Preparing Wisconsin Invasive Species Policy for Future Climate Change

(or) how climate suitability models can support proactive management

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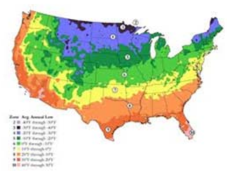
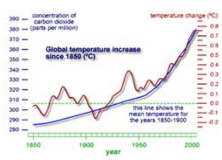
Exotic species can have major ecological and economic impacts.
To reduce or prevent impacts, we manage ecosystems
Management can be reactive – like when you propose a rapid response project
Or proactive, when you prevent invasions by monitoring boat launches
Effective management policy combines both elements, but today we're going to focus on the latter– proactive or preventative management

Outline





- Wisconsin's proactive invasive specie rule
  - NR40
  - Invader risk assessments
- Climatic tolerance of AIS
- Quantifying climate suitability
- Predicting suitability of future climate
- Prepare policy for climate change

2

The Chapter NR 40 rule creates a comprehensive, science-based system with criteria to classify invasive species into two categories: "prohibited" and "restricted."

2001 – Work toward a rule to identify, classify, control invasive species

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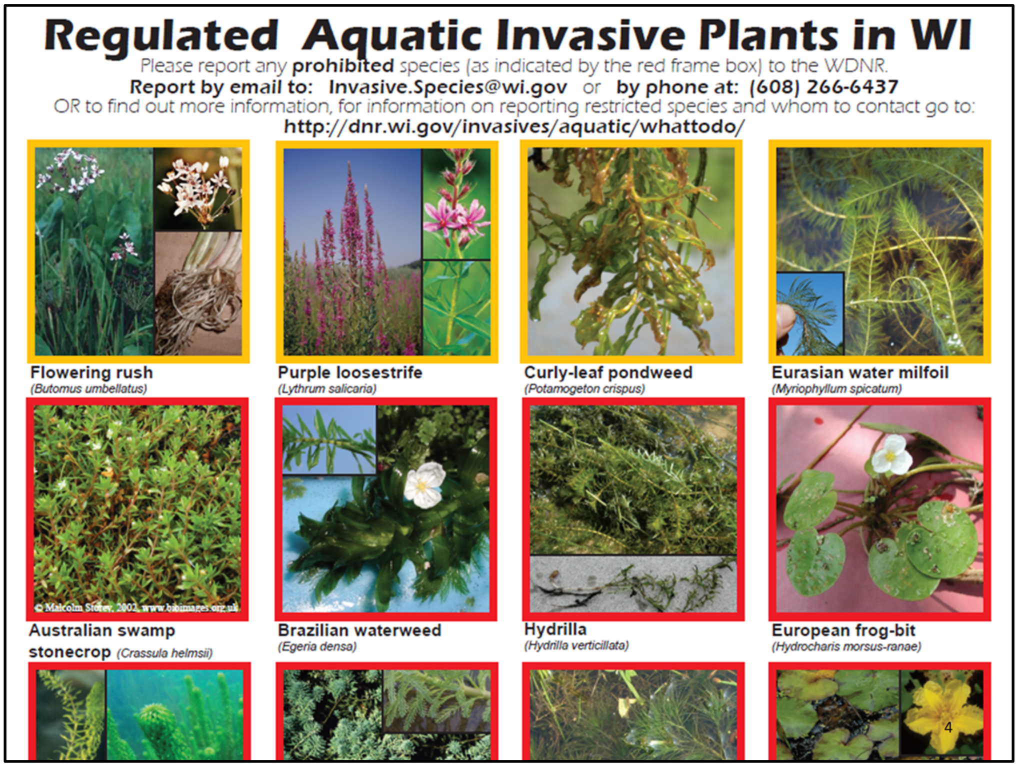
In 2001, the Wisconsin legislature took steps to make our policy more proactive by directing the Department of Natural Resources to promulgate rules to identify, classify and control invasive species
The council designated species assessment groups comprised of business, agency, extension, university, and citizen stakeholders and asked them to recommend a list of species for regulation based on a scientific review of the literature



In 2009, scientists used these recommendations to craft Wisconsin's Chapter NR40 Invasive Species Identification, Classification, and Control Rule which limits the sale, possession, transfer, and introduction of listed species.

The regulations are aimed at preventing new invasive species from getting to Wisconsin, and enabling quick action to control or eradicate those here but not yet established.

How do we decide which species to list?

An exotic species must be

likely to establish a population

and pose high risk to

Wisconsin ecosystems or economy

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High establishment risk is requisite for regulation.

A high-risk invader:

6

A high-risk invader might have some or all of the following characteristics:

A high-risk invader:

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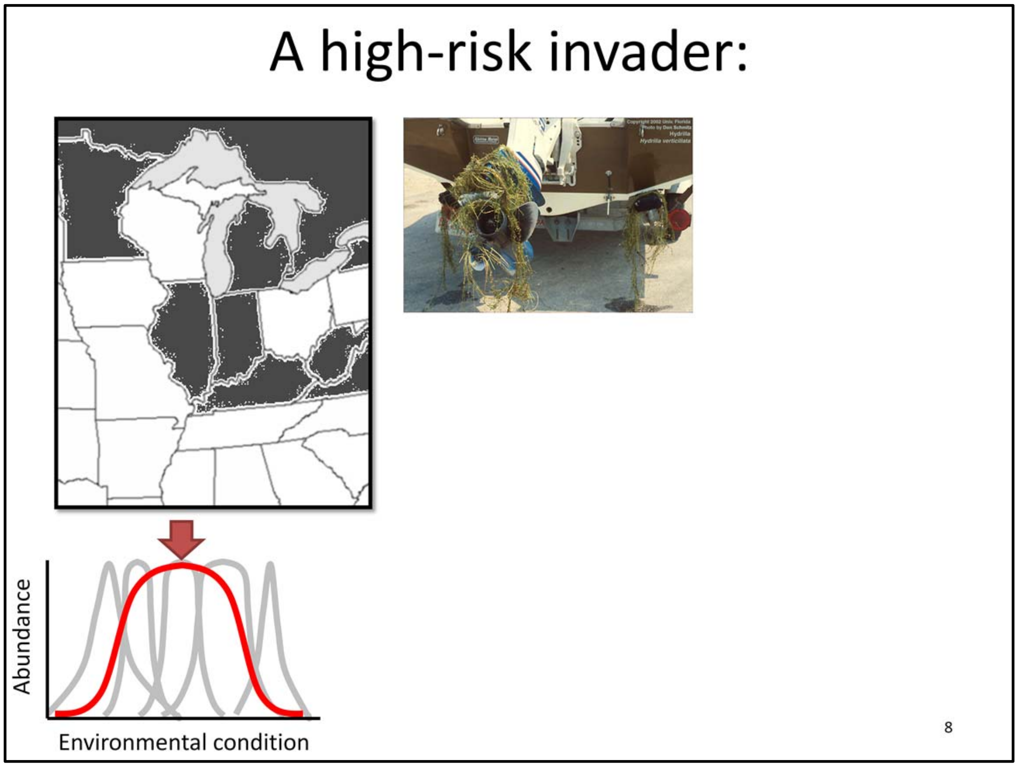
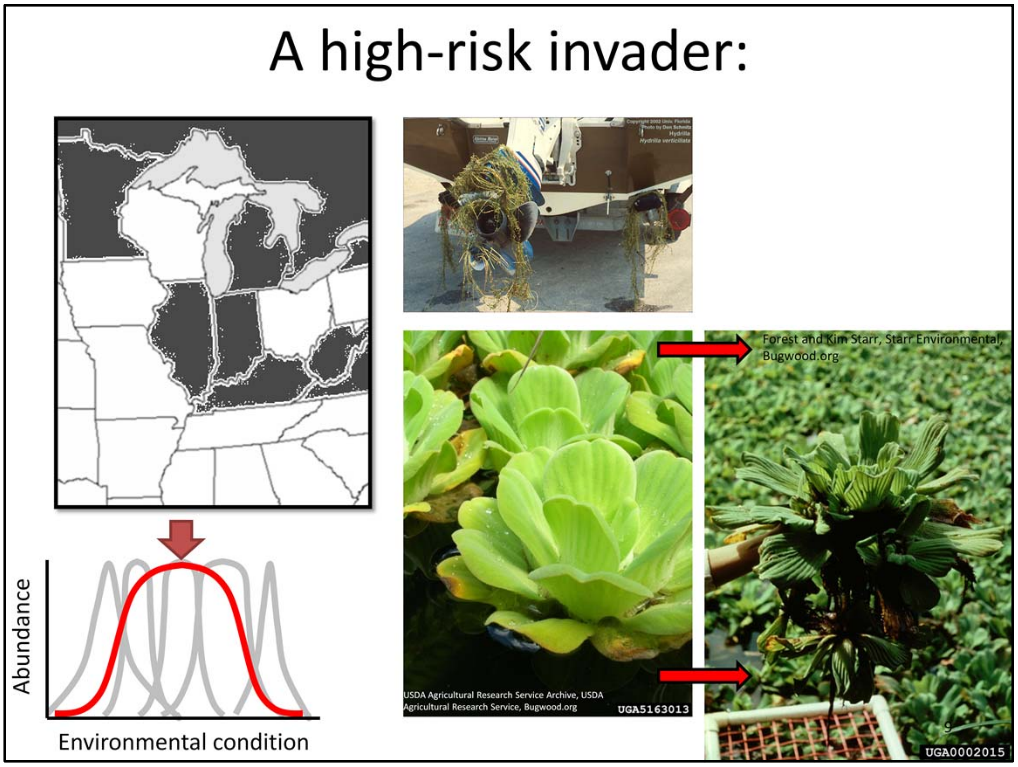
It must be able to get to Wisconsin.

