Amphibian response to climate change in the southeastern US: Identifying species and habitat priorities

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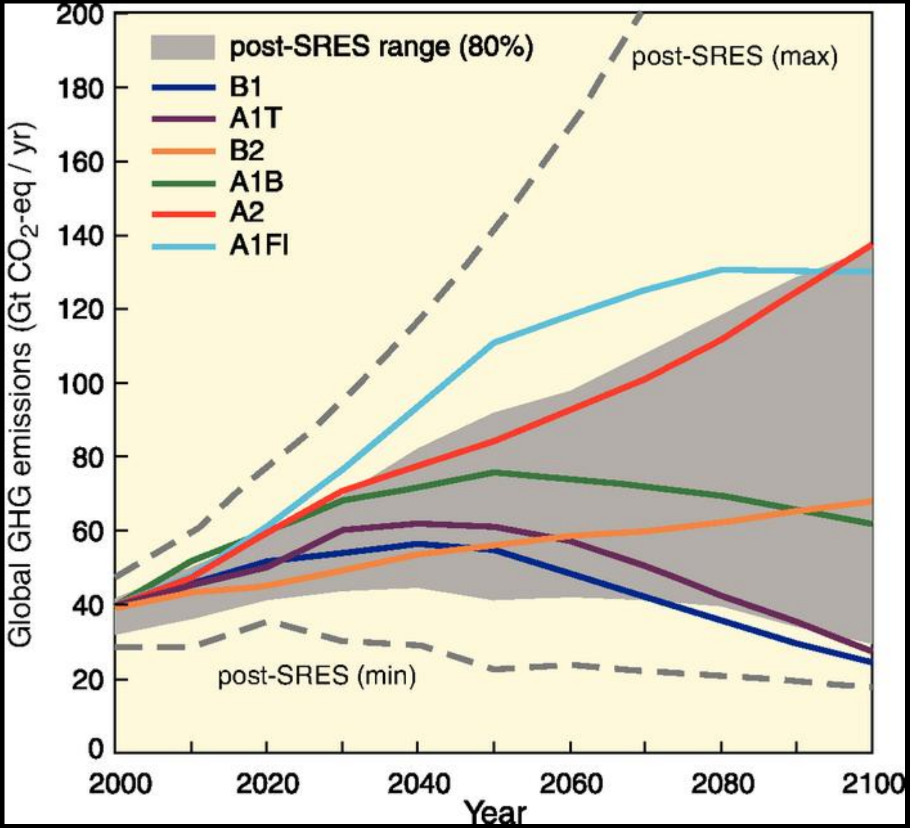
Uncertainty is ubiquitous

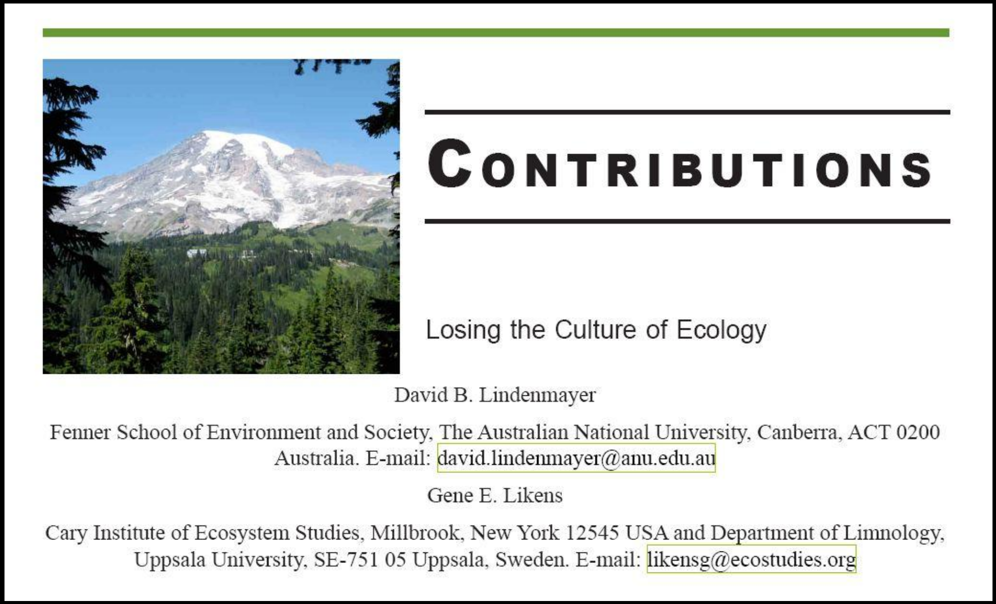


- Conservation decisions must be made now – prior to perfect information
- "Judicious use of model projections at appropriate scales may help us prepare[1]"

1Wiens, J.A. and D. Bachelet. 2011. Cons Bio 24:51-62

What approach do we take, and at what scale?

- Climate change is a large-scale threat that requires a large-scale approach
- Action plans should be data-driven
  - Qualitative assessment
  - Experimentation
  - Models



CONTRIBUTIONS

Losing the Culture of Ecology

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Methods for modeling species responses to climate change

- Forecasting distribution responses

  <u>Correlative models</u>:
  - Phenomenological
  - Relate current distributions to environmental variables

