Modeling Hydrologic Alteration and Ecosystem Response to Climate Change in the Southeastern U.S.

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NWQMC
Portland, OR
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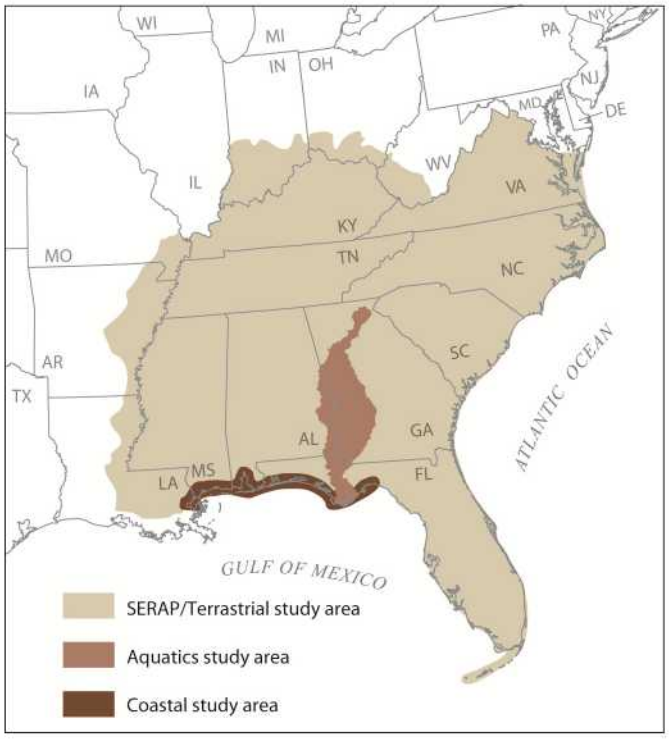
U.S. Department of the Interior
U.S. Geological Survey

Southeast Regional Assessment Project

SERAP is a pilot study for the USGS NCCWSC and CSC that integrates climate change, land-use change, and sea-level rise projections with habitat and species response models to assess future climate effects on terrestrial and aquatic species

- Regional Climate Change Projections
- Coastal Assessment
- Terrestrial Assessment
- Aquatic Assessment
- Optimal Conservation Strategies



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Project Team Members

Regionally Downscaled Probabilistic Climate Change Projections—Adam Terando, Murali Haran, Katharine Hayhoe, Klaus Keller

Integrated Coastal Assessment—Nathaniel Plant, Glenn Gutenspergen, Van Wilson, Cindy Thatcher, Alexa McKerrow, Adam Terando, Scott Wilson, Rob Thieler, Peter Howd

Integrated Terrestrial Assessment—Alexa McKerrow, Adam Terando, Steve Williams, Jamie Callazo, Barry Grand, Jim Nichols, Andrew Royle, John Sauer

Integrated Aquatic Assessment—Jim Peterson, Lauren Hay, Kenneth Odom, Brian Hughes, Robb Jacobson, John Jones, Mary Freeman, Jacob LaFontaine, Carrie Elliot, Steve Markstrom, Jeff Riley

Optimal Conservation Strategies—Barry Grand, Max Post van der Burg, Kevin Kliner, Allison Moody,

Dissemination of High-Resolution National Climate Change Dataset—Jamie Collazo, Lauren Hay, Katharine Hayhoe, Nathaniel Booth, Adam Terando, Jason Hopkins, Roland Viger

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Basic Questions Addressed by SERAP

What effects will climate changes have on terrestrial and aquatic ecosystems?

- What are the likely impacts of future sea level rise on coastal habitats?
- How will stream flow changes alter habitat conditions necessary for healthy fish and mussel populations?
- Will changes in vegetation and land use affect terrestrial habitats for bird populations?

What can we do to avoid the worst effects of climate change?

- What are the causes and degree of uncertainty in forecasts of climate change and responses?
- What are the benefits and effectiveness of adaptation strategies?

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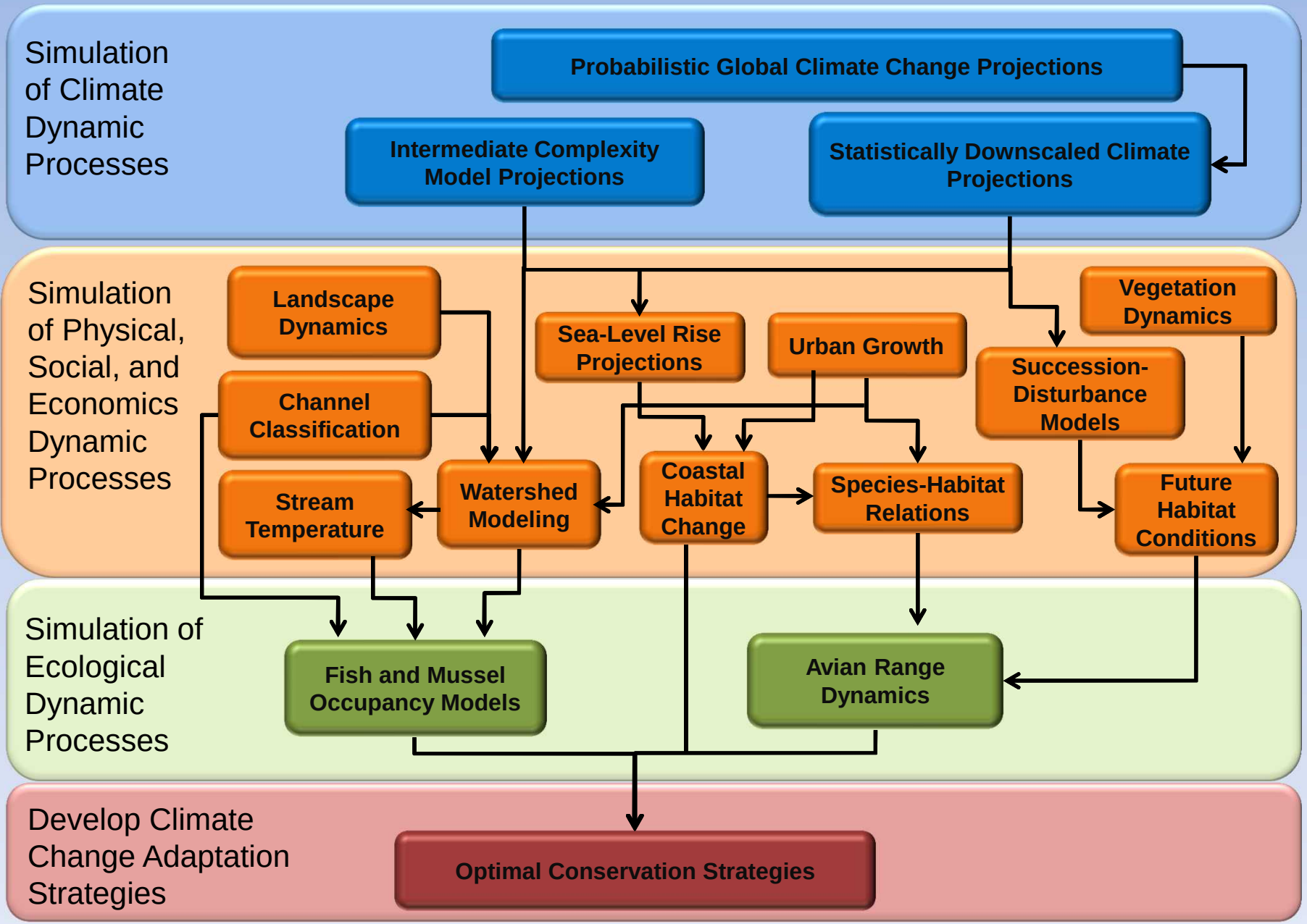
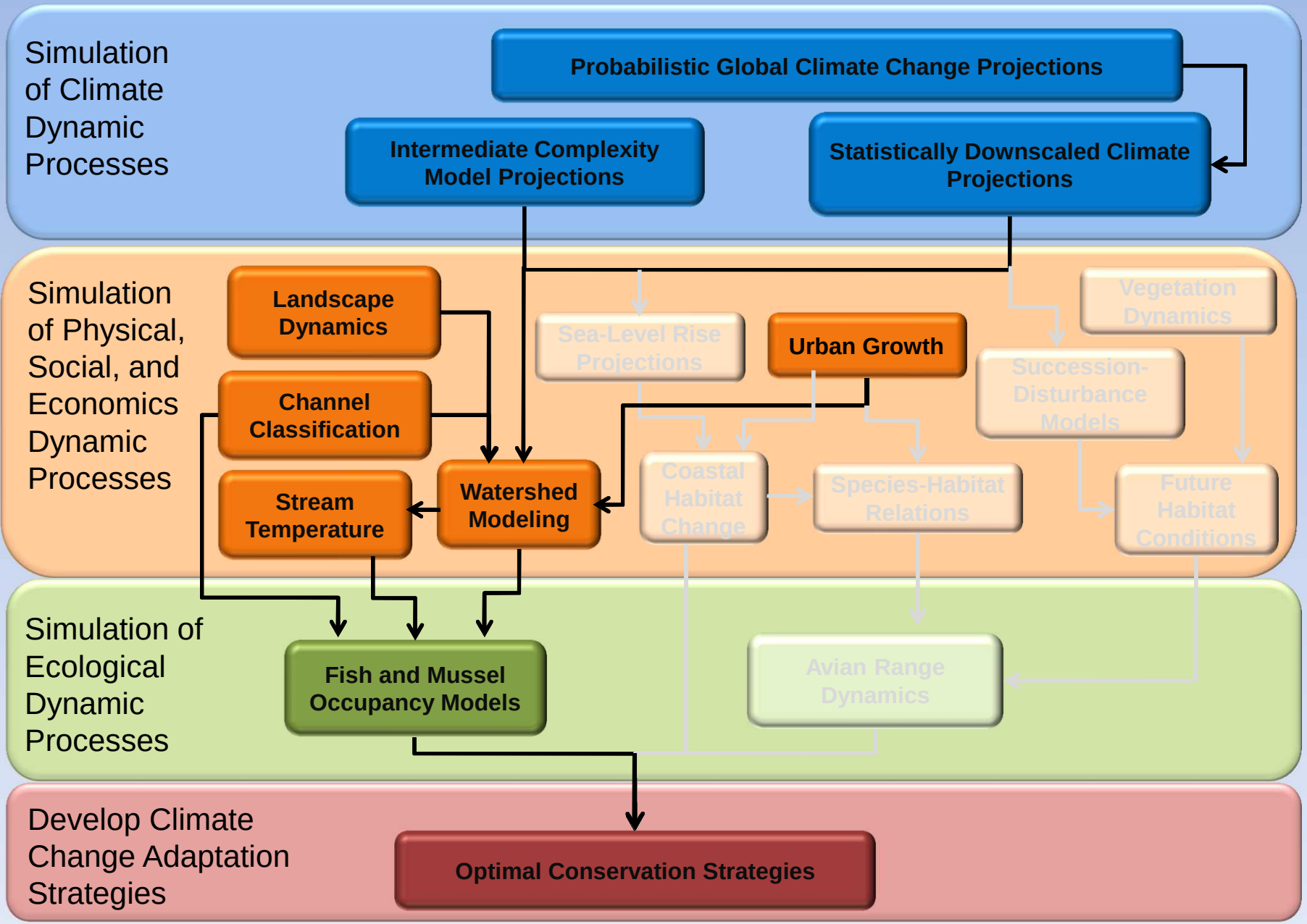
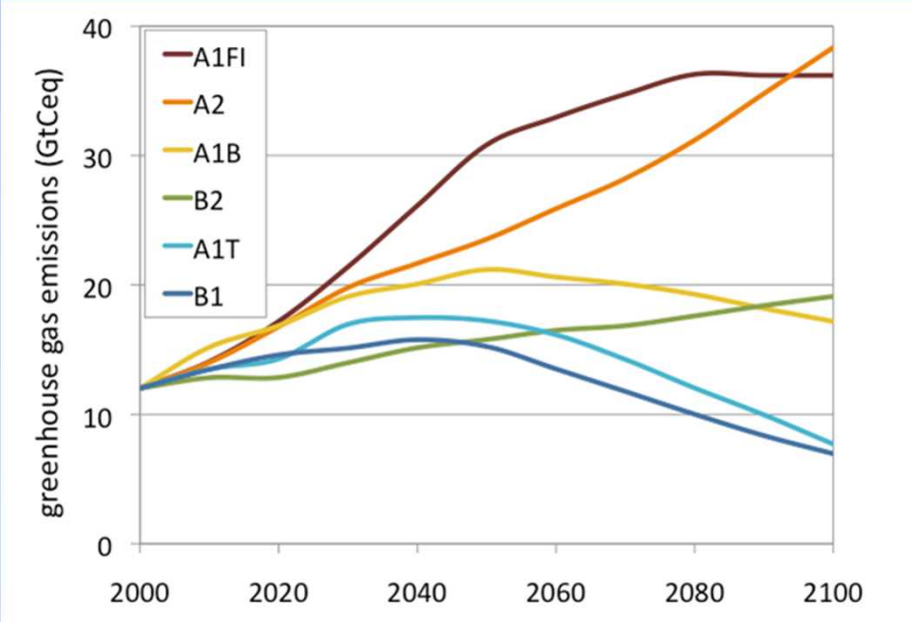
SERAP COMPONENTS DATA FLOW