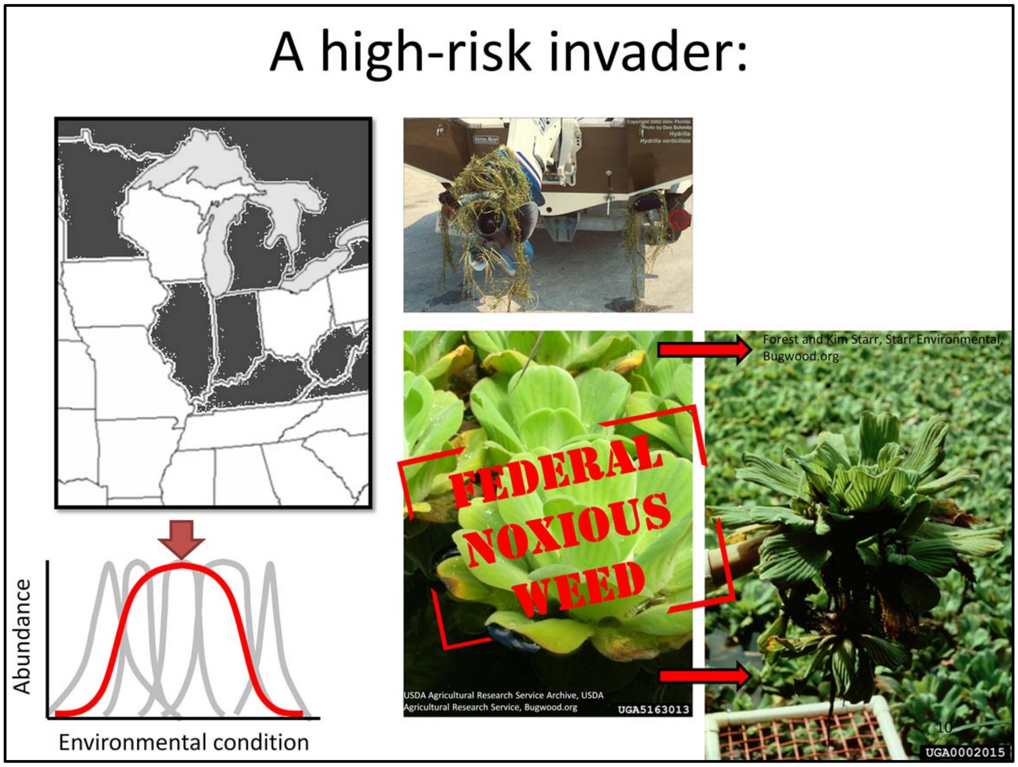
It helps if there are nearby source popualtions, if the species is heavily used in trade, or it has propagules that stay viable and are easily transported or released into Wisconsin waters



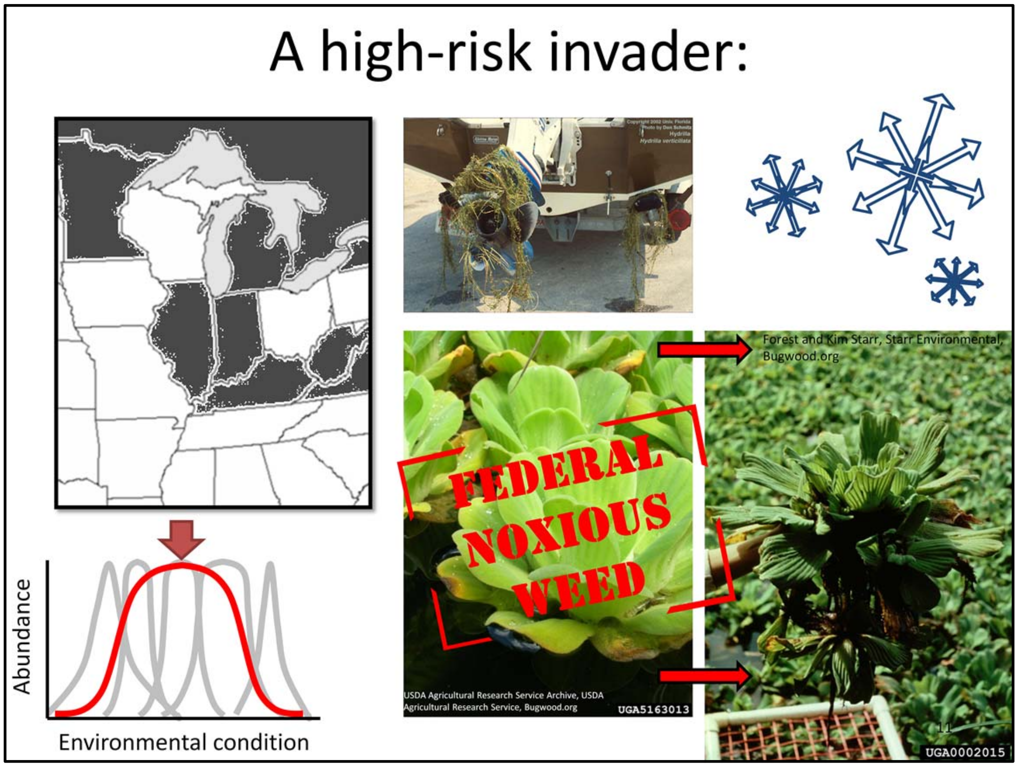
Second, It tolerates a broad range of environmental conditions, or is suited to thrive in Wisconsin lakes



Third, it has a high growth rate or reproductive potential that would allow it to establish a viable population and grow to high abundance



Fourth, that there is evidence that the spp is likely to have high ecological and economic impact based on its growth form, life-history strategy, or other information. In particular, we documented whether the species was reported as invasive from other regions.



Finally, the Wisconsin's climate must be suitable for the invader, in particular, the groups focused on whether the species was likely to overwinter.

I’m not quite sure yet whether *I* overwintered. I’ll get back to you in a few months.

In any case, this was a key piece of information that the committees considered, however, we know shockingly little about the climatic tolerance of most aquatic macrophytes. So, decisions were based on the best (or only) information available,

“I can’t get this species to overwinter in my pond”

“I’ve never seen this species survive a Wisconsin winter”

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which was often limited to anecdotal accounts and personal experiences with the species in controlled environments.

There was insufficient information to accurately guage how suitable our climate is for a majority of invaders.

In the first round of species assessments, the most frequently-documented reason for not regulating a give species was a personal observation of low winter tolerance.

