The Past, Present, and Future of Stonefly Assemblages in the Midwest

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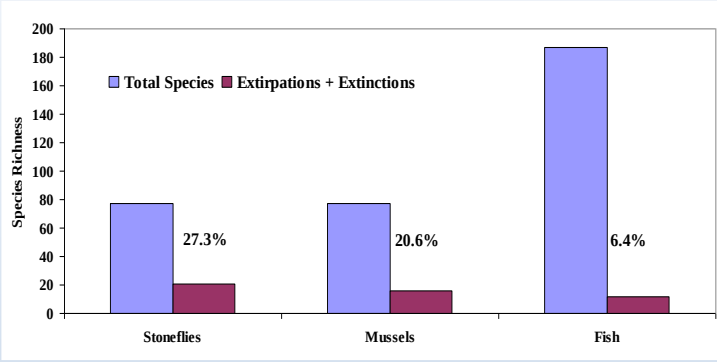
The Value of Distribution Data

- Assessing conservation needs
- Understanding genetic diversity patterns
- Assessing patterns of biodiversity
- Informing restoration & management
- Reintroducing species
- Defining reference conditions
- Assessing climate change impacts

Forest Stonefly

Challenges to Reconstructing Distributions

- Range loss has already occurred



- Published distributions often inadequate:
  - often without vouchers—unverifiable
  - obsolete taxonomy
  - incorrect identification
  - low taxonomic resolution
  - Incomplete location information

Museum Specimens Are a Source of Data

Pros	Cons
Oldest records/greatest range	Presence data-only
IdentificationsVerifiable	Sample effort unclear
Many specimens available	Some old labels have inexact location data

Imperfect data, yes, but often the best available!

Objectives

Reconstruct the historic range of stoneflies in Midwest

- NSF sponsored
- Predict ranges of individual species
- Predict species richness
- Predict biodiversity hot- and coldspots

