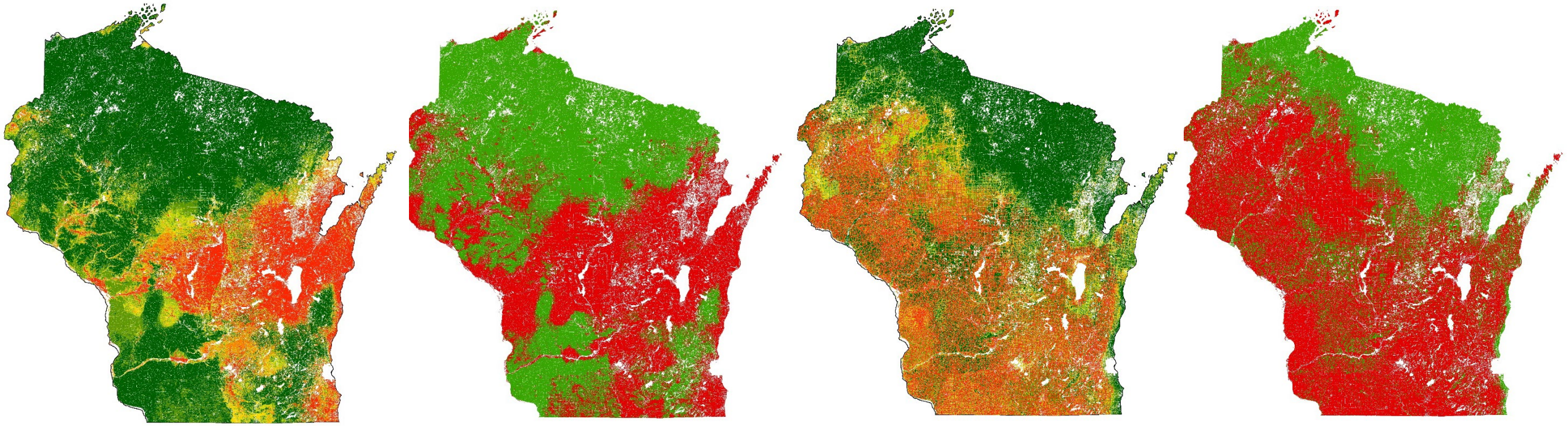
Ensemble Habitat Suitability Modeling for Invasive Plants:

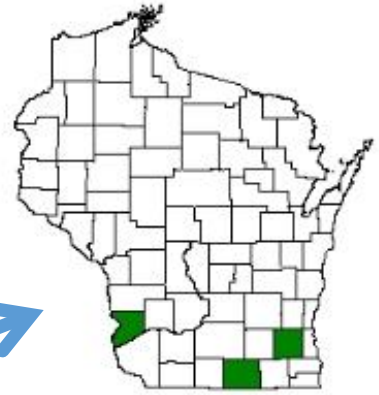
Assessing Model Performance and Accuracy Across 21 Species in WI



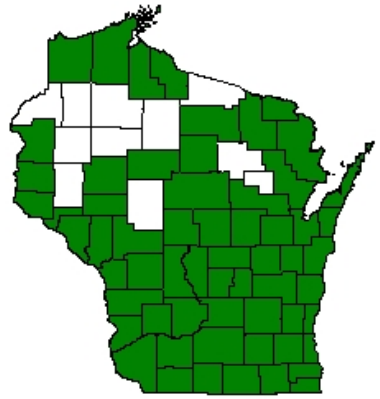
Mark Renz & **Niels Jorgensen**

University of Wisconsin-Madison

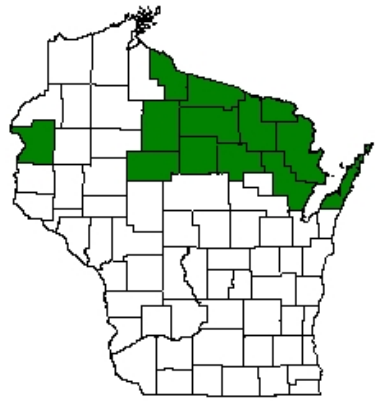
Wisconsin has a large number of regulated invasive species



- Over 145 invasive plants are regulated
  - 68 are prohibited = **must control**

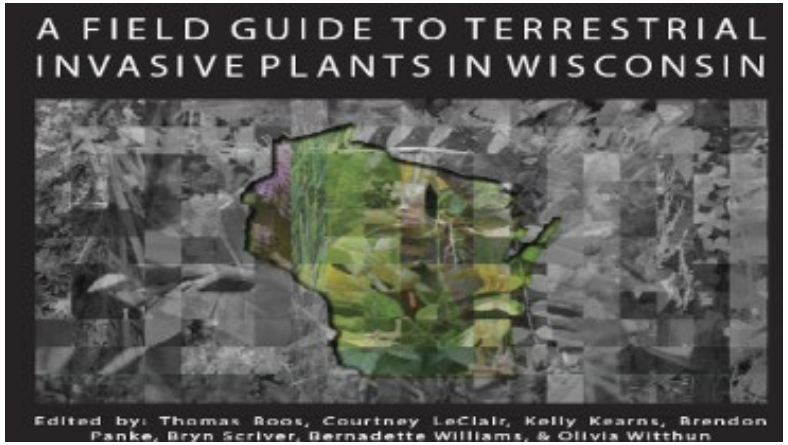


  - 63 are restricted
    - recommend control
    - can’t move propagules to un-infested areas
  - 14 are split listed
    - prohibited where uncommon/absent
    - restricted where common



Large # of regulated plants challenge land managers ability to identify and monitor for

- Resources have been made to help with ID
- Land managers want tools to help prioritize monitoring efforts




MANAGEMENT OF
INVASIVE PLANTS IN WISCONSIN

A3924-11

Brendon Panke and Mark Renz

Japanese knotweed
(Polygonum cuspidatum)

Japanese knotweed is an herbaceous perennial, growing up to 10 tall. Hollow, reddish, arching bamboo-like stems are smooth and stout, and they can persist after plant dies back each year. The base of the stem above each joint is swollen and surrounded by a membranous sheath (ocrea).

Legal classification in Wisconsin: Restricted

Leaves: Alternate, egg-shaped to almost triangular, 4–6" long, 3–4" wide. Dark green on upper surface and pale green on lower surface.

Flowers: Bloom in late summer. Flowers are numerous, highly branched, tiny, creamy white or greenish, and found where the leaf attaches to the stem (axils) near the tips of stems.

Fruit and seeds: Small, winged, triangular fruits carry very small, shiny seeds.

Roots: Plants arising from seed have a taproot up to 6' deep. Stout rhizomes can reach 45' or more from parent plants and give rise to new stalks. Plants arising from seed and rhizome also have fibrous roots.

Similar species: Giant knotweed (*P. sachalinense*) is also invasive, but grows up to 13' tall with larger leaves. The two species are known to hybridize.