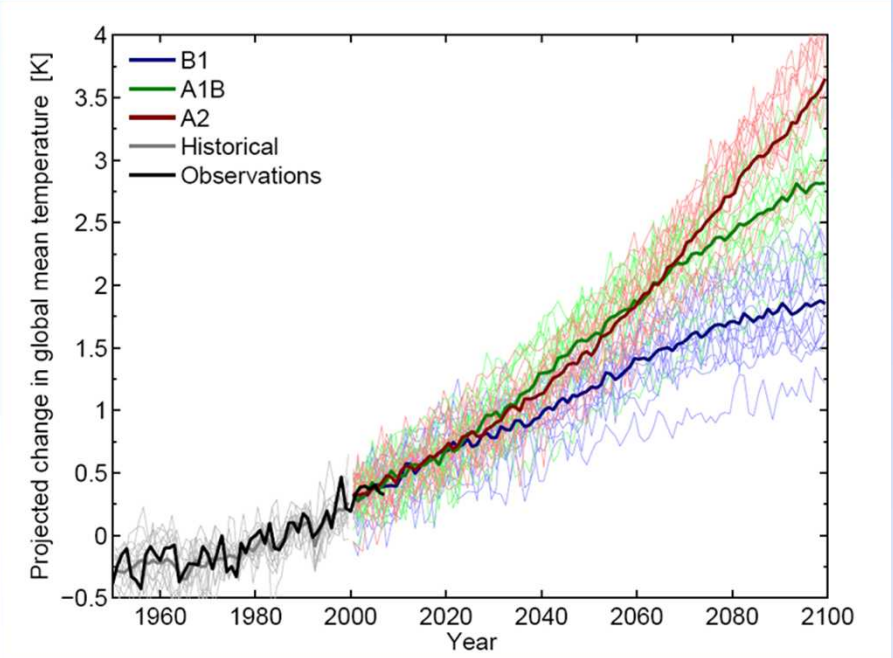
SERAP COMPONENTS DATA FLOW



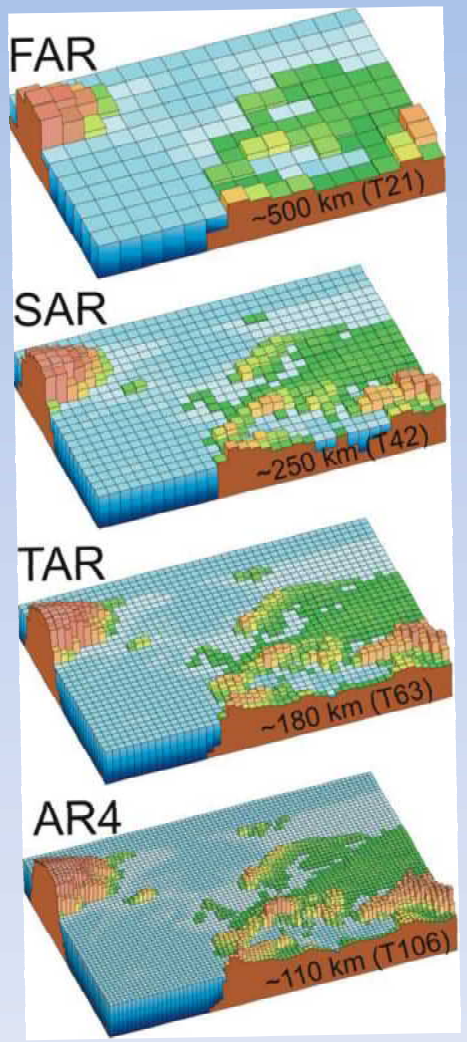
Climate Scenarios Simulated



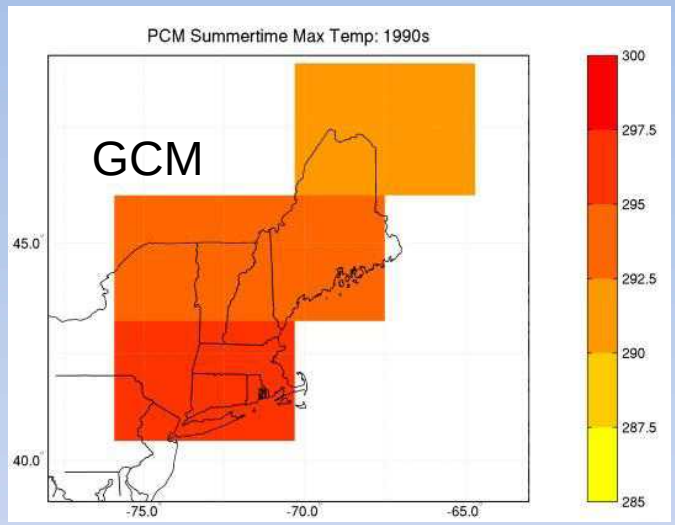
Currently using only two emission scenarios representing worst case and best case scenarios.

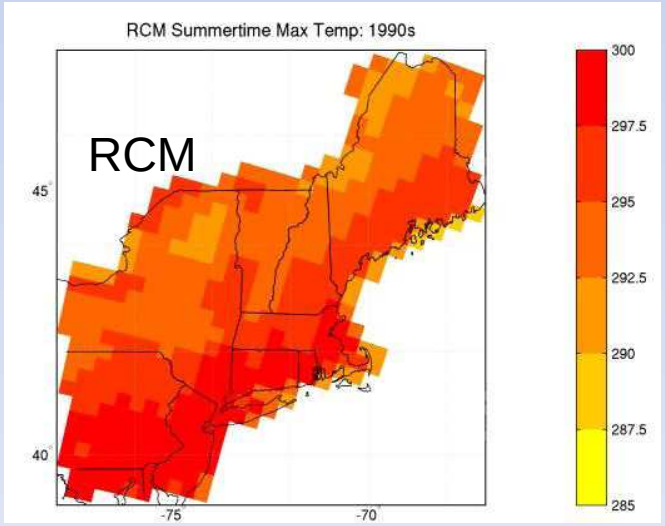


Regional Climate Downscaling



Present





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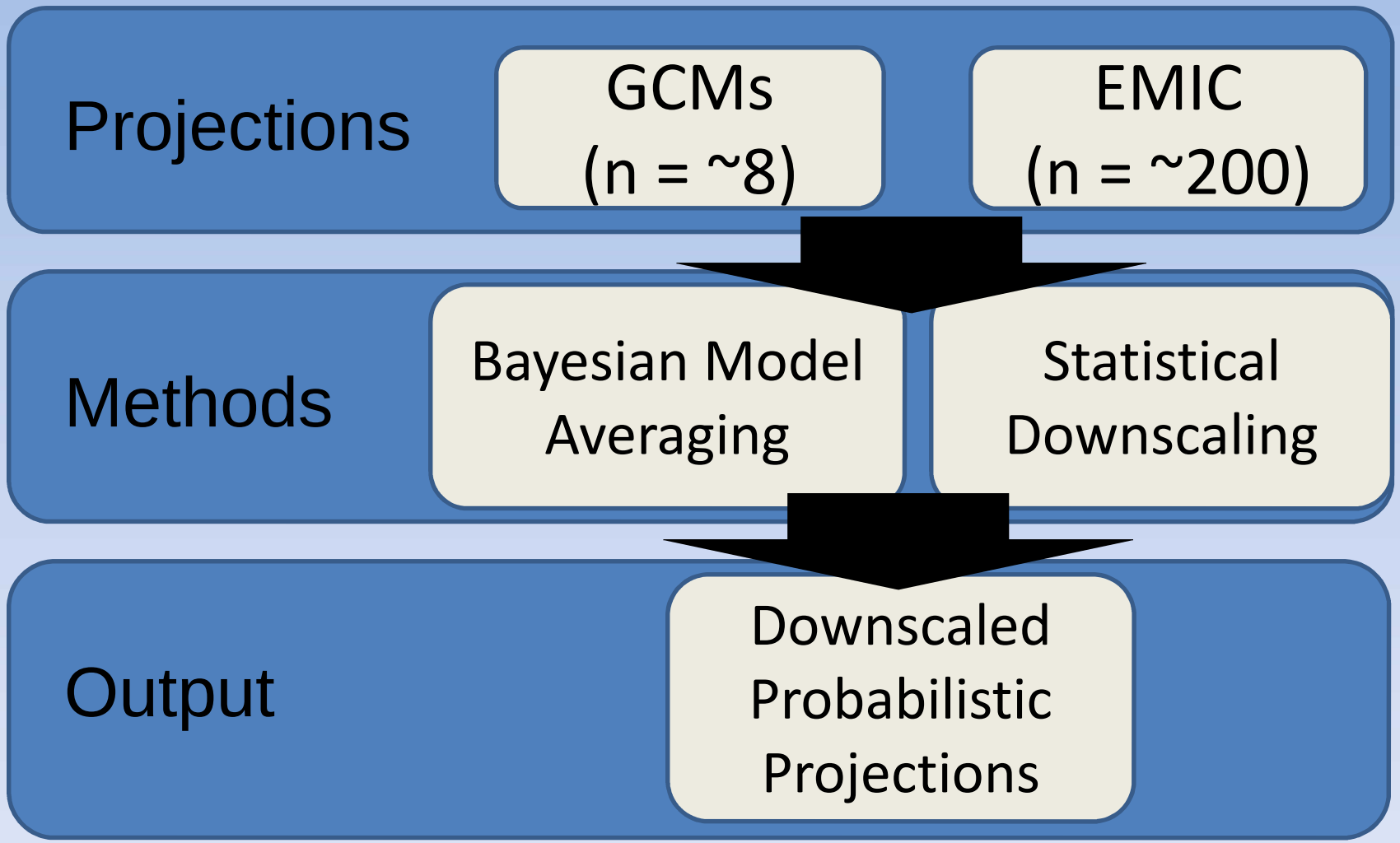
Regional Climate Change Projections

Climate Models



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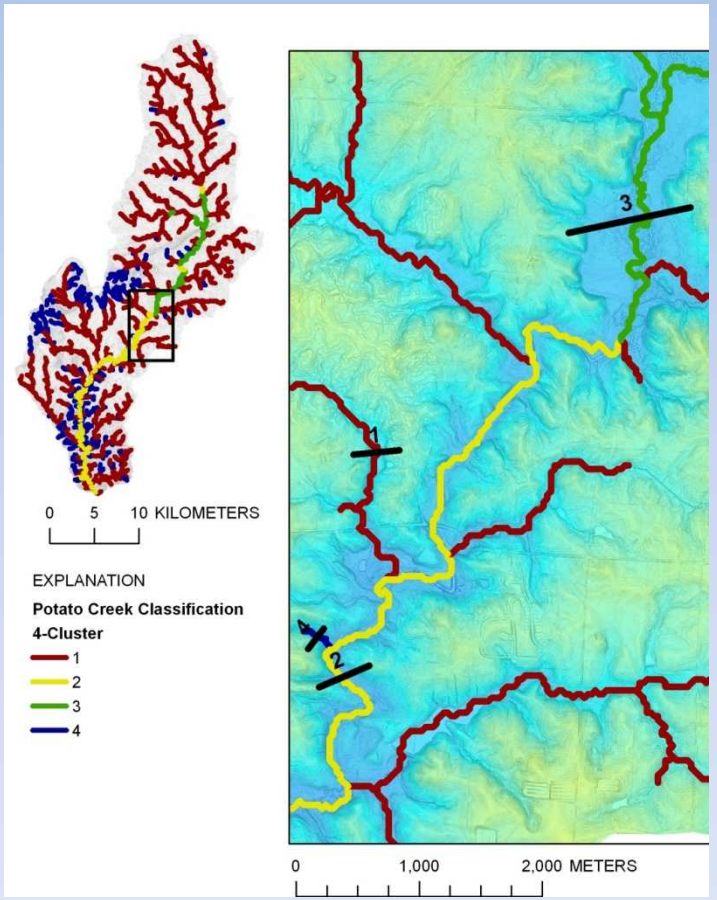
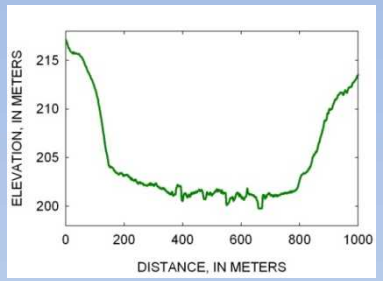
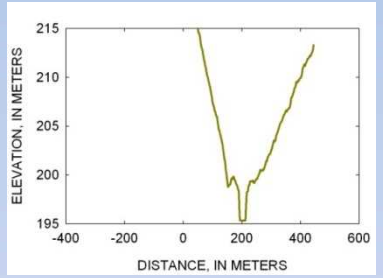
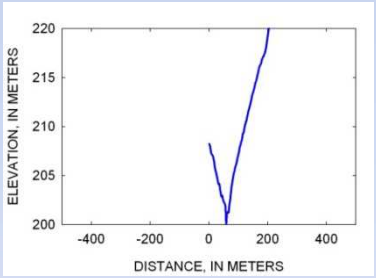
Aquatics Assessment - Stream Classification