Model climate related changes in Midwest

- USFWS sponsored
- Changes in individual species
- Changes in richness

30,000 records
25 museums & new collections
7,300 unique locations

Pre-European Settlement Range Prediction

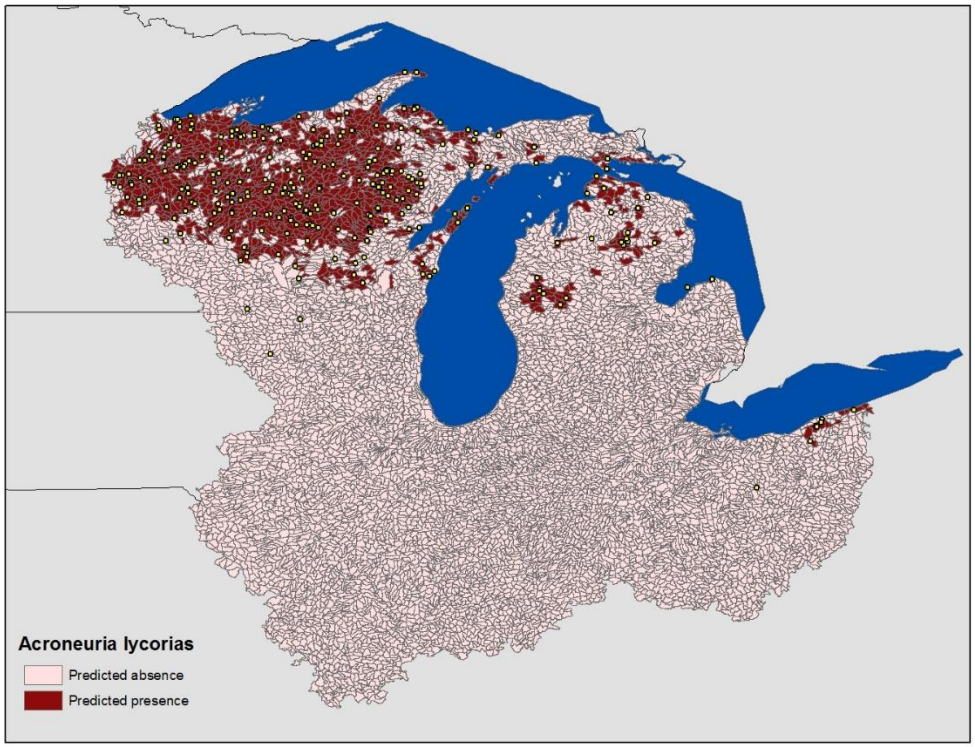
Environmental variables

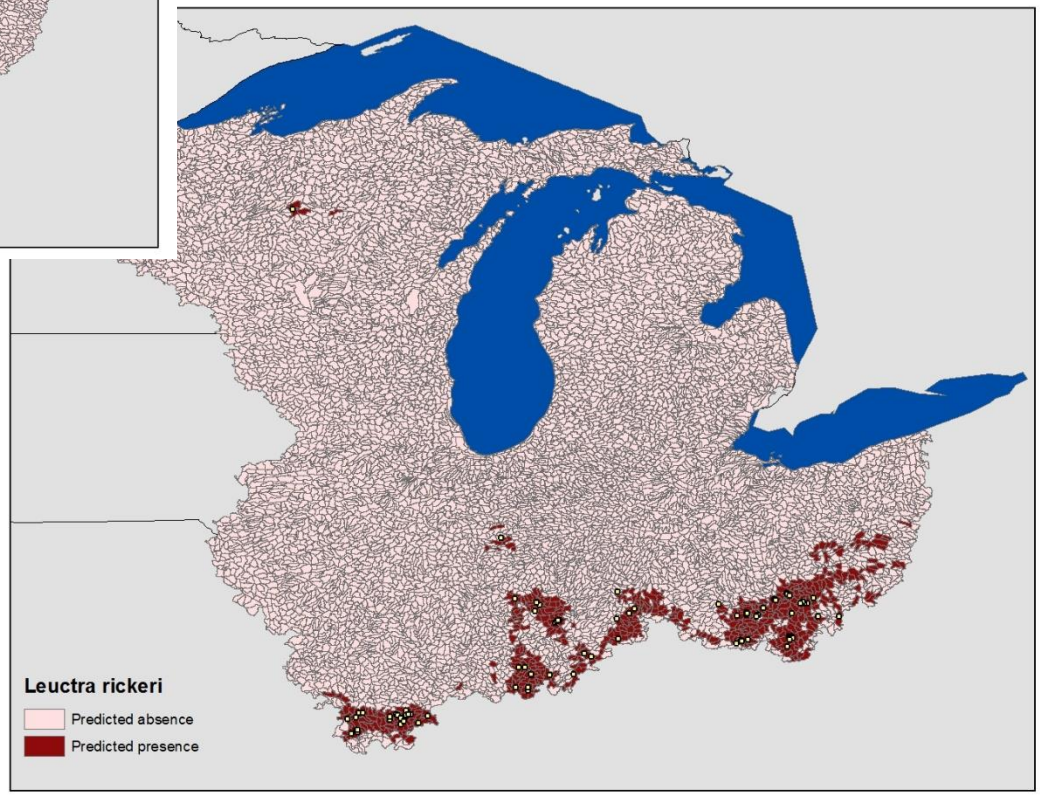
- ~8700 HUC12 drainages, ~20,000 acres
- 300 variables, eco-hydrology & historical vegetation
- Variable reduction through cluster analysis