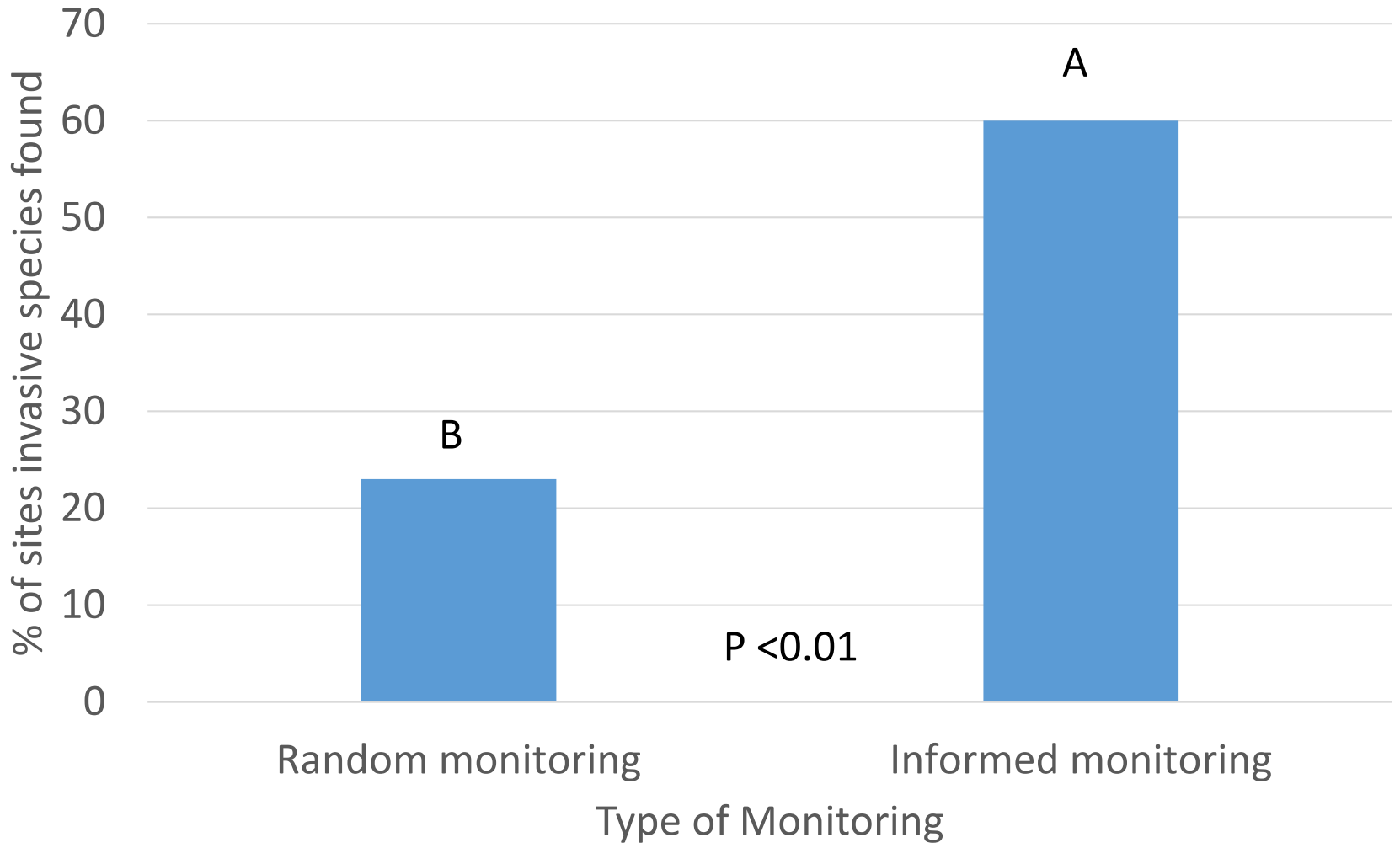
Ecological threat:
- Invades upland and lowland sites that are disturbed and undisturbed.
- Poses a significant threat to riparian areas, where it can rapidly spread.
- It tolerates shade, high temperatures, high salinity, and drought.
- It can be transported to new sites as a contaminant in fill dirt or on equipment. During floods, it spreads downstream by shoot fragments, rhizomes, or occasionally by seeds. Escapes from neglected gardens and discarded cuttings are common routes of dispersal from urban areas.
- Although reported to not produce viable seed, several studies have shown that populations of knotweed in the United States can produce viable seed that readily germinate and survive in field conditions.

Invasive plants can thrive and aggressively spread beyond their natural range, disrupting ecosystems. The Management of Invasive Plants in Wisconsin series explains how to identify invasive plants and provides common management options. Management methods recommend specific timings for treatment, as well as expected effectiveness. For more information, go to: fyi.uwex.edu/weeds/category/invasive-plants-of-wisconsin.

UW Extension Cooperative Extension
NPM

Habitat suitability models can help improve monitoring efforts

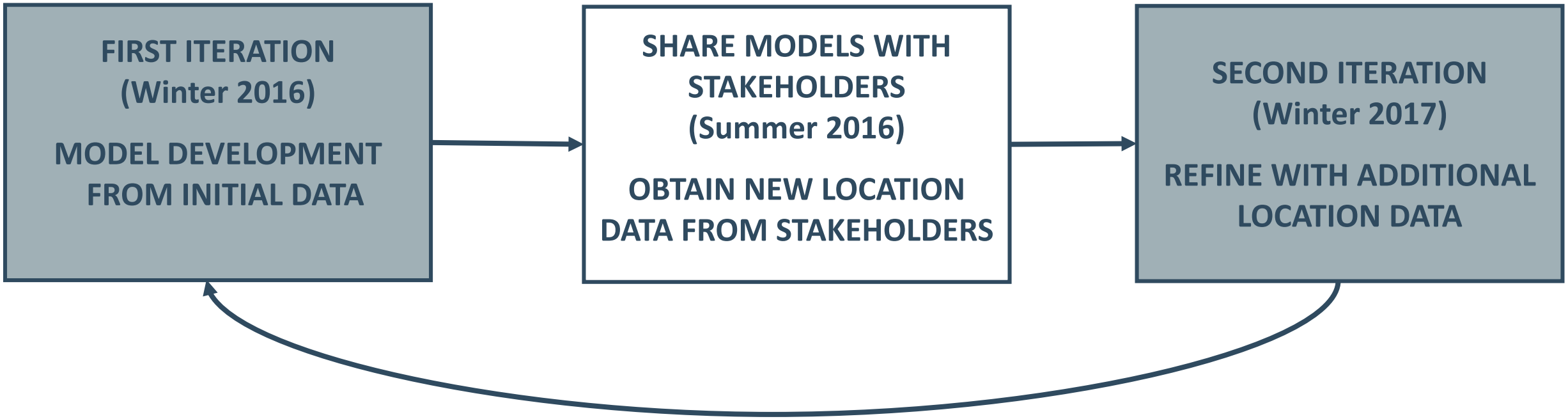
- Using a model to inform monitoring for 1 invasive species **<u>can improve success rate</u>**
  - Crall et al. 2013



Funded to create 21 habitat suitability models for WI regulated plants

- Ensemble modeling approach using 5 models
  - boosted regression tree (BRT), generalized linear model (GLM), multivariate adaptive regression splines (MARS), maximum entropy (MaxEnt), random forests (RF)
- Observations
  - Existing databases (Great Lakes Early Detection Network, EDDMapS, WI DNR)
  - Citizen scientists (data verified)
- Used common environmental, topographic, and climactic conditions available for geo-referenced locations.