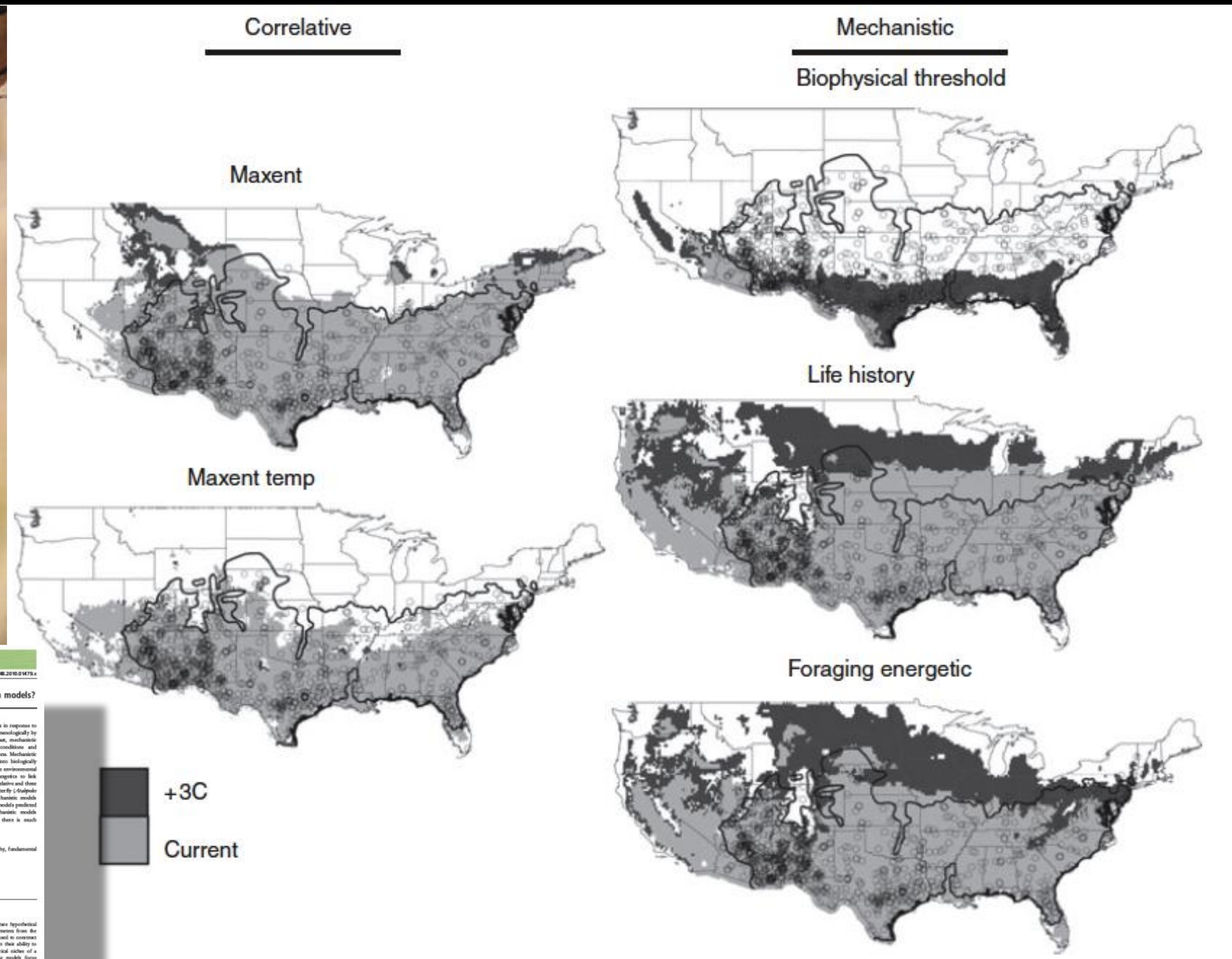
  <u>Mechanistic models</u>:
  - Use explicit relationships between environmental variables and organismal performance
  - Estimated independently of species current distribution

Methods for modeling species responses to climate change


ECOLOGY LETTERS

REVIEW AND SYNTHESIS

Can mechanism inform species' distribution models?



re 1 Range predictions for *Sceloporus undulatus* in current climates (light gray) and predicted range expansions following a uniform 3 °C
perature increase (dark gray). Localities (o) and the atlas range polygon are shown.

So many problems, so little time

- The southeast represents one of the world's most diverse region for amphibians
  - Nearly 200 species
  - > 50 endemics
- Climate change is likely to result in a loss of climatically suitable habitat for many of these species

Prioritizing model effort: Expert solicitation

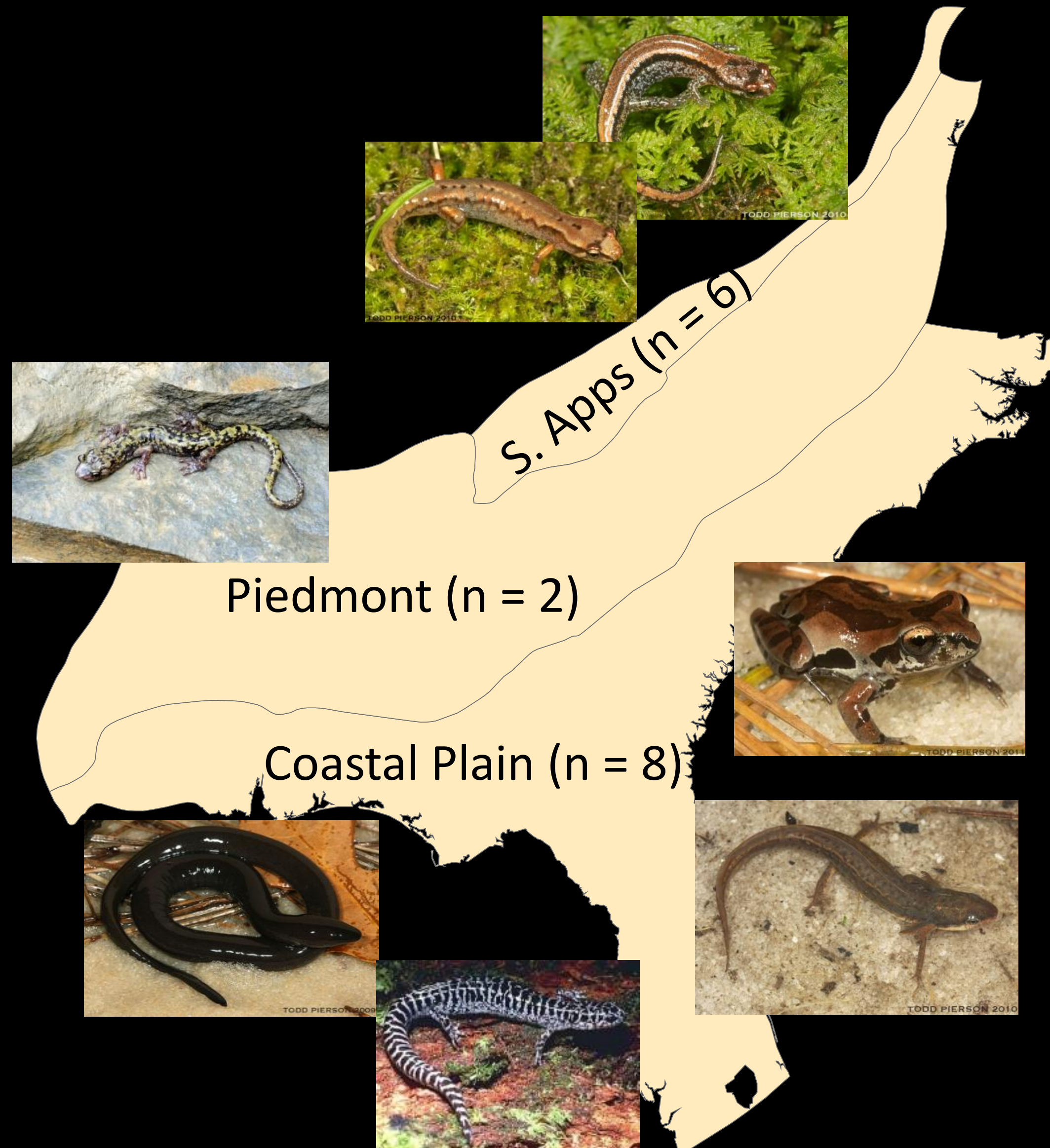
- Surveyed state herpetologists to identify priority species
- Identified results most relevant to wildlife managers

