Wisconsin's changing climate and forecasting invasive species spread.

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WISCONSIN
DEPT. OF NATURAL RESOURCES

Great Lakes
RESTORATION

Major topics

- Future climate scenarios for Wisconsin from WICCI
- Selecting species for analysis
- Using Risk Assessment Mapping Program (RAMP) for climate match scores
- Applying RAMP to Wisconsin
- Identifying species patterns for current and future threats
- How other states may follow this process

Future climate scenarios

- In coming decades Wisconsin's climate is expected to shift with changes in precipitation and temperature.

- Areas of Wisconsin are expected to resemble adjacent states. Known as "climate analogues".

- As climates shift ecosystems will be under increased strain as community compositions, dynamics, and species-specific responses are altered by novel climates.

- However it is possible to predict how species may respond to future climates using free modelling tools.

WISCONSIN
INITIATIVE ON
CLIMATE
CHANGE
IMPACTS

WISCONSIN'S CHANGING CLIMATE:
IMPACTS AND ADAPTATION

The first report of the Wisconsin Initiative on Climate Change Impacts

2011

Predicting how species respond in the future

Since there are thousands of species, how do we select the targets for analysis? See what species are found in climate analogue states.
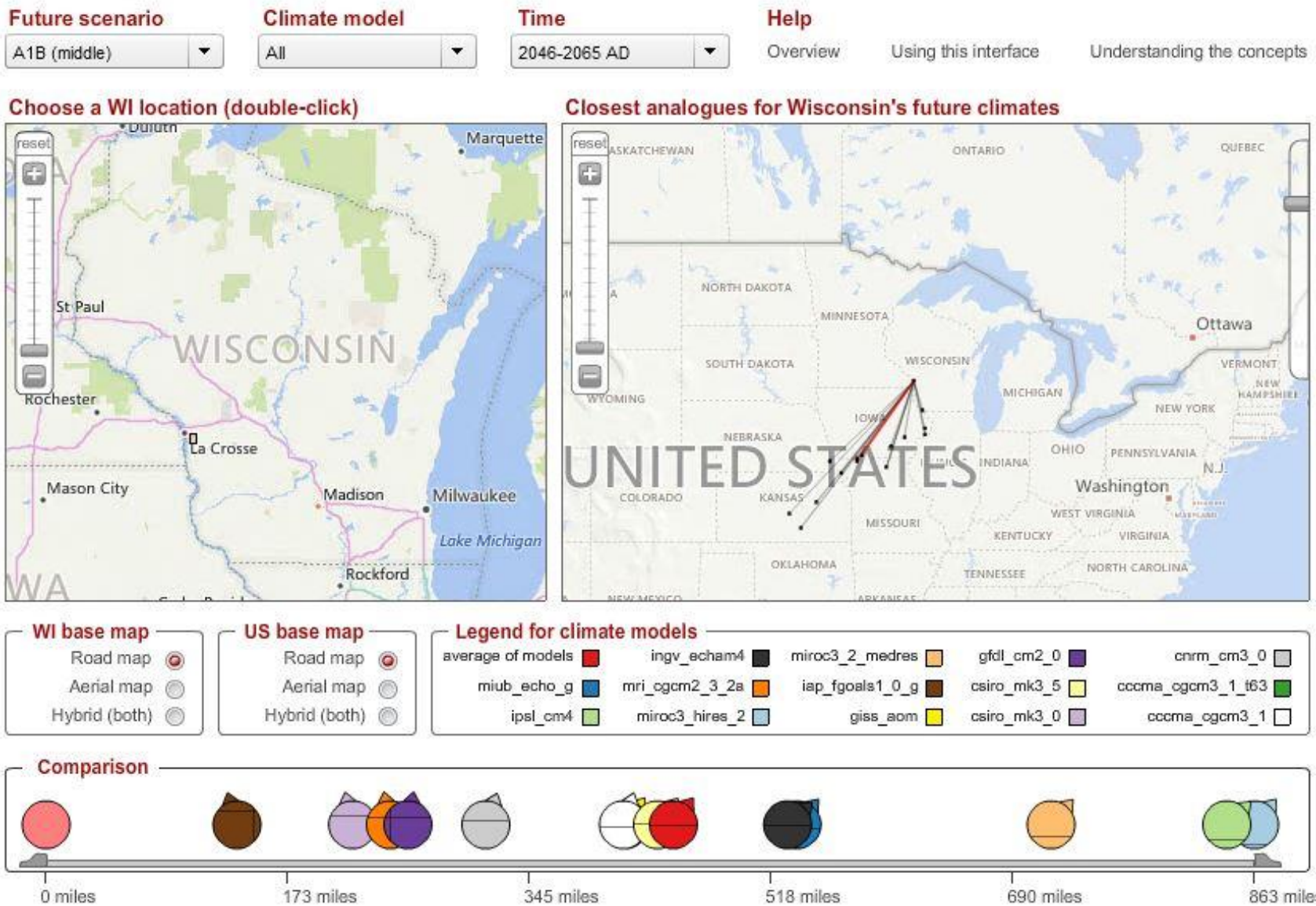
WICCI Interactive Mapping Tool

WICCI has a climate analogue match tool.

Modelled for all of Wisconsin at USGS sub-quadrant cells (53 square miles each)

Predicts how the target area may appear under future climate scenarios.

https://www.wicci.wisc.edu/climate-map.php

WICCI Interactive Mapping Tool

- Each cell was assessed using the IPCC median emission scenario (A1B)
  - Mid Century (2046 to 2065)
  - End Century (2081 to 2100)
- Average of WICCI model was used to define analogue state boundaries for each cell.
  - These other state boundaries help determine which species to analyze with climate matching tools.
  - States include: Wisconsin, Illinois, Indiana, Iowa, Kansas, Minnesota, Nebraska, Ohio, Michigan, & Virginia

