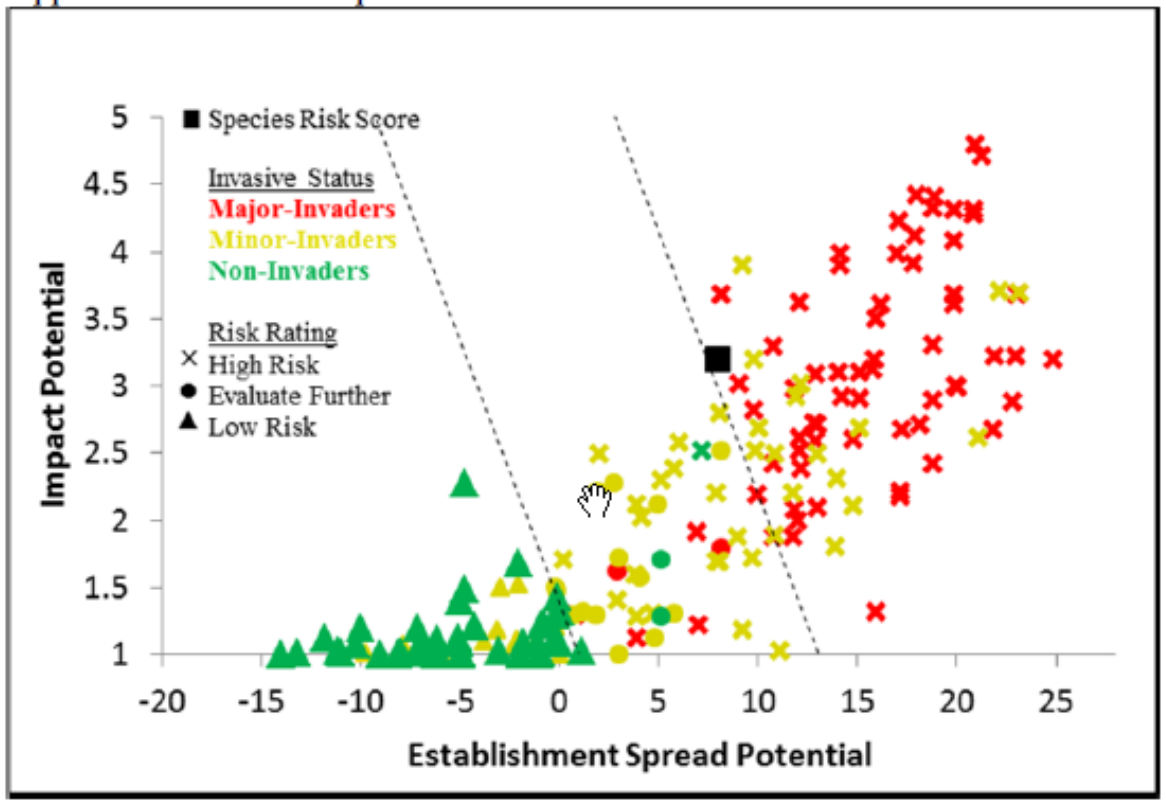
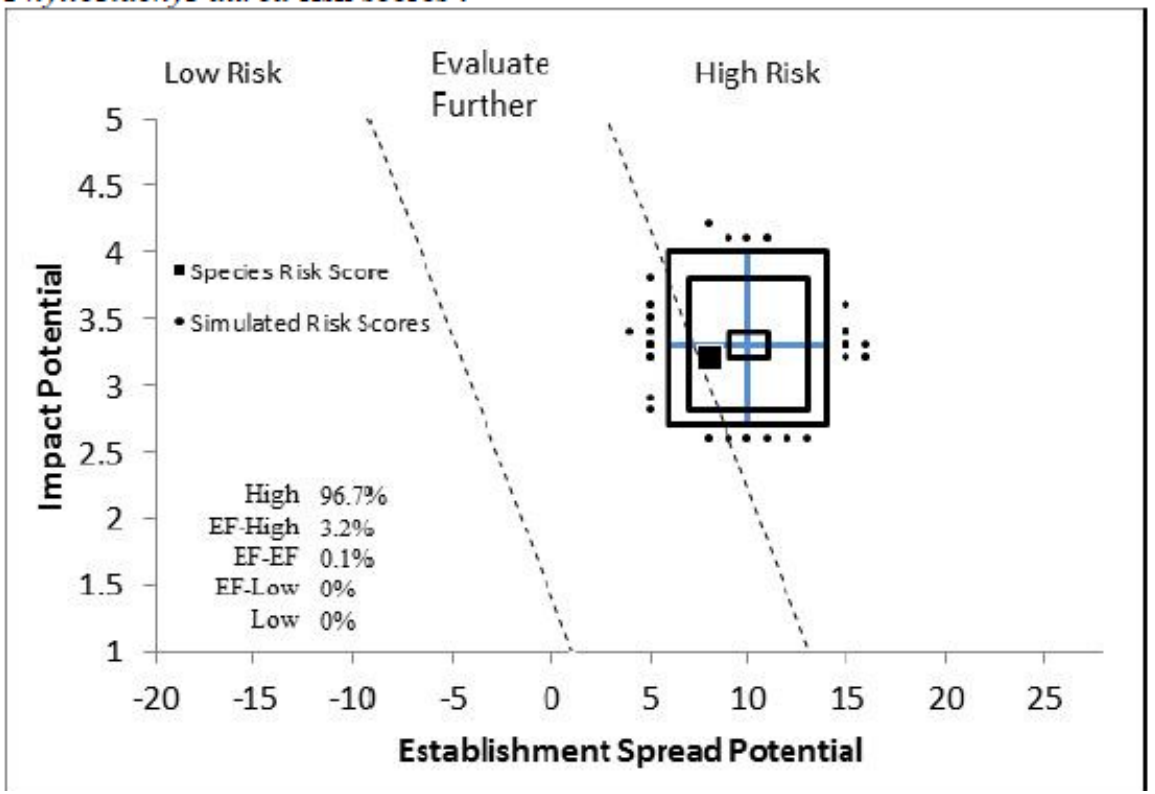