Climate change vulnerability assessment: target species

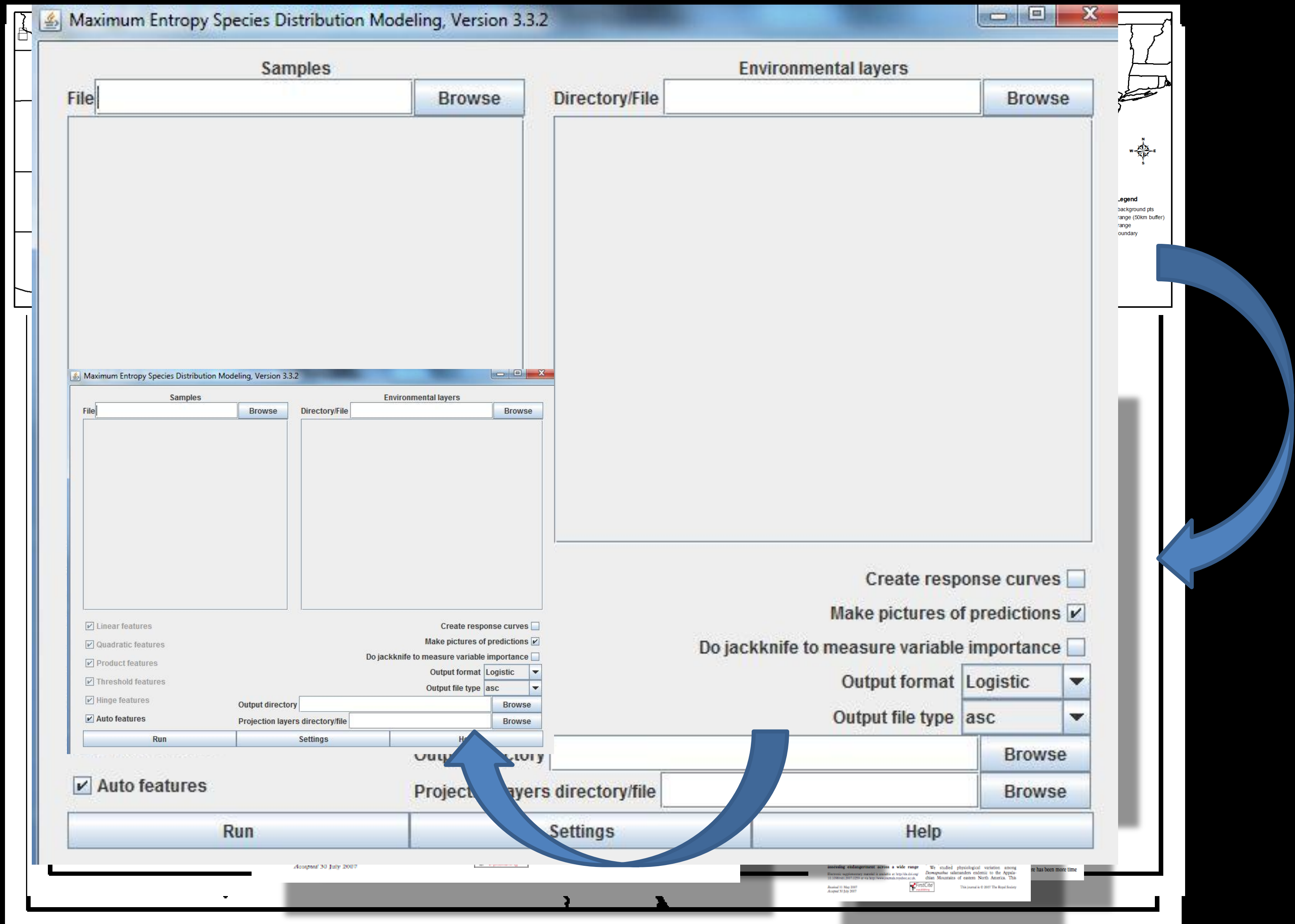
Salamanders	Frogs
Ambystoma cingulatum (2)	*Hyla andersonii (2)*
Ambystoma tigrinum	*Lithobates capito (3)*
Amphiuma pholeter	*Lithobates okaloosae*
Aneides aeneus (5)	*Lithobates sylvaticus*
Cryptobranchus alleganiensis (3)	*Pseudacris brachyphona*
Desmognathus aeneus (3)	*Pseudacris ornata*
Desmognathus welteri	
Desmognathus wrighti	
Hemidactylium scutatum (2)	
Necturus alabamensis	
Notophthalmus perstriatus (2)	
Plethodon ventralis	
Plethodon websteri (2)	
Plethodon wehrlei (2)	
Plethodon welleri	

Location of selected species

Generalist species (n = 5)