Water Lettuce (unregulated)

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As was the case for water lettuce, which in 2009 survived a mild winter

To expand over the next season cover 3.5 acres

and an expensive removal effort was mounted to control the species.
Which brings up another point:

Climate change is likely to favor many invasive species

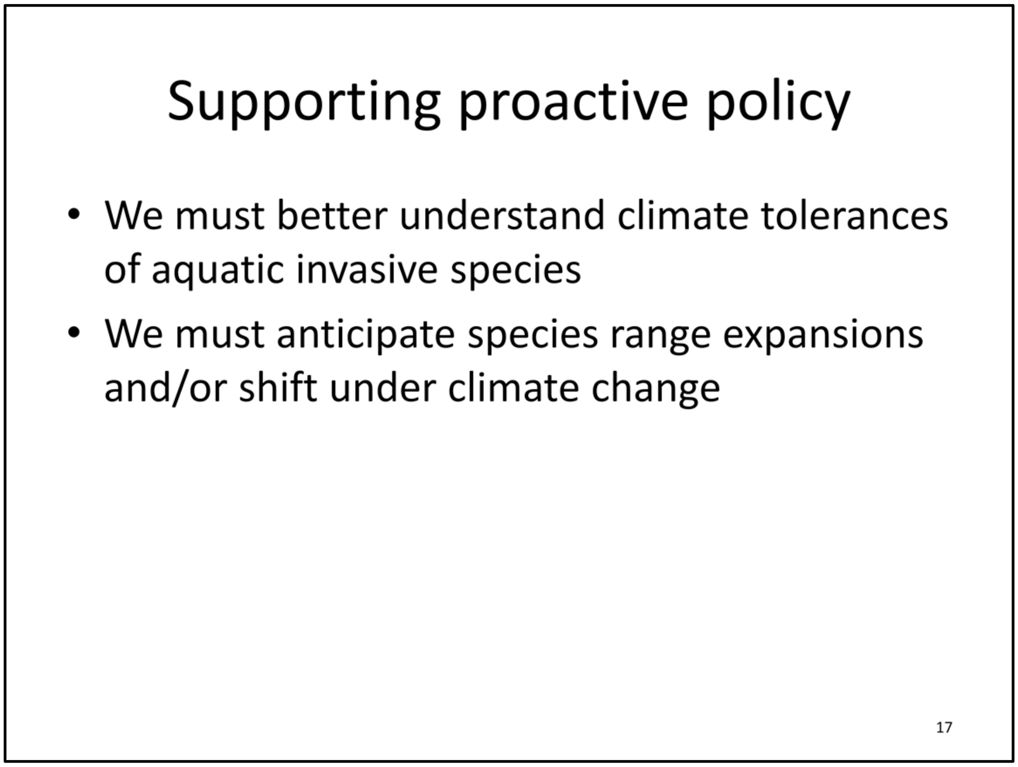
- We want PROACTIVE policies
  - that regulate species BEFORE they arrive

BUT:

- We haven’t quantified *current* climate suitability
- It is difficult to anticipate future changes in suitability

Dukes and Mooney 1999; Wrona et al. 2006

Many invaders have traits that will allow them to capitalize on our changing climate – many can shift ranges quickly or are tolerant of a broad range of environmental conditions.



I’m working with my colleagues at DNR and the UW to do both of these things, and let me walk you through how its going to work.

Supporting proactive policy

- We must better understand climate tolerances of aquatic invasive species
- We must anticipate species range expansions and/or shift under climate change

How?

Use global records of species occurrences to map suitable climate

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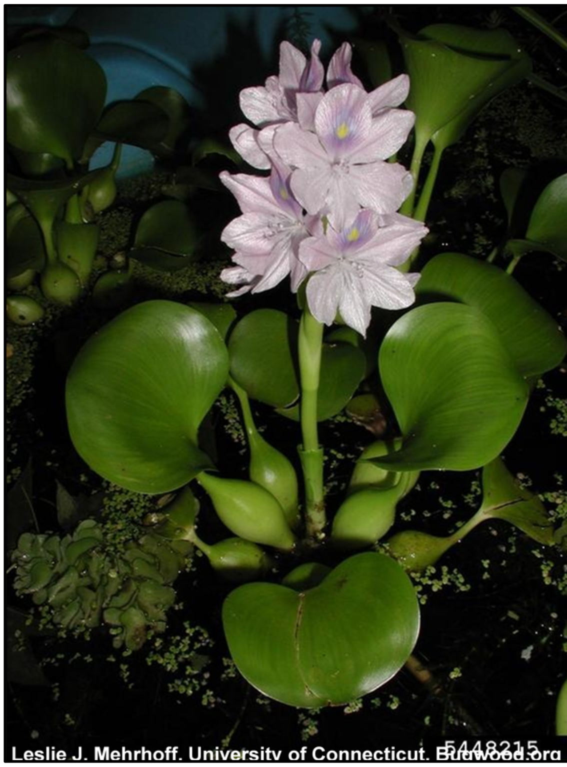
I'm working with my colleagues at DNR and the UW to do both of these things, and let me walk you through how its going to work.

As an example, I'm going to look at climate suitability for one invasive species not yet established in Wisconsin.

Though it's quite attractive, water hyacinth is regularly called 'one of the world's worst weeds'



“Lilac Devil”

Highest growth rate of ANY vascular plant

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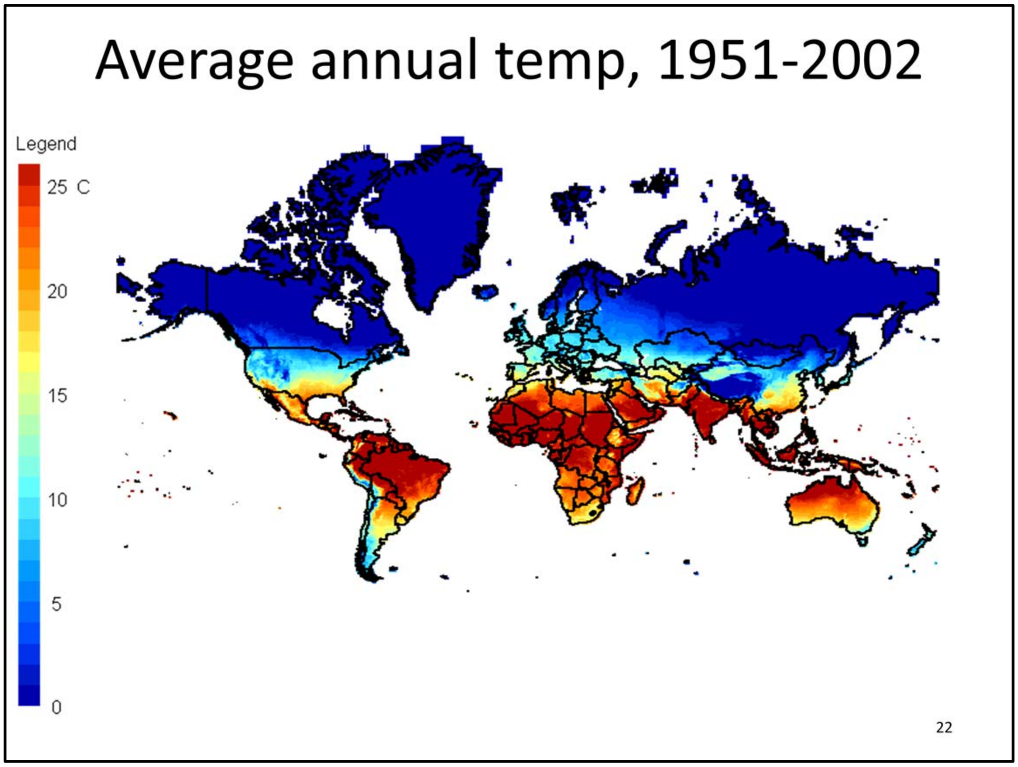
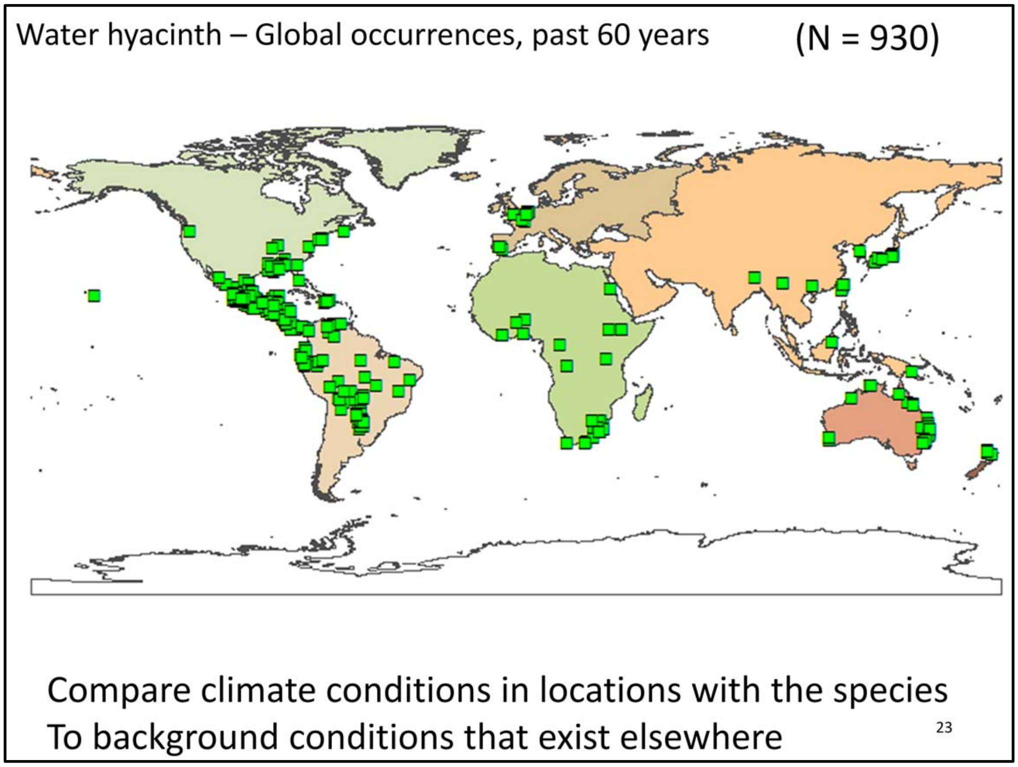
This plant is regularly planted as an ornamental in ponds,
It has the highest growth rate of any saltwater, freshwater, or terrestrial macrophyte.