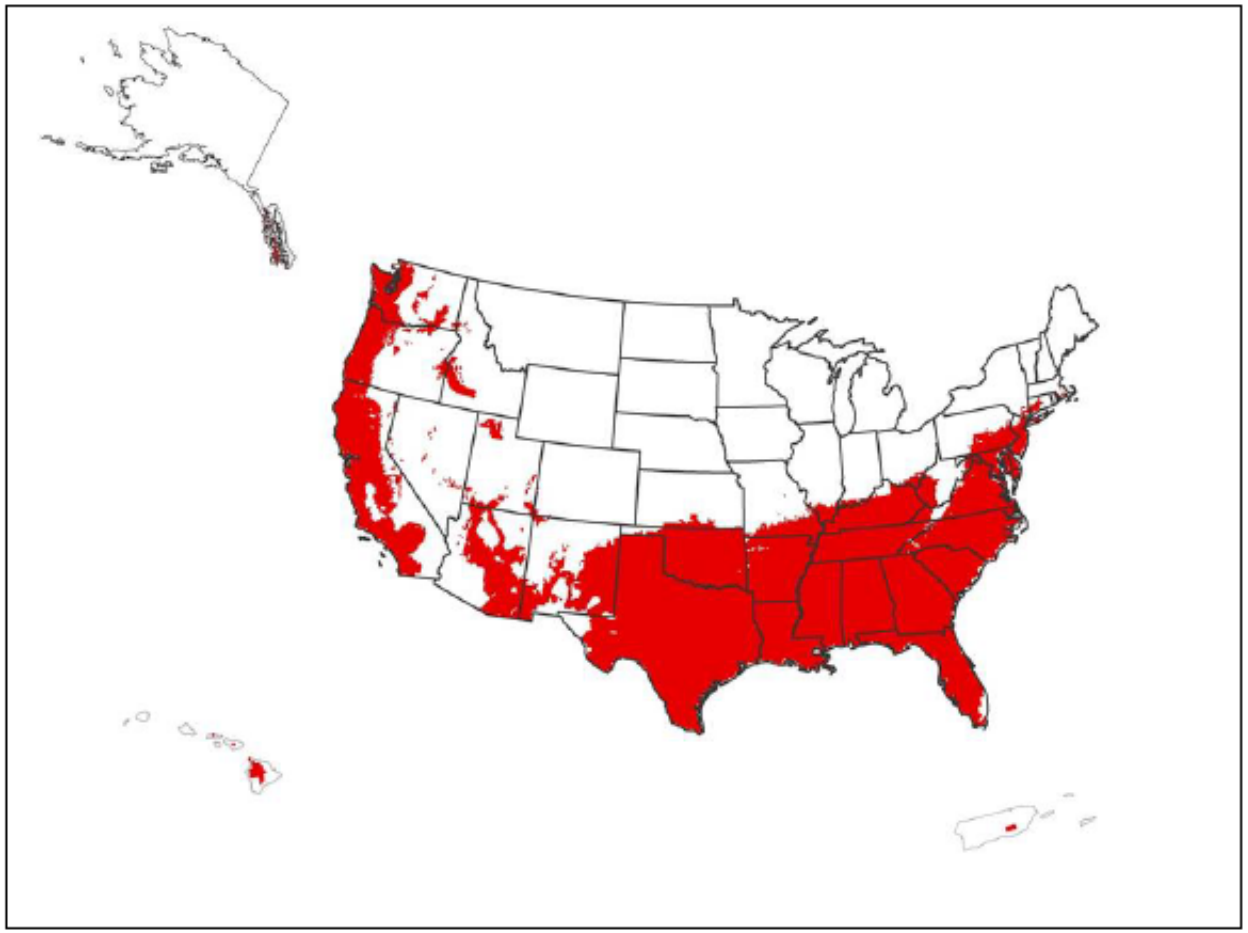