Simulated CO_2 Emissions Scenarios
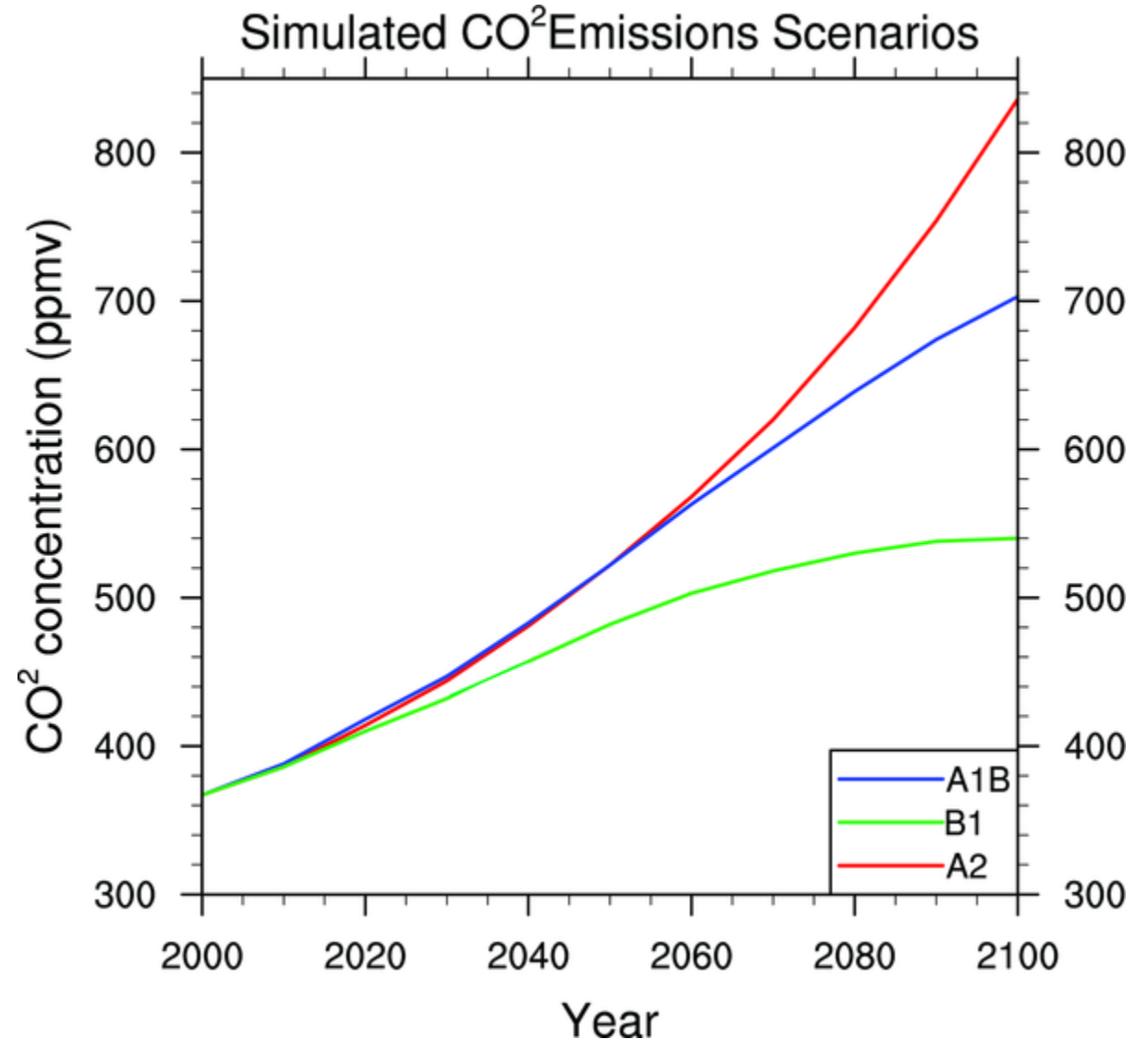
National Oceanic and Atmospheric Administration: https://www.esrl.noaa.gov/psd/ipcc/extremes/scenarios.html

Species Lists

- Lists include:
  - EDDMapS records from WICCI analogue states.
  - Wisconsin's NR40: Invasive Species Rule
  - Midwest Invasive Plant Network (MIPN) – Invasive Plant list
  - USFWS Ecological Risk Screening Summaries (High risk species)

- 436 species found for aquatic, wetland & terrestrial habitats.

- Species are then analyzed using USFWS' Risk Assessment Mapping Program (RAMP)

USFWS Risk Assessment Mapping Program (RAMP)

- USFWS uses RAMP for ecological risk screening summaries.

- RAMP uses environmental niche modelling: Climatch and CLIMATE algorithms.

- RAMP looks at similarities between selected global climate stations and matches them to climate stations within North America.
  - Looks at where target species is found now, then extrapolates where it can potentially live by correlating 16 climate variables.

- Has current and future climate matching at mid- and end-century.
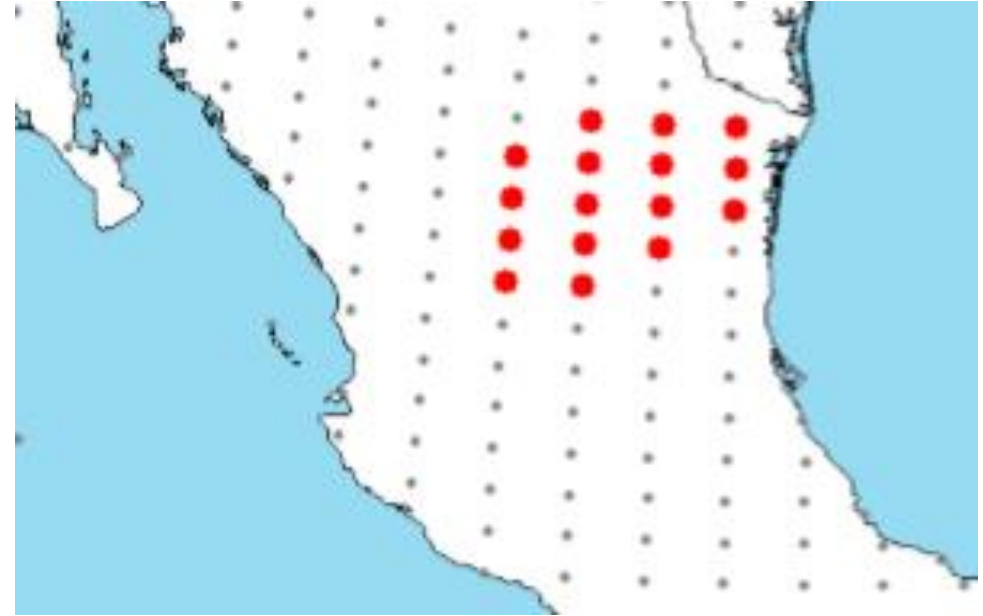
Example of climate matching stations. **Red** stations are linked to a species of interest while gray stations lack records.

