



Potential Effects of Changing Climate Patterns on Freshwater Habitats

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Important to consider when discussing climate impacts to ecosystems:

- Climate is a primary forcing phenomenon driving ecosystem dynamics
- Uncertainty in climate predictions compounded by complexity in ecological system behavior
- Poorly understood: Resistance of system structure & function to change, resilience to impacts, and stability in the face of climate or other environmental change
- Climate will interact with host of other *ongoing* system alterations with which organisms must cope
- Differential tolerances, shifting interactions among species
- Unique characteristics of aquatic ecosystems



Important Concepts for Aquatic Habitats

- Changes in air temperature influence changes in **water temperature**
- Water temperature affects **vital rates** of organisms, manifesting at ecosystem, community, population, and individual levels
- Changes in precipitation timing and amount will affect **water quantity** and **quality**, and **timing of flows**
- **Groundwater** also major determinant of flow stability for many surface waters
- **Connectivity** is a key concept for species negotiating a changing environment



Freshwater Habitats of South Carolina

- **Impoundments** (aka. reservoir, “lake”)
- **Ponds**
- **Wetlands**
 - Connected (e.g., river bottomland swamps)
 - Isolated (e.g., pocosins)
- **Flowing surface waters** (= lotic ecosystems)

Rivers and streams make up the vast majority of aquatic habitat in SC and harbor the greatest diversity of species

Fact is, the richness of the aquatic fauna in the Southeast is scarcely appreciated!

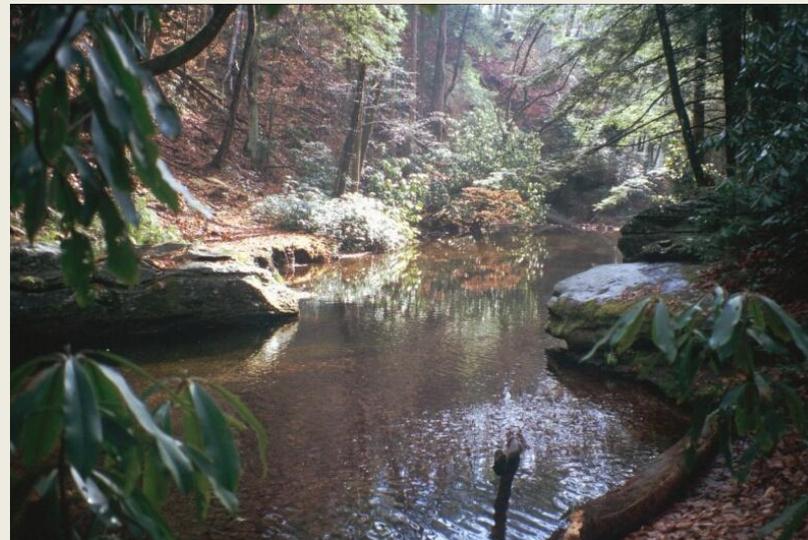


Southeastern U.S. is a global center of temperate aquatic diversity

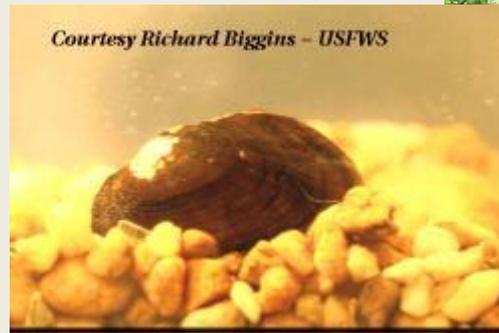
Compare freshwater fish species richness:

southeast U.S. = 530

Europe = 233



Freshwater mussels *Unionidae* 297 spp.
269 found in southeast – 127 endemic



Lasmigona decorata
Carolina heelsplitter



Crayfishes (mostly Cambaridae) 353 spp.
95% found in southeast



Freshwater fishes 790 spp. - 530 found in
southeast



Amphibians – 144 spp. in southeast

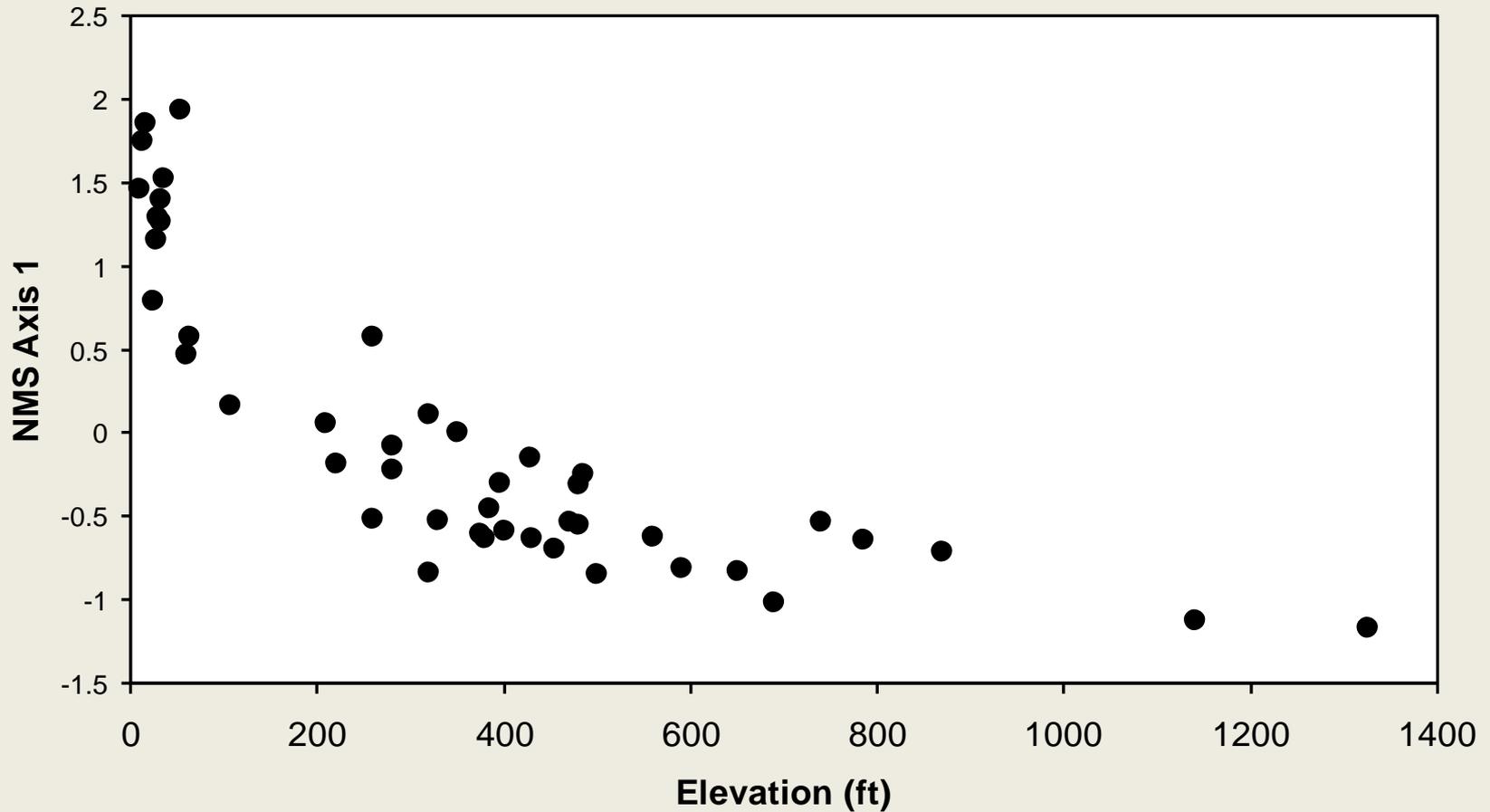


Reptiles – 73 spp. in southeast are
dependent on aquatic habitats

Life histories of lotic organisms

- Tolerant of flow variability
- Flow changes can cue behavioral response
 - Spawning
 - Migration
- Extirpation & recolonization dynamics more stringent for obligatory aquatic taxa
- Some species have documented ability to withstand desiccation
- Shift in mean temperatures likely to favor lowland warmwater species over cool or coldwater upland species