Producing a **Full Model** for Each Species w/ Maxent Software

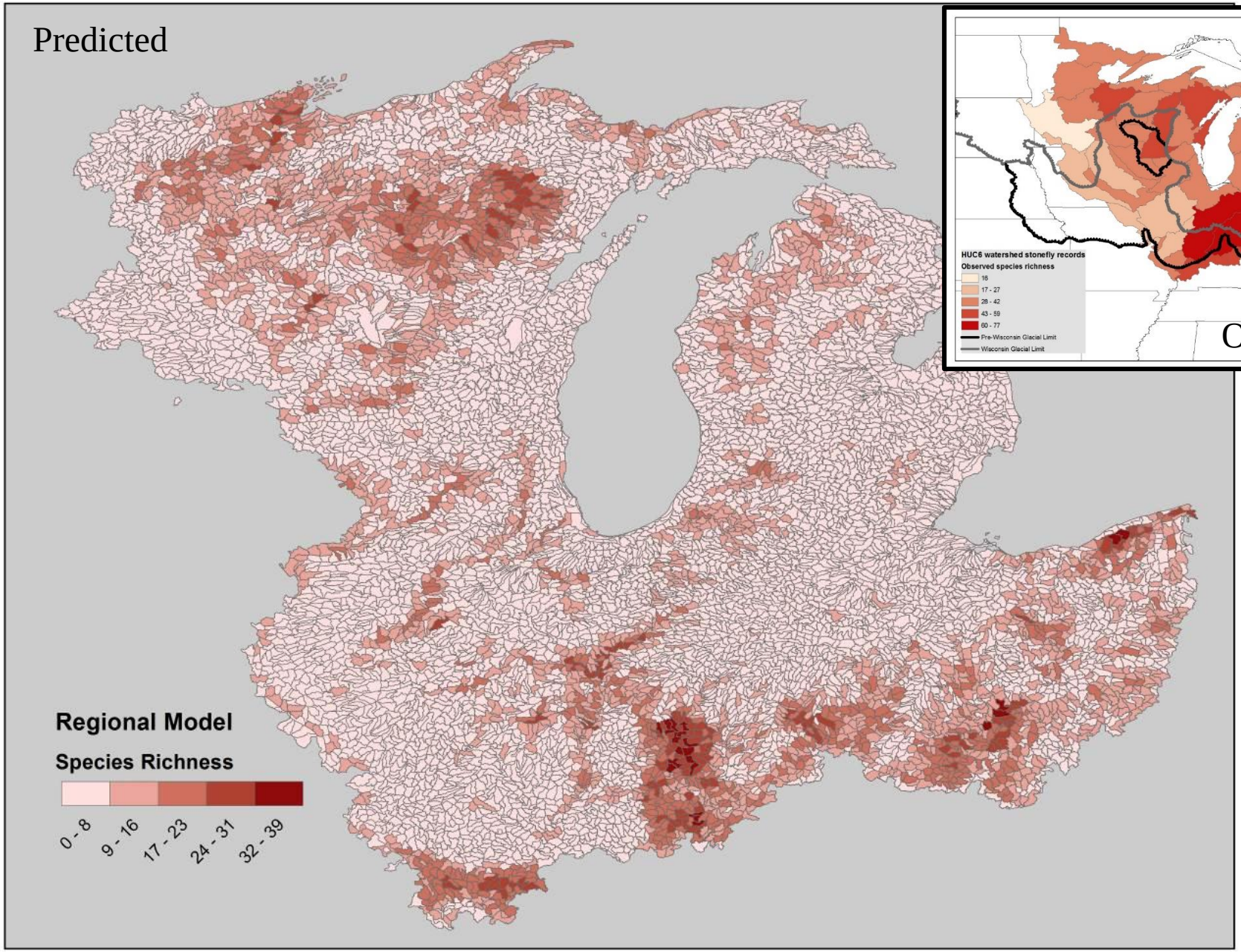
- Single record/species/HUC12
- Threshold for entry ≥14 HUC12s
- Default regularization β=1
- 2 step process, model once, remove variables with weight of zero, model again

Full Models for 78 of 146 Species





Regional Species Richness Model



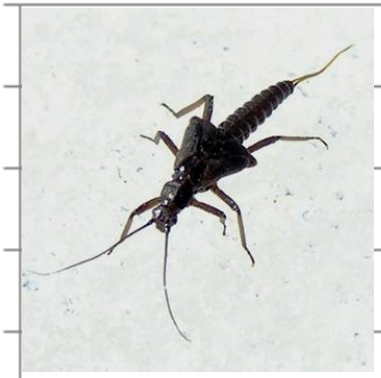
Model Calibration

- 80 “best” watersheds removed from **Full Model** to form **Calibration Model**

- Correlation of incidence & richness between the calibration model and observed values in 80 watersheds