doubling in biomass every 6-18 days, creating incredible mats that change hydrology and prevent light from penetrating the surface of water bodies. It causes huge problems in tropical and subtropical areas, but is commonly thought to be less of a problem in temperate areas.
But it’s time to quantify its climate preferences and make a MAP of suitable areas.



We can develop a quantitative understanding of the climate conditions where this plant is known to occur.

Here is a map of Annual Mean Temperature averaged over the last 60 years.



And, thanks to new, global-scale compendia of plant records, we can overlay on this map, known presences of a particular species.

We then compare climate conditions in locations with the species, to the background conditions that exist elsewhere.

Where is climate suitable for water hyacinth?

- Compare climate patterns in occurrence sites
- To climate patterns in background sites

- Extrapolate using gridded climate data to create a continuous suitability surface

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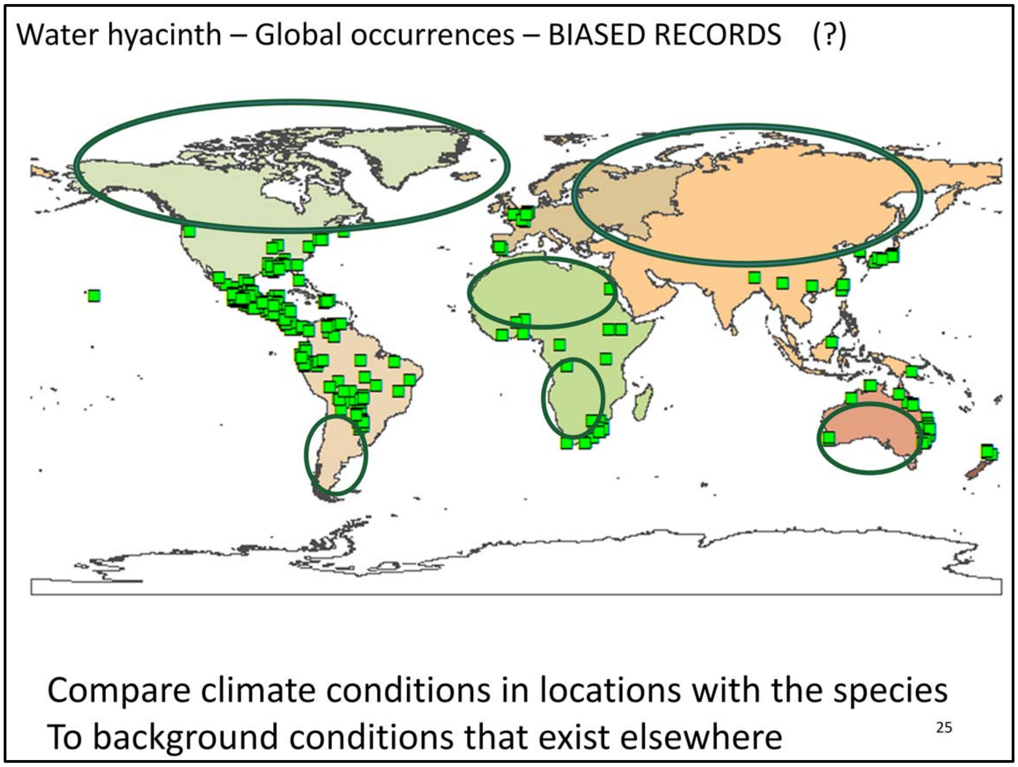

Global records are notoriously biased– areas that are easy to get to in regions with enough money to fund sampling programs are well-represented. We don't see occurrences here, but is that due to lack of sampling?

Unfortunately, including a great many areas that are suitable and might support the species in the model background can bias the predictions.
But there's a trick we can play to get around this problem.

Removing sampling bias: Cosmopolitan Species

Graves Lovell, Alabama Department of Conservation and Natural Resources, Bugwood.org

Species	Occurrences
Bolboschoenus maritimus	37061
Ceratophyllum demersum	47865
Cladium mariscus	12402
Eleocharis acicularis	15266
Eleocharis palustris	85739
Lemna gibba	23840
Lemna minor	100744
Lemna perpusilla	322
Lemna trisulca	54365
Najas marina	3763
Phragmites australis	243000
Potamogeton crispus	23144
Ruppia cirrhosa	2375
Schoenoplectus lacustris	33145
Spirodela polyrhiza	53986
Stuckenia pectinata	3756
Typha angustifolia	23181
Typha latifolia	78460
Vallisneria spiralis	152
Wolffia arrhiza	7995
Zannichellia palustris	27352
Total	**877913**

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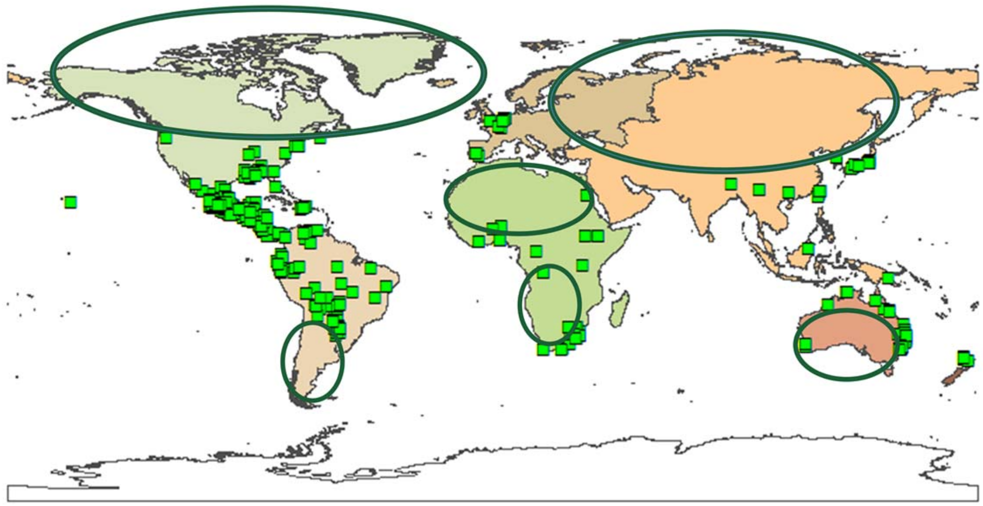
There is a list of 21 species that are known to be globally widespread. Since they occur globally, we can use the known occurrences of these species to pick out areas that were probably sampled for aquatics.