Utilized Iterative Approach



Assess Models
To determine if further improvement is needed
(Fall 2017)

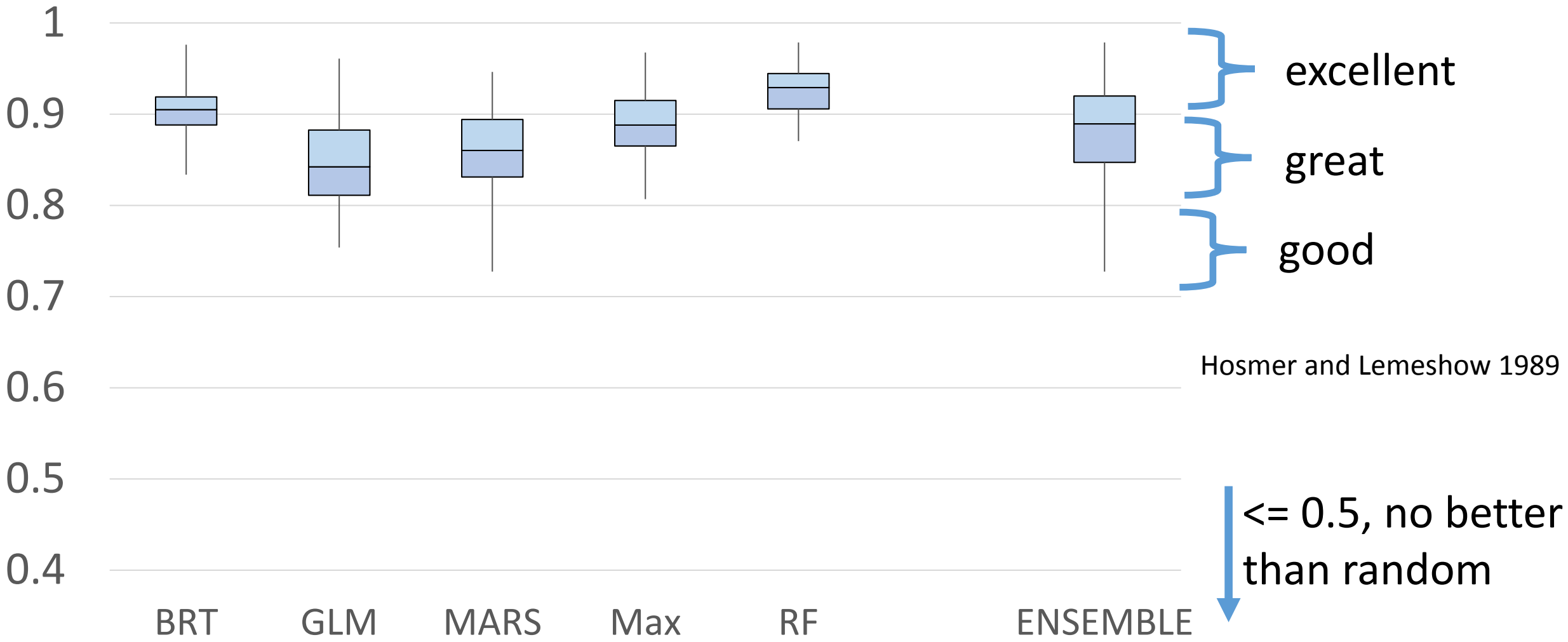
How well did the iterative approach work?

Common Name	Scientific Name	inc	Total
Garlic mustard	*Allaria petiolata*	44%	3,520
Japanese barberry	*Berberis thunbergii*	13%	474
Oriental bittersweet	***Celastrus orbiculatus***	**4%**	**223**
Spotted knapweed	*Centaurea stoebe*	37%	6,899
European marsh thistle	***Cirsium palustre***	**59%**	**1,369**
Teasels	*Dipsacus spp.*	3%	1,541
Autumn olive	*Elaeagnus umbellata*	59%	156
Leafy spurge	*Euphorbia esula*	106%	698
Knotweeds	***Fallopia spp.***	**17%**	**1,069**
Bush honeysuckles	*Lonicera spp.*	27%	3,943

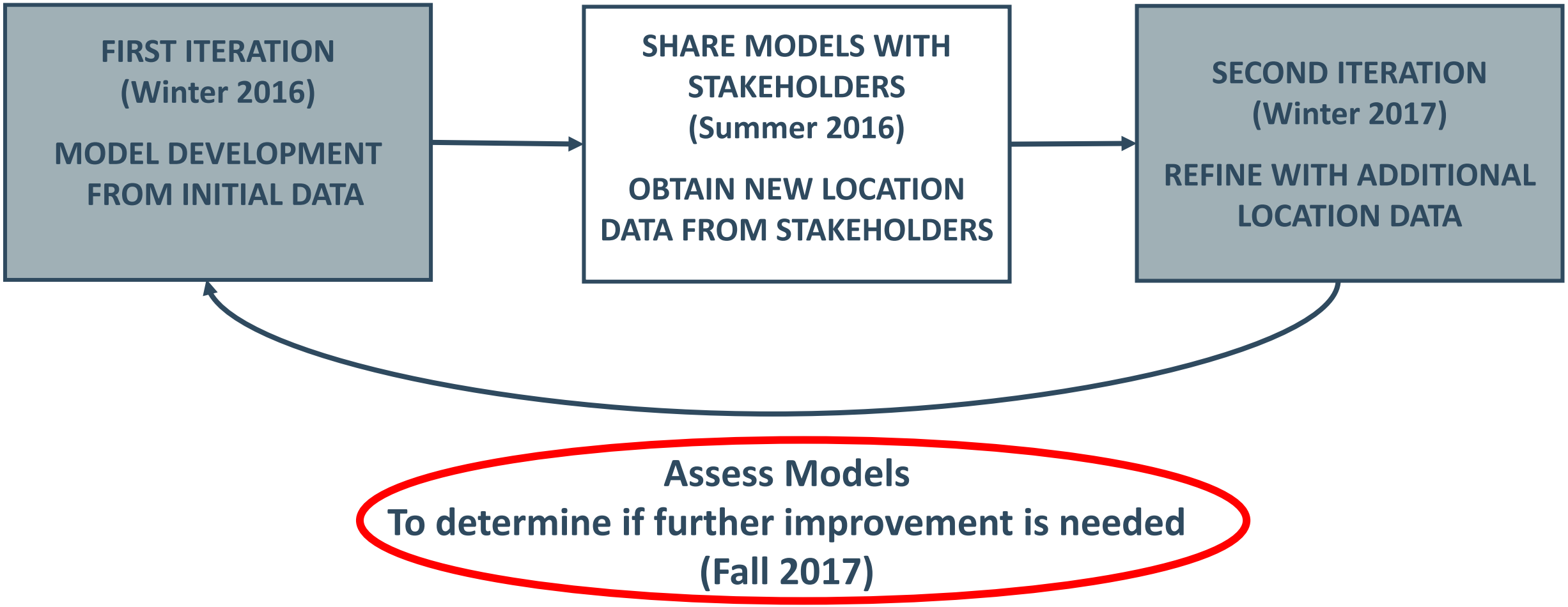
14,314 more points (37% increase)