Figure 3. Monte Carlo simulation results (N=5000) for uncertainty around *Phyllostachys aurea* risk scores[a].



USDA WRA projected distribution of *Phyllostachys sp.* in the US

Figure 1. Predicted distribution of *Phyllostachys aurea* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.



Species listed as invasive or potentially invasive by the CT-IPC that are not prohibited

- Acer platanoides – Norway Maple
- Ampelopsis brevipedunculata – porcelainberry
- Artemisia vulgaris – mugwort
- Berberis thunbergii – Japanese barberry
- Eichhornia crassipes – water hyacinth (PI)
- Euonymus alatus – winged euonumus
- Frangula alnus – glossy buckthorn
- Ligustrum ovalifolium & L. vulgare – privets (PIs)
- Lysimachia vulgaris – garden loosestrife (PI)
- Miscanthus sinensis – Chinese silver grass (PI)
- Ornithogalum umbellatum – star-of-Bethlehem (PI)
- Phalaris arundinaceae – reed canary grass
- Pistia stratoites – water lettuce (PI)
- Robinia pseudoacacia – black locust
- Rosa rugosa (PI)

Variation in scorings from a subset of workshop participants

Species	Acer	Akebia	Ampelopsis	Berberis	Bromus	Cirsium	Eleagnus	Euonymus	Froelichia	Ligustrum
1	5	5	5	5	5	5	5	5	5	5
2	5	3-5	3-5	5	3-5	4-5	?&3-5	2-5	2-5	?&2-5
3	3-5	2-3	2-5	5	3-5	3-5	?&2-3	1-5	1-5	?&1-2
4	3-5	2-3	2-5	5	3	4-5	?&2-3	1-4	1-3	?&1-2
5	4-5	1-5	1-5	5	3-4	1-5	?&2-3	2-3	1-3	?&1-3
6	5	2-5	2-5	5	2-5	3-5	?&2-3	1-5	1-5	?&1-2
7	3-5	1-3	1-5	5	2-5	3-5	?&1-2	2-3	1-5	?&1-2
8	3-5	2-5	2-5	5	2-4	1-4	?&2-5	2-4	1-3	?&2
9	4-5	1-3	2-5	5	2-4	2-5	?&2-3	1-5	1-4	?&1-2
C-scores	3-5	1-5	1-5	3-5	2-5	2-5	1-5	2-5	2-5	1-5