- Correlation of **Full** & **Calibration** model incidences per species

Calibration Model Performance: Incidence



Predicted species incidence

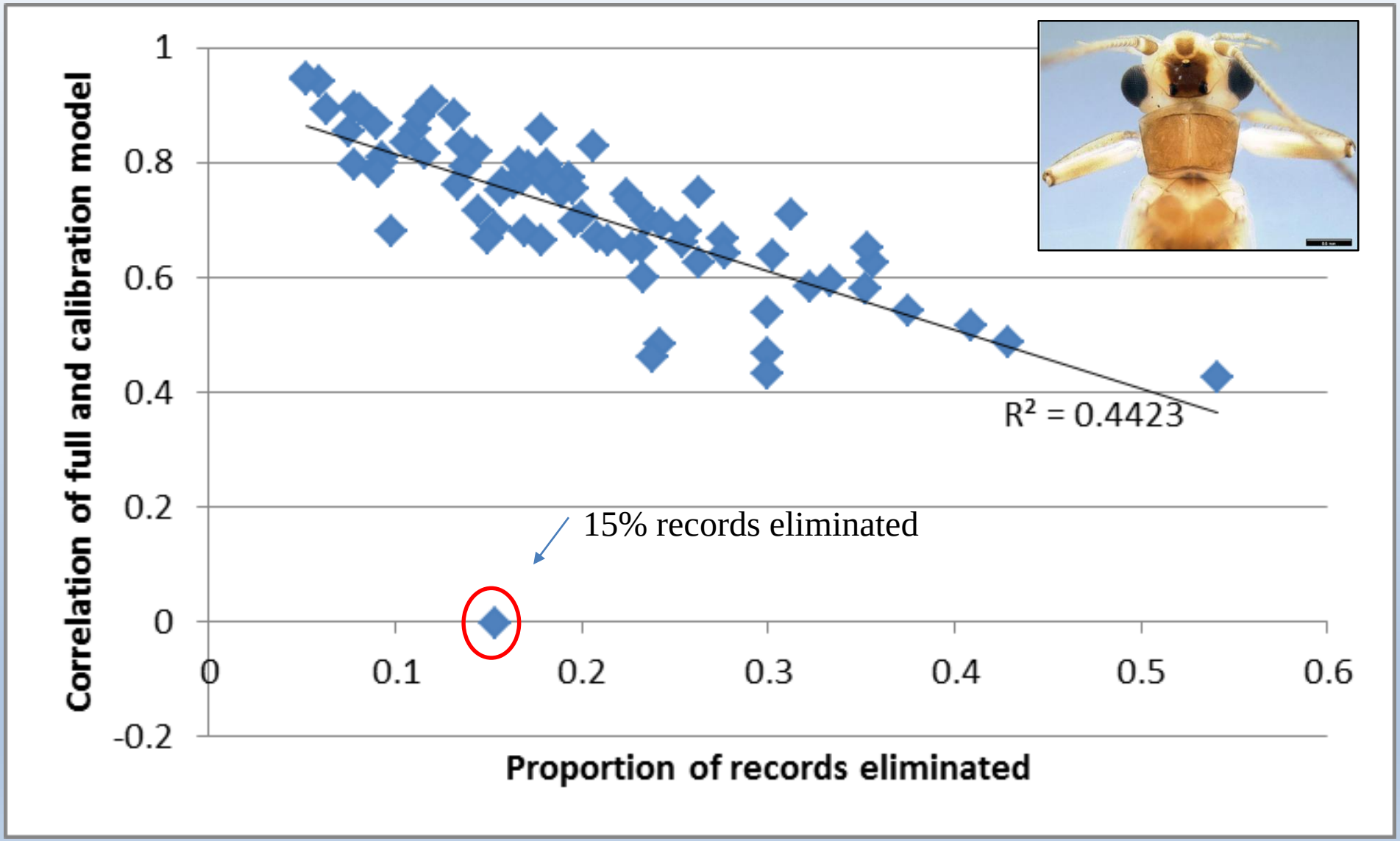
Observed species incidence (regional 80)