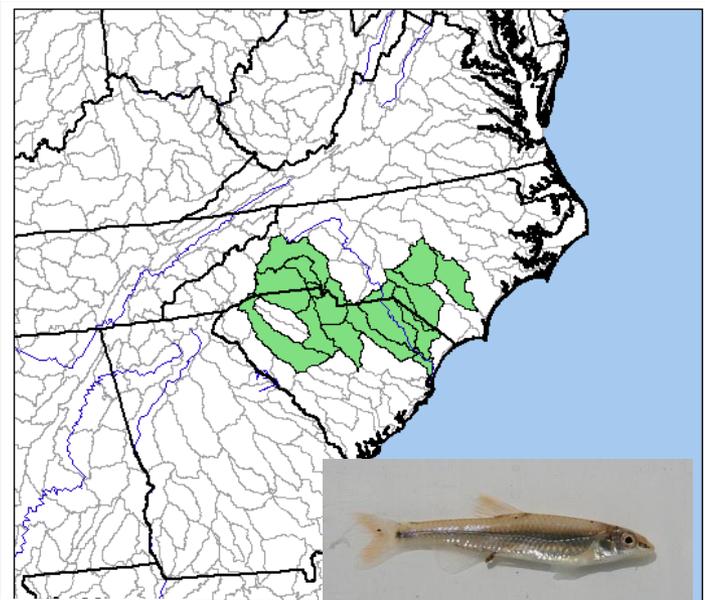




Fish assemblage composition across SC broadly corresponds to site elevation



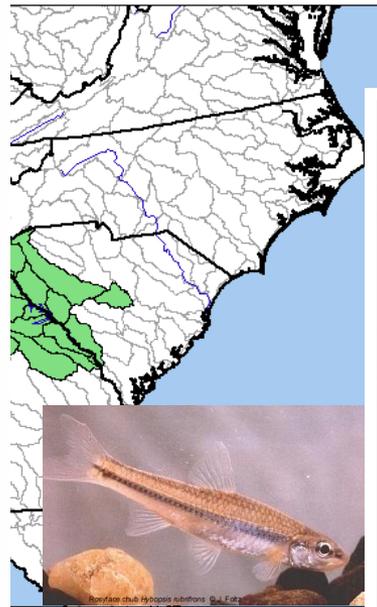
Endemism is responsible for biotic uniqueness of the region