Common Name	Scientific Name	inc	Total
Purple loosestrife	*Lythrum salicaria*	17%	1,642
Wild parsnip	*Pastinaca sativa*	18%	8,139
Canada thistle	*Cirsium arvense*	-	4,250
Phragmites	***Phragmites australis***	**1%**	**5,529**
Common buckthorn	*Rhamnus cathartica*	63%	1,673
Glossy buckthorn	*Rhamnus frangula*	12%	753
Wild chervil		-	613
Crown vetch	*Securigera varia*	36%	988
Tansy	*Tanacetum vulgare*	148%	10,778
Hedgeparsleys	***Torilis spp.***	**12%**	**509**
Garden valerian	*Valeriana officinalis*	5%	506

Did the iterative process improve models? AUC values for each model vs ensemble



Where are we in the process?



Objectives:

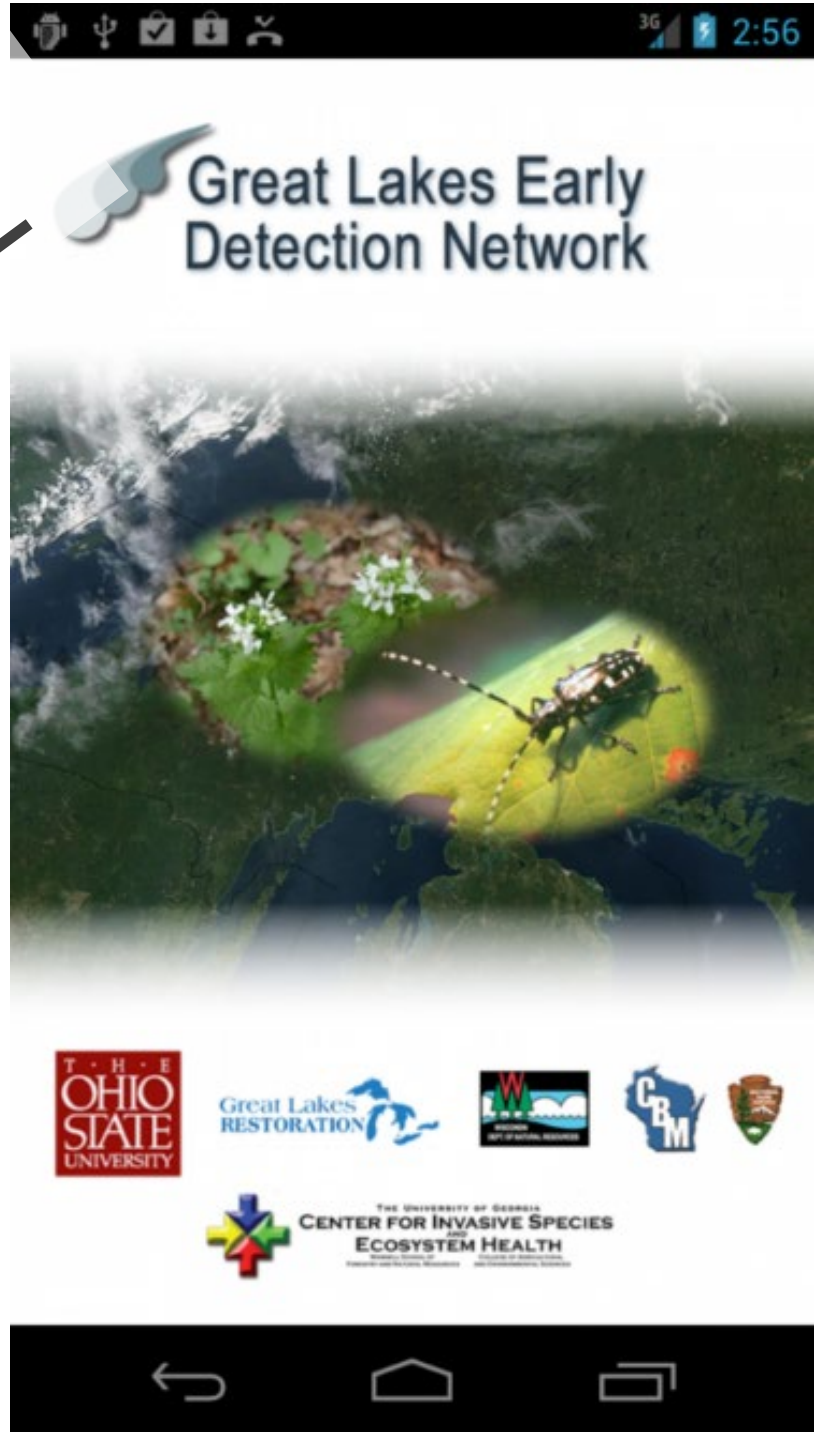
- Determine if models are providing an acceptable correct classification rates for suitable habitat for modeled invasive species?
  - Across all species
    - Ensemble vs individual models
  - Within each species
    - Ensemble only

Assessment of classification

- Independent dataset from stakeholders submitted in summer 2017
  - Submitted via the Great Lakes Early Detection App