Variation in scorings continued

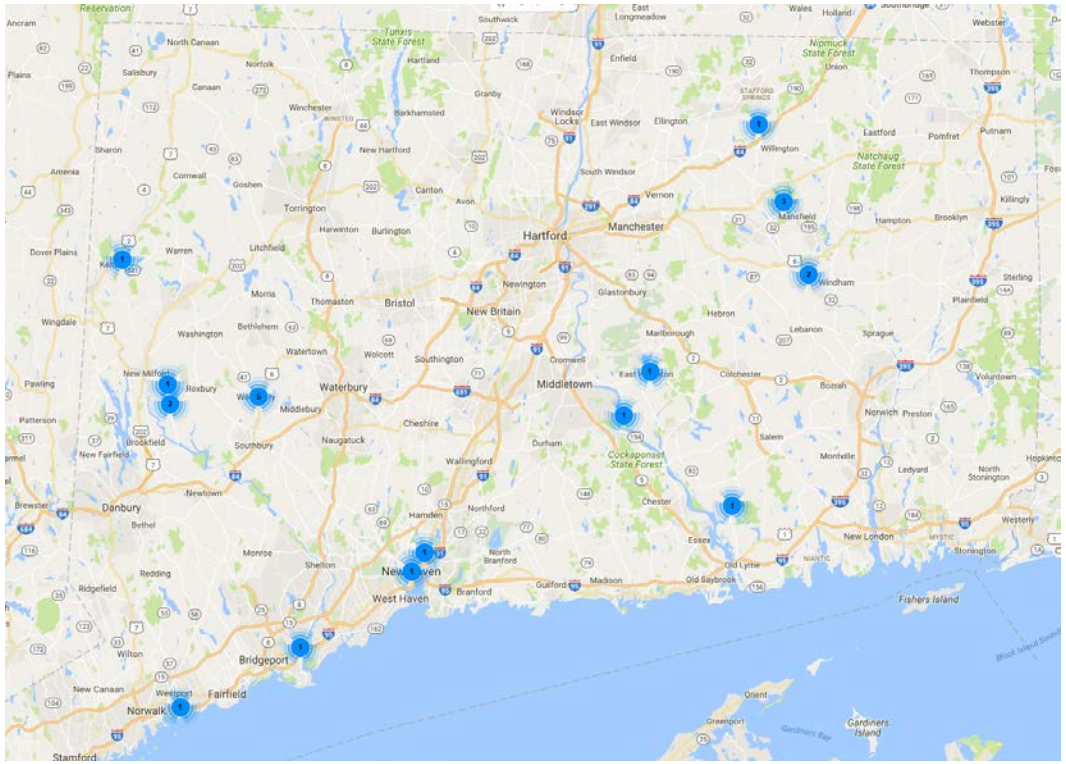
Species	Lonicera	Lythrum	Myriophyllum	Phragmites	Phyllostachys	Pistia	Polygonum	Pyrus	Robinia	Rumex
1	5	5	5	3-5	5	5	5	5	5	5
2	?&2-5	5	?&3-5	5	1-4	?&1-2	2-5	2-5	4-5	3-5
3	?&2	3-5	?&3-4	5	2-3	?&1-2	2-5	3-5	3-5	2-5
4	?&1-2	2-5	?&4-5	2-5	2-4	?&2-3	1-5	3-5	3-5	2-5
5	?&1-3	5	?&4-5	5	3-5	?&2-3	1-5	3-5	3-5	2-5
6	?&1-2	5	?&2-5	5	2-4	?&1-2	2-5	1-5	4-5	3-5
7	?&1-2	5	?&2-5	1-5	2-5	?&1-2	2-5	1-3	3-5	3-5
8	?&2-3	2-5	?&3-5	4-5	3-5	?&2-4	2-3	2-3	3-3	1-3
9	?&2-3	5	?&2-5	1-5	2-3	?&2-3	2-5	2-5	3-4	2-5
C-scores	1-5	4-5	1-5	1-5	1-5	1-5	2-5	2-5	3-5	3-5

Detailed background information on a subset of the species scored during the workshop

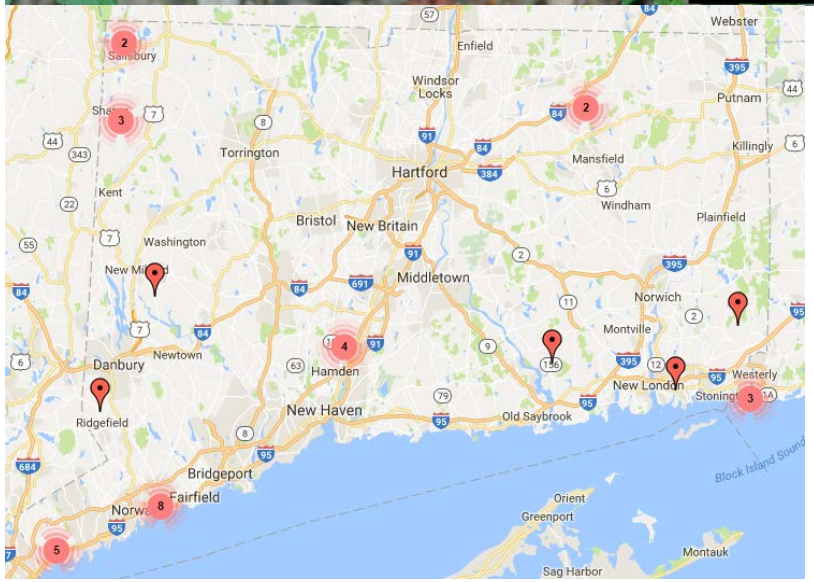
Akebia quinata: IPC listed research species