USFWS Risk Assessment Mapping Program (RAMP)

- 16 Climate Variables used in RAMP
- Divided into two major categories:

Temperature Variables	Precipitation Variables
Average Mean Temperature	Annual Precipitation
Max Temperature of Warmest Month	Precipitation of Wettest Month
Min Temperature of Coldest Month	Precipitation of Driest Month
Temperature Annual Range	Precipitation of Seasonality
Mean Temperature of Wettest Quarter	Precipitation of Wettest Quarter
Mean Temperature of Driest Quarter	Precipitation of Driest Quarter
Mean Temperature of Warmest Quarter	Precipitation of Warmest Quarter
Mean Temperature of Coldest Quarter	Precipitation of Coldest Quarter

Running RAMP…

- Easy to use program in ArcGIS.
- Name the species in prompt script.
- Script gets records from Global Biodiversity Information Facility (GBIF), a international species record database. It has 987,000,000+ records across aquatic, wetland, terrestrial species.
- Obtains a subsample of records and joins them to climate stations.
- User can manually expand stations with local records
  - WDNR's SWIMS
  - UW-Herbarium records

Species: *Butomus umbellatus*
Selected Climate Stations

0   850 1,700   3,400   5,100
km

selected •
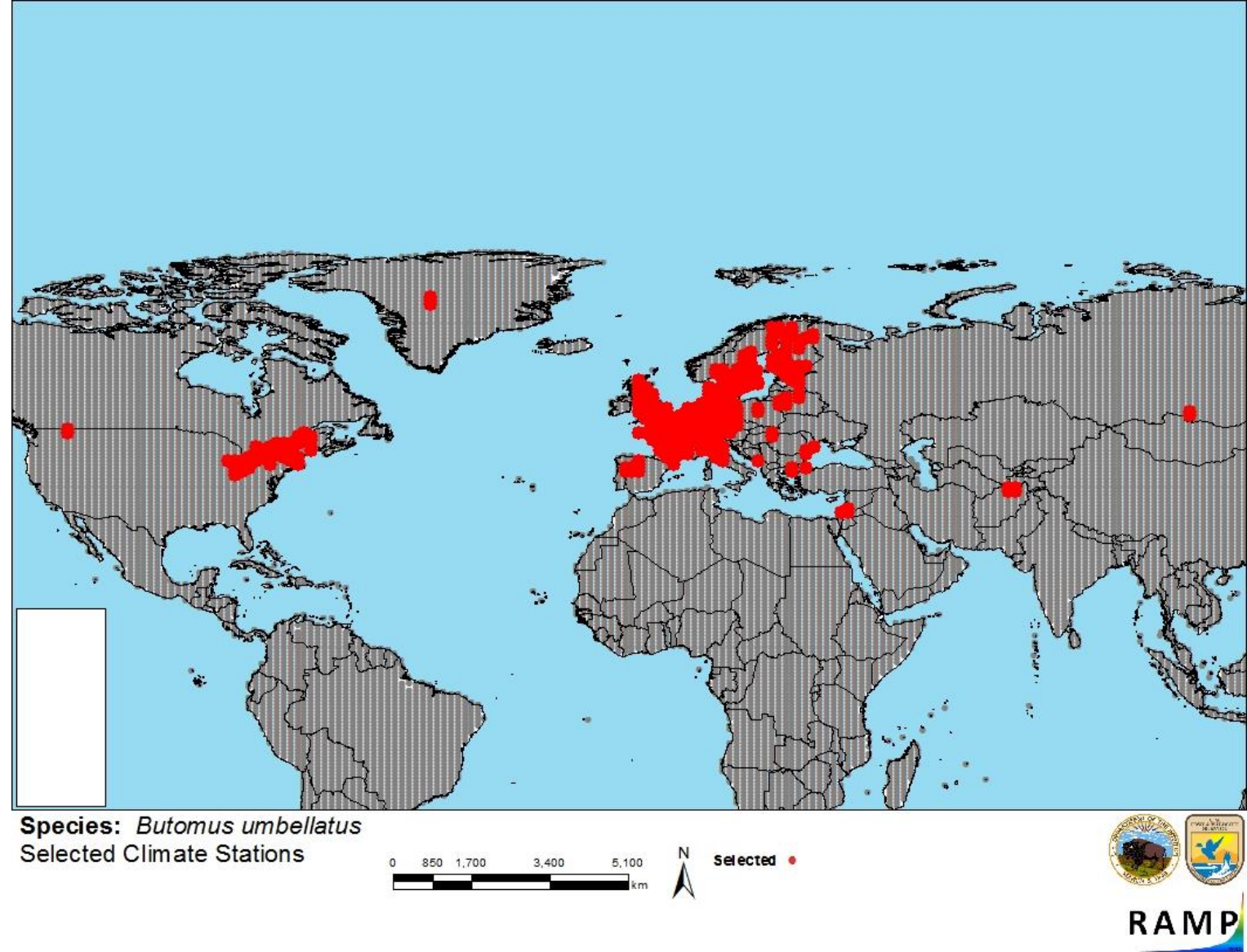
Example of GBIF records linked to climate stations