Water hyacinth – Global occurrences



Compare climate conditions in locations with the species
To background conditions that exist elsewhere

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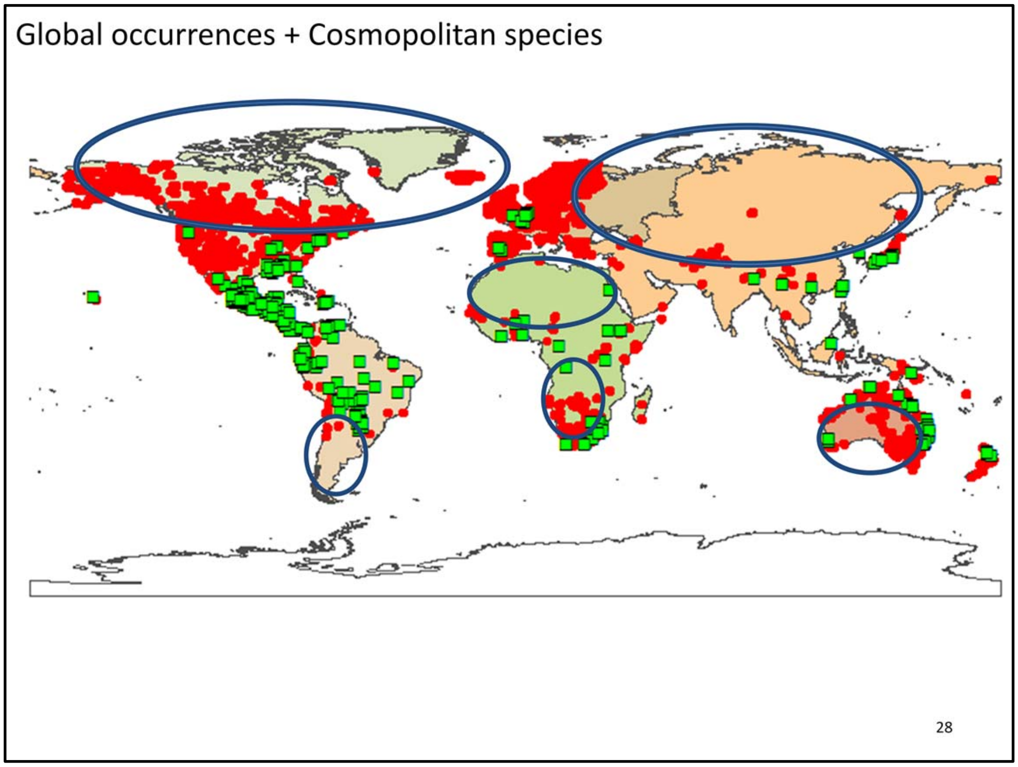
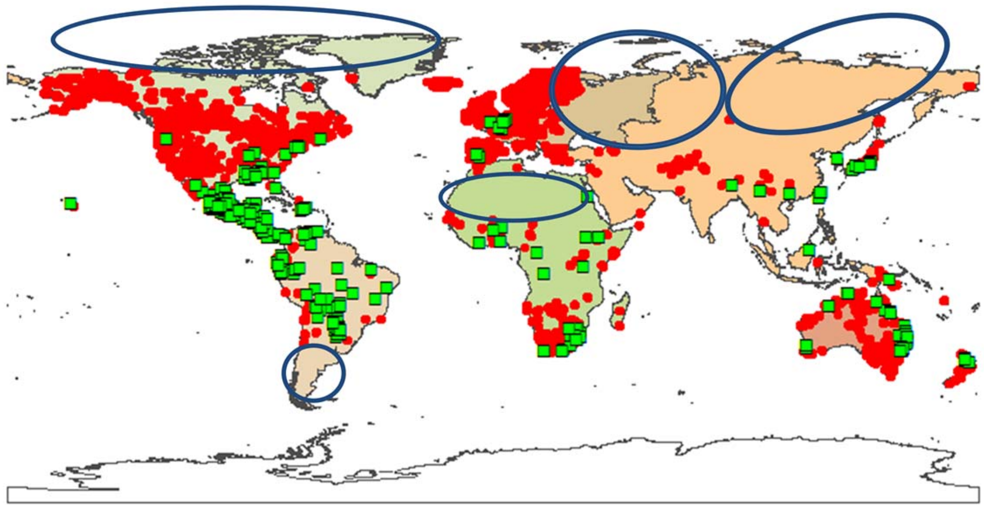


Now that we know which areas have likely been inventoried for aquatics, we can target our characterization of the 'background' conditions relative to conditions where the species occurs.

By mimicking the sampling bias in our selection of background sites, we can reduce the amount of bias in our estimations and produce better predictions.

Global occurrences + Cosmopolitan species = sample mask



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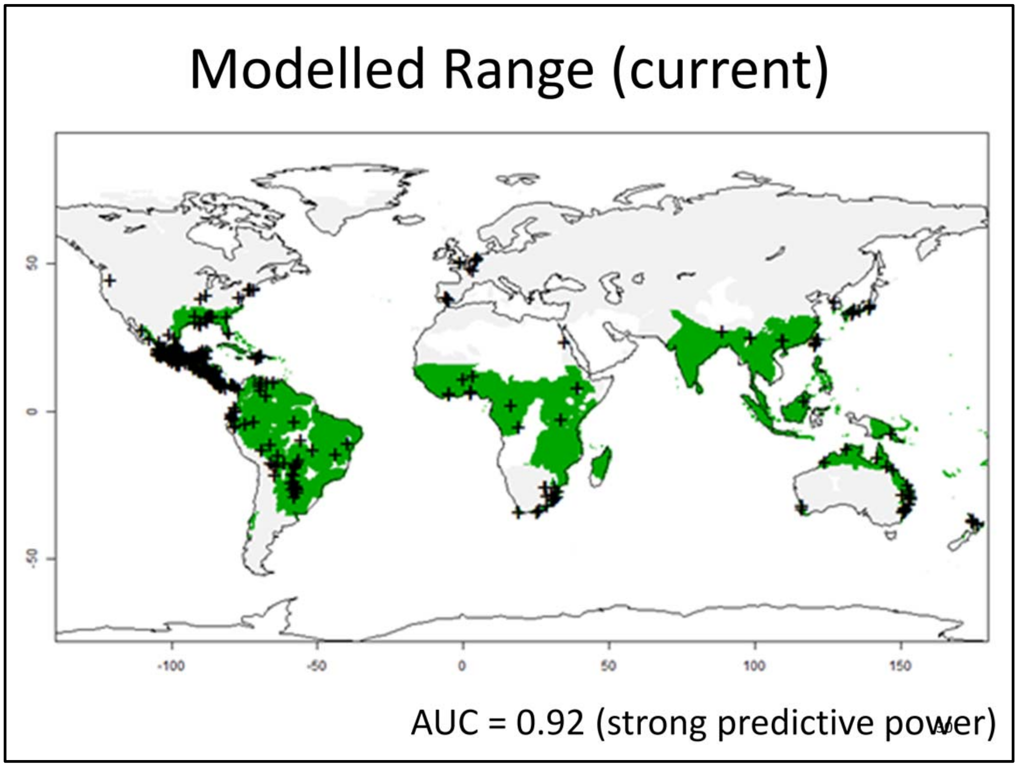
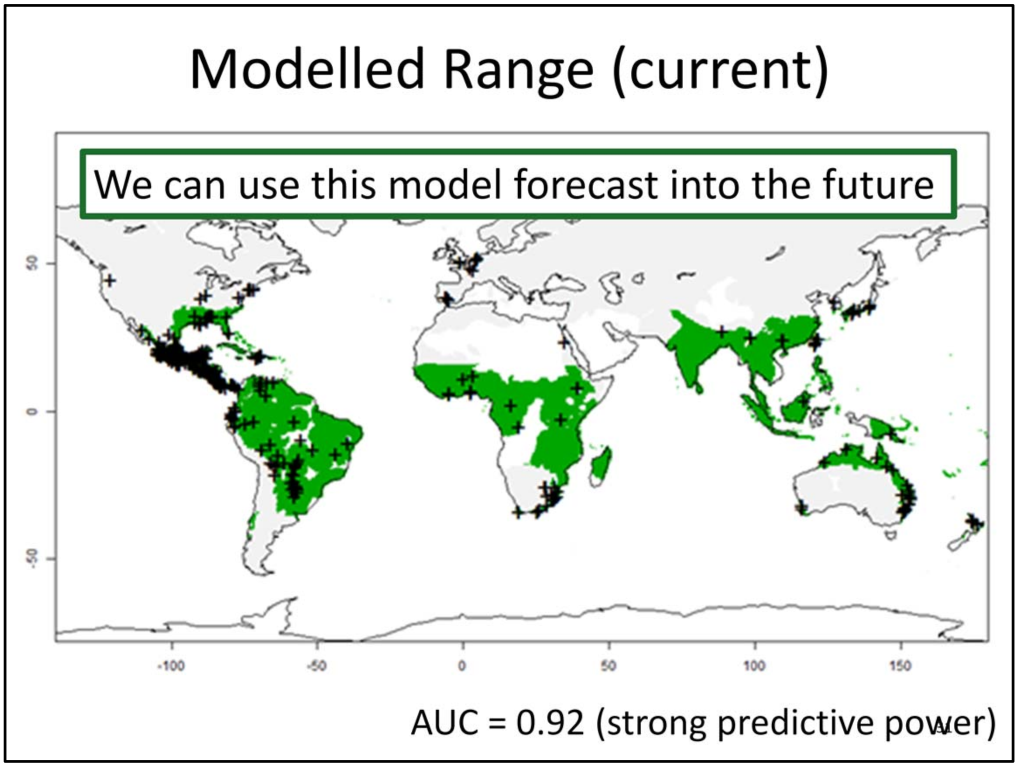