VA population

Rarely flowers or sets seed; seems to spread in CT only by scrambling and rooting from original planting sites. 7 herbarium records in CT. No IPANE records in New England. Mentioned in EDDMapS but no point distribution maps. Not listed in any other state, other than NJ as a species not to plant. But “regulated” in GA, SC and KY.



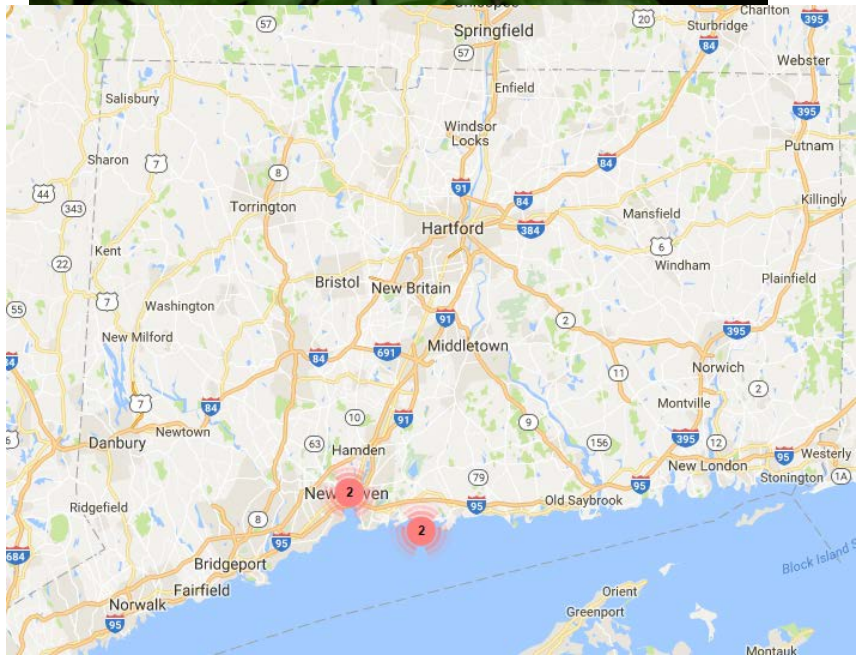
Ampelopsis brevipedunculata listed as Invasive by IPC