Climate match output:
National map for each species

Example: Flowering rush (*Butomus umbellatus*)
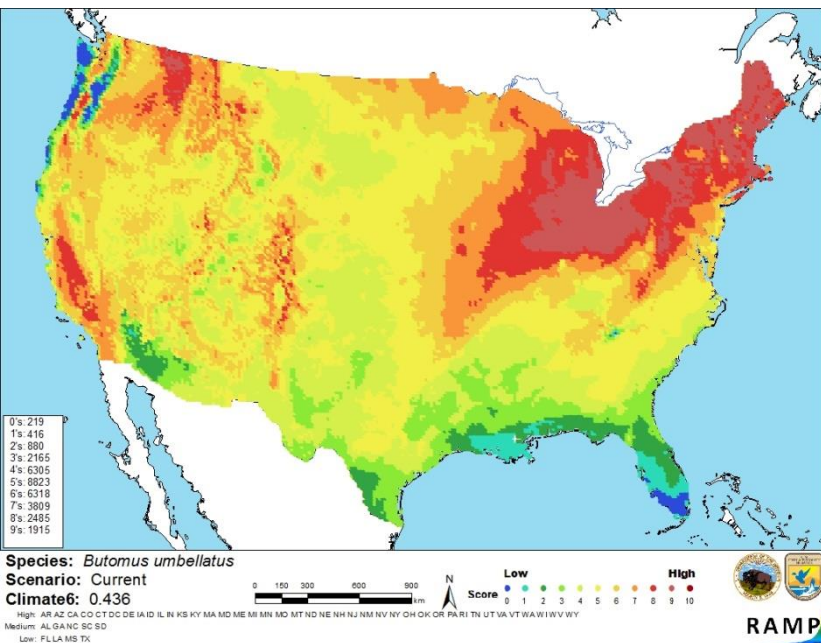
Current emissions scenario
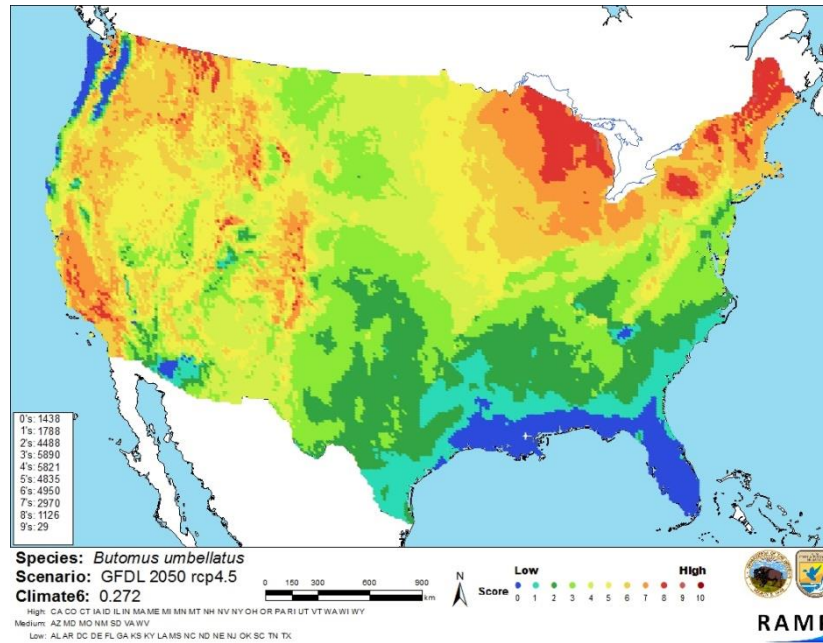
Mid-century (2050) –
Median emissions scenario
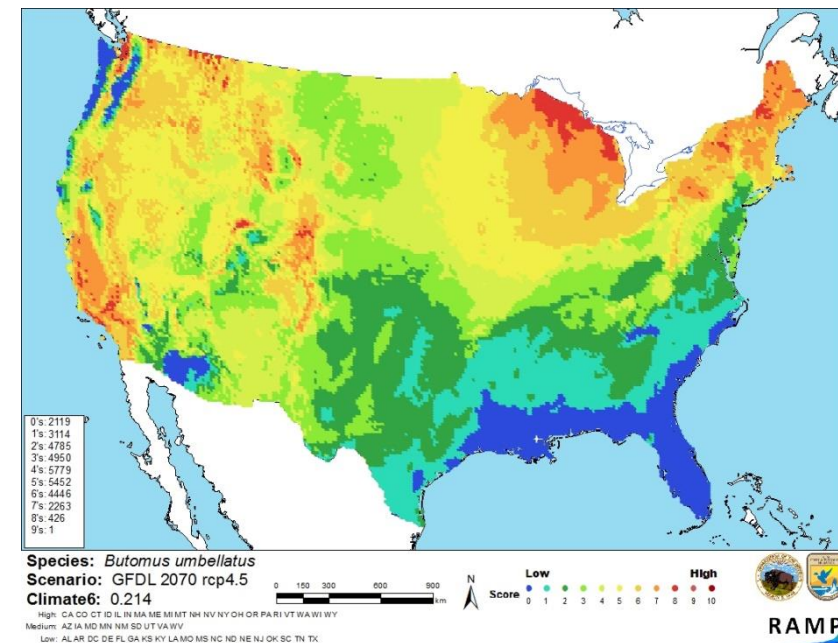
End-century (2070) –
Median emissions scenario

Values range from **0 (Blue)** to **5 (Yellow)** to **10 (Red)**. The warmer the colors, the better the climate match & suitability. Scores 6+, climate matches.
1,311 simulations for all species

RAMP output in Wisconsin

How suitable is this species to Wisconsin?
National scores clipped to Wisconsin, southern Lake Superior and Lake Michigan.

Scores interpreted using "Climate 6 Proportion Score" and Score Average.

If the species' average is greater than 6, then the climate is suitable for the species at some point during its life history.
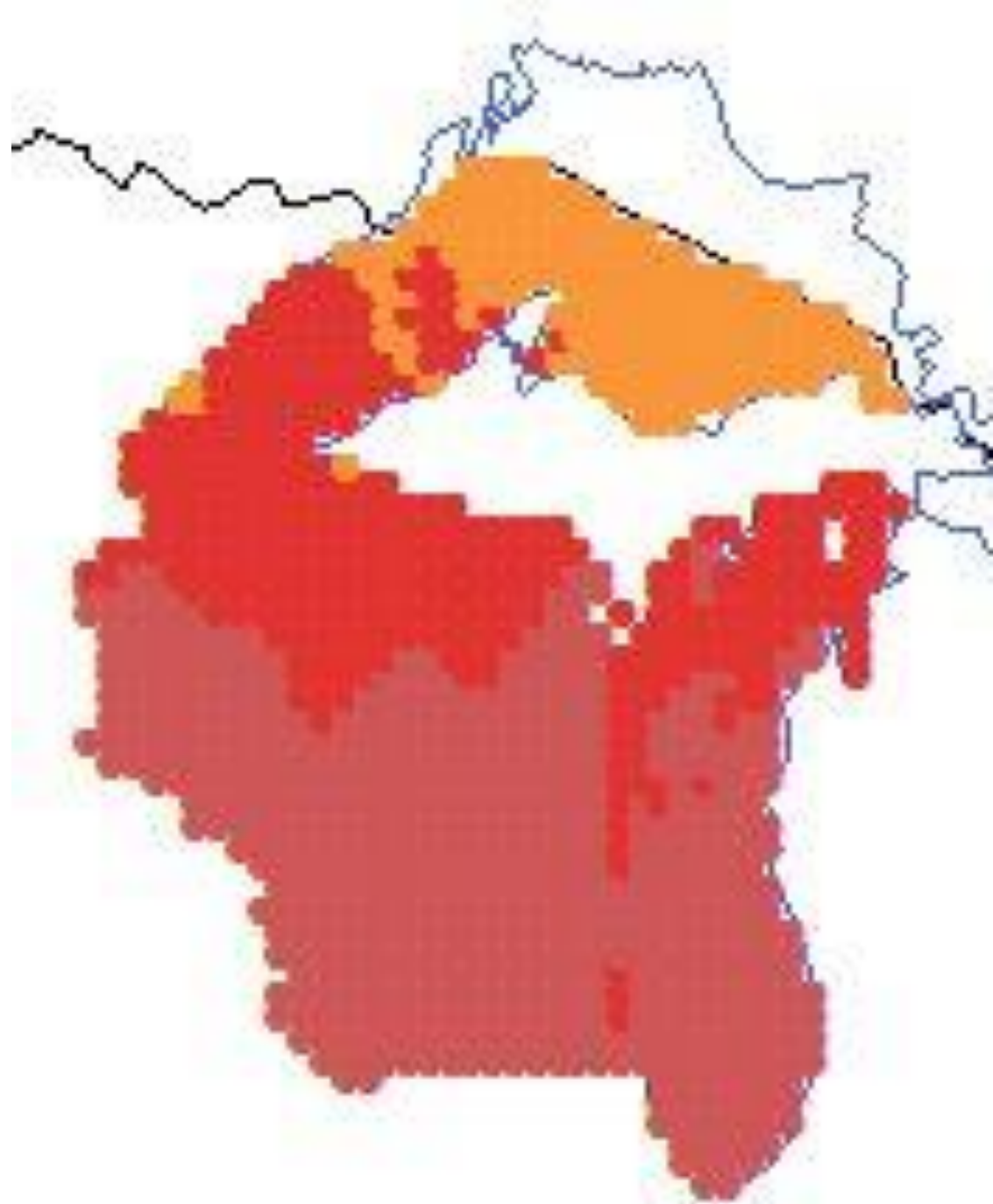
Species referenced for presence/absence.
Is it in Wisconsin?