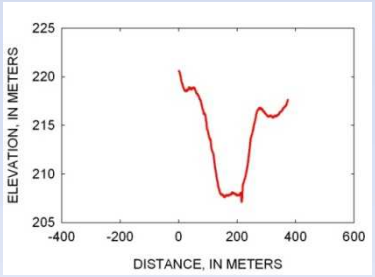
Four-cluster multivariate channel classification of the Potato Creek stream network using LiDAR for validation

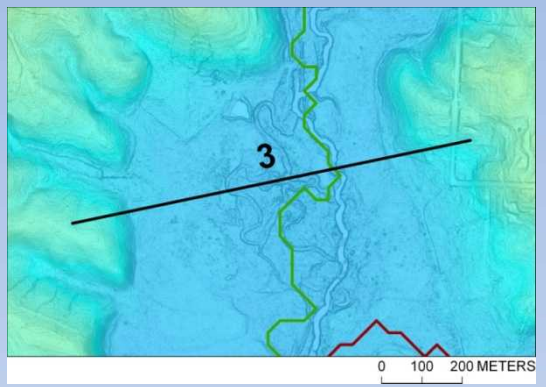


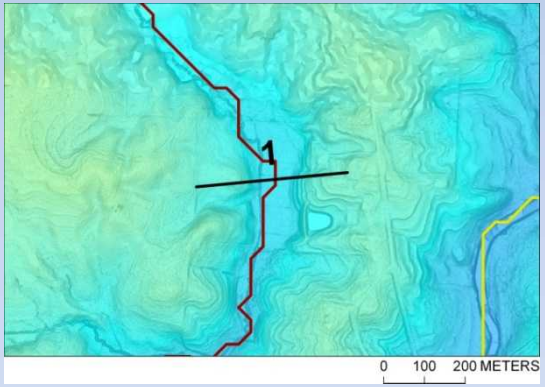


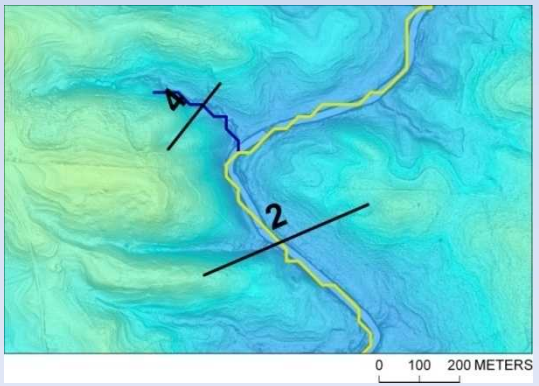






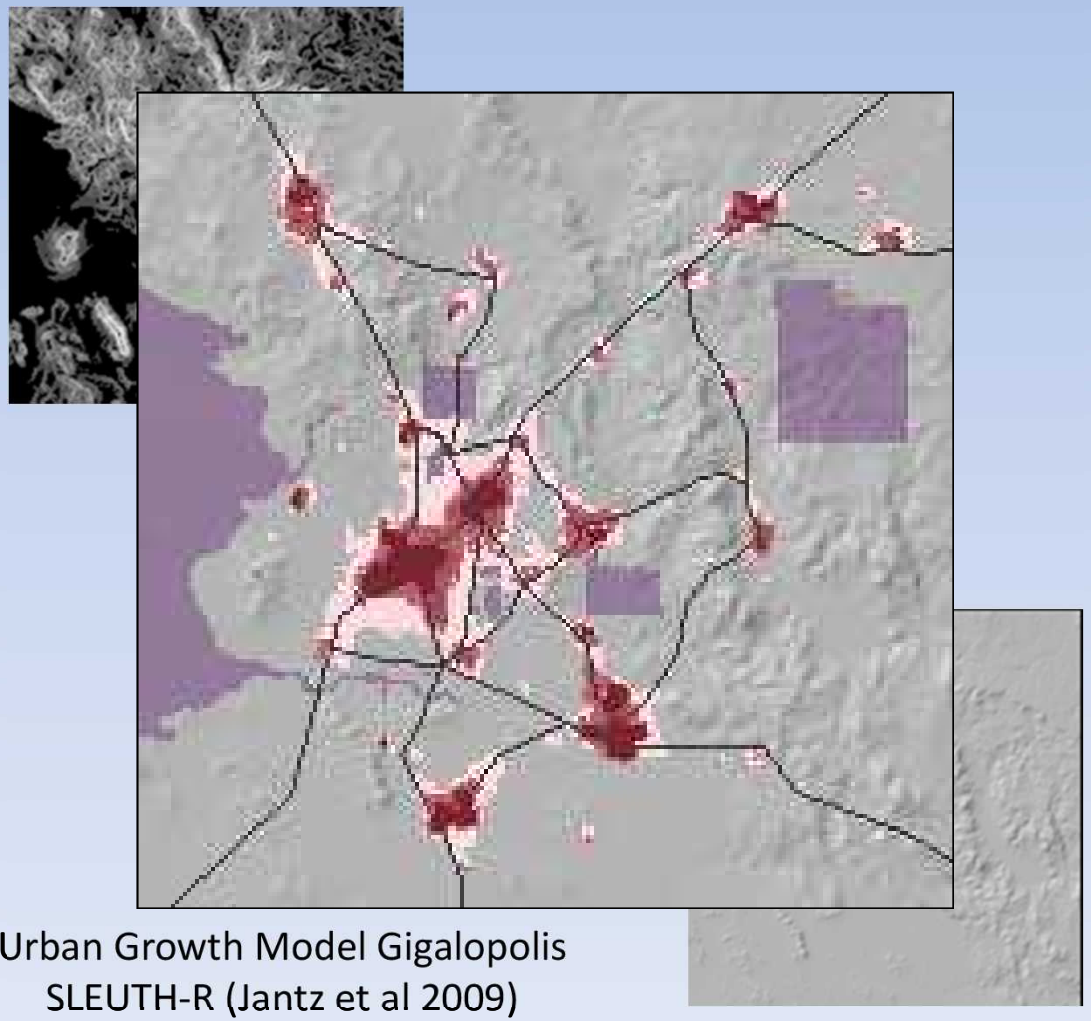






Landscape Dynamics - Urban Growth

- **S**lope,
- **L**and Cover,
- **E**xclusion,
- **U**rbanization,
- **T**ransportation, and
- **H**illshade



Urban Growth Model Gigalopolis
SLEUTH-R (Jantz et al 2009)

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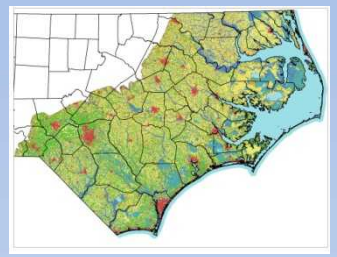
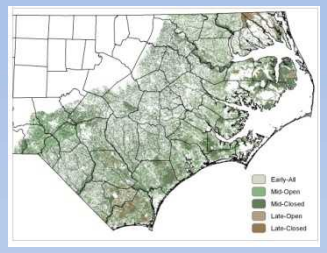
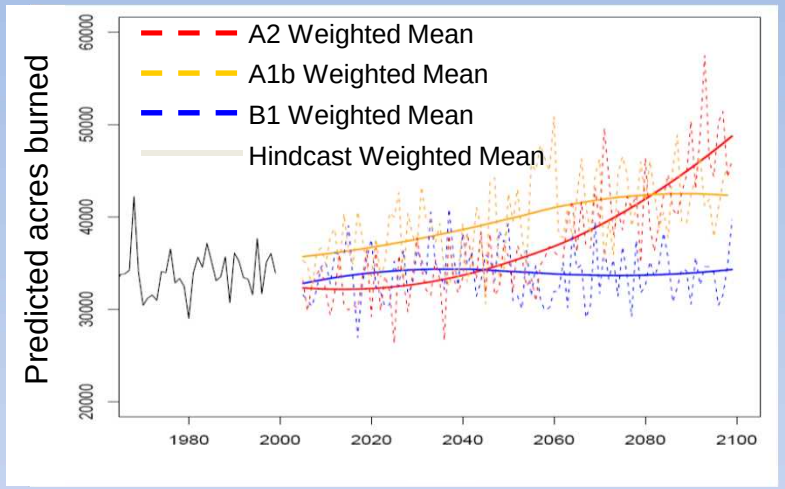
Landscape Dynamics - Vegetation

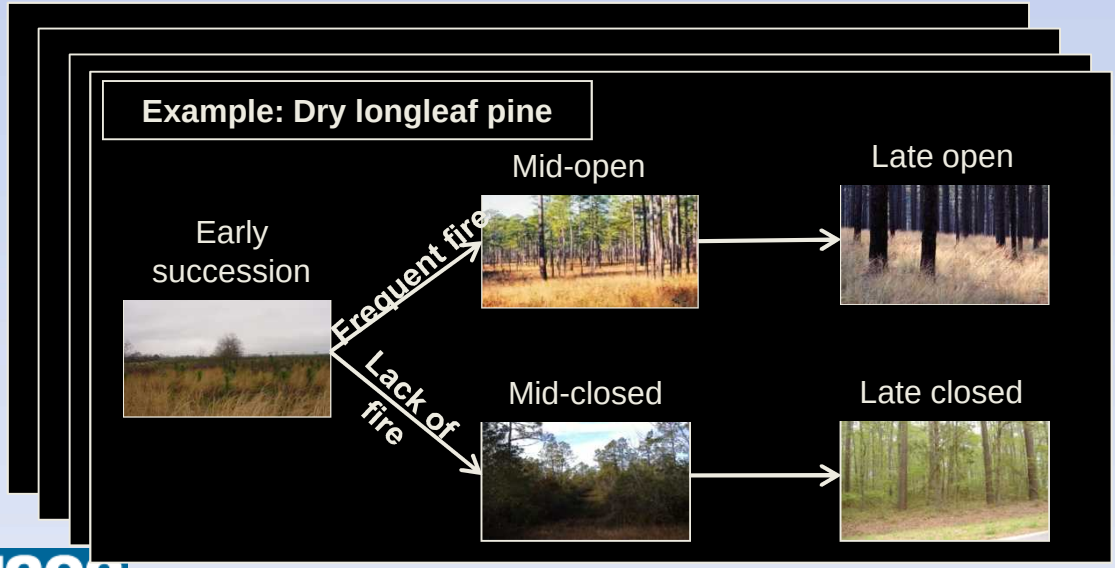


Habitat types



Stage and structure





Future landscape conditions
Input for habitat distribution models: priority species