Modelled continuous distribution – validated by comparing to actual presences.

The validated model contains all the information we need about this species relationship to climate, so if we want to explore what might happen under different climate change scenarios, we need only change the climate input:



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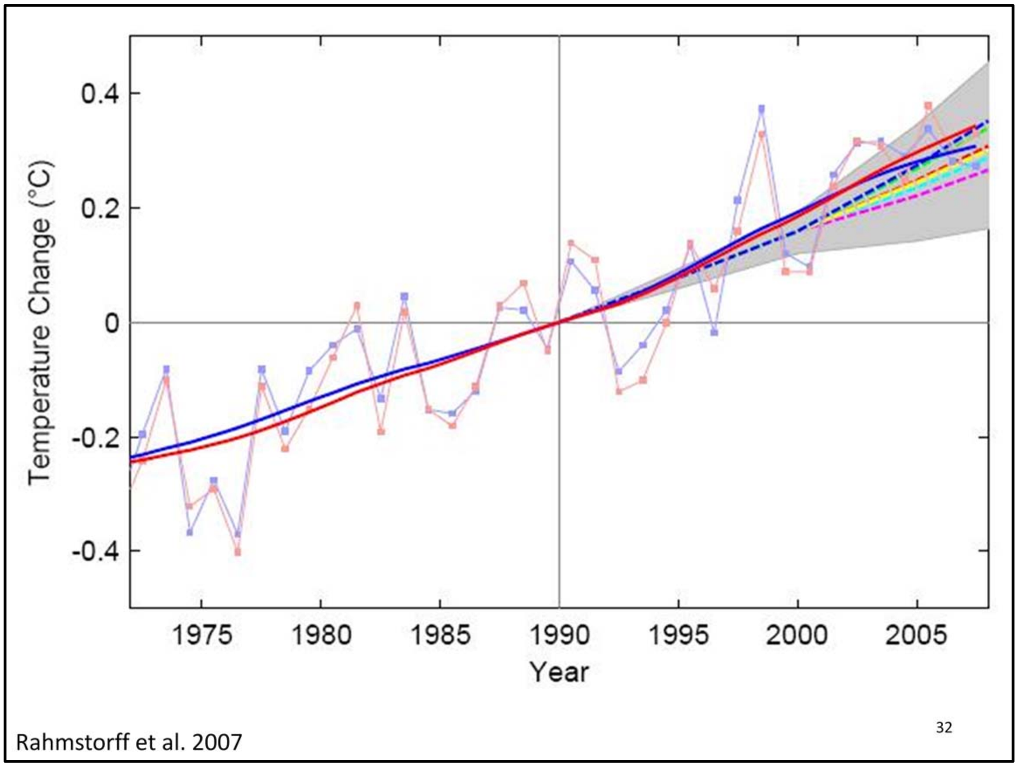
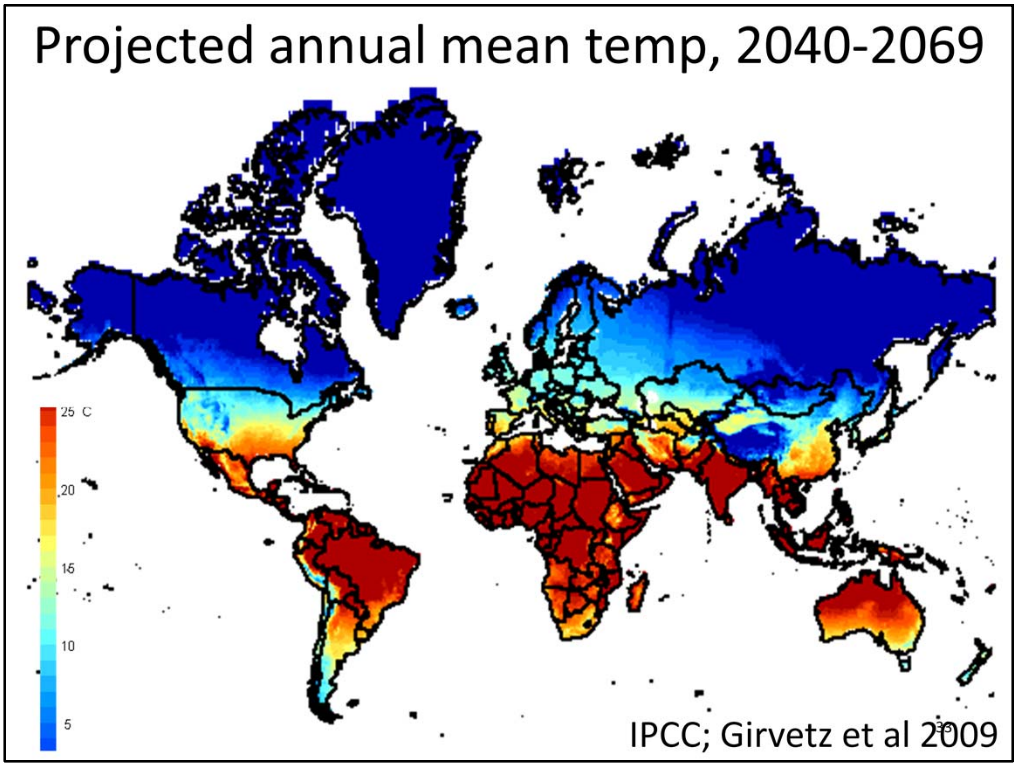