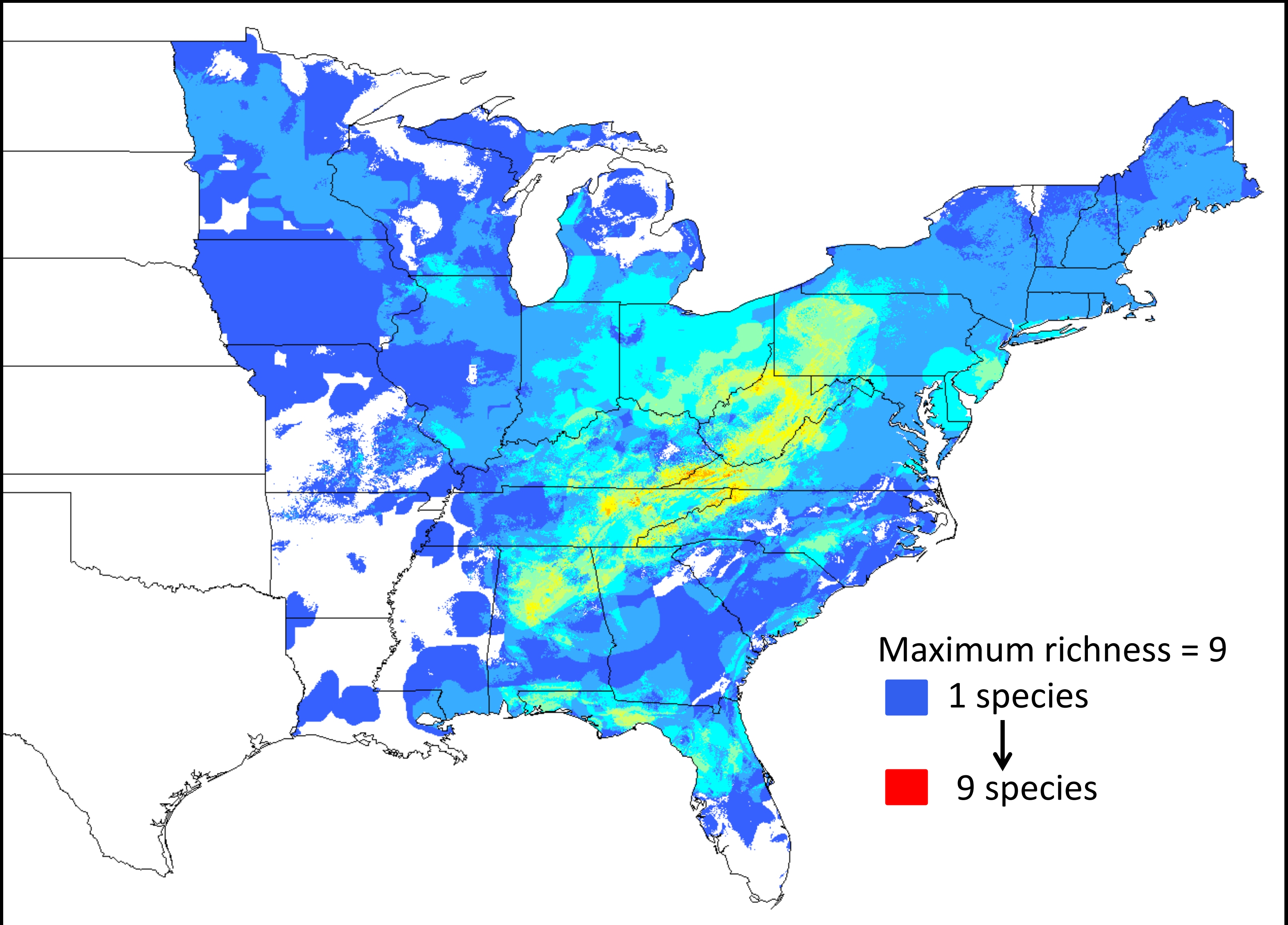
Building a correlative model



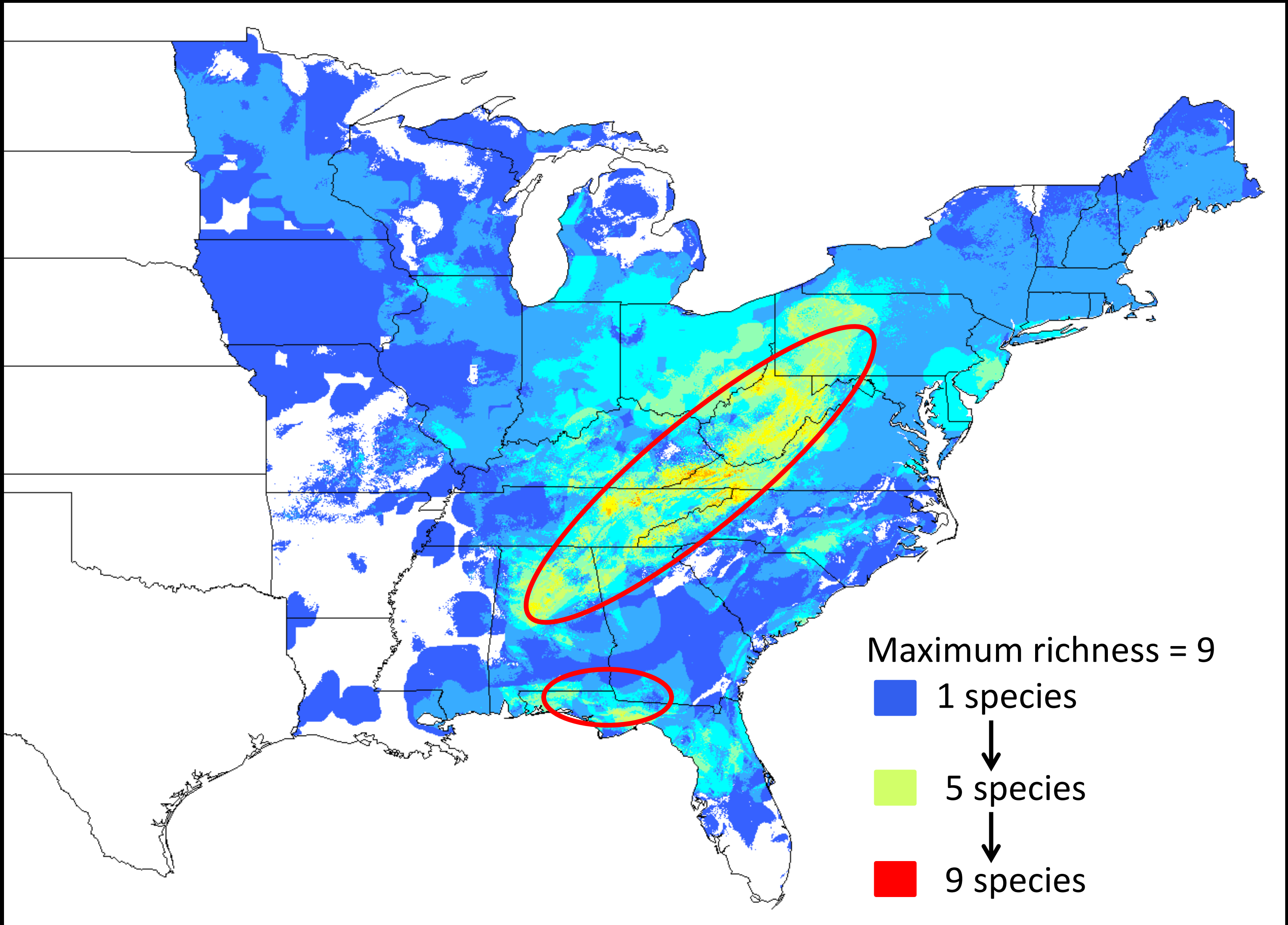
Building a correlative model Output

- Examined species richness and individual species projections
  - A2a and B2a scenarios x 2 GCMs = 4 outcomes
  - Examined 3 thresholds per outcome
  - Generated ensembles of threshold and GCM