- For plants, I checked for records in University of Wisconsin's Flora of Wisconsin website for herbarium records , verified & vouchered SWIMS records.

- For animal species, I checked records from USGS' Nonindigenous Aquatic Species (NAS), verified & vouchered SWIMS records.

FLORA of WISCONSIN
Consortium of
Wisconsin Herbaria

Open Interactive Map

NAS

Cyprinus carpio

USGS
for a changing world

Native HUCs
HUC 8 Level Record
HUC 6 Level Record
Non-specific State Record

Map created on 5/5/2018. United States Geological Survey
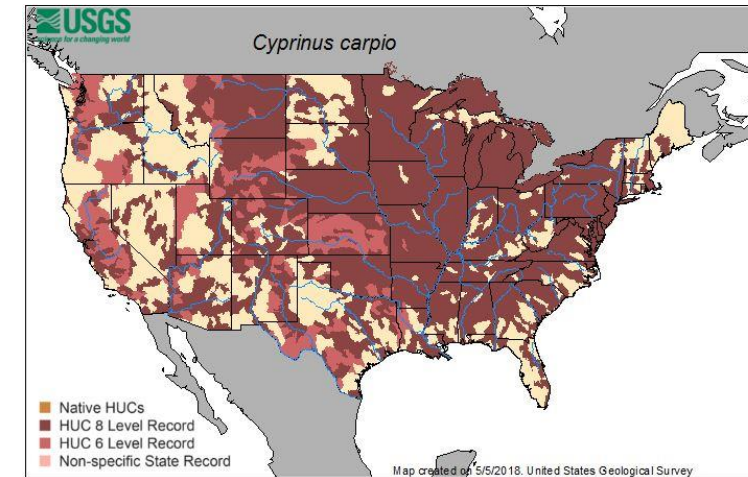
Wisconsin Department of Natural Resources

Surface Water Integrated Monitoring System (SWIMS)

Outputs: General patterns for all species

- 340/436 (78%) target species are compatible with current climate.
- 335/436 (76%) target species are compatible with future climate at 2050.
- 323/436 (74%) target species are compatible with future climate at 2070.

- 28 species increase from unsuitable in current climate to suitable in future climate.
    - Future RAMP Score is >= 6
    - 8 records in climate 4 range, 21 records in climate 5 range move to suitable
- 33 species decrease from suitable in current climate to unsuitable in future climate.
    - Future RAMP SCORE < 6
    - 32 records in climate 6 range, 1 record in climate 7 range move to unsuitable

Outputs: General patterns for all species

Species RAMP Scores in Current Climate
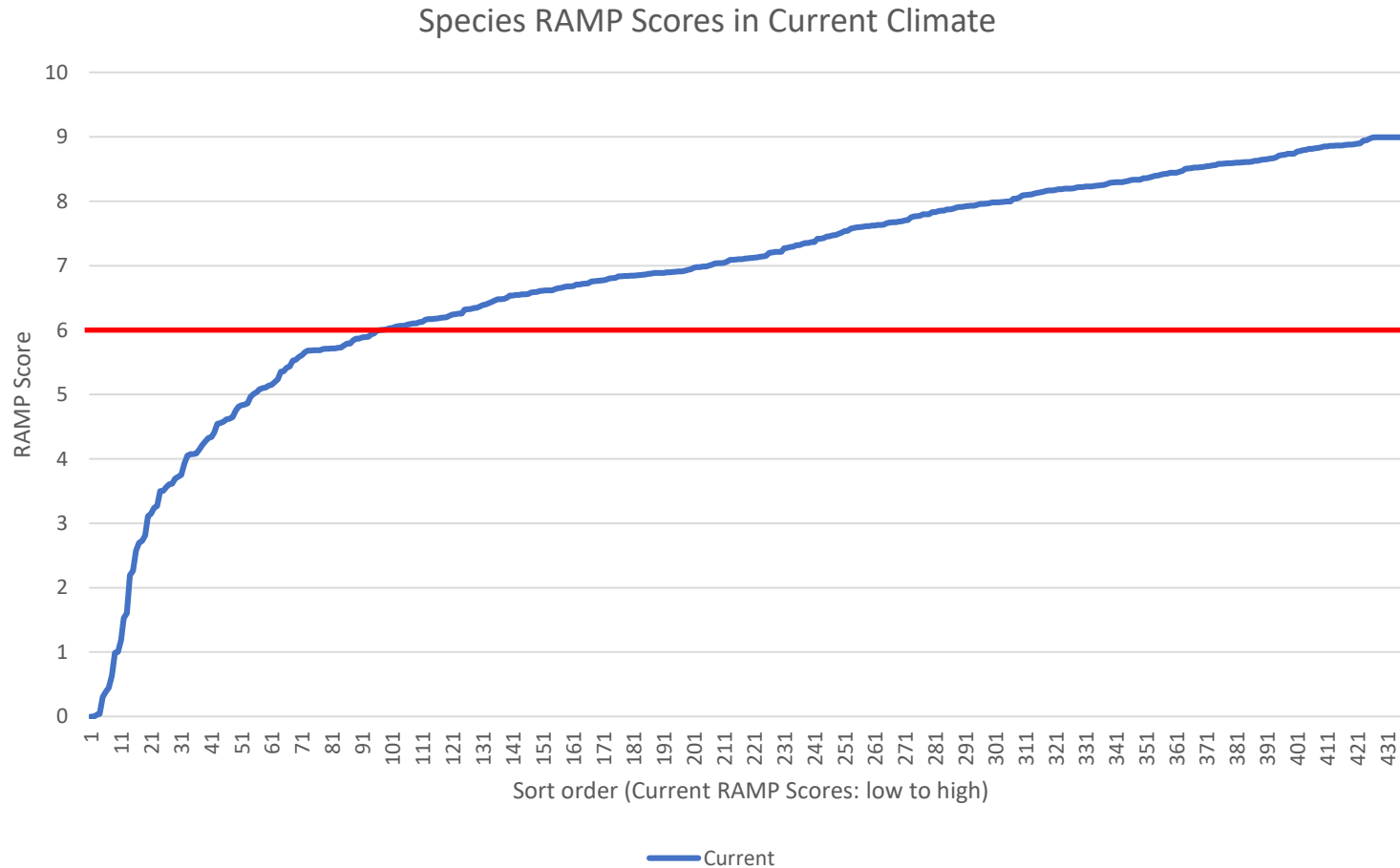
- X-axis Sort order (smallest to largest RAMP score)

- Y-axis RAMP score

- Scores greater than 6 (red line) are compatible with current climate.