N=78

$R^2 = 0.6365$

p<0.0005

Model Correlation vs. proportion records eliminated

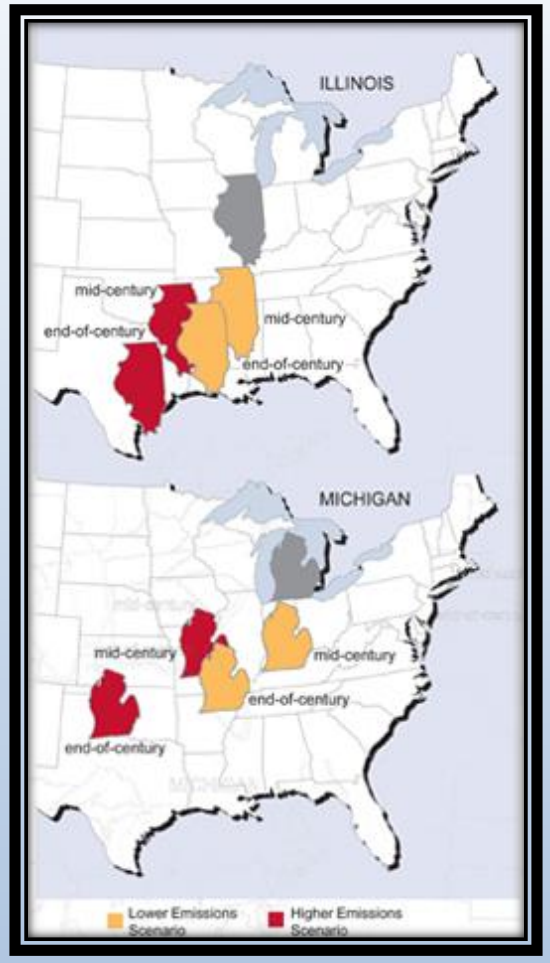


One outlier, when removed, improves the R^2 to 0.69.

Future Assemblage Under Climate Change

- Analysis w/ 9 BIOCLIM variables only by 2100
- Predict **current** distributions
- Predict **future** distributions

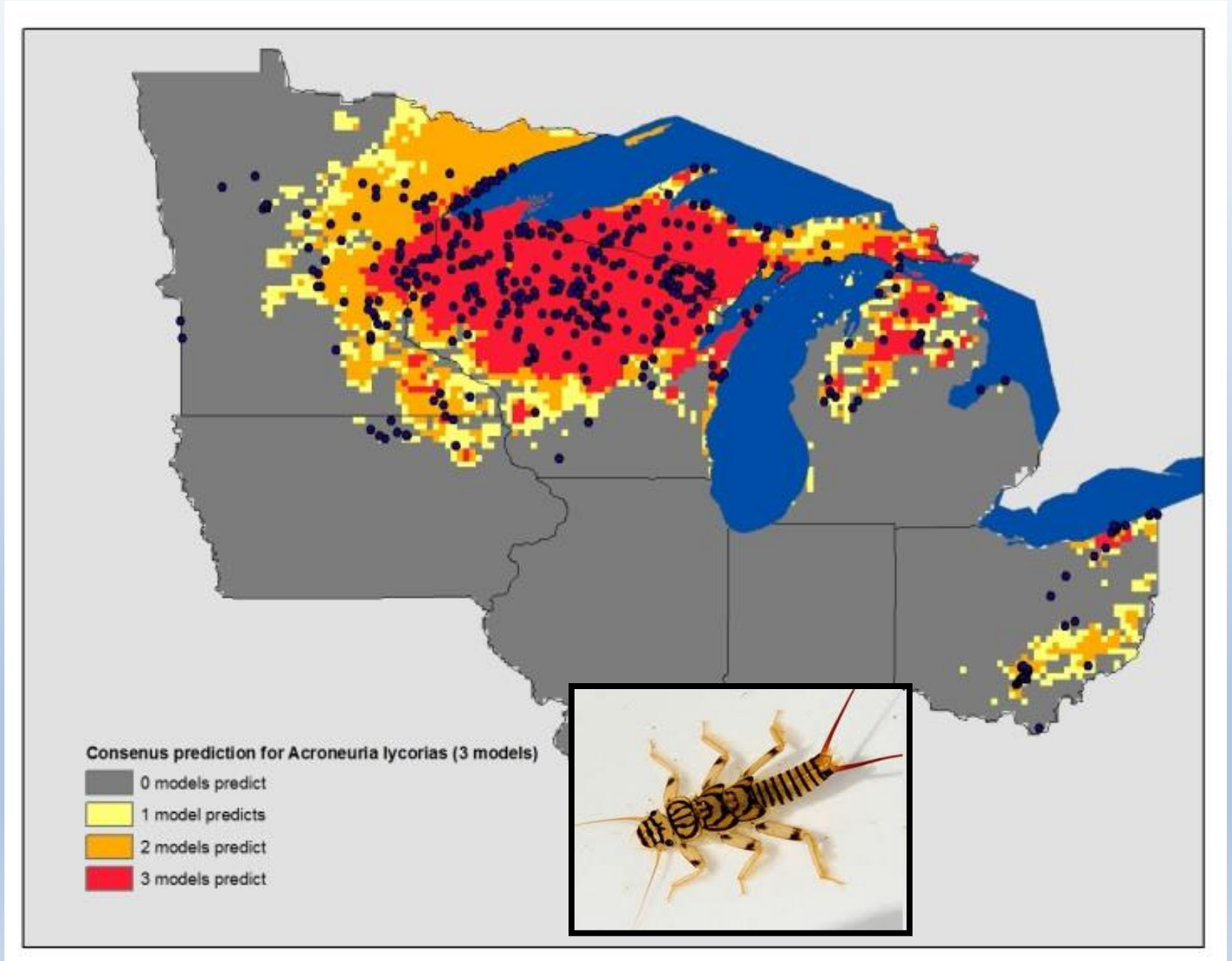
	Current	Future
Climate Models	CCMA, GISS, CCMA_t63	CCMA, GISS
Emissions Scenarios	NA	A1b (high), a2 (moderate)