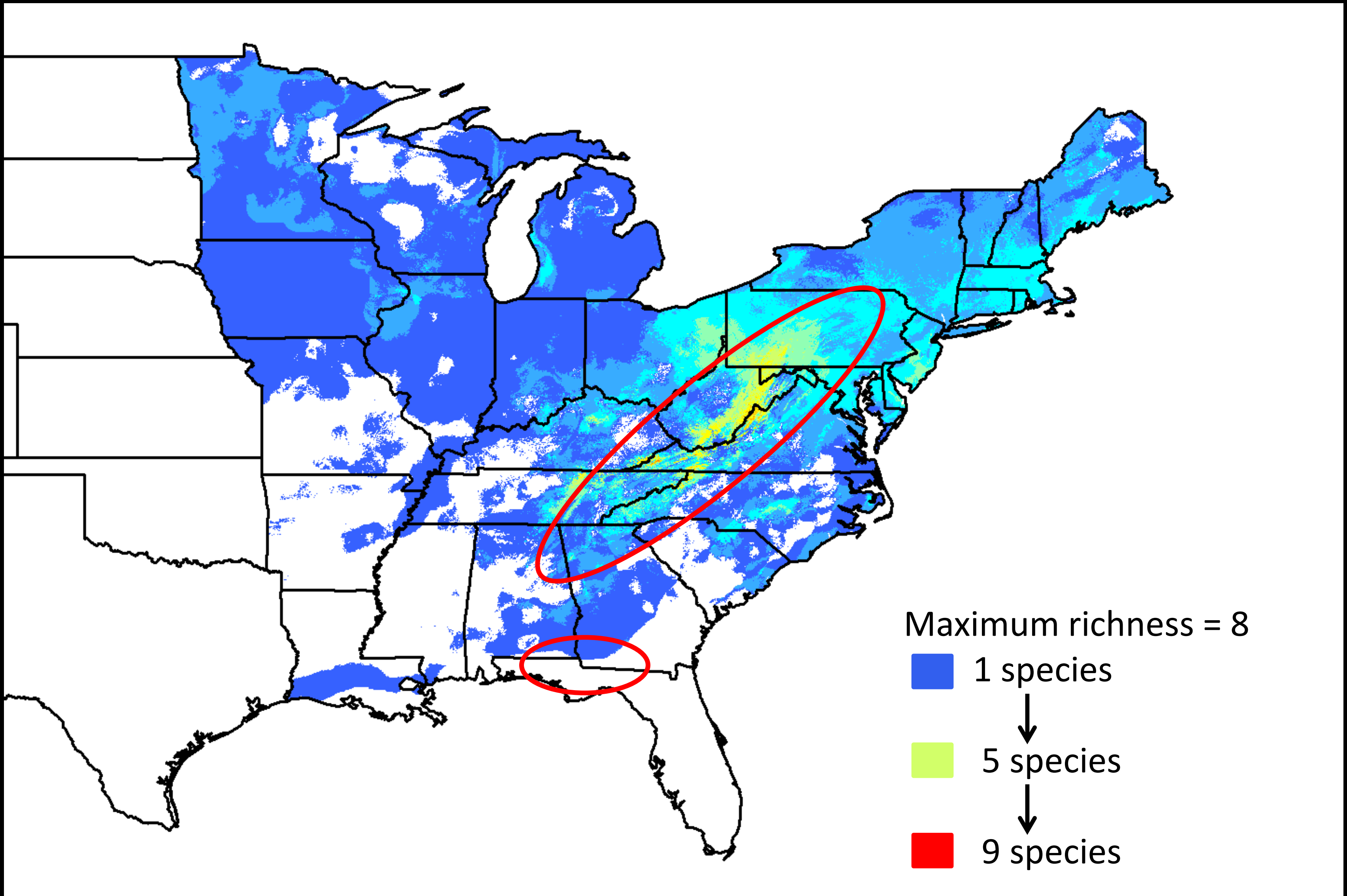
Identifying sensitive areas
Current species richness (F10)



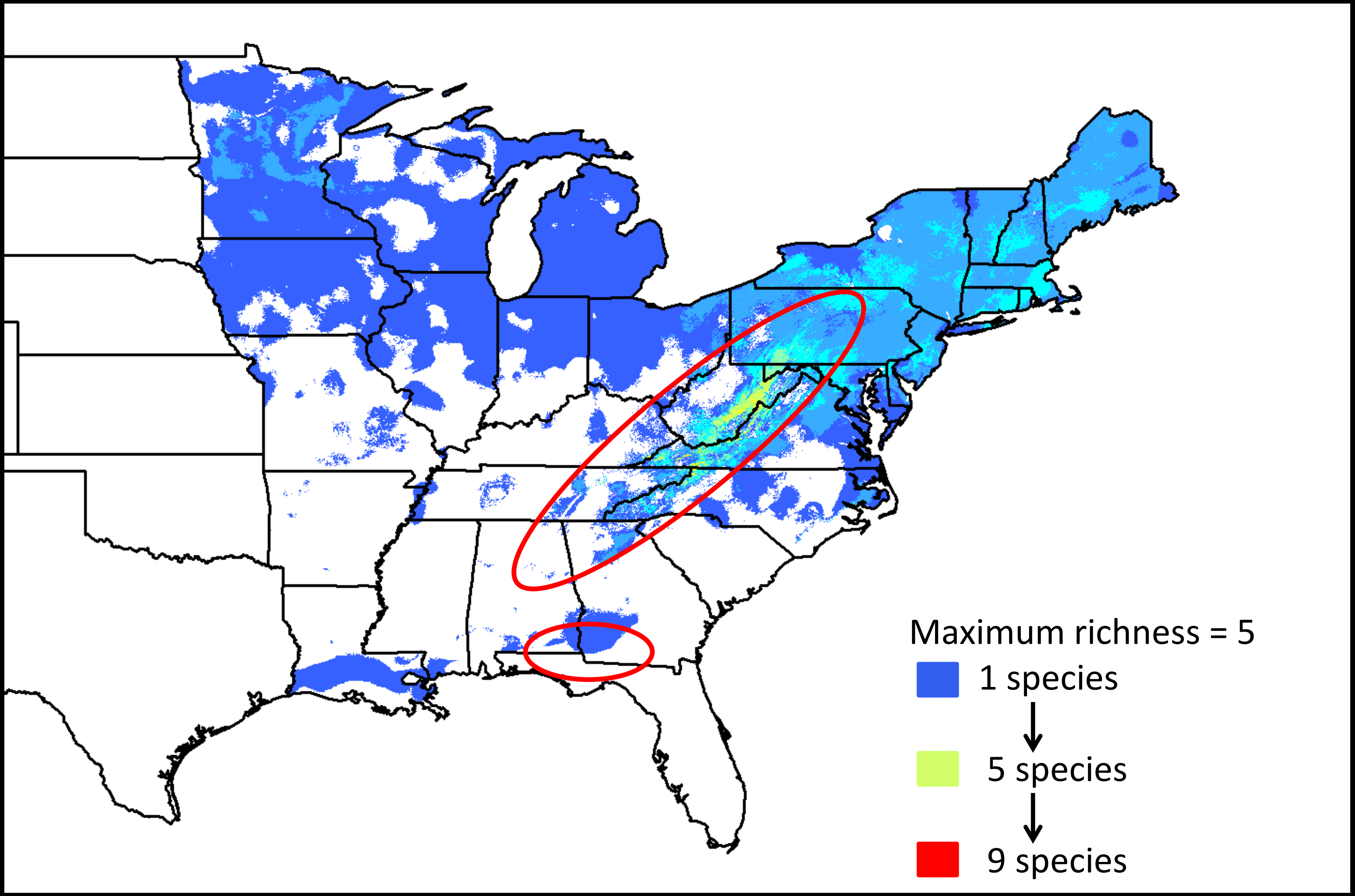
Identifying sensitive areas
Current species richness (F10)



Identifying sensitive areas
Hadley B2a 2020 species richness (F10)



Identifying sensitive areas
Hadley B2a 2050 species richness (F10)



Identifying sensitive species: species w/ 100% projected loss of suitable habitat