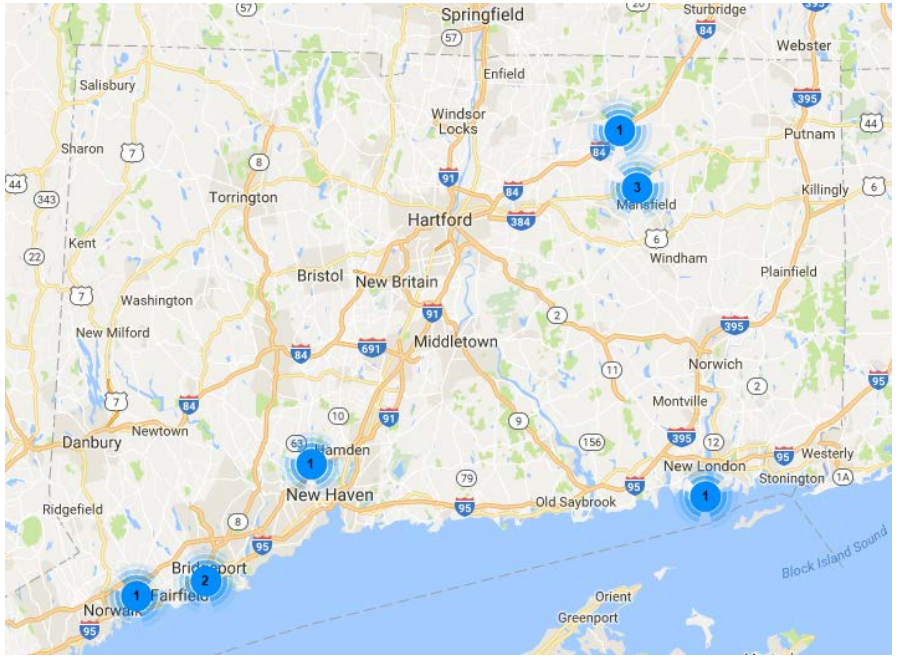


Does flower and produce seed. 28 herbarium records in CT; 13 IPANE sightings in New England. Listed as Invasive in MA, NY, and RI; potentially invasive in ME. Watch list in NH and VT

Ligustrum ovalifolium – IPC listed potentially invasive

Does flower and fruit; 2 IPANE sightings in New England; 9 Herbarium records in CT. Not listed in any neighboring state; ranked low by NY, and do not plant in NJ. There may be confusion with the 4 other privets that are hard to discriminate among.



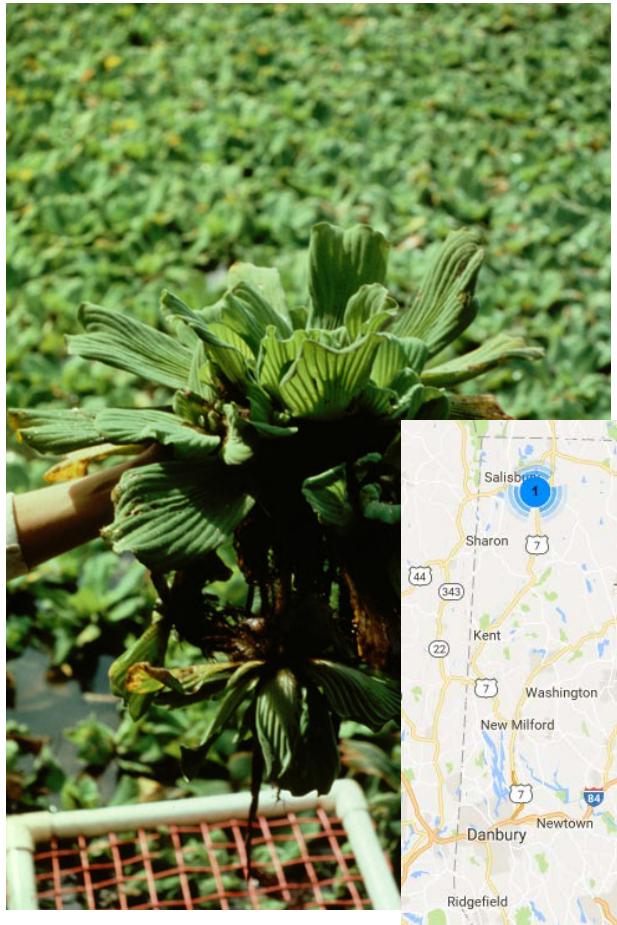


Phyllostaychys sp.

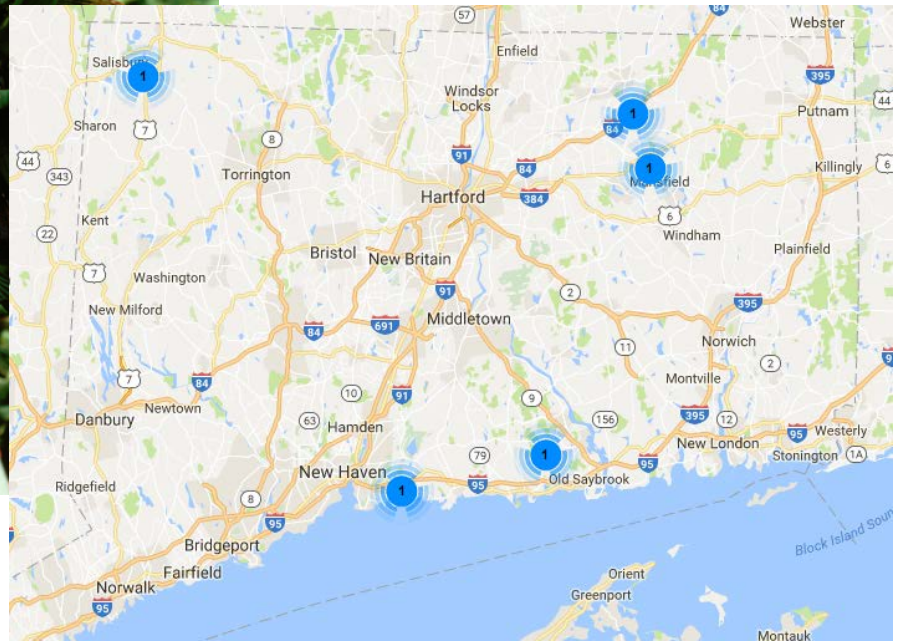
This species complex rarely if ever has set viable seeds; but bamboo species may live in a vegetative state for 100 years before synchronous, mass seed set. Populations appear to spread primarily from plantings and maybe occasionally spread via rhizome fragments. These species are shade tolerant and can thrive in forest understories to which they have spread. No distribution maps in EDDMapS; no herbarium records in CT or IPANE records in New England.