- Scores show we are sampling across a range of responses.

Outputs: Overall changes in climate matching between time periods for all species

Species RAMP Scores in Current Climate Compared to Future Climate (2050)

RAMP Score

Sort order (Current Ramp Score: low to high)

Current — GF54

* Species records maintain position on X-axis
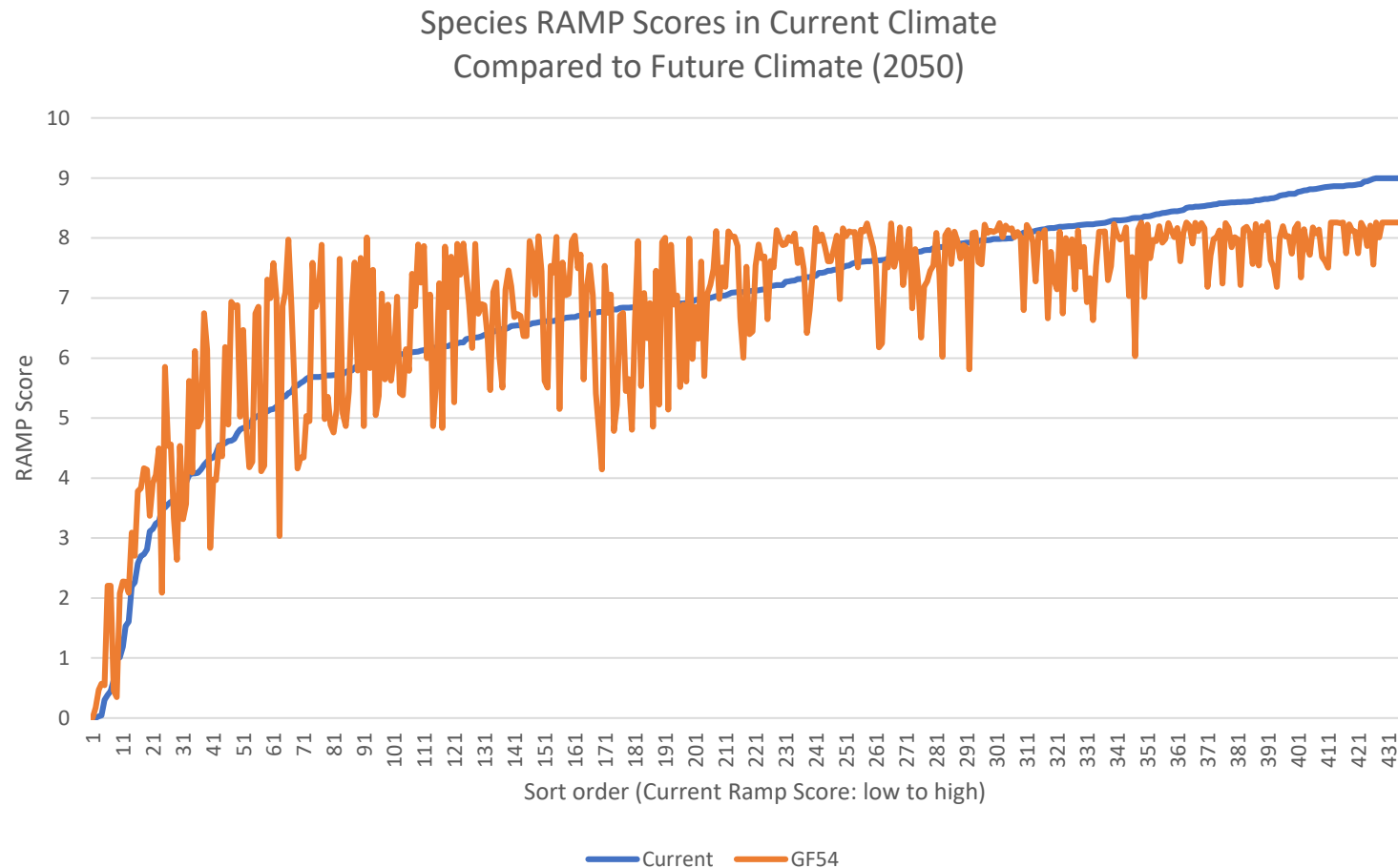
- High RAMP scoring species (7+) under the current climate are more likely to remain compatible with future climate scenarios.

- Lower RAMP scoring species tend to vary in compatibility under future scenarios. So its harder to predict overall patterns with low ranking species.

Top Ranking Species: Wetland Plants in Wisconsin

Agrostis gigantea	redtop	*Ambrosia artemisiifolia*	annual ragweed
Alnus glutinosa	European alder	*Veronica officinalis*	common speedwell
Dactylis glomerata	orchardgrass	*Phleum pratense*	timothy
Morus alba	white mulberry	*Acorus calamus*	calamus
Phragmites australis	common reed	*Lonicera tatarica*	Tatarian honeysuckle
Rumex crispus	curly dock	*Berberis thunbergii*	Japanese barberry
Salix alba	white willow	*Achillea millefolium*	common yarrow
Trifolium pratense	red clover	*Elaeagnus angustifolia*	Russian olive
Phalaris arundinacea	Reed canarygrass	*Stellaria media*	common chickweed
Solanum dulcamara	climbing nightshade	*Ranunculus acris*	tall buttercup

Top Ranking Species: Wetland Plants *not* in Wisconsin yet...