Species	Hadley						Canadian						# of "extinction" scenarios
	A2a			B2a			A2a			B2a			
	MTP	F10	MTR	MTP	F10	MTR	MTP	F10	MTR	MTP	F10	MTR	
Ambystoma cingulatum	■	■	■	■	■	■	■	■	■	■	■	■	12
Lithobates okaloosae	■	■	■	■	■	■	■	■	■	■	■	■	12
Necturus alabamensis	■	■	■	■	■	■	■	■	■	■	■	■	12
Plethodon websteri	■	■	■			■	■	■	■	■	■	■	10
Plethodon ventralis	■	■	■	■	■	■				■	■	■	9
Amphiuma pholeter	■	■	■	■	■	■							6
Desmognathus wrighti	■	■	■	■	■	■							6
Lithobates capito		■	■			■		■	■			■	6
Desmognathus welteri							■	■	■			■	4
Notophthalmus perstriatus			■			■					■	■	4
Desmognathus aeneus										■	■	■	3
Hyla andersonii								■	■				2
Plethodon wehrlei									■				1
Plethodon welleri									■				1

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	MTP	F10	MTR	MTP	F10	MTR	MTP	F10	MTR	MTP	F10	MTR	
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Lithobates okaloosae													12
Necturus alabamensis													12
Plethodon websteri				0.98	0.98								10
Plethodon ventralis							0.97	0.97	0.95				9
Amphiuma pholeter							0.82	0.80	-1.56	0.99	0.99	0.89	6
Desmognathus wrighti							0.96	0.99	0.96	0.96	0.99	0.98	6
Lithobates capito	0.96			0.96	0.98		0.99			0.93	0.98		6
Desmognathus welteri	0.91	0.91	0.90	0.90	0.90	0.87				0.97	0.98		4
Notophthalmus perstriatus	0.96	0.99		0.93	0.99		0.97	0.94	0.79	0.99			4
Desmognathus aeneus	0.95	0.95	0.93	0.93	0.93	0.91	0.97	0.98	0.96				3
Hyla andersonii	0.83	0.83	0.83	0.87	0.92	0.93	0.98			0.94	0.95	0.98	2
Plethodon wehrlei	0.92	0.93	0.95	0.89	0.94	0.99	0.94	0.99		0.73	0.80	0.87	1
Plethodon welleri	0.81	0.96	0.99	0.74	0.90	0.99	0.96	0.99		0.86	0.95	0.97	1

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= Coastal Plain

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= Coastal Plain

= Piedmont

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= Coastal Plain

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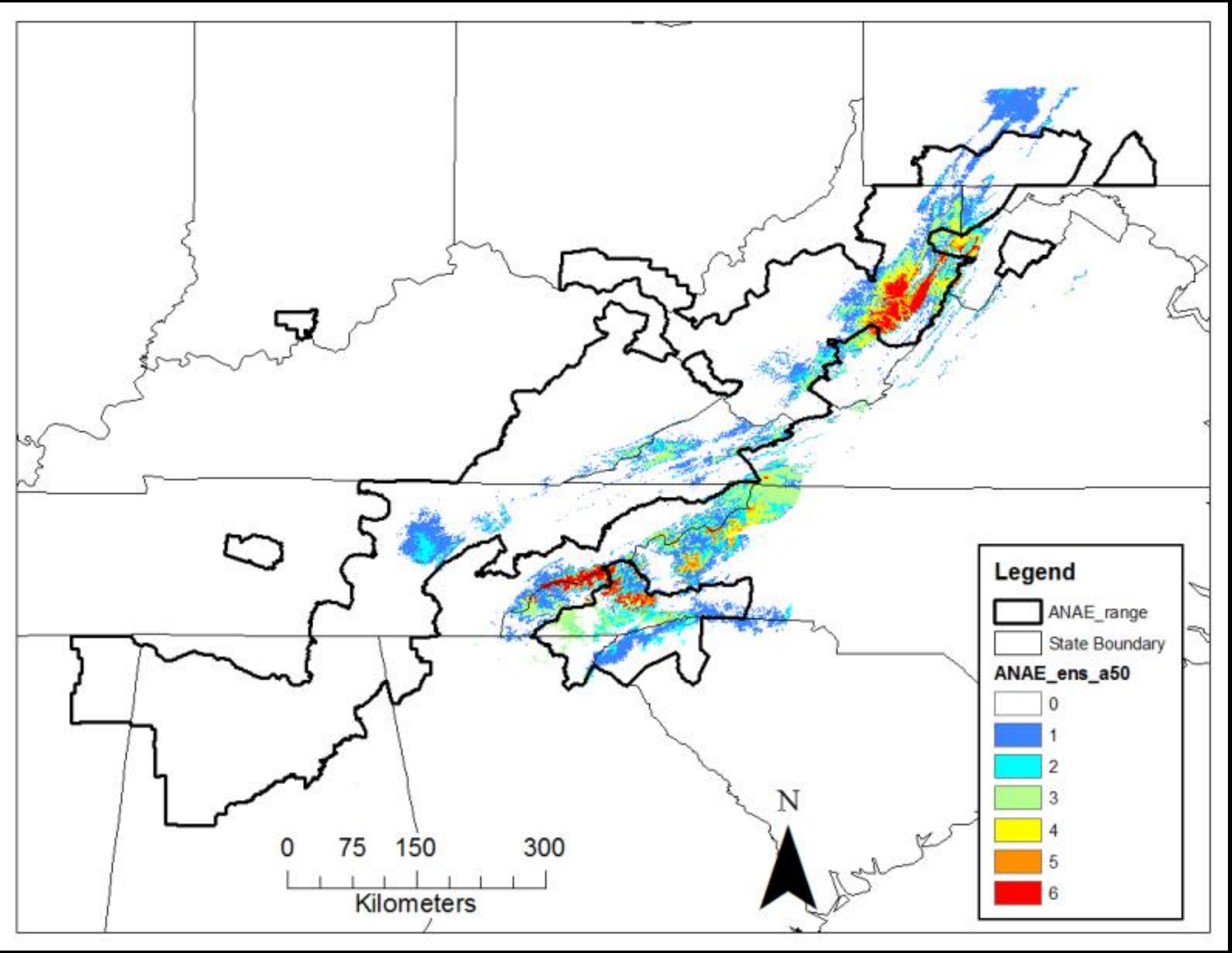
= Appalachian Mnts