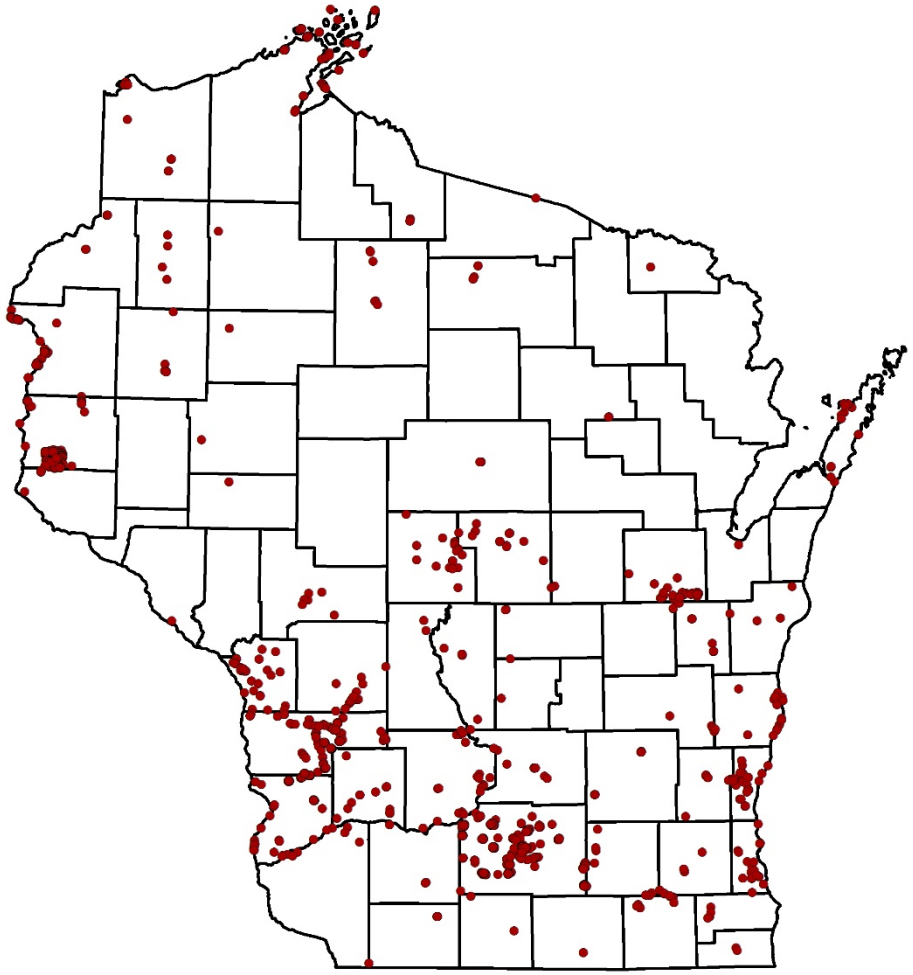
Only assessing type 1 error

EDDMapS
Early Detection & Distribution Mapping System



Reports

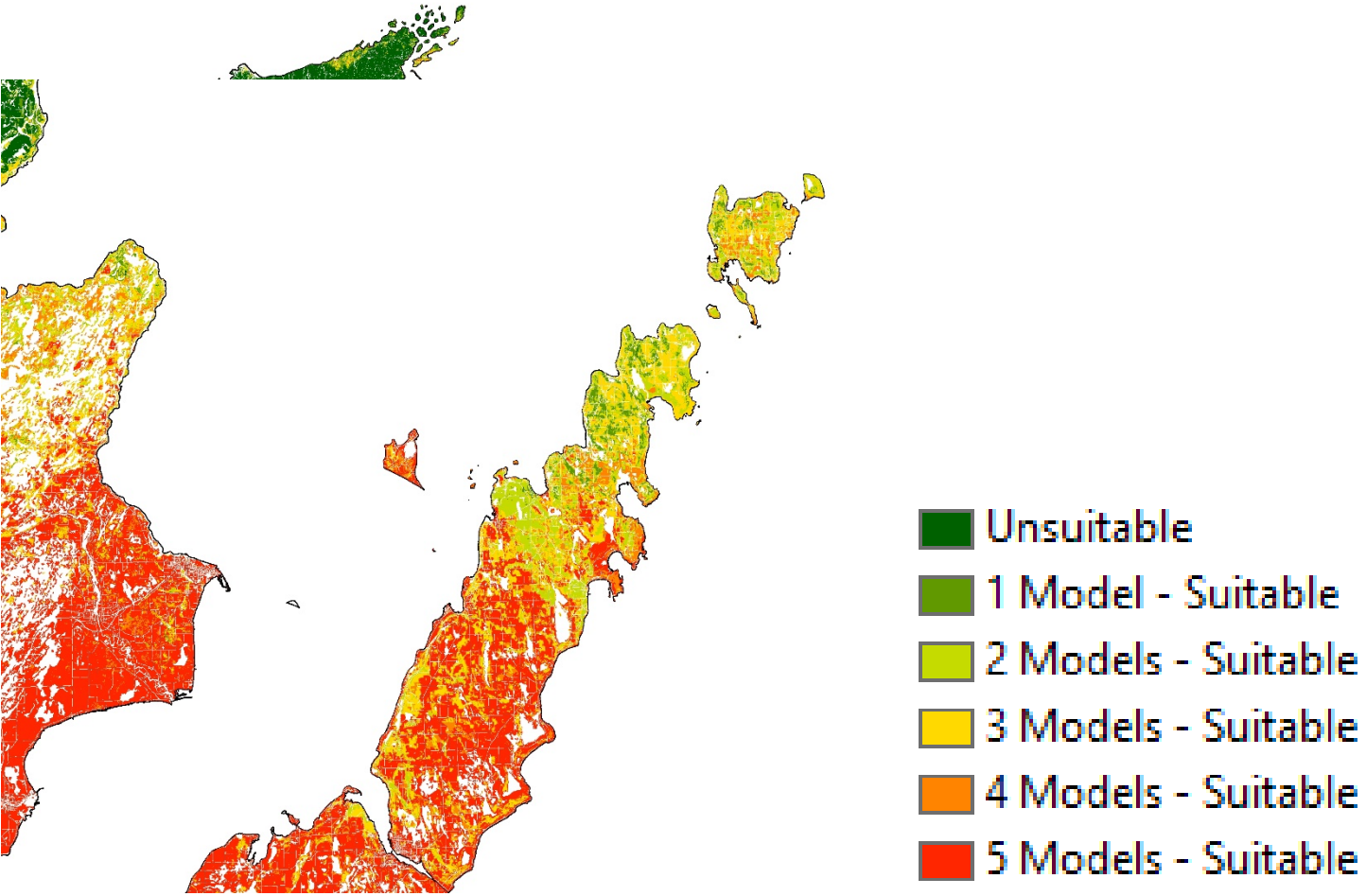
- 3,916 reports
  - 89% of Wisconsin counties reported at least one
  - 2,937 were used
    - Excluded if in novel areas or within road networks
- Calculated the % correct/incorrect classification for each species
  - Compared ensemble vs **each model**
    - All species
    - Early detection species
    - Widespread species
  - Evaluated ensemble only within species