Listed as a research species by IPC. NY lists as not assessable but prohibited. Not listed by any other surrounding state.

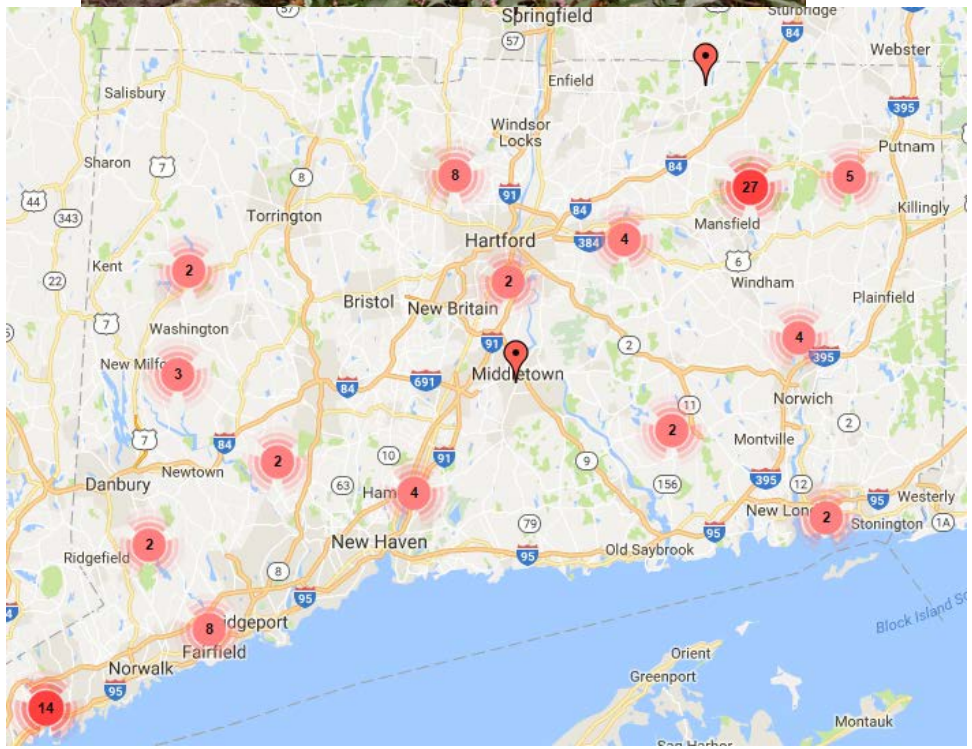
Pistia stratoites water lettuce IPC listed potentially Invasive



Some populations may produce viable seed that could overwinter. The vegetative state does not overwinter in New England. 5 herbarium records in CT; no IPANE sightings in New England. Listed as potentially invasive in RI but not listed any other neighboring state.



Polygonum caespitosum aka *Persicaria longiseta and Polygonum posumbu* (bristled knotweed, oriental ladysthumb



Annual, prolific seed producer; mainly confined to disturbed areas, abandoned fields, edge habitat, etc.
10 herbarium records in CT; 45 IPANE sightings in New England.
Listed as invasive and prohibited in CT by IPC; listed as moderately invasive but not restricted by NY; not listed by any other surrounding state.