Habitat-specific succession and disturbance models

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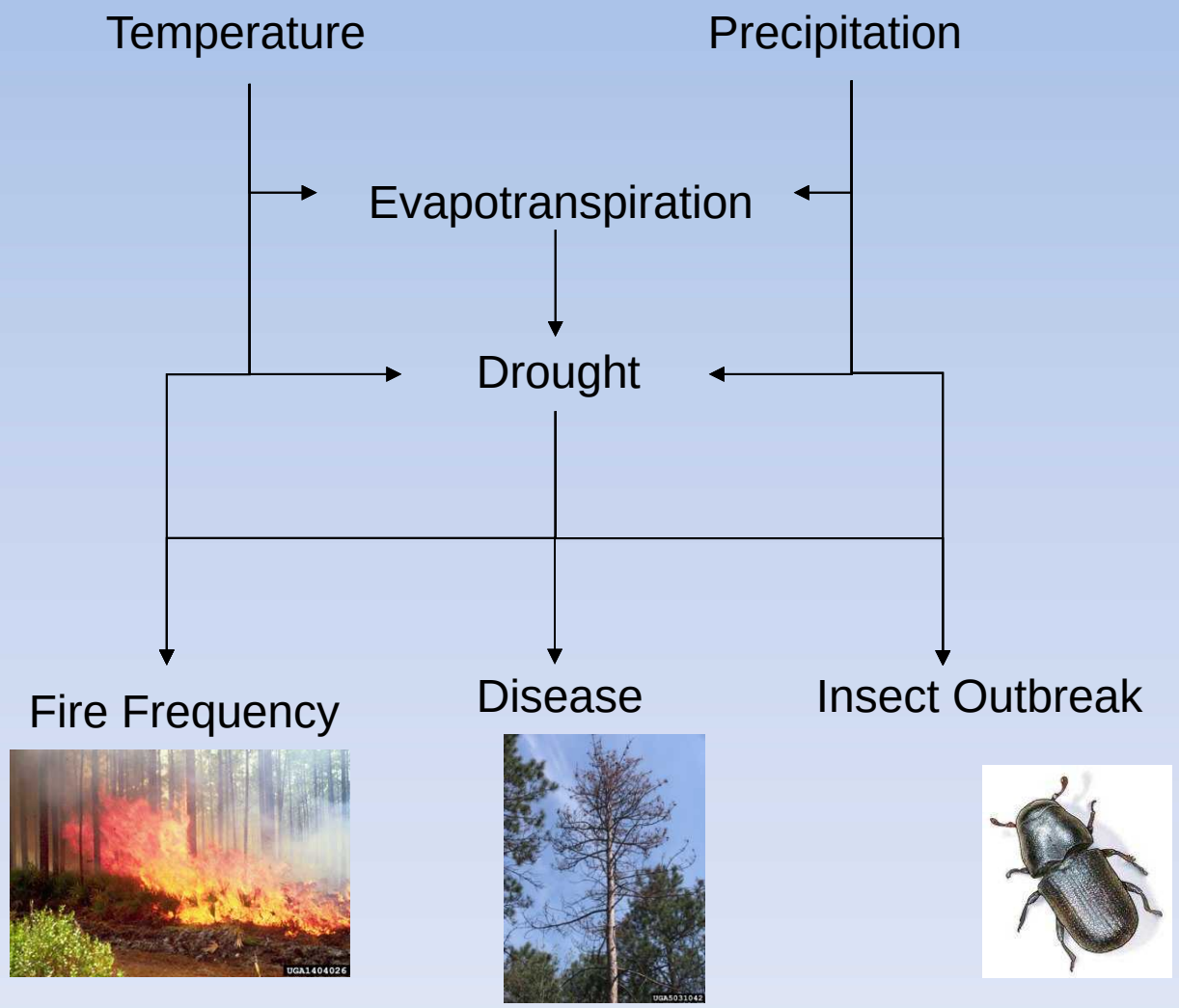
Landscape Dynamics – Disturbance



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Hydrologic Modeling - PRMS

- PRMS is being used to develop coarse- and fine-scale watershed models
- Both coarse and fine scale models will incorporate probabilistic downscaled climate change projections to predict daily stream-flow through 2100

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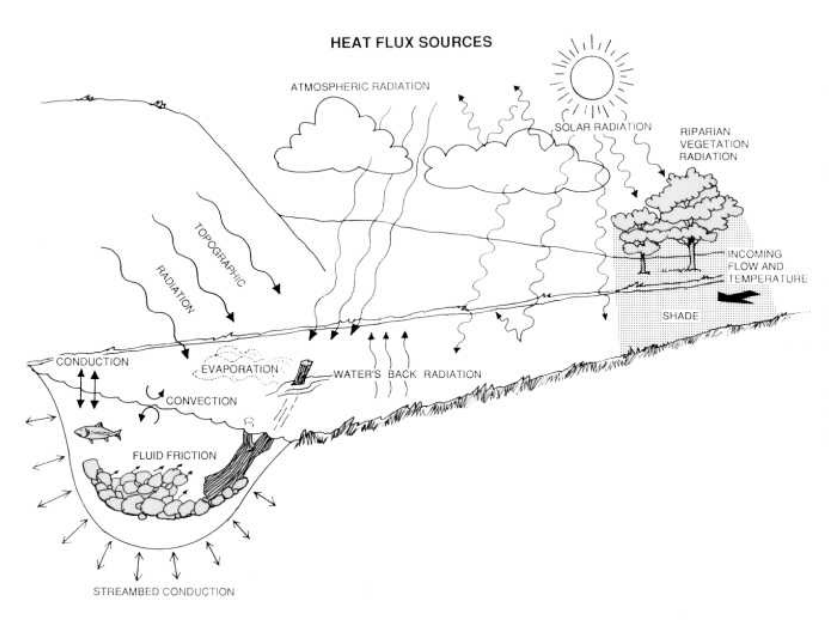
Simulating Water Quality – PRMS/SNTEMP



- Stream temperature is being simulated using a coupled PRMS/SNTemp model
- SNTemp developed by USFWS and USGS to predict how changes in flow regime affect water temperature
- Uses PRMS output parameters and physical channel characteristics
- Daily minimum and maximum temperatures through 2100 will be predicted

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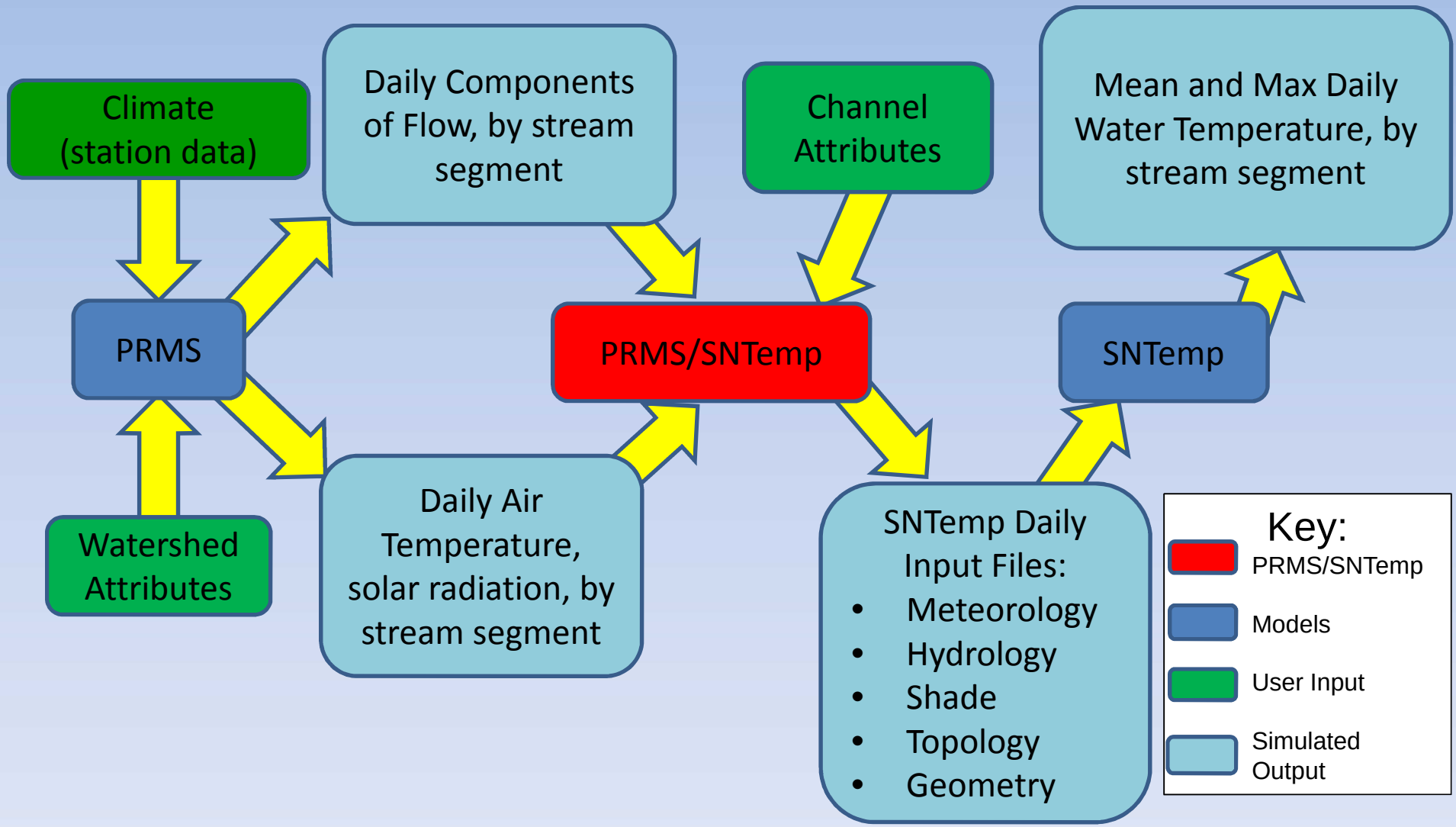
Coupled PRMS/SNTEMP



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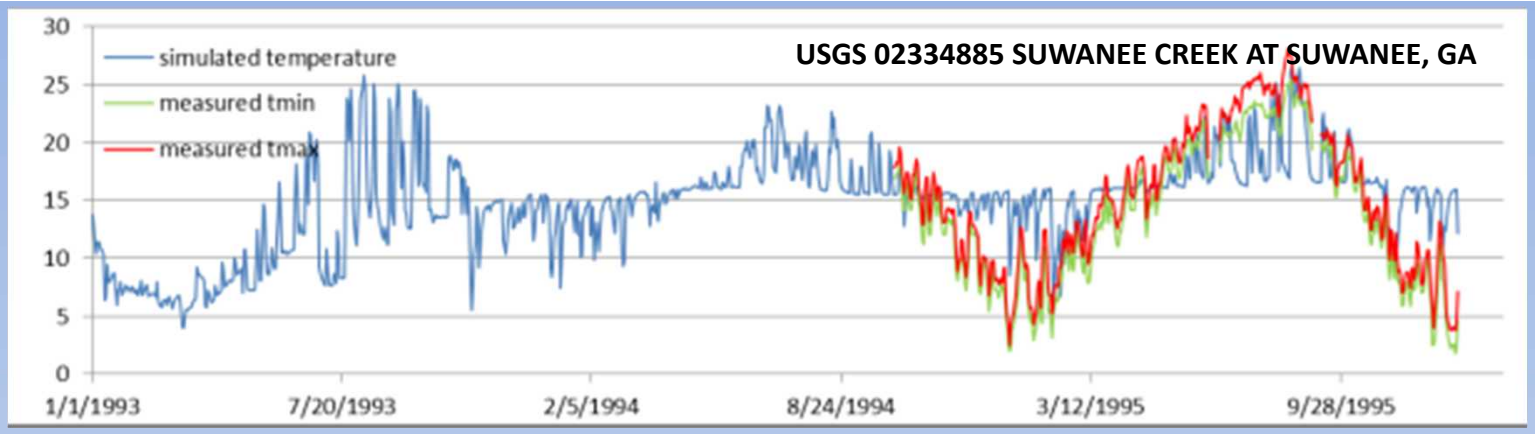