Aneides aeneus – Ensemble A2a 2050



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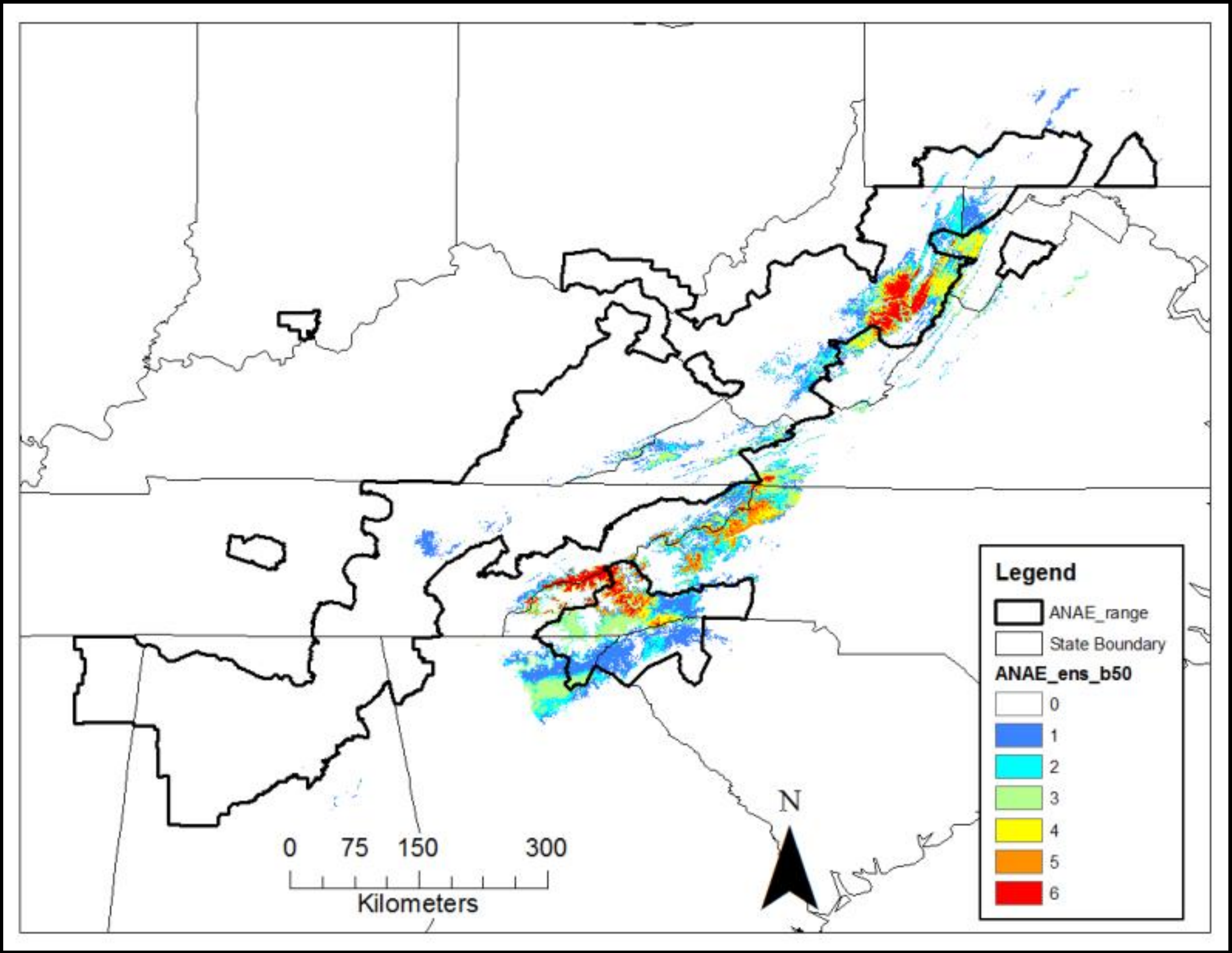
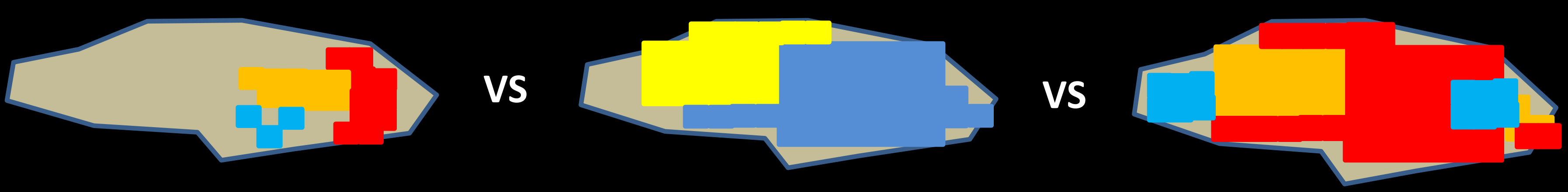


Prioritizing protected areas
(Identifying climate refugia for a species)

Primary Designation Type	Primary Designation Name	Area (ha)	B2a Percent	B2a Weighted Avg	A2a Percent	A2a Weighted Avg
		Alabama				
State Resort Park	Cheaha Resort SP	802	0.90	0.35	0.20	0.10
Wilderness Area (USFS)	Cheaha Wilderness	2,964	0.35	0.17	0.03	0.01
National Forest (USFS)	Talladega National Forest	162,802	0.01	0.00	0.00	0.00
		Georgia				
State Park	Don Carter SP	476	1.00	0.50	0.00	0.00
State WMA	Lula Tract WMA	499	1.00	0.50	0.00	0.00