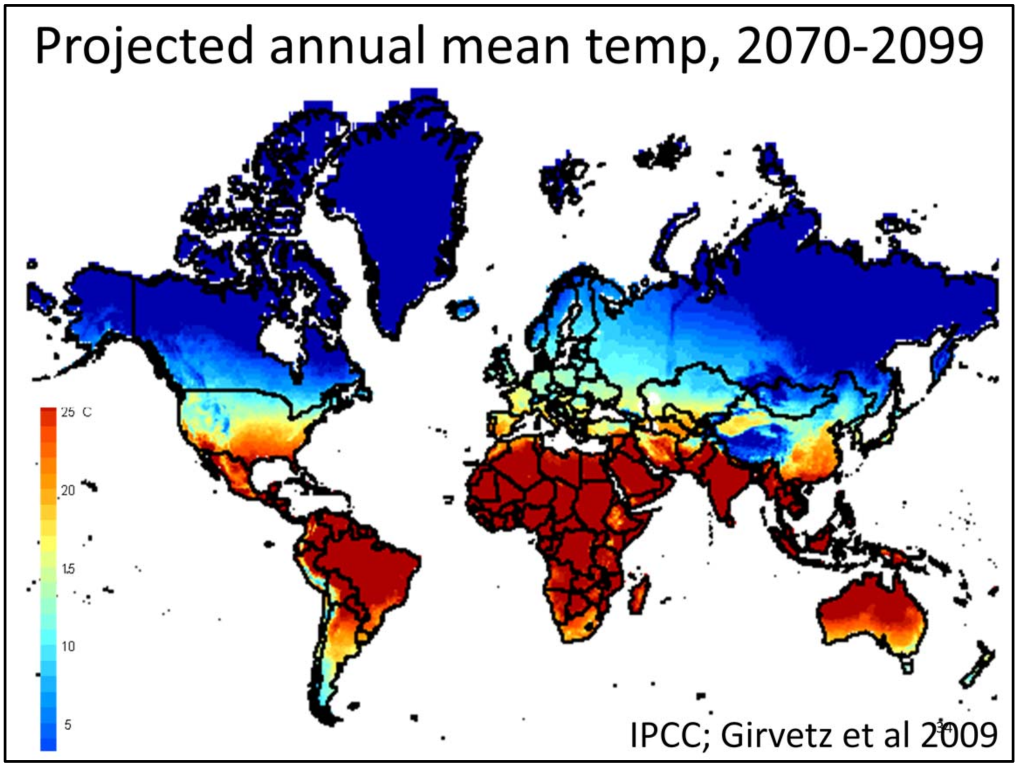
IPCC has projected the likely future increase in global temperature, presenting 4 alternate scenarios that make increasingly severe predictions.
However, over the last 20 years, Actual temperature increases have been at the HIGH end of the range of predictions.

So, we used the projections under the most extreme scenario. Future climate maps look like this:



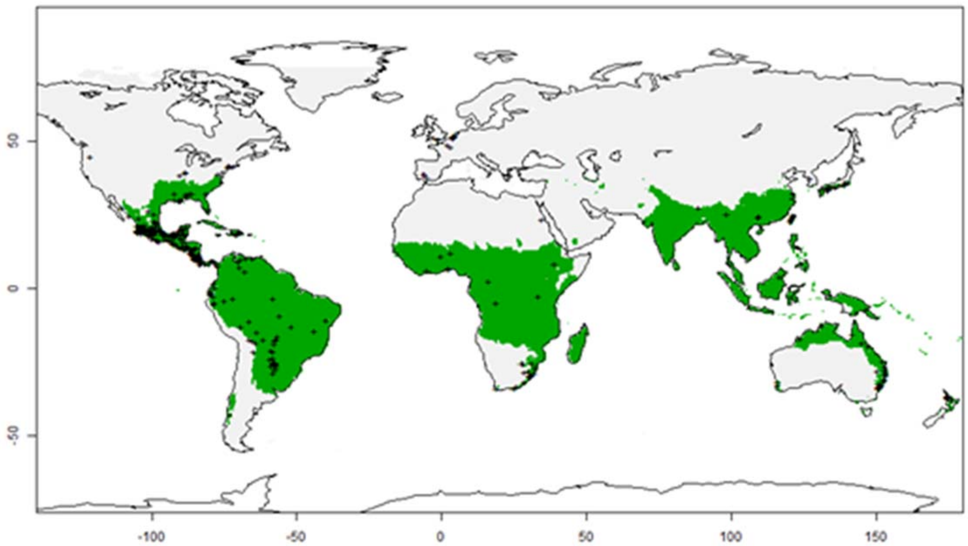
The

2040-2069
Scenario A2



2040-2069
Scenario A2

Modelled Suitable Climate (2040-2069)



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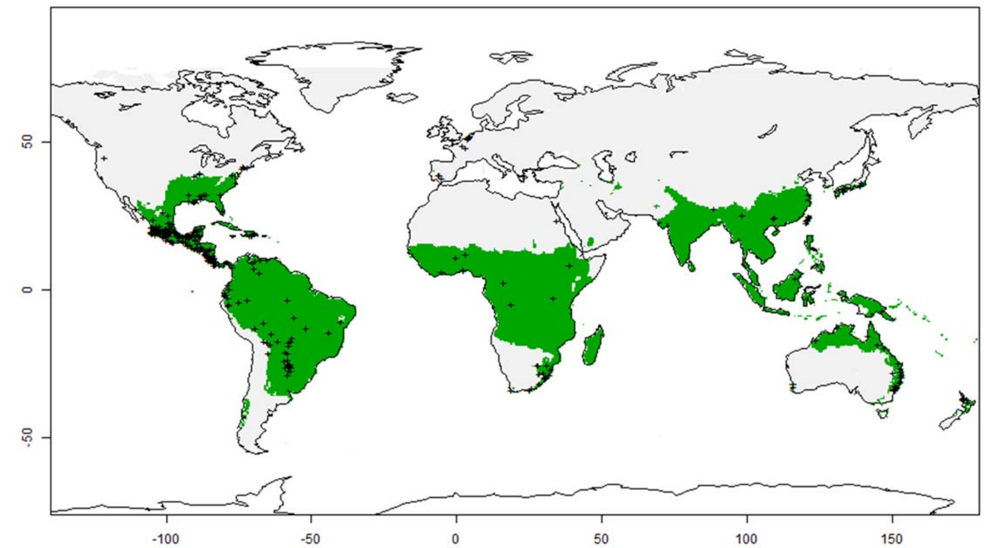
Modelled Suitable Climate (2070-2099)



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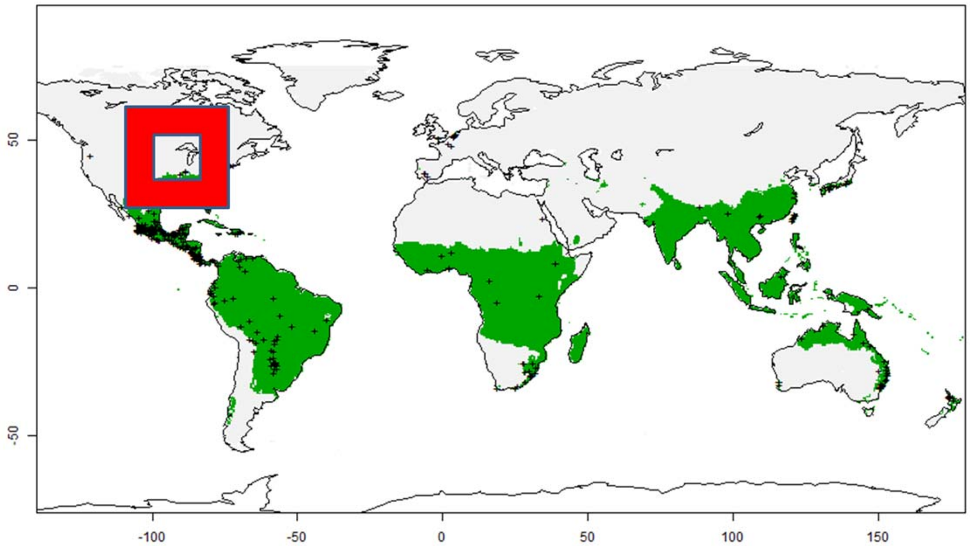
Modelled Suitable Climate (2070-2099)