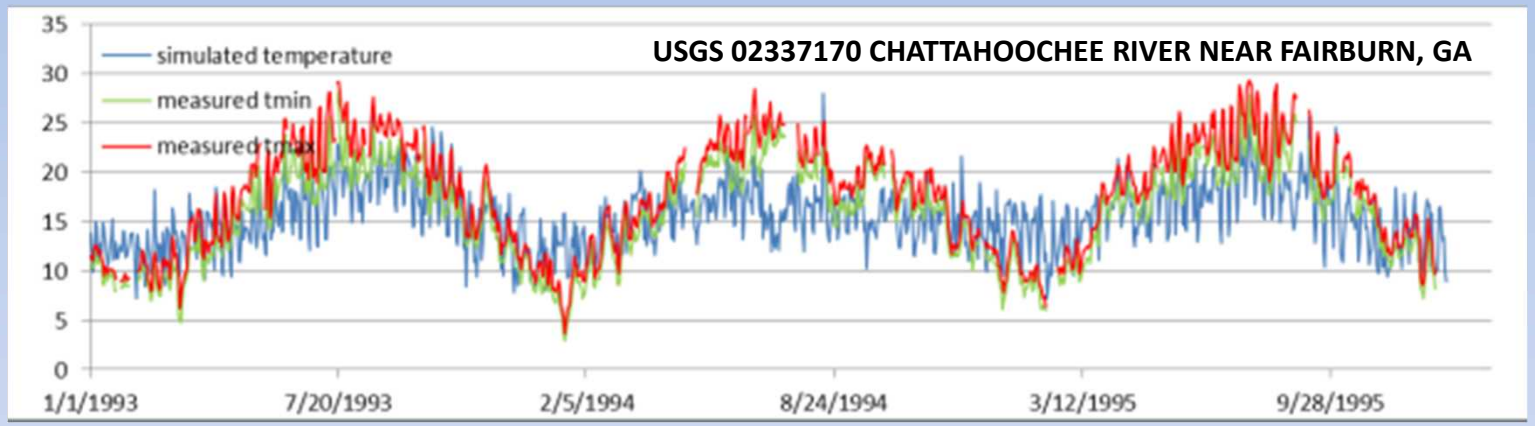

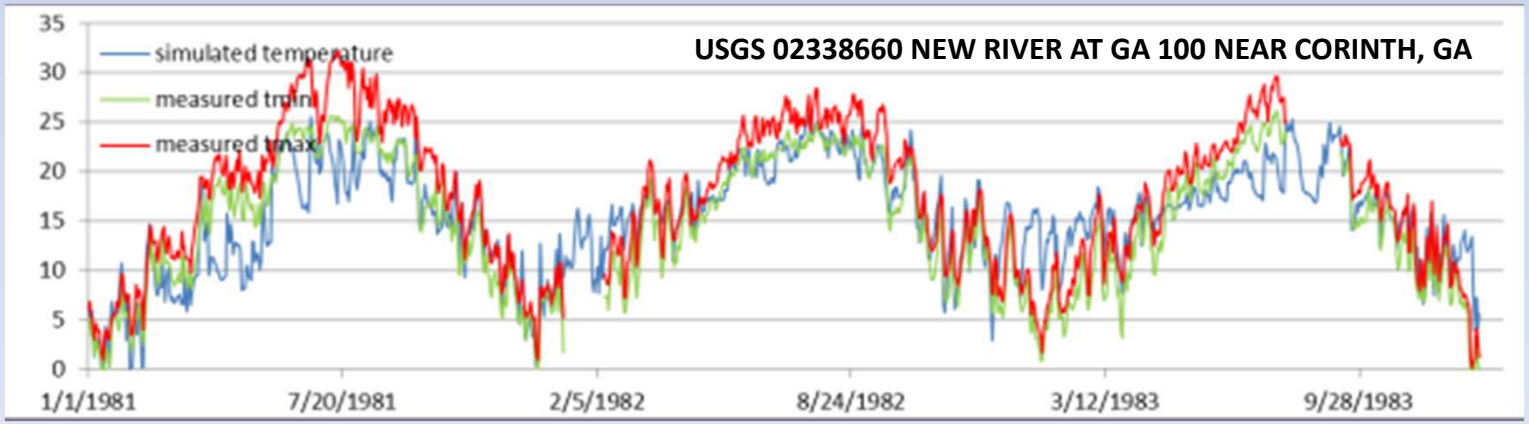

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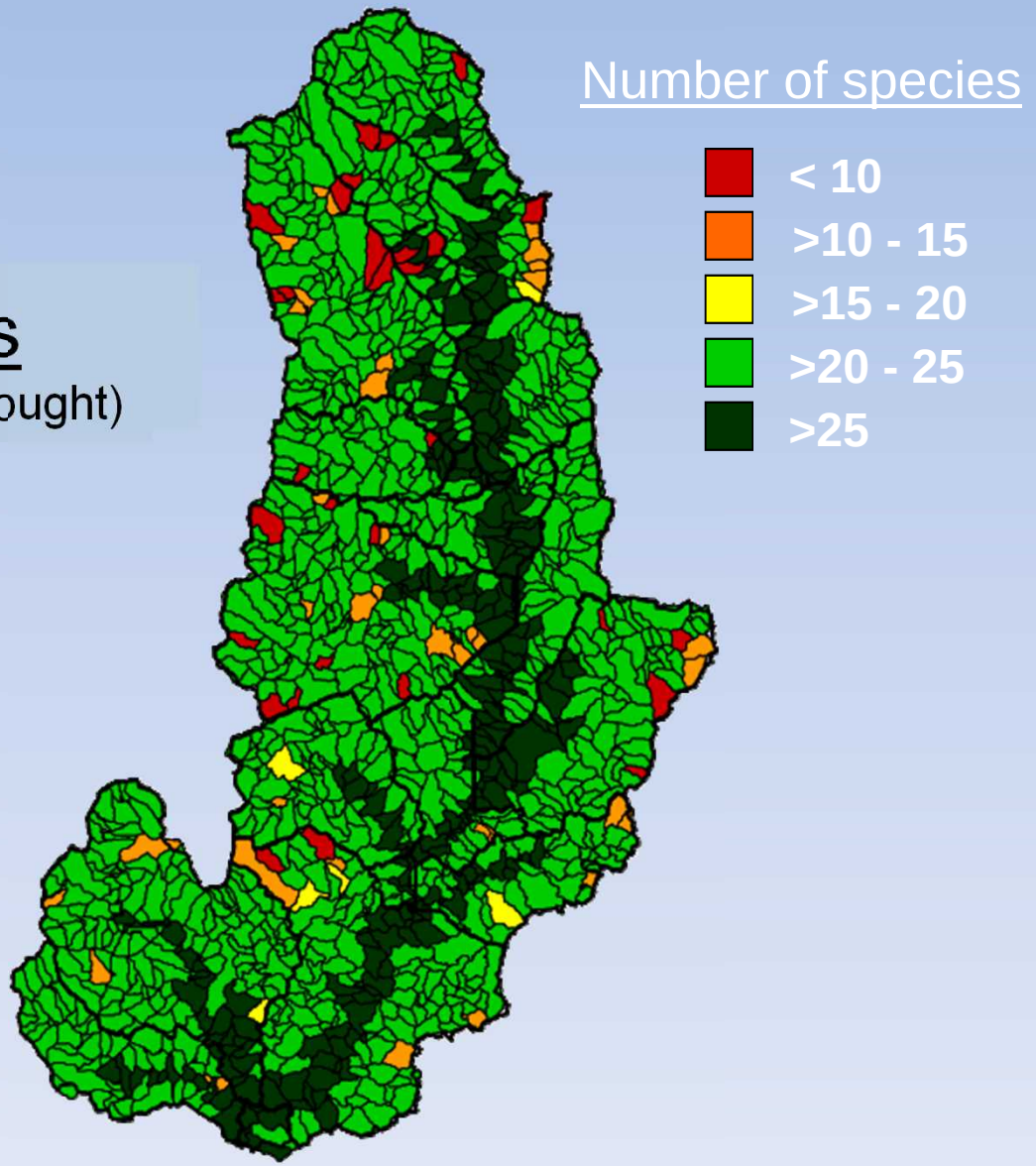
Ecological Modeling - Fish and mussel occupancy

- Empirical multi-state, multi-season occupancy model.
- Models estimate the occupancy (presence) of fish species in a stream segment (defined as a section of stream from tributary junction to tributary junction).
- The dynamics of the populations (colonization, reproduction, extinction) are modeled as a function of geomorphic channel characteristics, stream size, seasonal discharge statistic, and stream temperature.
- Specific species characteristics (preferred habitat, locomotion mode, body size, spawning duration, etc.) are used in models.

Integrated Aquatics Assessment

Modeling Fish Occupancy



Composite estimates

Fish species richness 2004 (post- drought)

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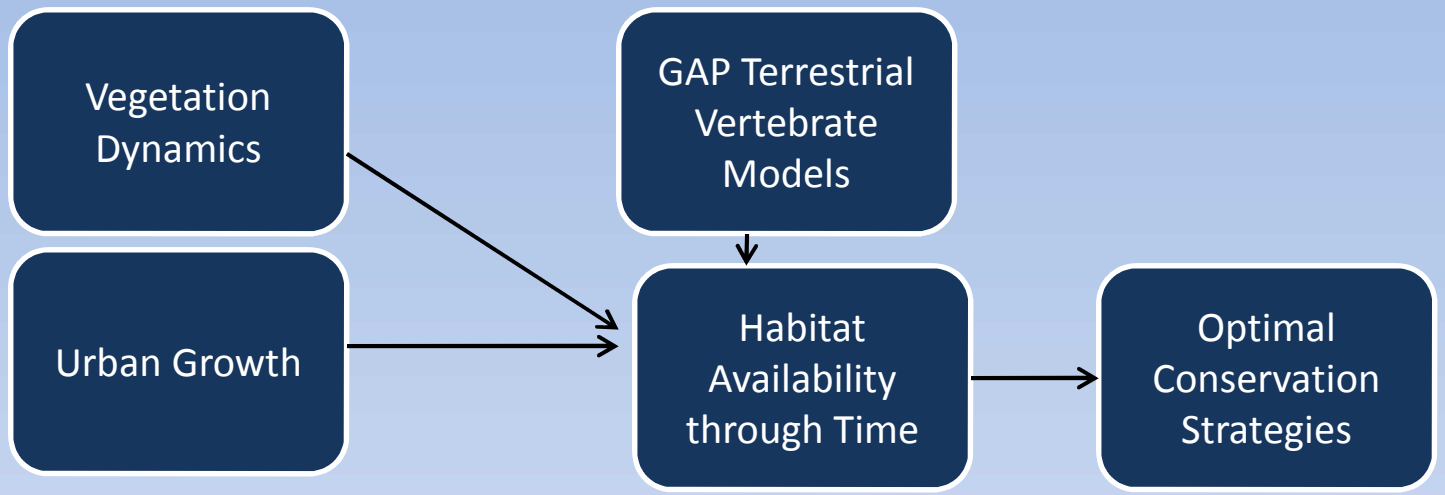
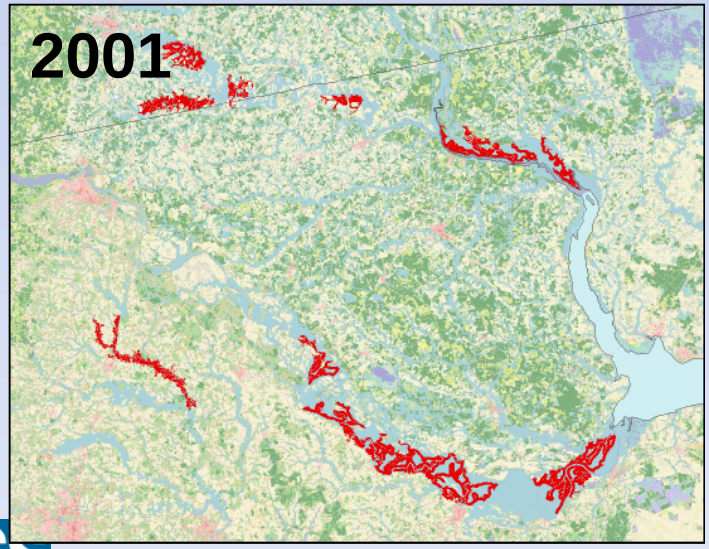
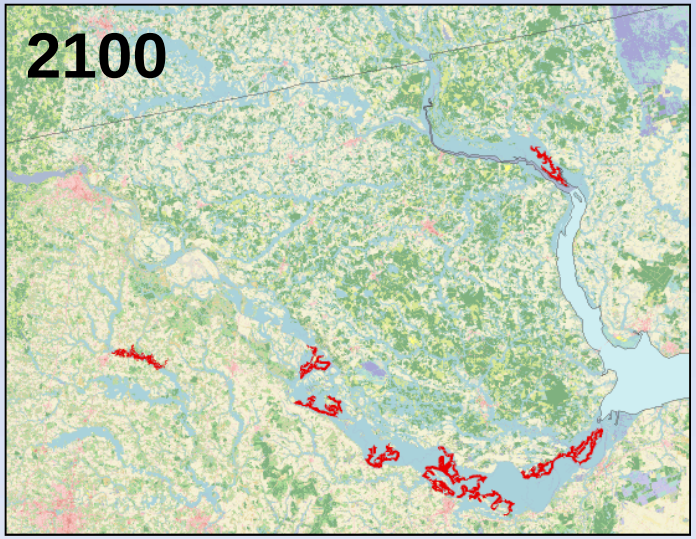
Integrated Terrestrial Assessment

Habitat models for priority species



Cerulean Warbler
Dendroica cerulea





Suitable habitat

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Questions?