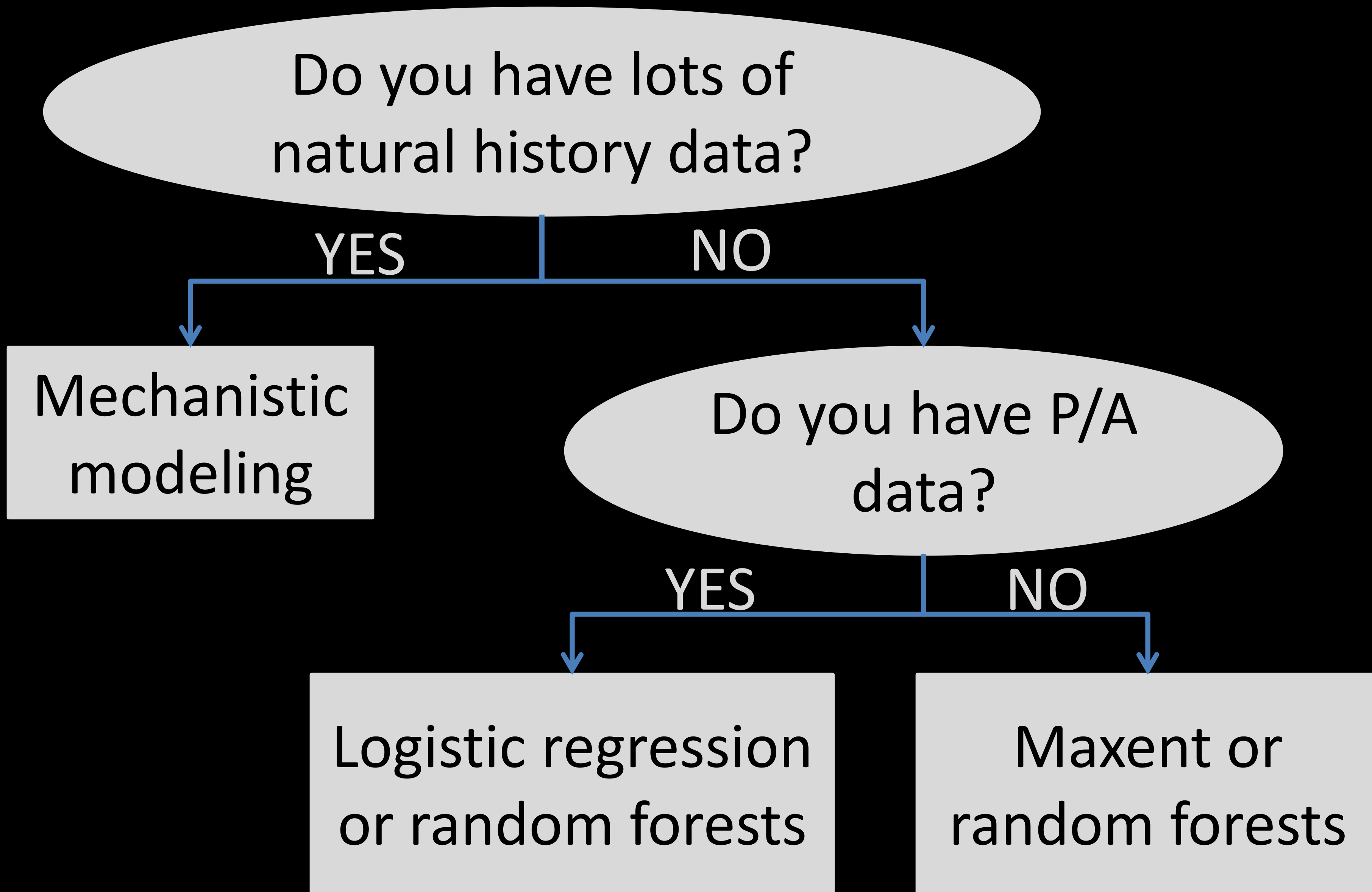
Model summary

- Coastal Plain habitats shift in suitability as much as other hotspots (southern Apps)
- Over half of the modeled species are projected to lose* ≥ 90% of currently suitable habitat
- Individual species models can be ensembled
  - Identification of protected areas that may provide management opportunities
  - Quantification of uncertainty

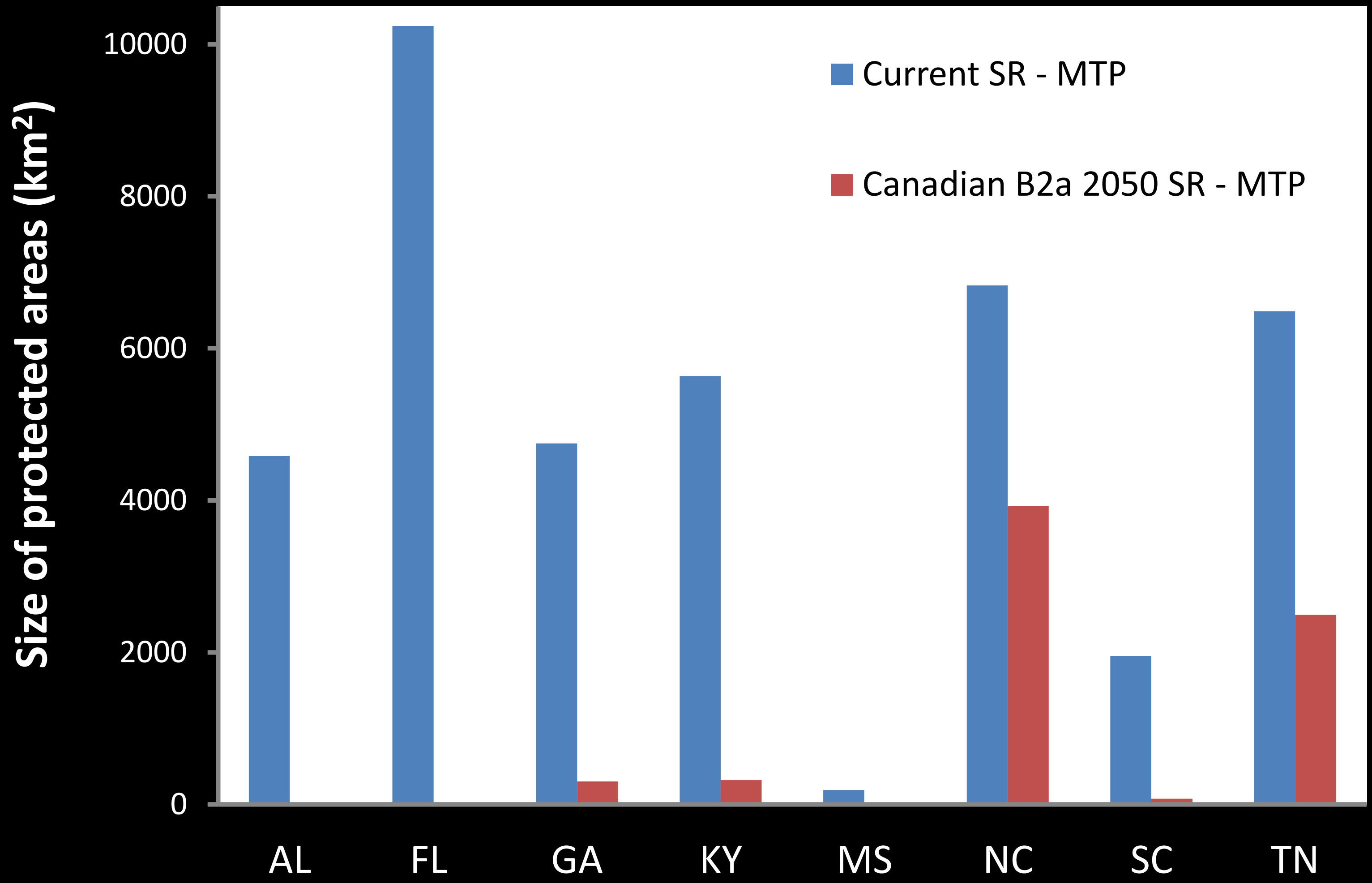
Climate change and conservation planning

- Downscaled models with ecologically-relevant predictors are essential
- Importance of uncertainty is recognized, but it is often considered difficult to incorporate
- Developing ensembled projections that distill uncertainty down to a few synthetic products will make it more user friendly

Selecting a SDM approach



Conservation opportunities MTP threshold (liberal)



Planning for climate change

- Forecasting species responses to climate change is a necessary evil.

  Necessary because:

  - Provide stakeholders with planning tools when developing action plans.
    - Identify species that might shift status unexpectedly.
    - Help prioritize allocation of resources, management activities, and areas.

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- Forecasting species responses to climate change is a necessary evil.

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    - Identify species that might shift status unexpectedly.
    - Help prioritize allocation of resources, management activities, and areas.

  Evil because:

  - Fraught with assumptions and uncertainties that make forecasts challenging.
  - "Alternative models can be so variable as to compromise their usefulness for guiding decisions."

Building a correlative model

- Collected locality data from HerpNet and state-managed collections
- Background points limited to buffered species range
- Selected 12 ecologically relevant bioclim variables
- Used Maxent to construct habitat suitability models
- Examined species richness and individual species projections
  - A2a and B2a scenarios x 2 GCMs = 4 outcomes
  - Examined 3 thresholds per outcome
  - Generated ensembles of threshold and GCM