Cyprinella zanema
Santee Chub

Map created June 2003

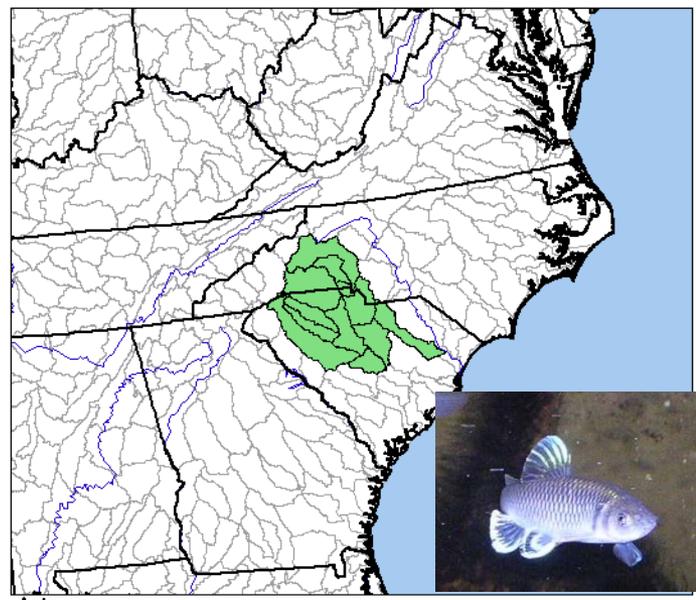
200 0 200 Kilometers



Notropis rubrifrons
Whiteface Chub

Map created June 2003

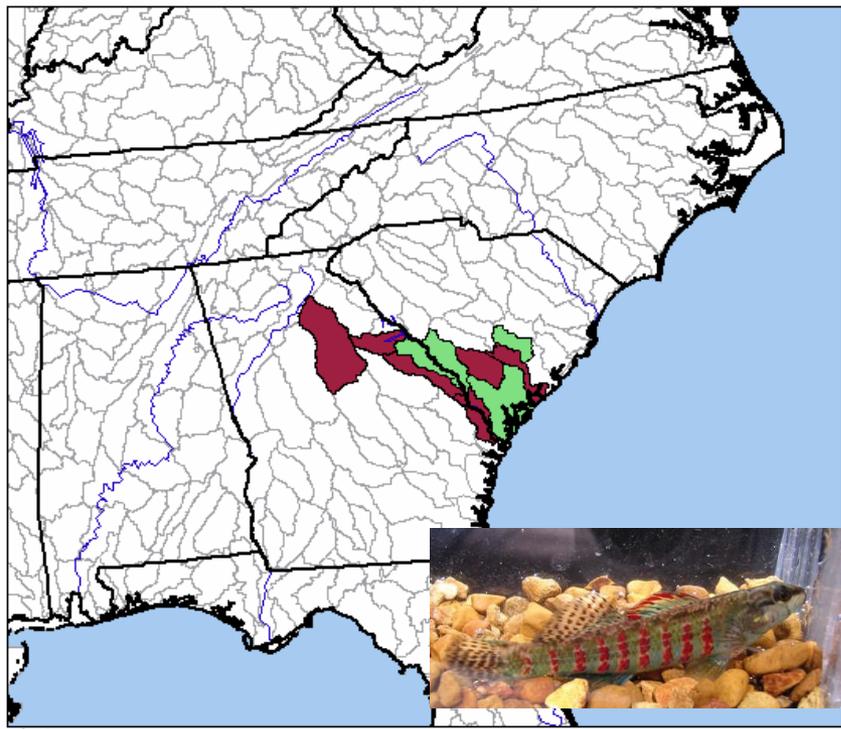
0 200 Kilometers



Cyprinella chloristia
Greenfin Shiner

Map created June 2003

200 0 200 Kilometers



Etheostoma fricksium
Savannah Darter

Map created June 2003

200 0 200 Kilometers



- State Boundary
- Major Rivers
- USGS 8-digit HUC
- Current Distribution
- Historic Distribution
- Out of Scope

Big Branch (Saluda / Slate Belt)
11 March 2008



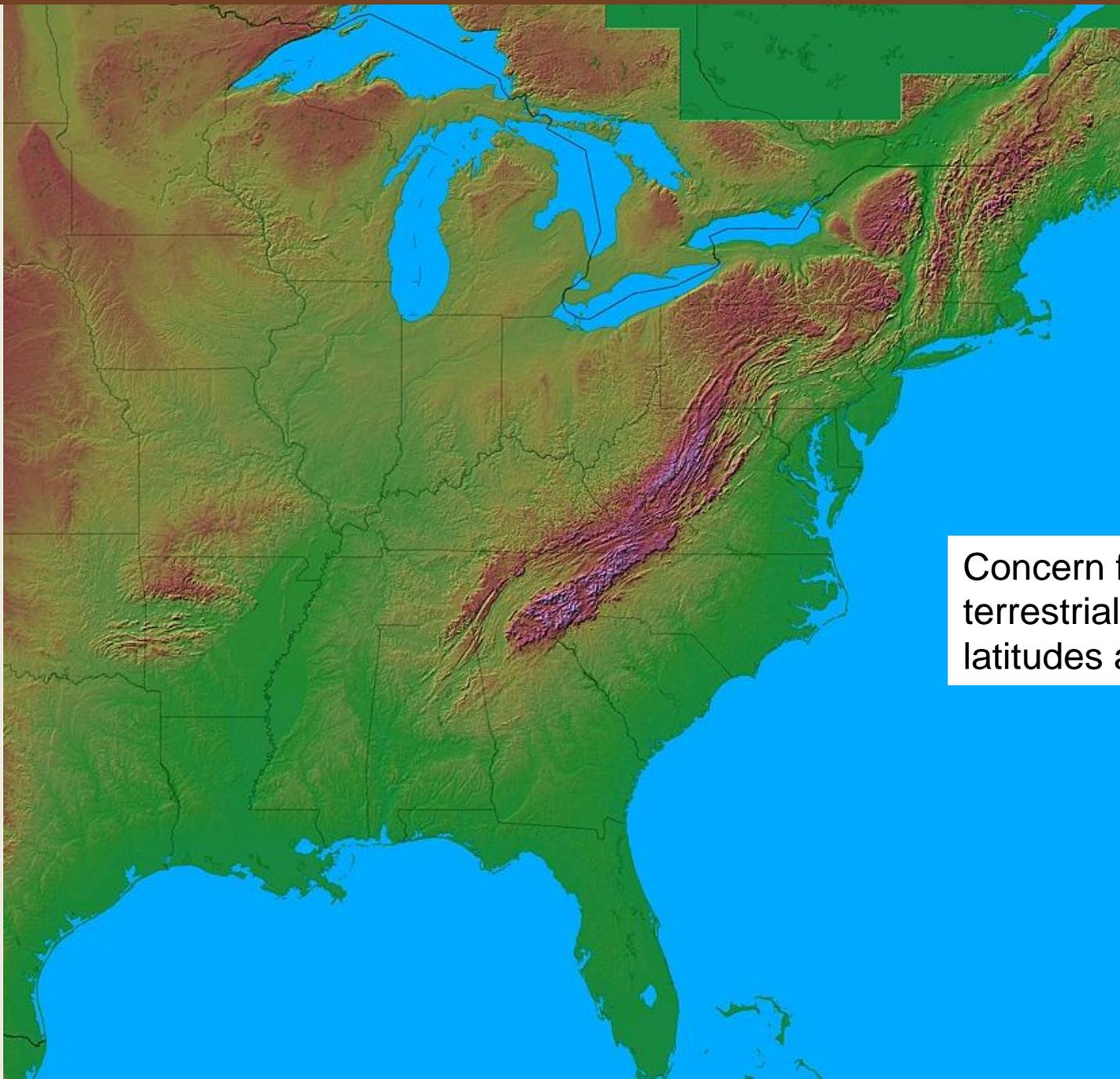
Big Branch (Saluda / Slate Belt)
19 August 2008