http://www.epa.gov/climatechange/impacts-adaptation/midwest.html

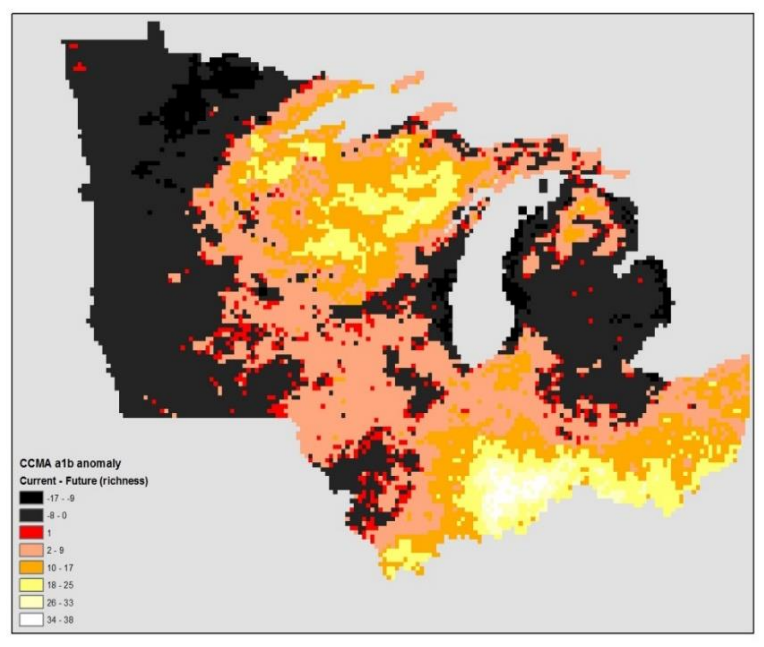
- Compare current to future distributions to estimate range loss
- Compare current to future species richness to predict changes in pattern

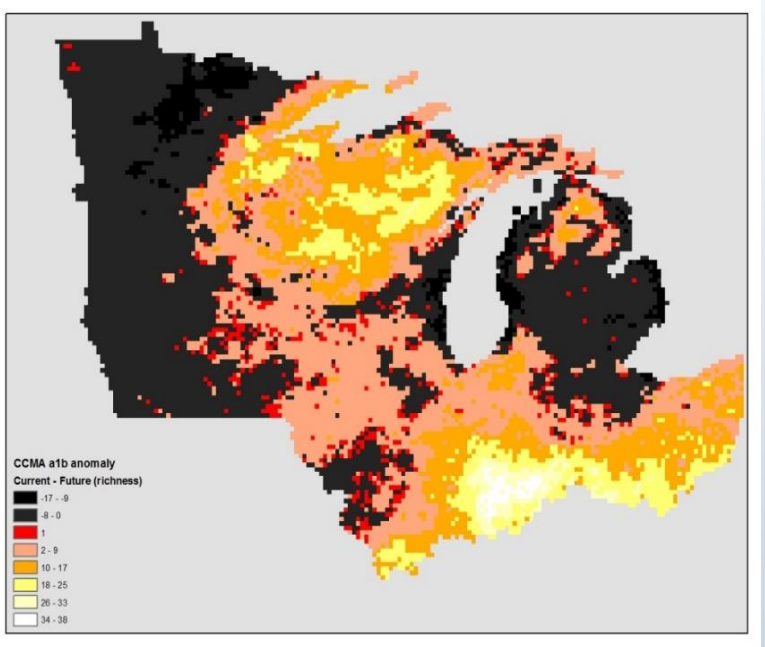
Consensus Current Distribution, 3 models, *Acroneuria lycorias*