Eichhornia crassipes	common water hyacinth*	*Polygonum caespitosum*	Oriental Lady's thumb
Lonicera sempervirens	trumpet honeysuckle	*Rubus phoenicolasius*	wine raspberry
Petasites hybridus	pestilence wort	*Marsilea quadrifolia*	European waterclover
Jacobaea vulgaris	stinking willie	*Microstegium vimineum*	Nepalese browntop
Ligustrum sinense	Chinese privet	*Schoenoplectiella mucronate*	bog bulrush
Persicaria perfoliata	Asiatic tearthumb	*Saccharum ravennae*	ravennagrass
Bothriochloa bladhii	Caucasian bluestem	*Epilobium parviflorum*	mallflower hairy willowherb
Juncus inflexus	European meadowrush	*Kummerowia striata*	Japanese clover
Buddleja davidii	orange eye butterflybush	*Arundo donax*	giant reed
Carex acutiformis	lesser pond sedge	*Mentha pulegium*	pennyroyal

* Site in Wisconsin has been controlled.

Top Ranking Species (RAMP 6+): Aquatic Plants in Wisconsin

- *Nasturtium officinale*   watercress
- *Potamogeton crispus*   curly pondweed
- *Hydrilla verticillata*   waterthyme
- *Najas minor*   brittle waternymph
- *Myriophyllum spicatum*   Eurasian watermilfoil
- *Nitellopsis obtuse*   starry stonewort
- *Nymphoides peltata*   yellow floatingheart
- *Nelumbo nucifera*   sacred lotus

Top Ranking Species (RAMP 6+): Aquatic Plants not in Wisconsin yet…

- *Eichhornia crassipes*   common water hyacinth
- *Egeria densa*   Brazilian waterweed
- *Marsilea quadrifolia*   European waterclover
- *Trapa natans*   water chestnut

Top Ranking Species (RAMP 6+): Aquatic Animals in Wisconsin

- *Dreissena polymorpha*   zebra mussel
- *Cyprinus carpio*   common carp
- *Orconectes rusticus*   rusty crayfish
- *Bythotrephes longimanus*   spiny waterflea
- *Dreissena bugensis*   quagga mussel
- *Neogobius melanostomus*   Round goby
- *Cipangopaludina chinensis*   Chinese mystery snail
- *Morone americana*   White perch
- *Alosa pseudoharengus*   Alewife
- *Bosmina coregoni*   a waterflea
- *Oncorhynchus tshawytscha*   Chinook salmon

Top Ranking Species (RAMP 6+):
Aquatic Animals *not* in Wisconsin yet…

Ameiurus catus	White catfish
Pterygoplichthys pardalis	Amazon sailfin catfish
Tilapia zillii	redbelly tilapia
Perccottus glenii	Chinese sleeper
Oreochromis niloticus	Nile tilapia
Silurus glanis	wels catfish
Rhodeus sericeus	Amur bitterling
Hypomesus nipponensis	Wakasagi
Oreochromis mossambicus	Moazambique tilapia
Pseudorasbora parva	stone moroko

Limitations

- GBIF subsampling doesn't keep all the records or fields with other information. No easy way to QA/QC records.

- If a species is under-surveilled, it can have poor RAMP fitting
  - Graceful cattail (*Typha laxmanii*) has a RAMP score of 5, but is likely a new threat in Wisconsin.

When assessing new threats with RAMP

- Use RAMP scores with literature reviews:
  - Potential environmental, economic, or human health impacts
  - Life history traits
  - Reproductive rates
  - Abundance and distribution
  - Vulnerable habitats or species-specific habitat needs
  - Methods of control
  - Ability to naturalize with native ecosystems.
- RAMP scores are coarse-grained and not useful for small scale planning at state scale.
- RAMP scores do not imply competitive advantage of one species over another.

RAMP outputs for other Great Lakes States

- Once RAMP scores have been calculated nationally, they can be clipped for different study areas.

- Current range of selected species were selected for impacts to Wisconsin, but may not capture different threats to other Great Lakes States.

  - Our list doesn't consider species climate suitabilty within other states.
  - Eastern Great Lakes states may have different climate analogue matches than what was found for Wisconsin.
  - Other states will need to conduct their own climate matching to find additional species for analysis.

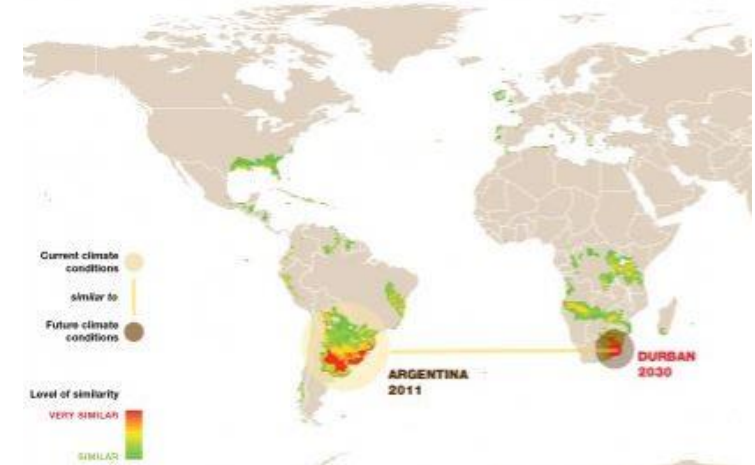 *So...how do other states find target species?*

Climate analogue matching tools for other areas: CGIAR

- CGIAR (Consultative Group for International Agricultural Research) has a climate analogue matching tool.

- http://www.ccafs-analogues.org/tool/

- Allows you to find matches between selected areas based on emission models (A1B)

- Uses 16 climate match variables found in RAMP.

- Still developing, web portal doesn't always work.

Growing Conditions Today Mirror Future Climates

The 2030 climate of a maize-growing area near Durban will correspond to the current climate of a major maize-growing area in the Argentina. Growers in Durban can learn from these analogous climates how to adapt as their climate shifts.

Current climate conditions
similar to
Future climate conditions

Level of similarity
VERY SIMILAR
SIMILAR

ARGENTINA 2011

DURBAN 2030

Step 1: Select your location

i) Select a reference site:

Use the tab below to zoom to a country then click a location on the map to get coordinates, or alternatively, enter the latitude and longitude directly
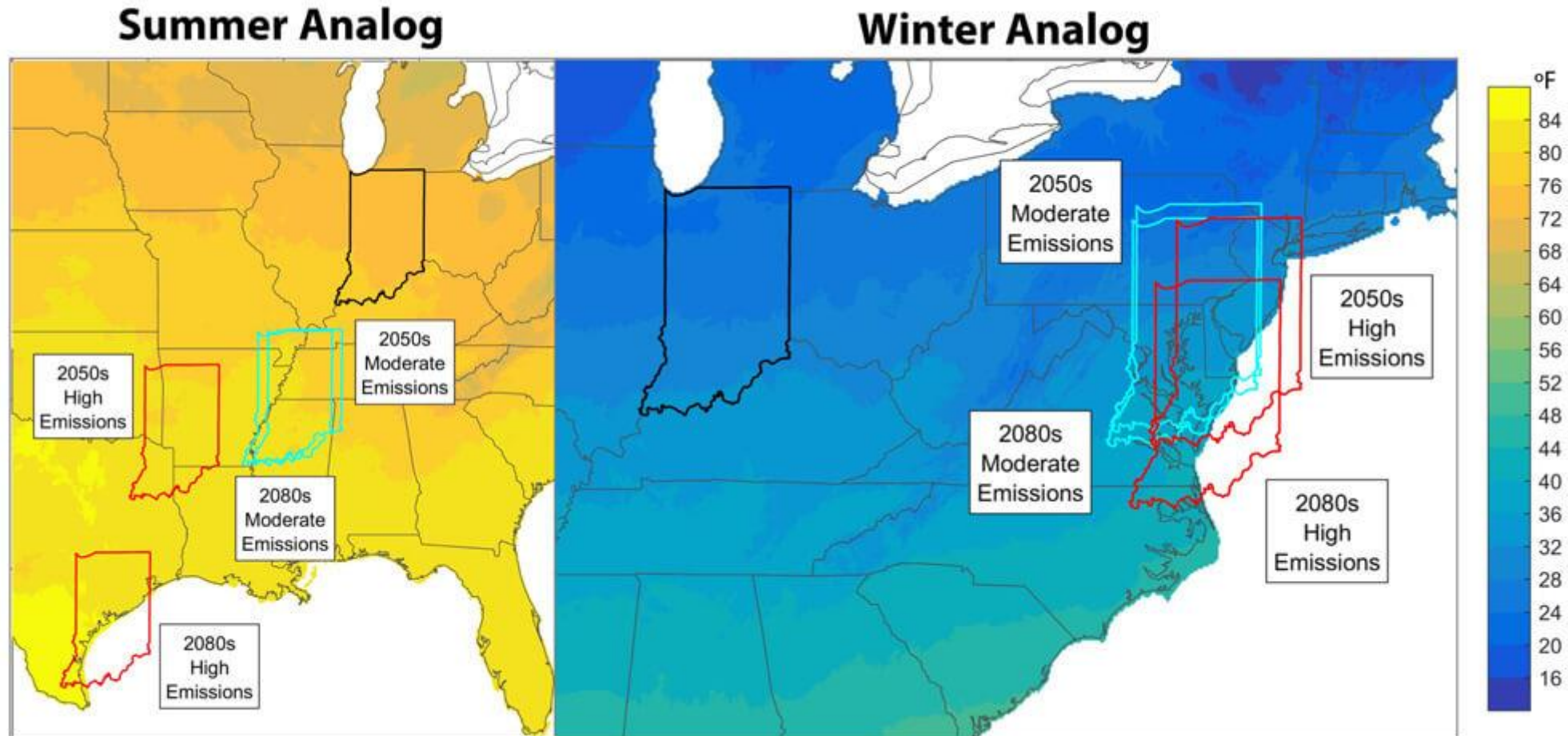
Global

Latitude: 39.960
Longitude: -82.991

ii) Select a search range: Global

Continue »

Climate analogue matching tools for other areas: Literature

- There may be literature specific to your geography

- Purdue University: Indiana Climate Change Impacts Assessment

https://ag.purdue.edu/indianaclimate/indiana-climate-report/

Climate analogue matching tools for other areas: Use RAMP itself.

- Use the RAMP tool to select all the climate stations within your state.

- Simulate current and future climates.

- Consider southern states that have RAMP scores near 6+
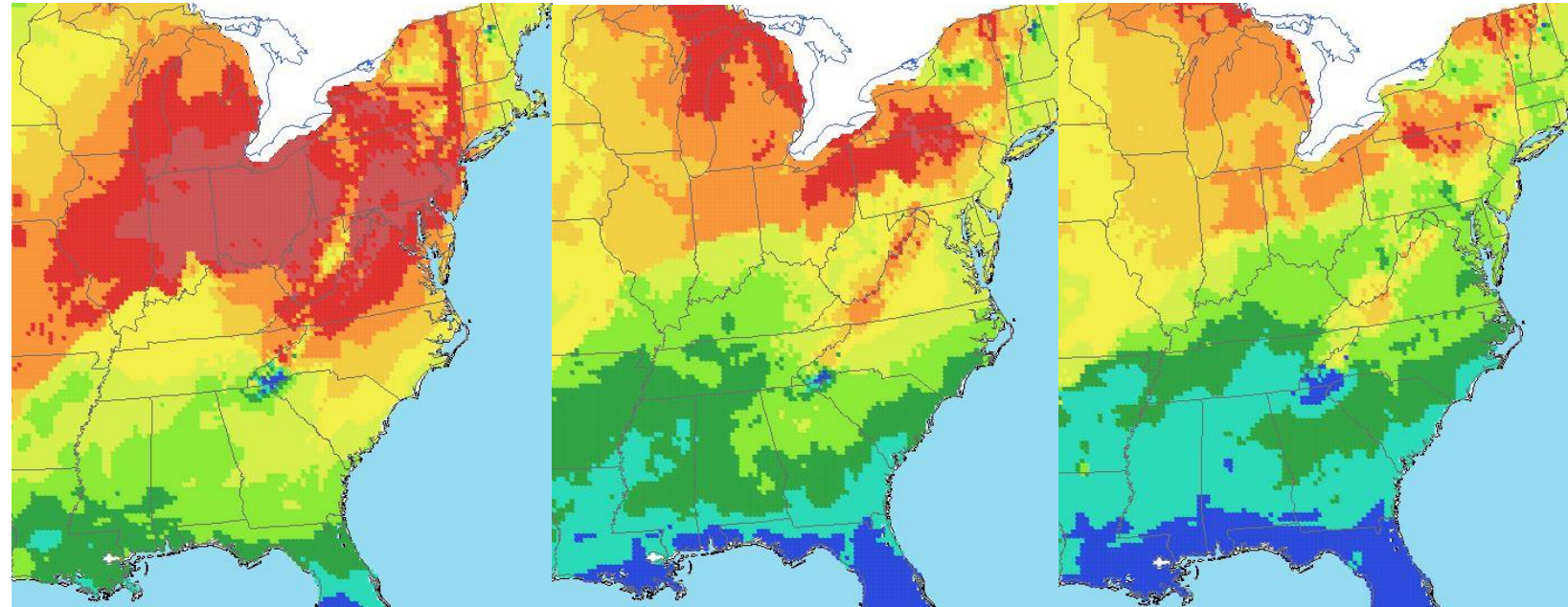
Ohio Current

Ohio 2050 median emissions scenario

Ohio 2070 median emissions scenario

Questions

For compete list of RAMP outputs send a request to my email: Jason.Granberg@Wisconsin.Gov