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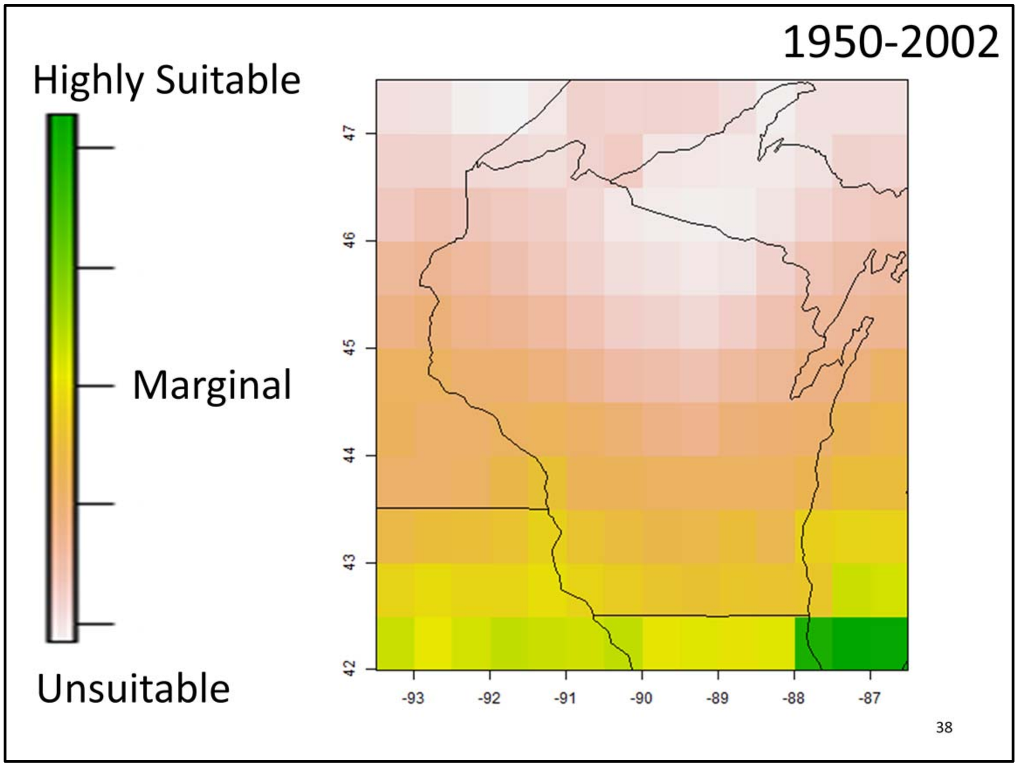
1950-2002
Highly Suitable
Marginal
Unsuitable
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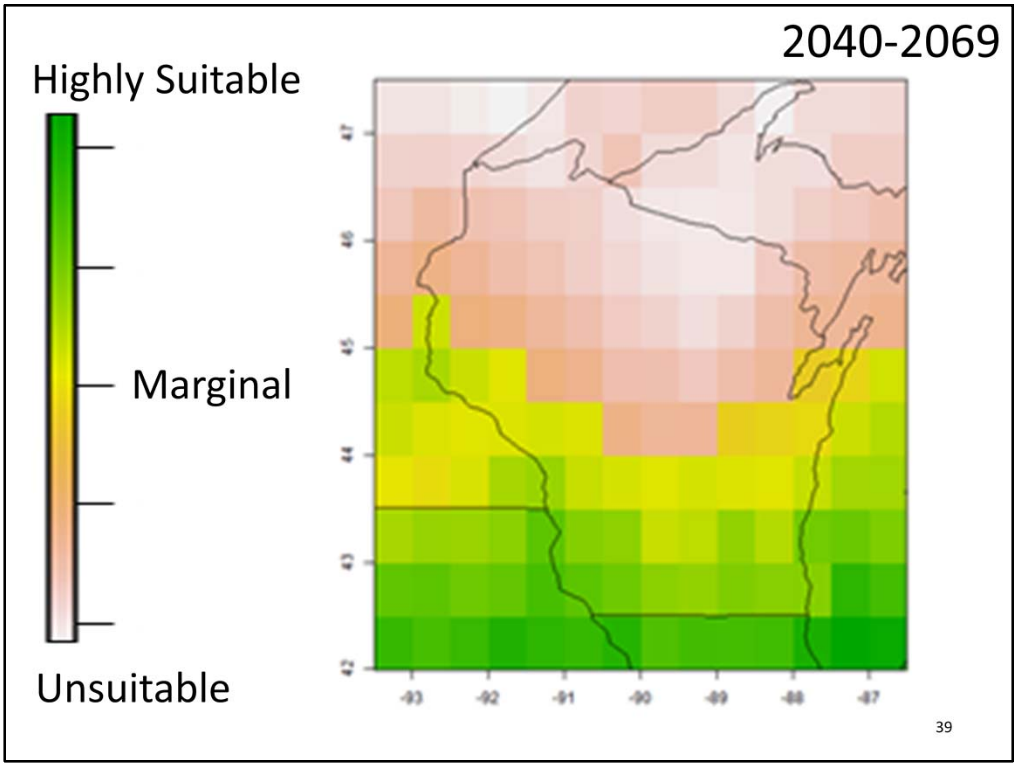
2040-2069
Highly Suitable
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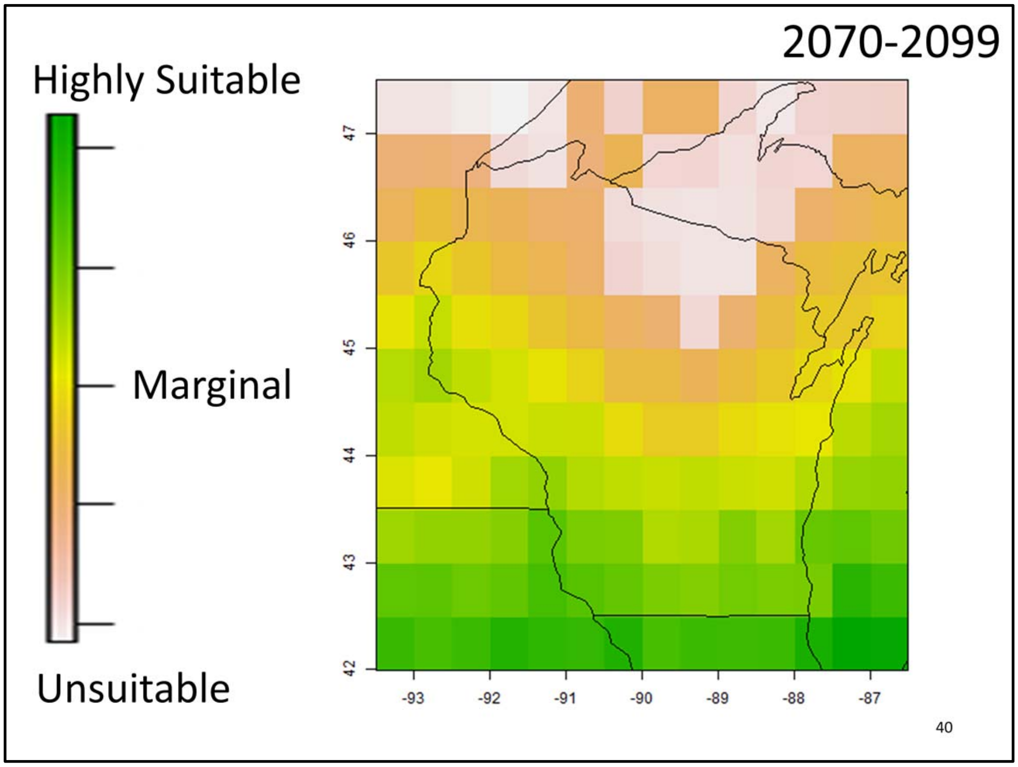
39


2070-2099
Highly Suitable
Marginal
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-87
40

Preliminary results

- We can use global species distributions to map climate suitability
- I think this approach will work
- It will help us better understand how climate change may impact the distribution of novel invaders
- 2 species tested:
  - Wisconsin climate was marginally suitable
  - Suitable climate likely to expand/shift northward
- We might want to consider regulation, soon.

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Next Steps

- Assess climate suitability for more species
- Estimate uncertainty and range in predictions
- Quantify range expansions and shifts
- Identify invaders for which Wisconsin's climate is (or will be) suitable
- Plan accordingly.

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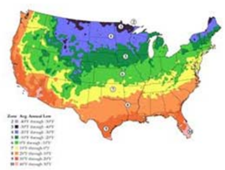
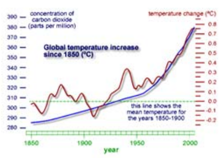
Final Thoughts





- We must prepare invasive species policy for a changing climate
- Quantifying climate suitability will improve risk assessments
- Explicitly considering climate change in invasive species policy will better prepare us for the future

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