Big Branch (Saluda / Slate Belt)
19 August 2008





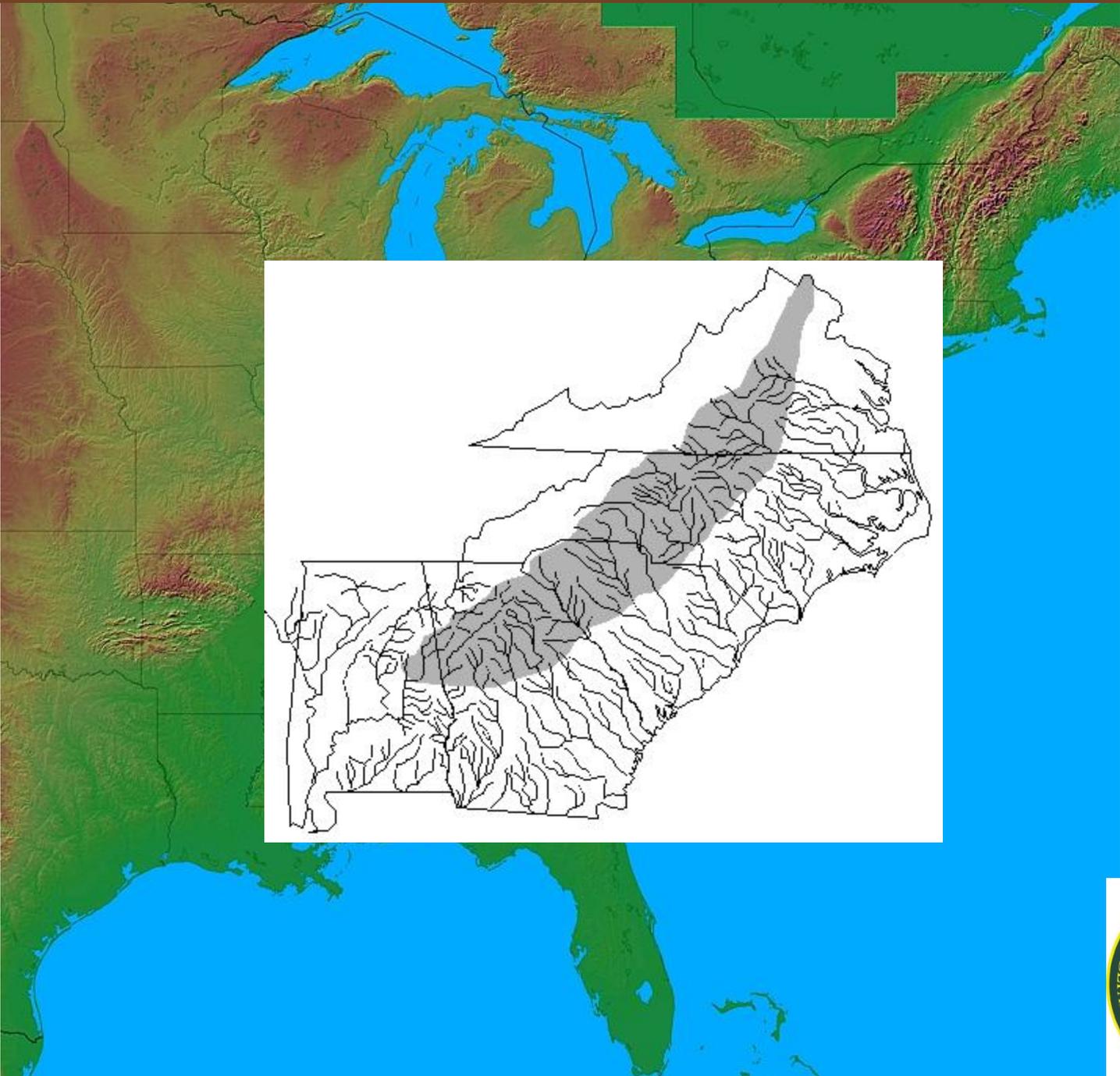


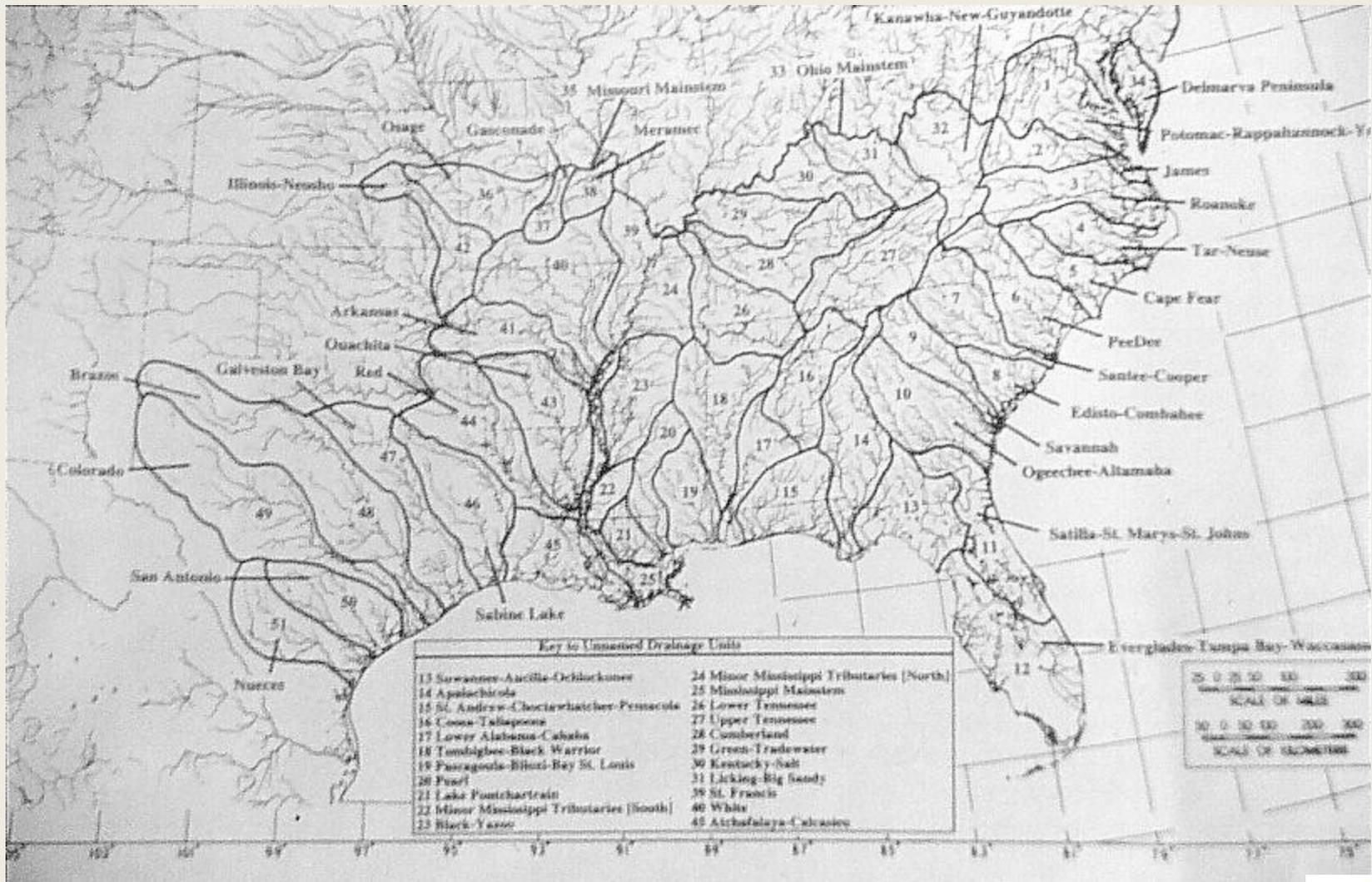
Connectivity

Migration pathways critical for species adjusting to climate change

Concern for maintaining terrestrial corridors to higher latitudes and higher elevations