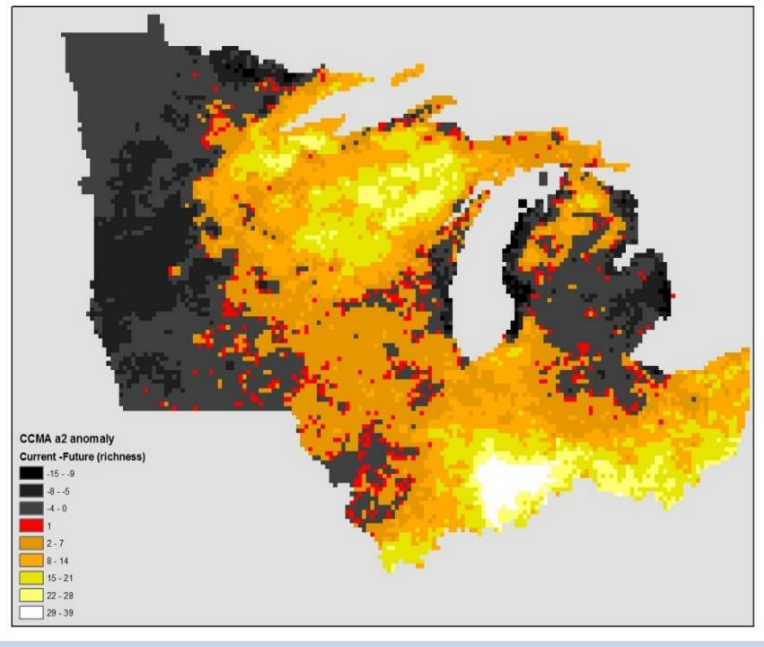


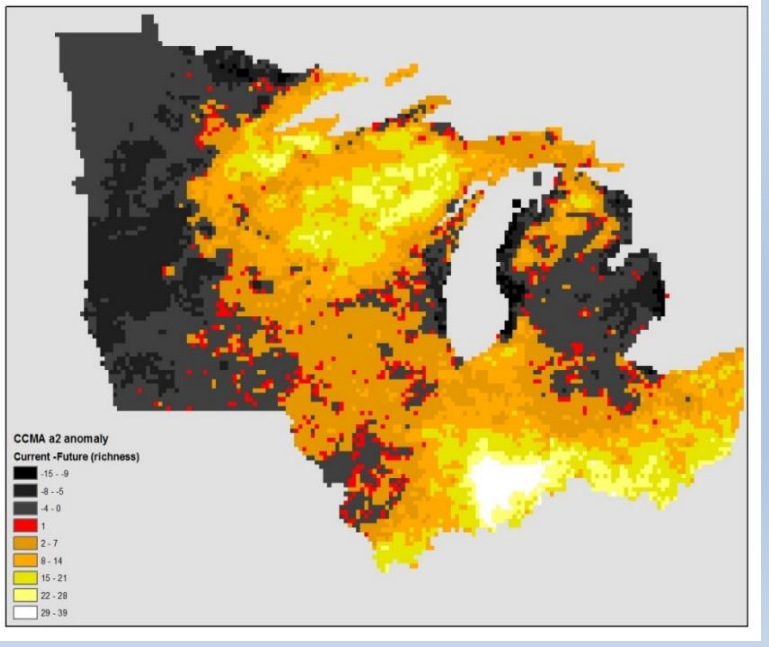
The Worst Case: Range Loss For 78 Species

The Worst Case: Species Richness Decreases in Rich Areas









Conclusions

- Predicted baseline distributions for an entire assemblage
  - 78 of 146 species modeled
  - Predict species occurrences well, but richness not as well
  - Distribution of species richness is highest in unglaciated areas and in cooler, forested areas
- Predicted worst case scenario for climate related change
  - Most species will lose range, many dramatically
  - Some warmwater species will increase in range
  - Species richness predicted to decline most steeply in currently rich area.
- Adding in mayflies (Ephemeroptera) and caddisflies (Trichoptera)