- What kinds of water quality parameters can be predicted under future climate scenarios with any certainty?
- Which of these are the most relevant for ecosystem and human health?

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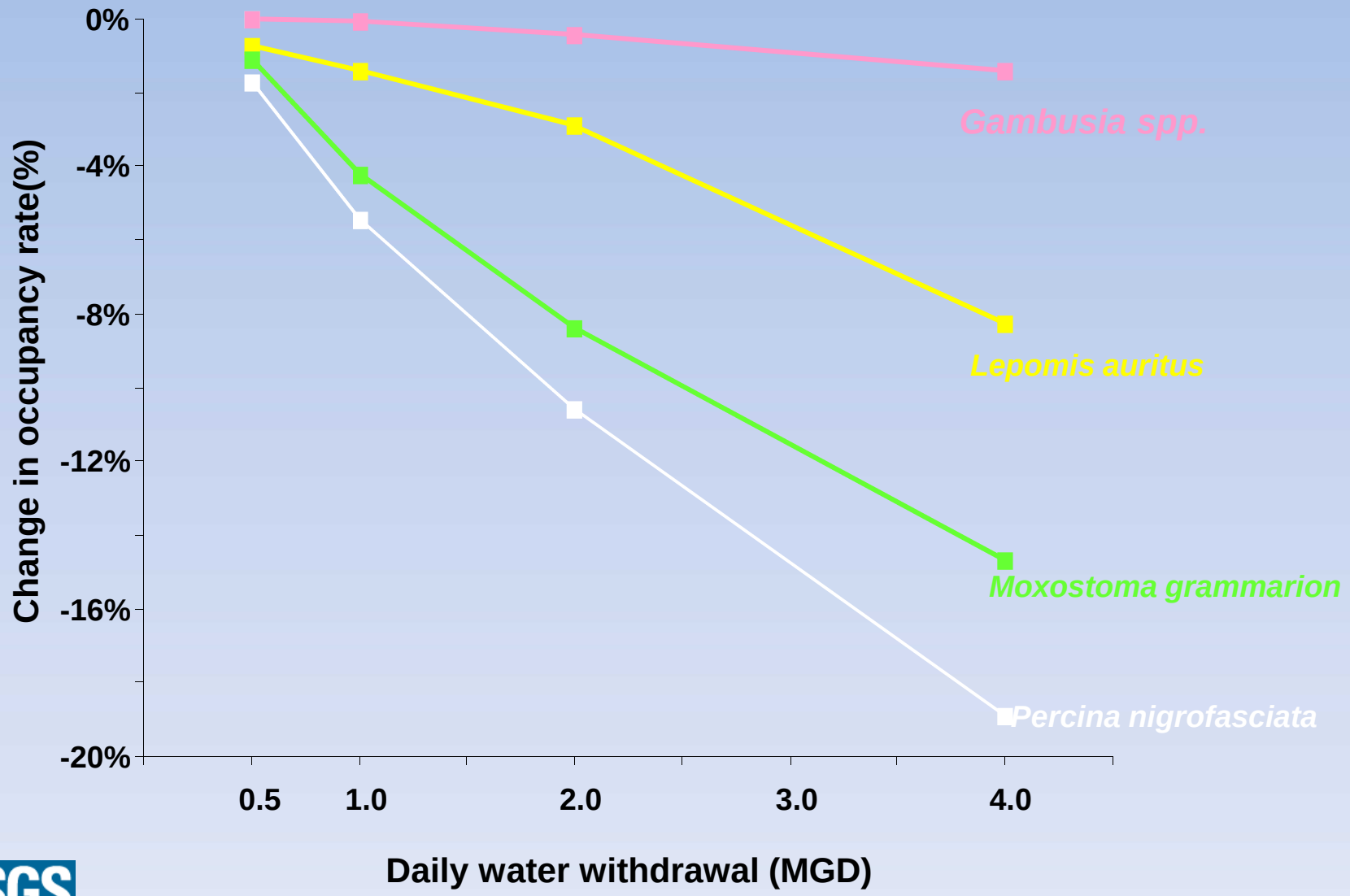
SNTEMP

- Developed by USFWS and USGS to predict how changes in flow regime affect water temperatures
- Uses output parameters from PRMS and physical channel characteristics

Composite species-specific estimates



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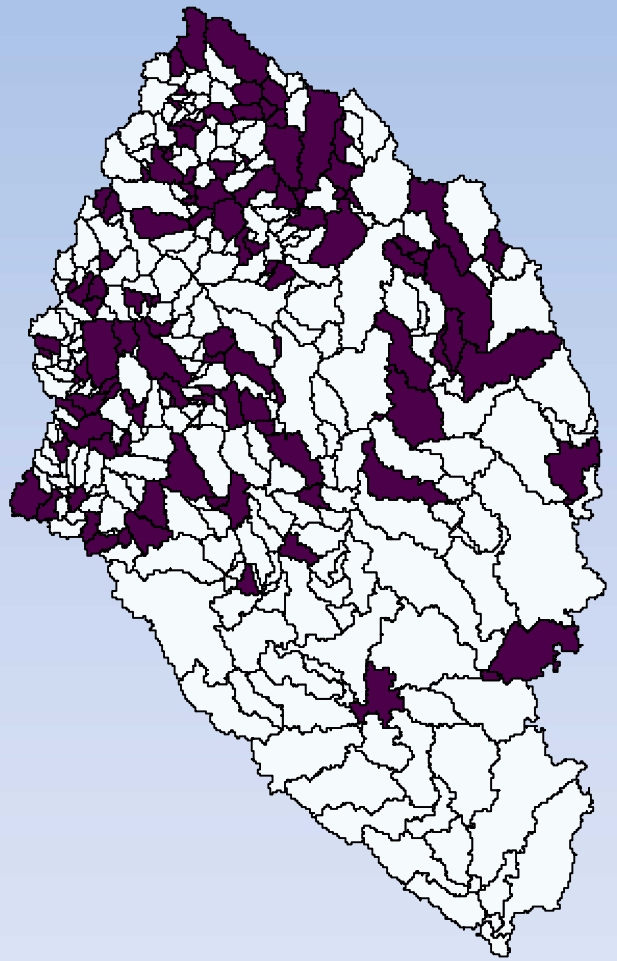
Climate Adaptation Strategies
Final Products

- Spatially explicit decision support tool to allow management agencies to prioritize conservation actions based on a range of predicted future habitat conditions, including:
  - Portfolio of best conservation actions
  - Locations of sites with greatest marginal gain
  - Incorporates land-use projections, climate change projections, and vegetation succession



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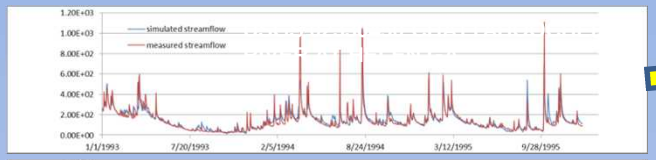