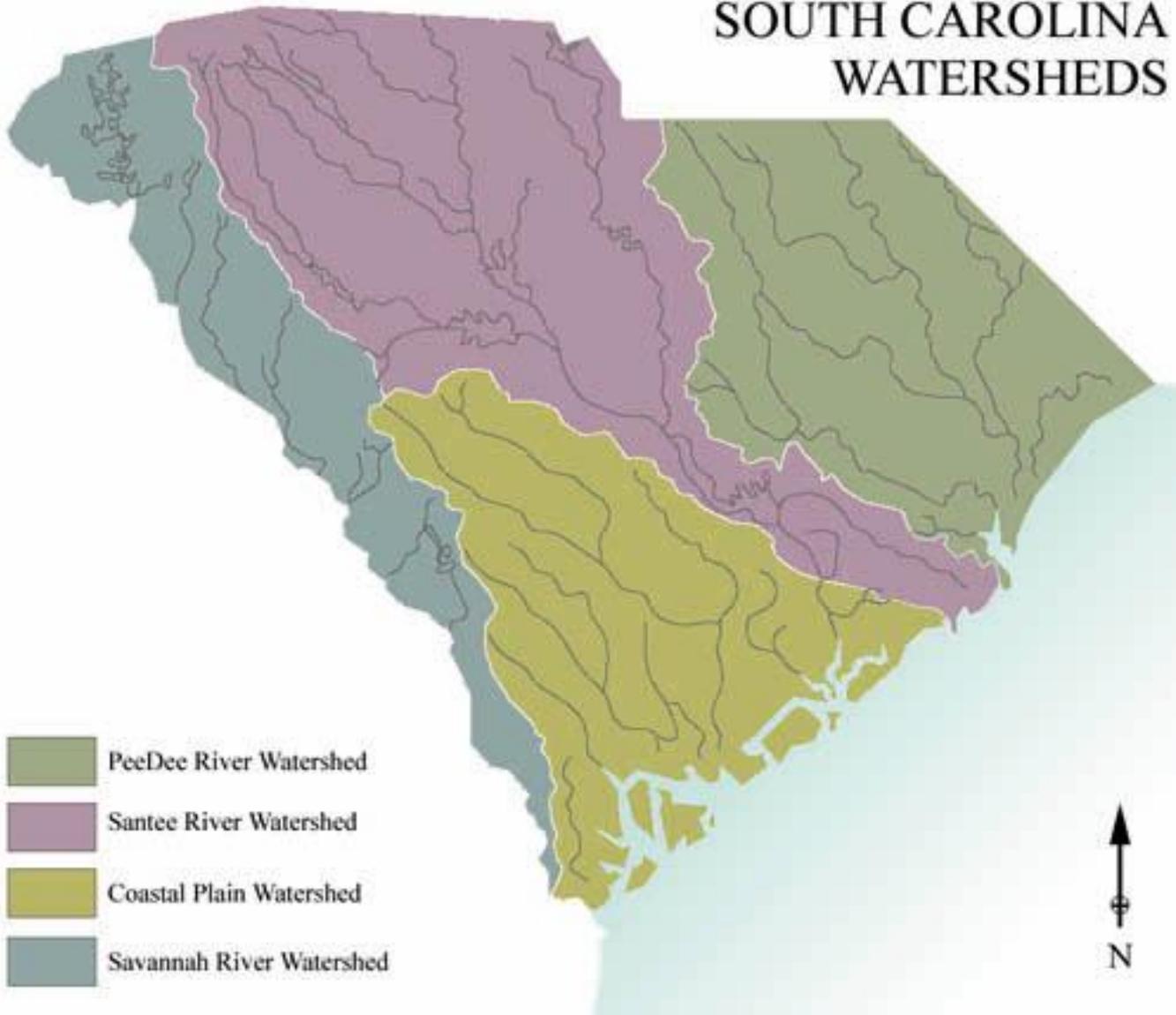




from Warren et al. 2000



SOUTH CAROLINA WATERSHEDS

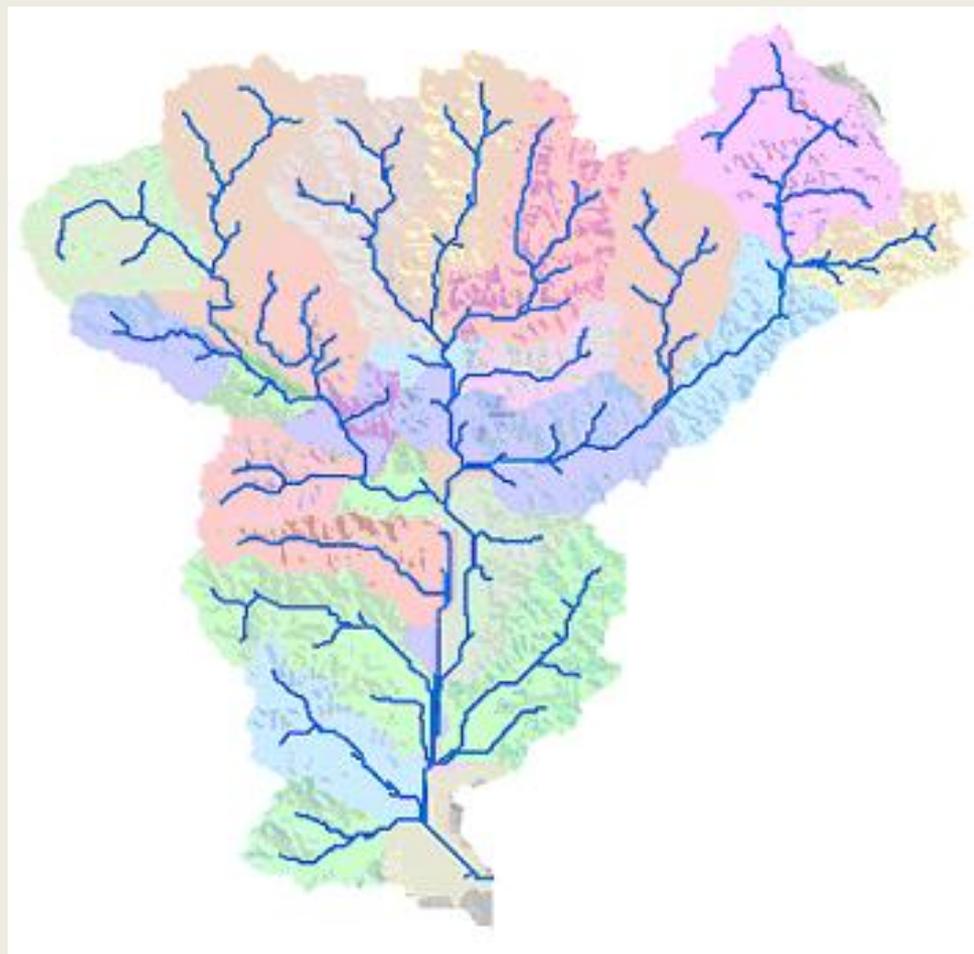


-  Pee Dee River Watershed
-  Santee River Watershed