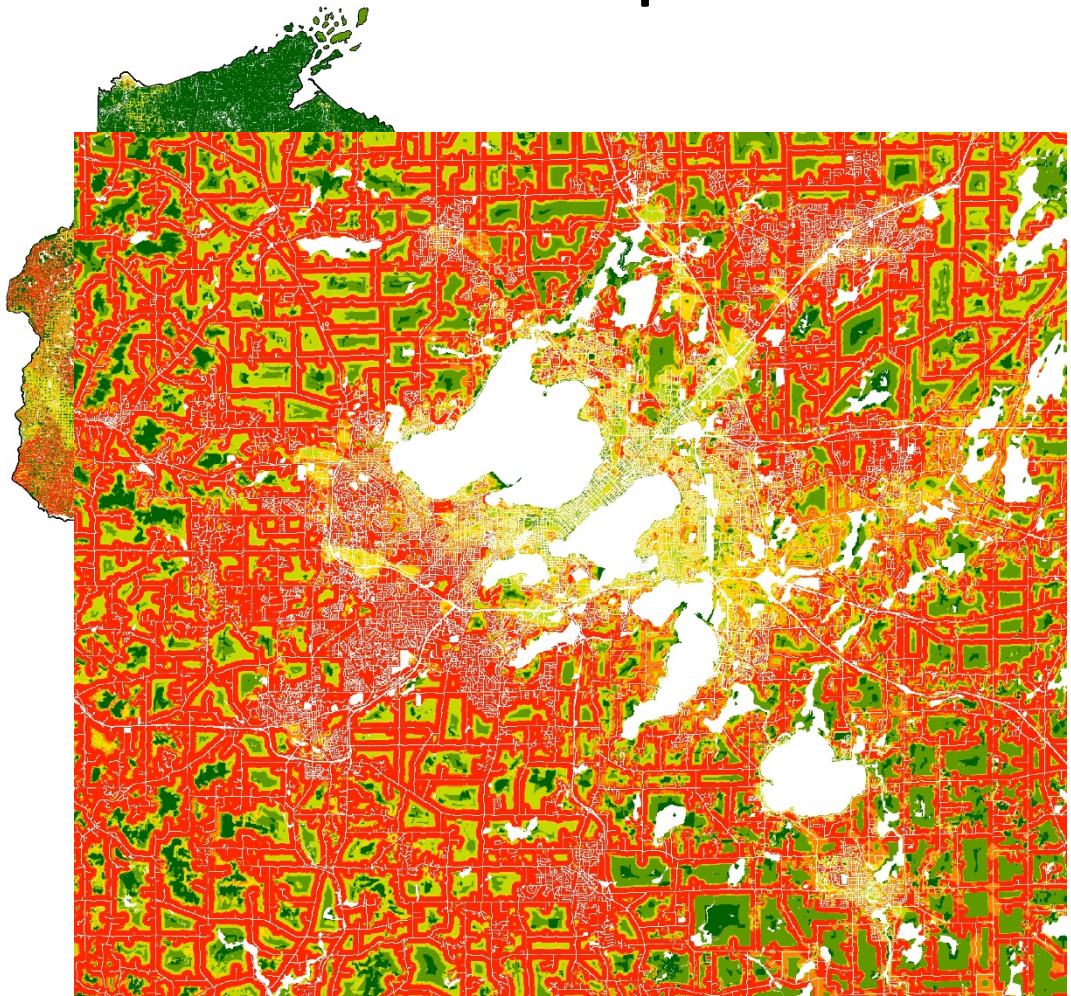
What Habitat Suitability Models look like

Models run at 30 m resolution

Phragmites

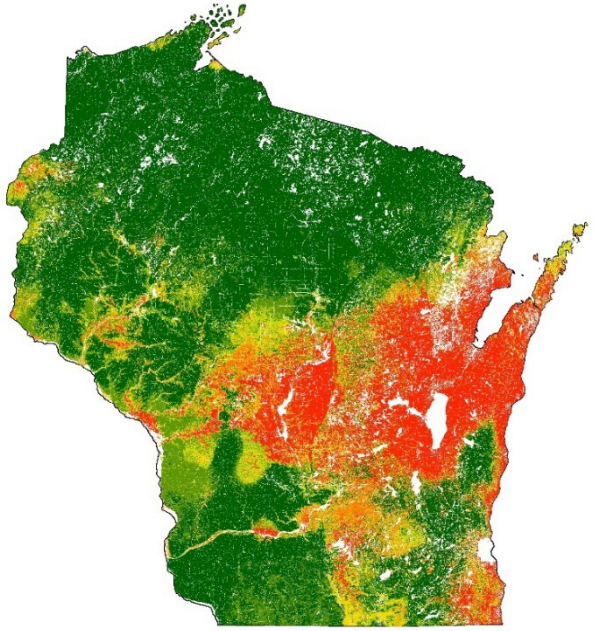


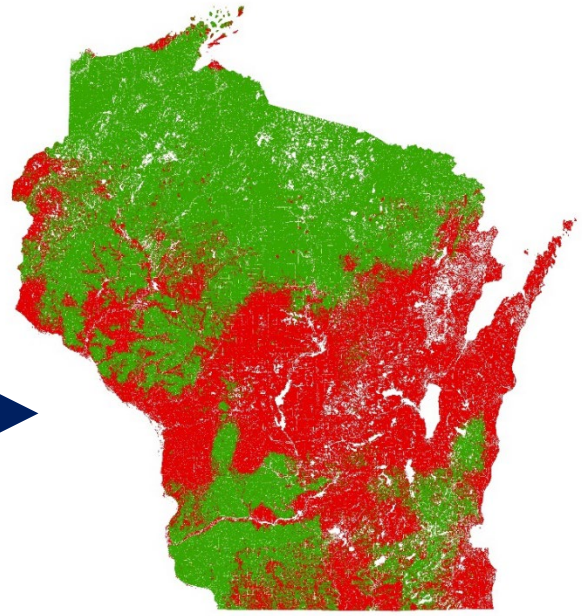
Wild Parsnip



Converting Models into Binary maps (Ensemble)