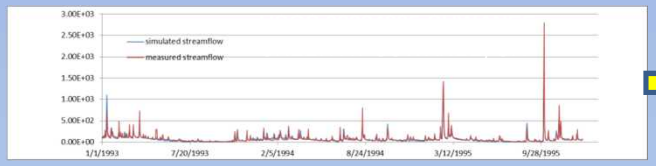

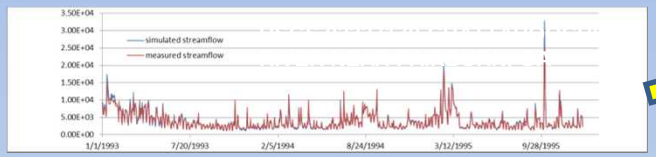

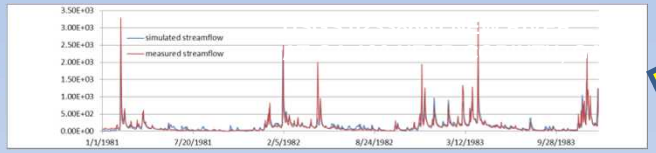

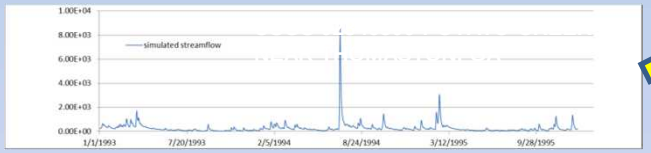

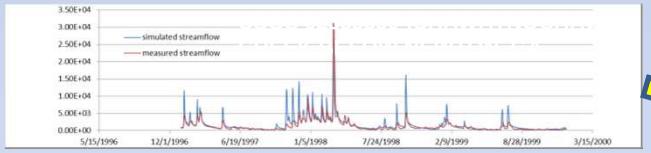

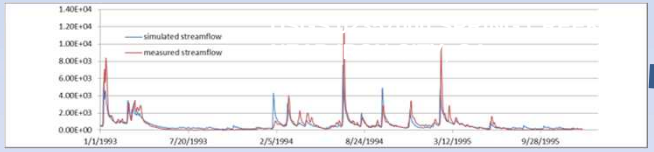

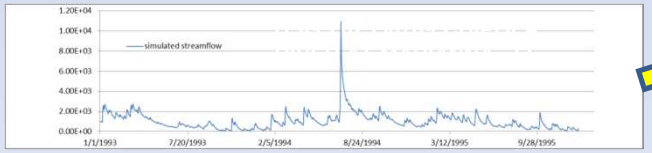

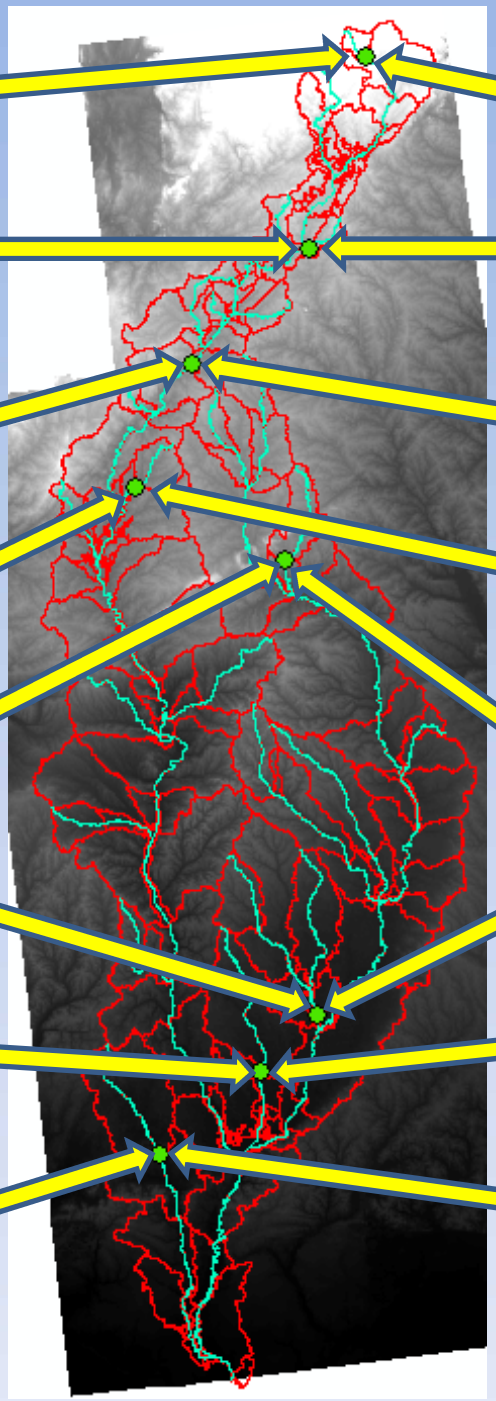

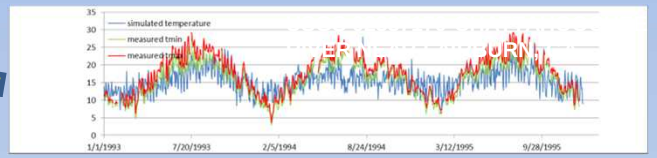

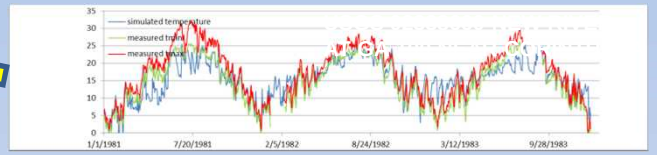

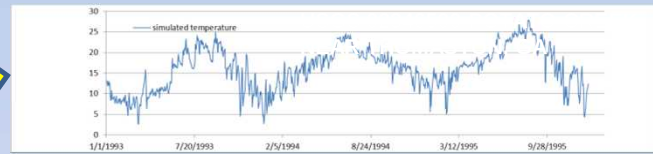

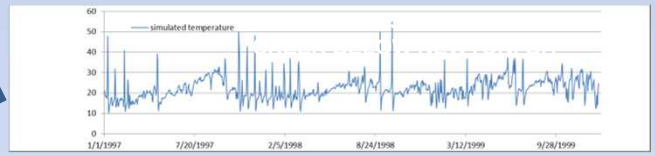

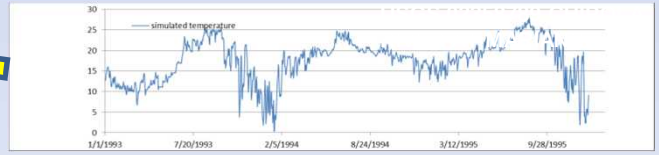

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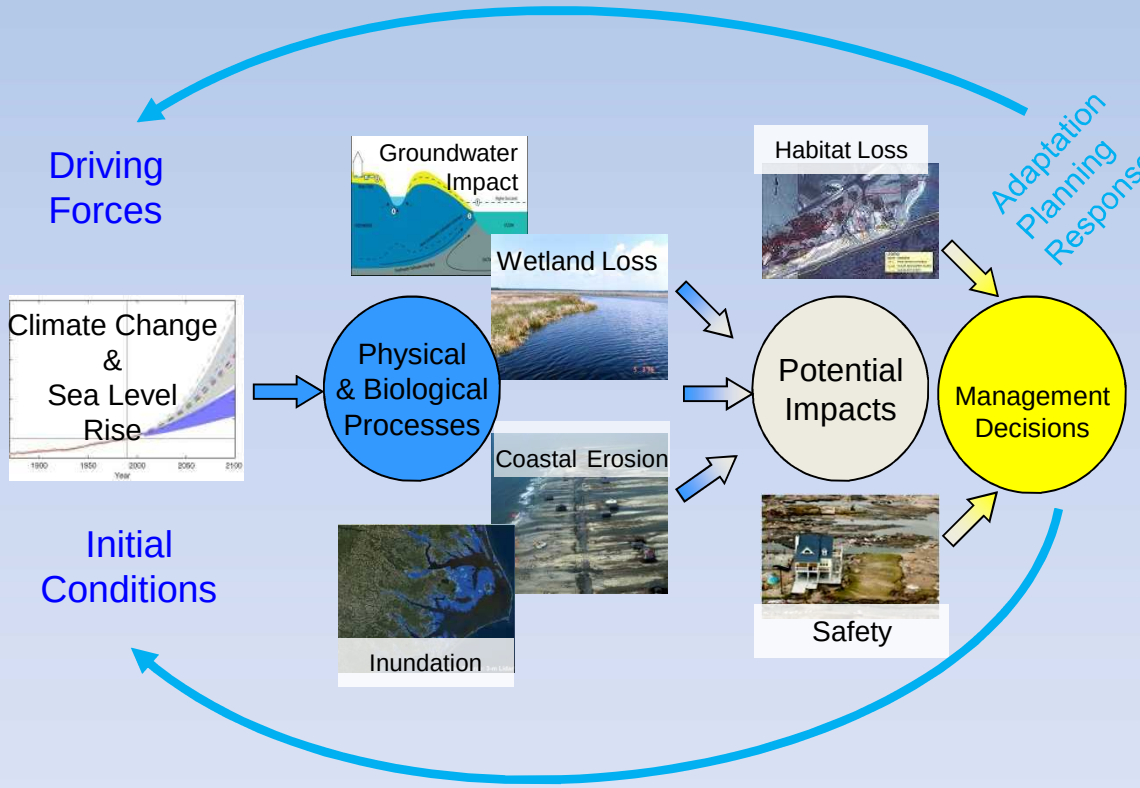
Integrated Coastal Assessment

Coastal Assessment

Coastal processes such as sea level rise, subsidence, and erosion will be modeled to support coastal resource management

- Develop Bayesian statistical framework for predicting coastal erosion and inundation
- Assess affects of sea level rise on coastal ecosystems and wildlife
- Direct observations
- Develop visualization tools for resource managers



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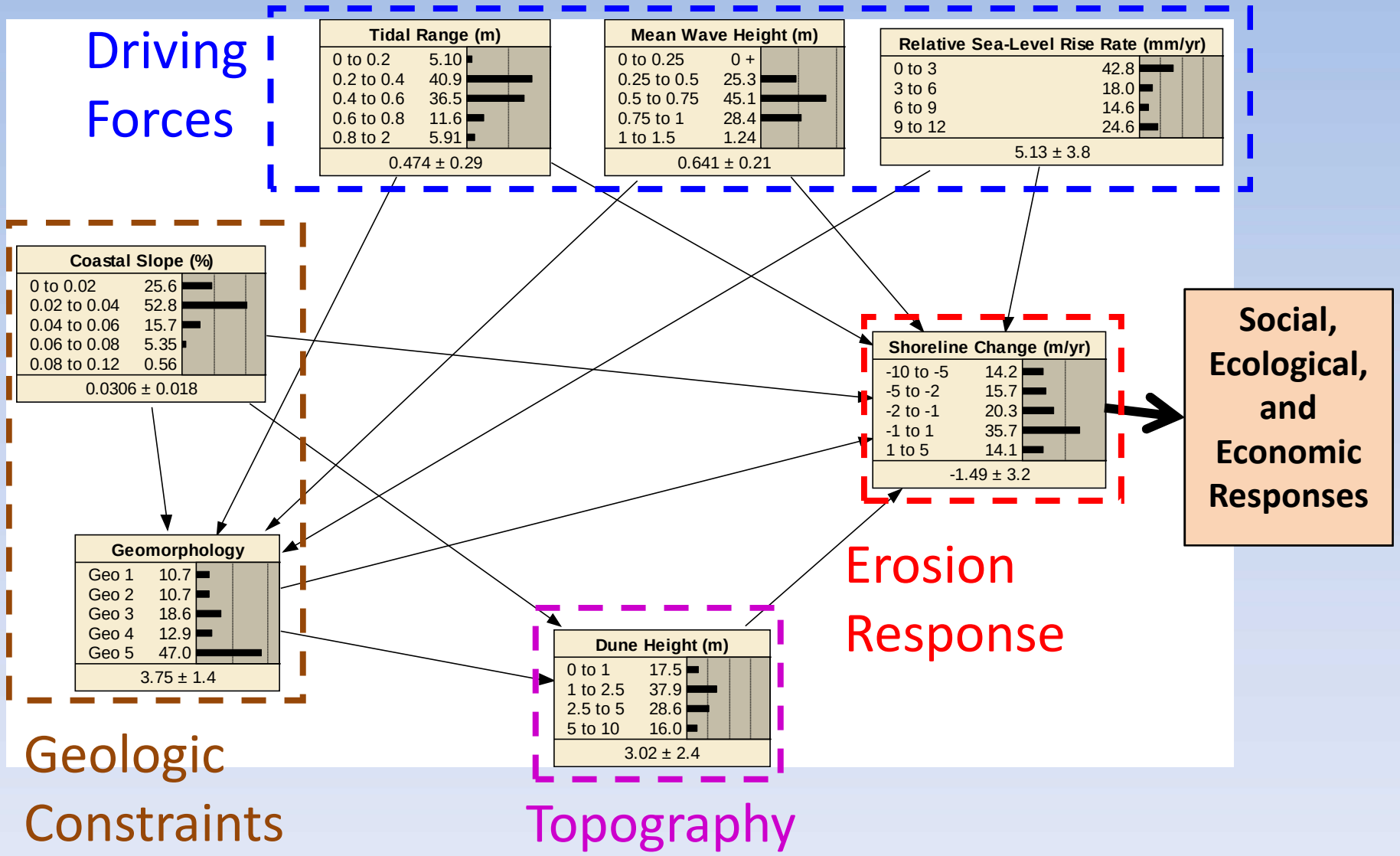
Integrated Coastal Assessment

Bayesian Sea Level Rise Model

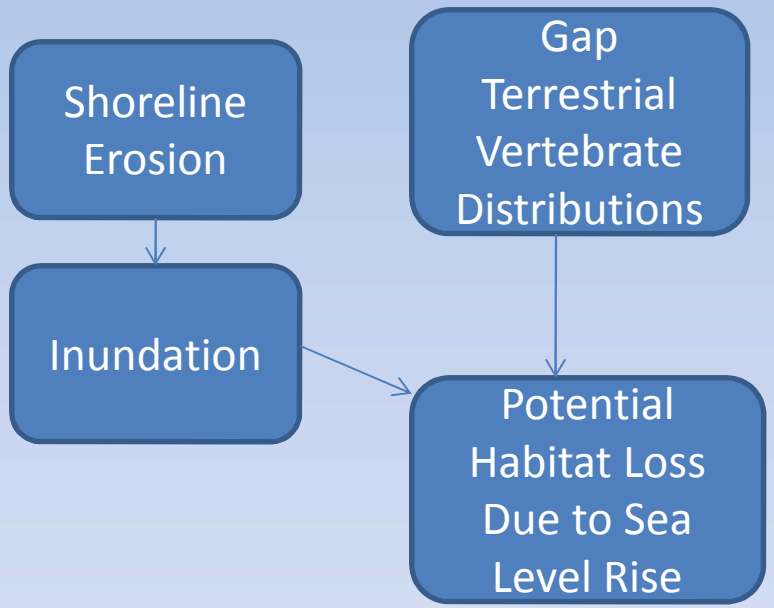


Integrated Coastal Assessment

Modeling Habitat Loss

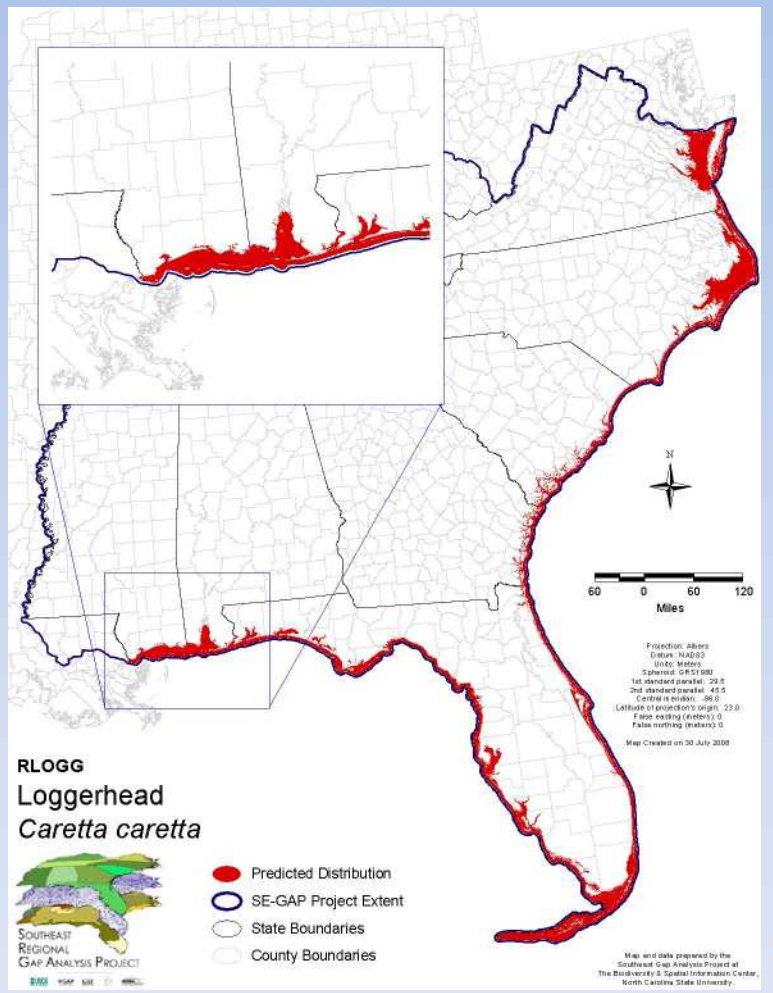
Developed 606 terrestrial vertebrate species models for the Southeastern U.S.

Relationships



Products

Maps and summaries potential habitat loss by species under a variety of SLR projections.

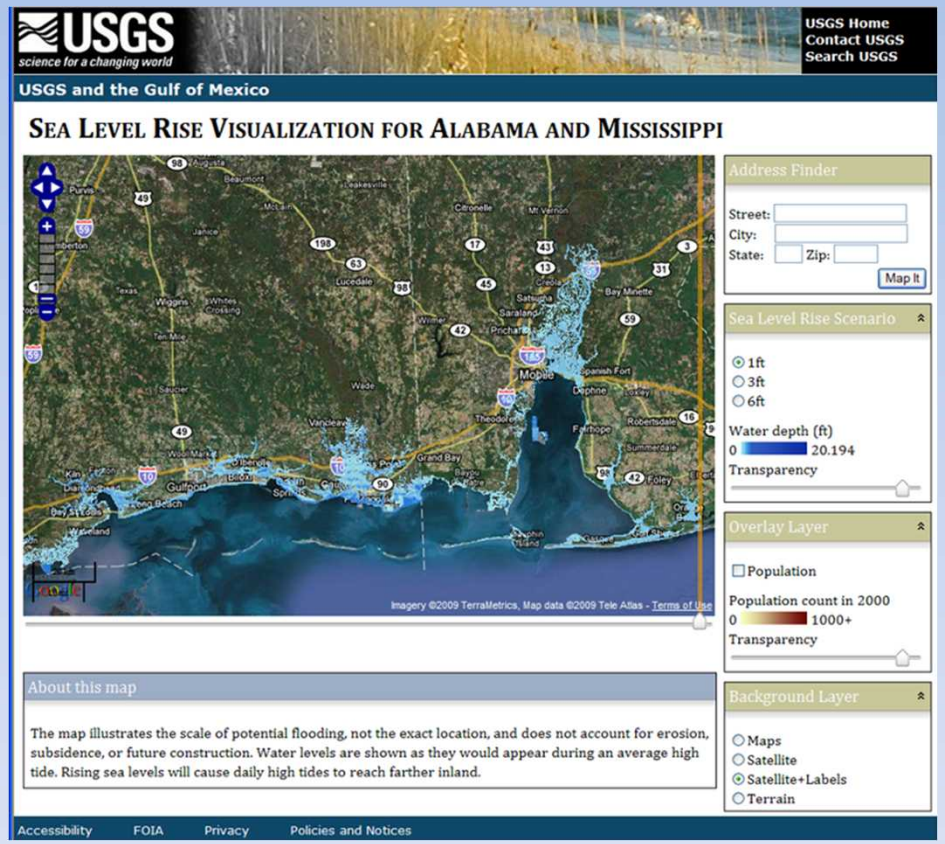


USGS science for a changing world

Integrated Coastal Assessment

Sea Level Rise Viewer

- Developing Google™ Thematic Mapper based map view that depicts inundation as sea level rises
- User friendly environment for resource managers and public to visualize impacts of sea-level rise
- Interactive map displays elevations of 1, 3, and 6 feet above Mean Higher High Water datum



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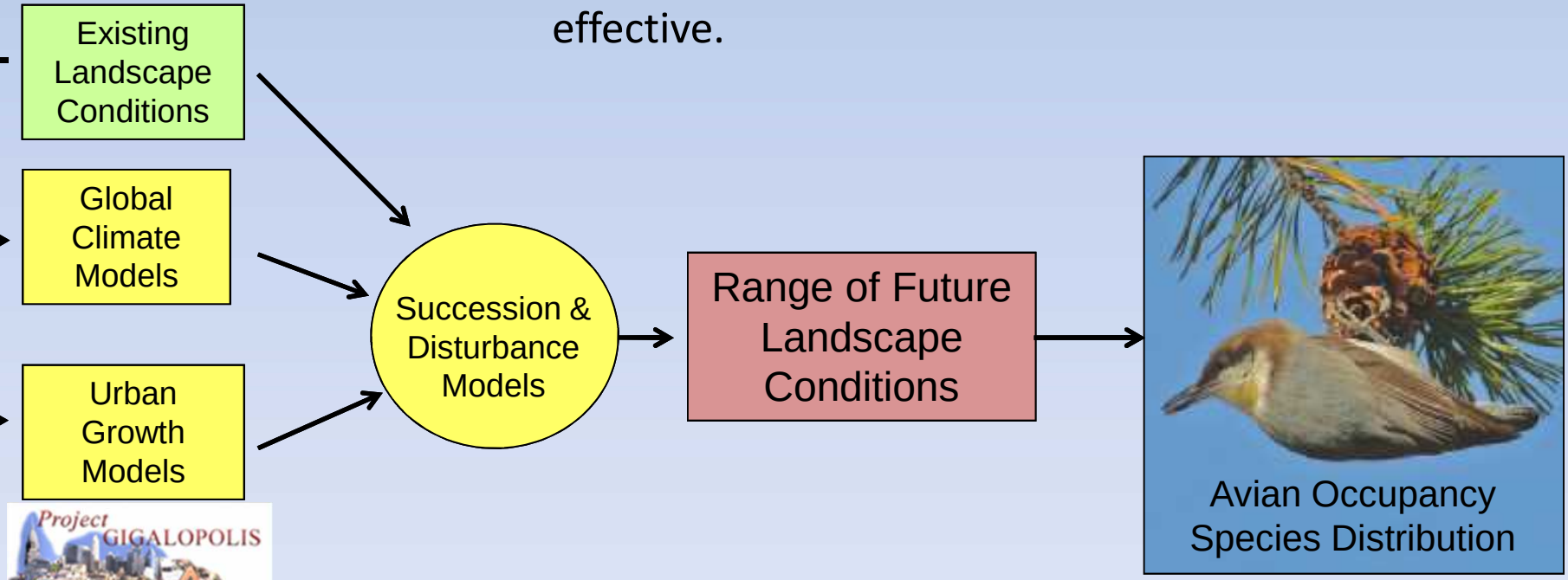
Integrated Terrestrial Assessment

Linking landscape, climate, and urbanization models

A decision making process that accounts for the uncertainty associated with predicting environmental dynamics and population responses, and the uncertainty associated with conservation policies and whether they will be effective.



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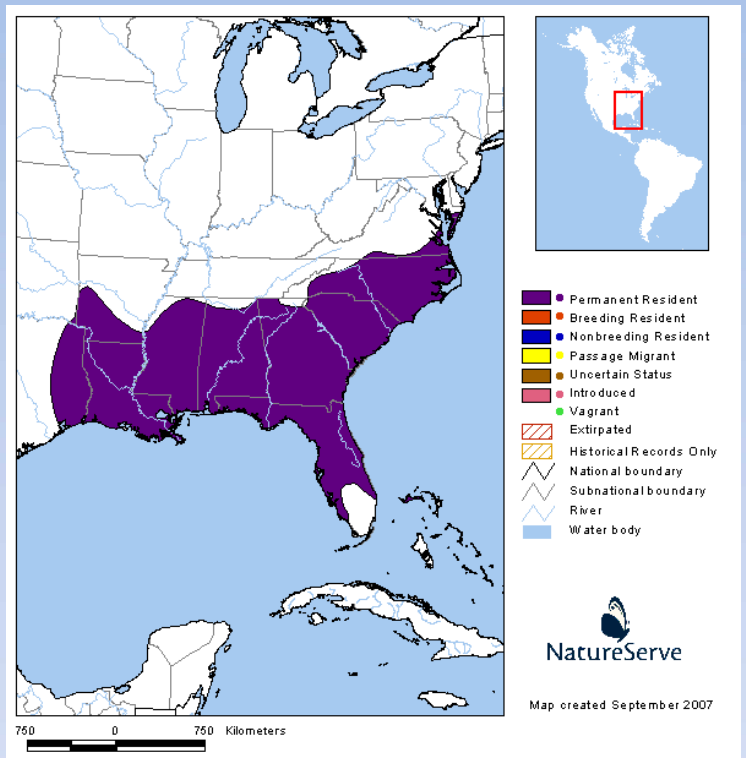
Integrated Terrestrial Assessment

Modeling North American land bird range dynamics

- Basic objective: Test hypotheses about avian range dynamics as function of climate change and other relevant factors.
- Probabilities of local extinction and colonization predicted as function of:
  - Climate change
  - Land-use change
  - Location within overall species range
  - Neighbor effects (occupancy of nearby locations)
- Ranges are likely to shift or contract and can be modeled by varying rates of extinction/colonization



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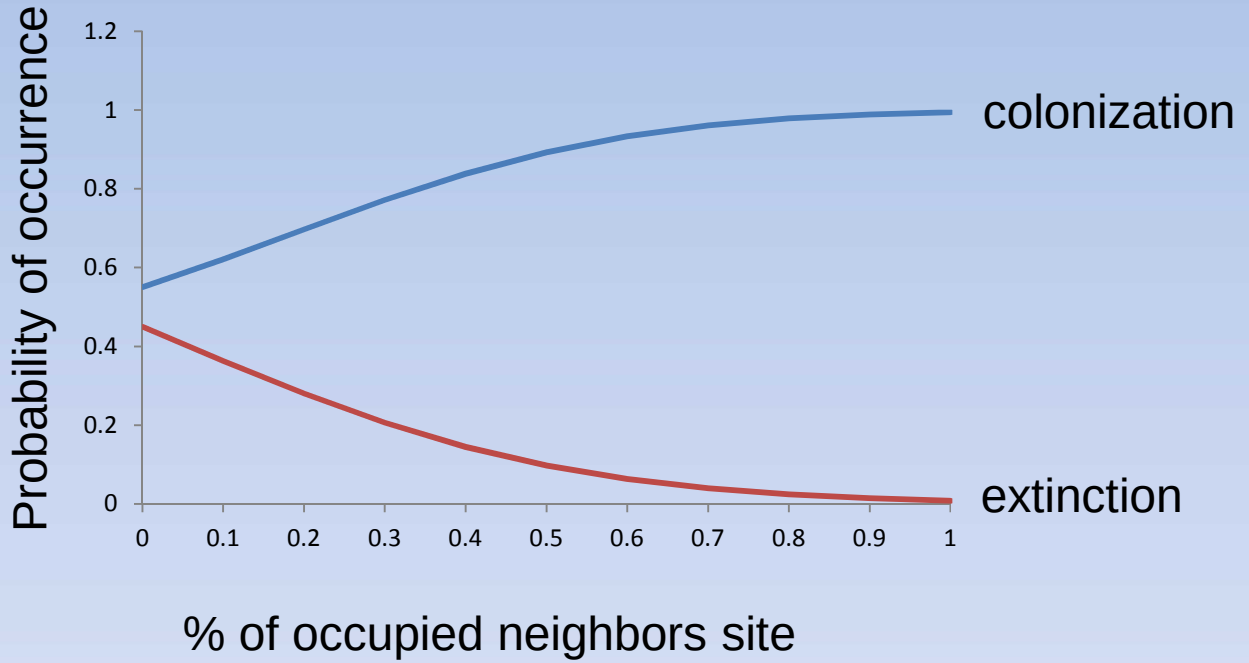
Integrated Terrestrial Assessment

Modeling occupancy dynamics

Loggerhead Shrike
(*Lanius ludovicianus*)

BBS data for 1996-2006



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Climate Adaptation Strategies

Optimal Conservation Strategies

Determine optimal conservation Strategies through:

- Implementation of Strategic Habitat Conservation using Adaptive Management
- Incorporation of potential effects of climate change on fish and wildlife population
- Development of strategy at an ecoregional scale.

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Climate Adaptation Strategies

Simple model example

Site	Utility Species 1	Utility Species 2	Site Utility
1	0.5	0.3	0.8
2	0.2	0.6	0.8
3	0.2	0.8	1.0
4	1.0	0.3	1.3

Compare among sites

	Weighted		
Site	Utility Species 1	Utility Species 2 (2x)	Site Utility
1	0.5	0.6	1.1
2	0.2	1.2	1.4
3	0.2	1.6	1.8
4	1.0	0.6	1.6

Incorporate species value

	Site Utility			
Site	No Management	Management	Cost	Marginal Gain
1	1.1	1.8	20	0.035
2	1.4	1.6	20	0.01
3	1.8	1.9	5	0.02
4	1.6	1.8	5	0.04

Compare alternatives

$$\text{Marginal gain} = \frac{\text{Management} - \text{No Management}}{\text{Cost}}$$

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Questions?