Phragmites





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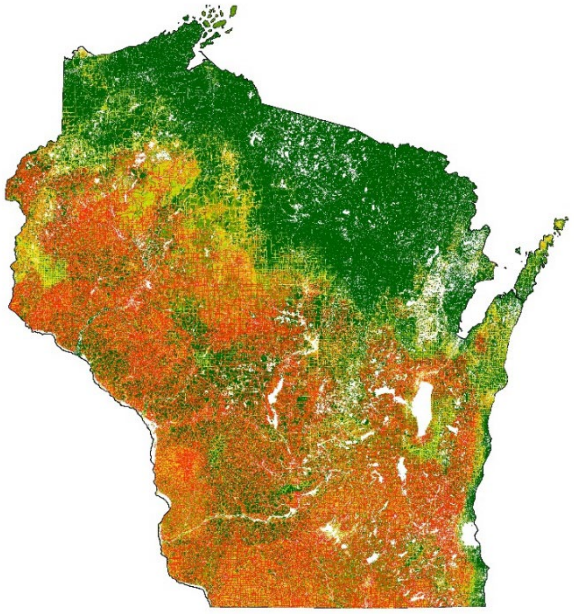
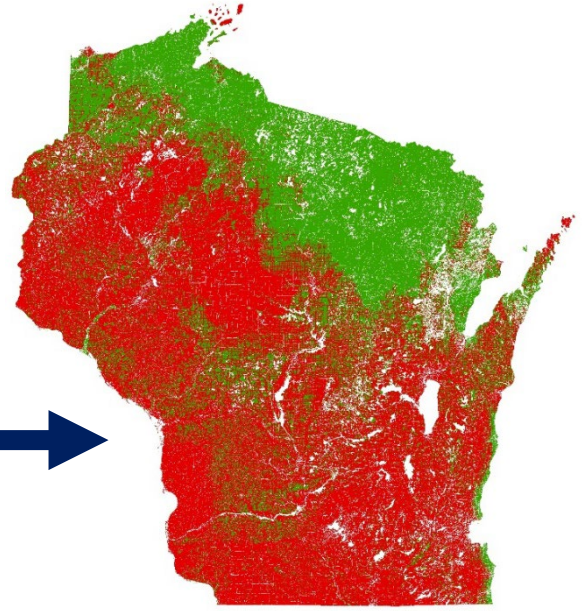
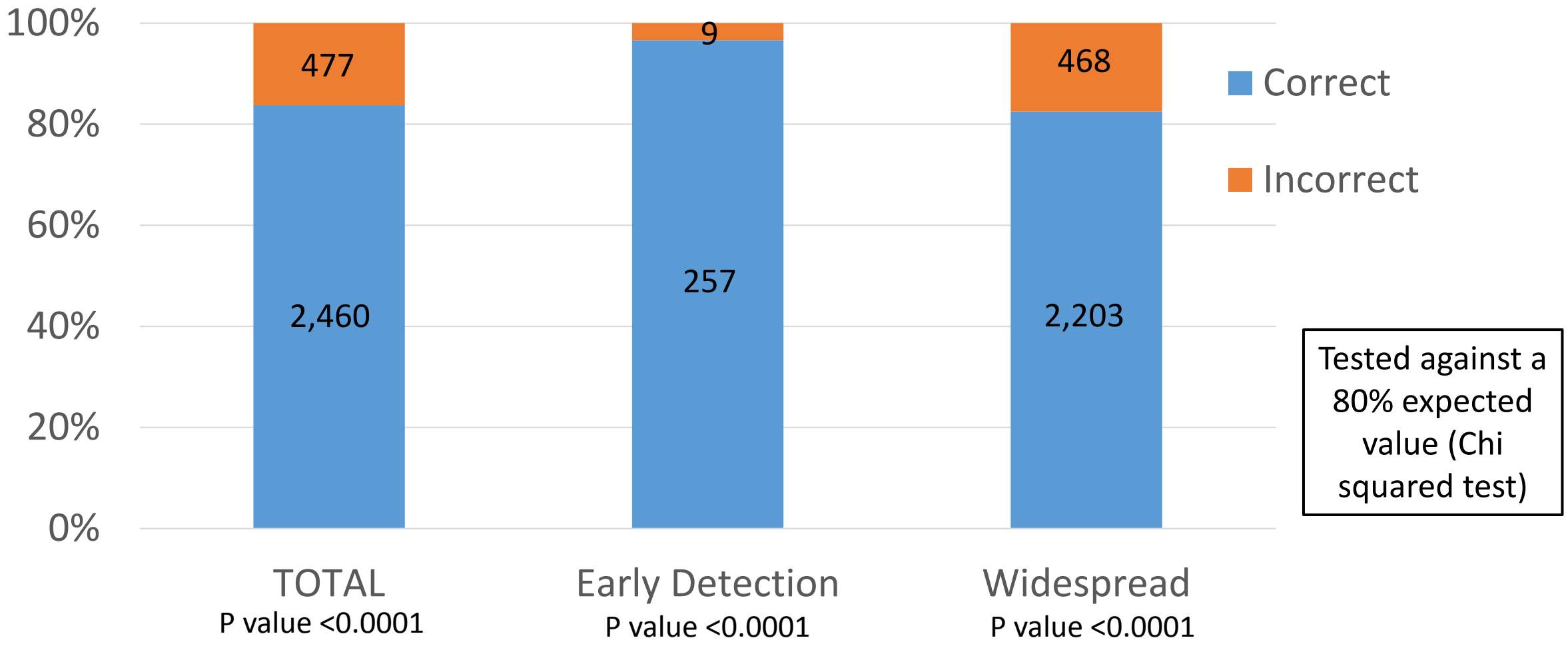




Percent of observations that were classified correct/incorrect as suitable habitat

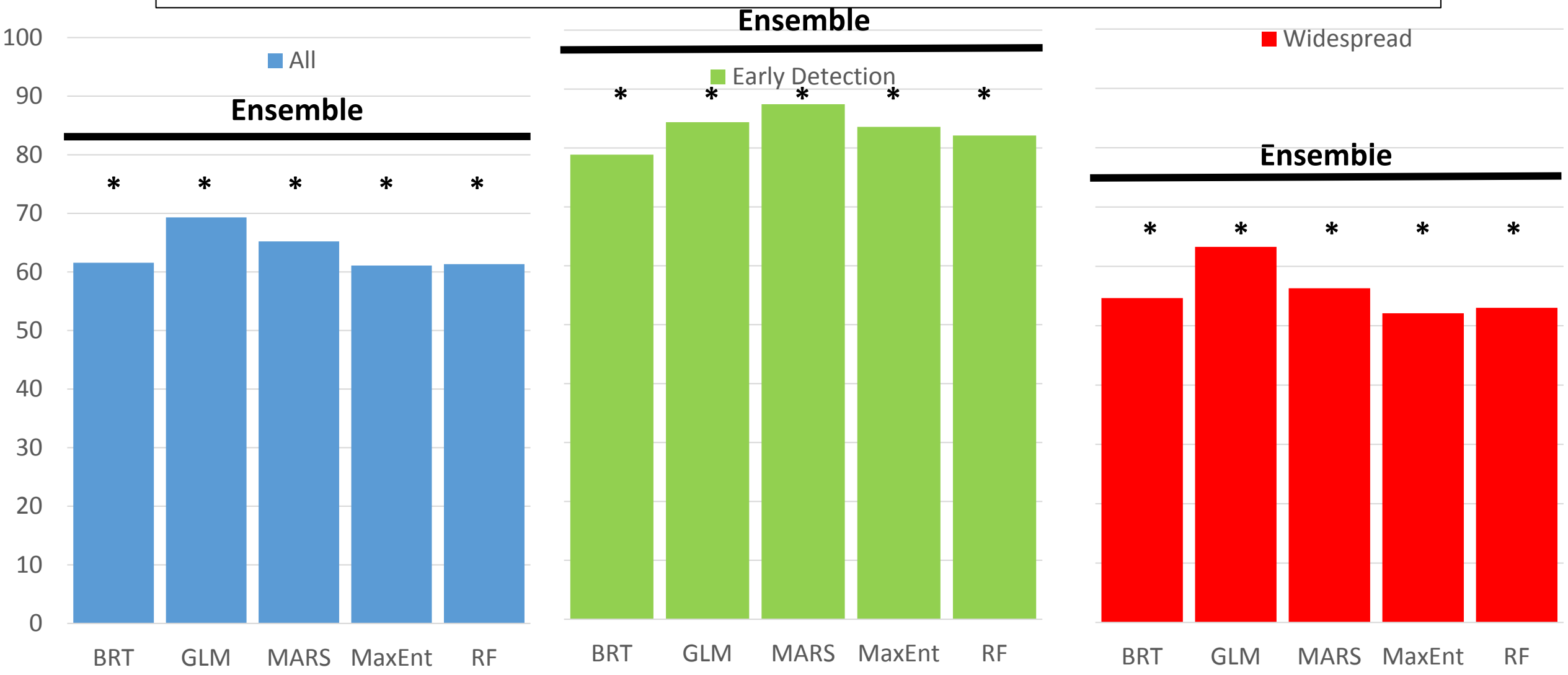
Ensemble (*at least one model correct)*



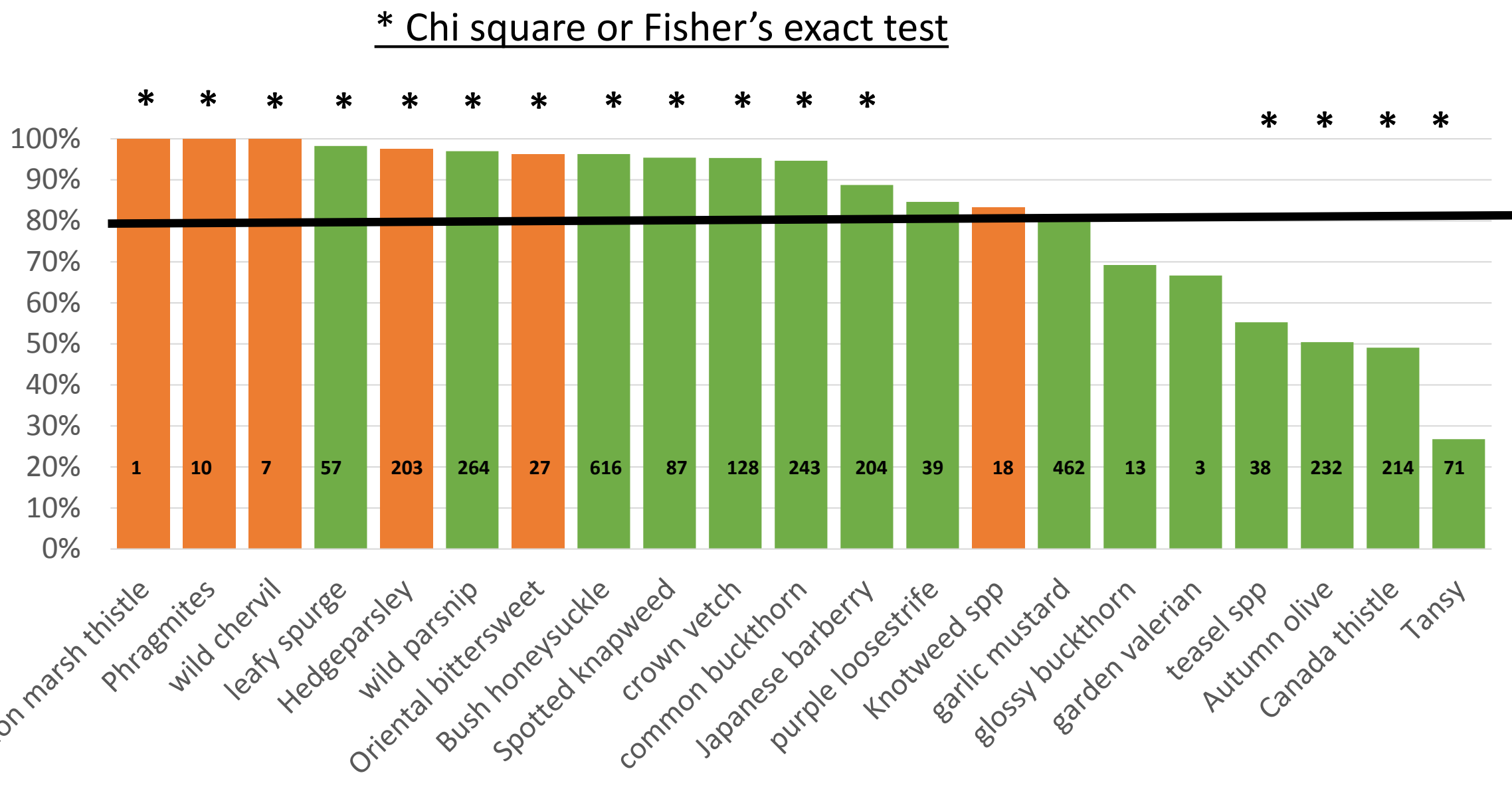
Percent correctly classified

ensemble vs each model

* In all cases the ensemble approach had a higher % of correct classifications (t-tests p<0.05)



Percent correctly classified by species (ensemble)



Summary

- Ensemble correctly classified suitable habitat better than any one model
- Ensemble correctly classified invasive plant locations > 80%
  - Early detection > up to 90%
- Individual species
  - 12 species were correct > 80%
  - 5 species were similar to 80% expected correct
  - 4 species were worse than 80%

Next steps

- Improve models of species that
  - <80% AUC (great)
  - <80% correct classification (type I error)
  - N for validation is > 50 and from at least 25% of counties

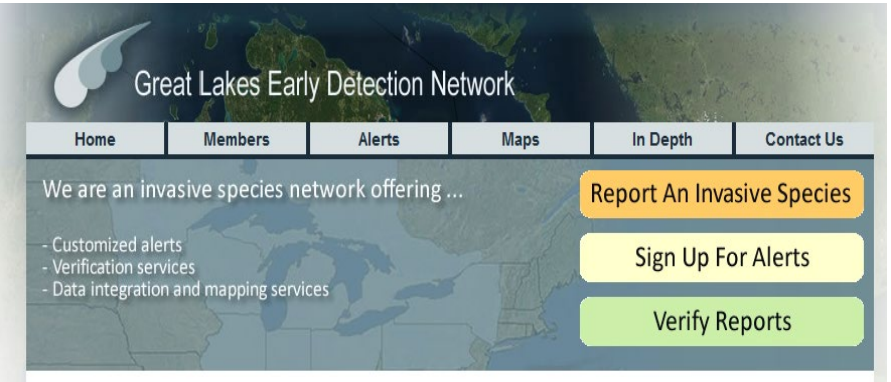
- Apply models to 5 climate change scenarios
  - Phragmites
  - Japanese barberry
  - Leafy spurge
  - Hedgeparsley

Wouldn't be possible without the development of previous resources and networks

EDDMapS

Early Detection & Distribution Mapping System

WISCONSIN FIRST DETECTOR NETWORK



EDDMapS Midwest