-  Coastal Plain Watershed
-  Savannah River Watershed

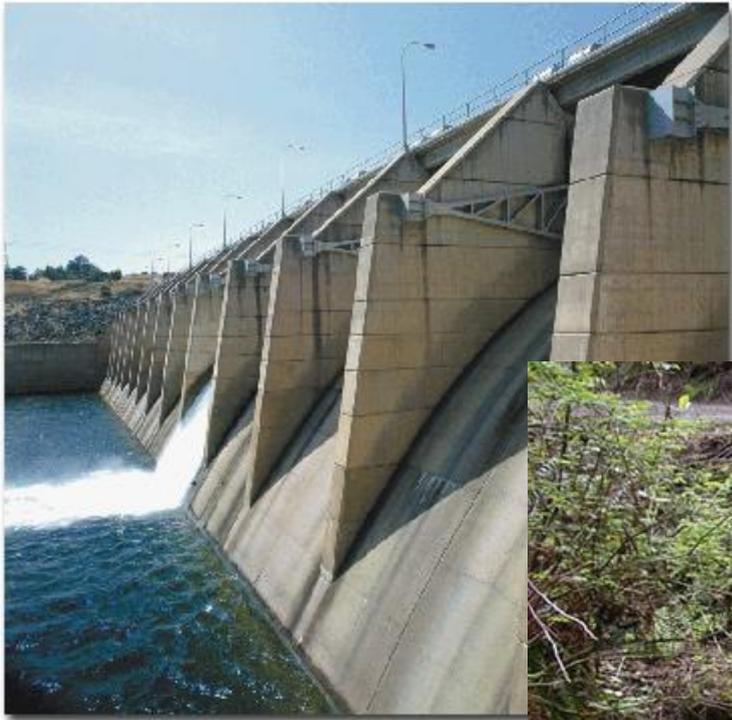


Connectivity critical issue for metapopulation dynamics

- Migration pathways differ for species with terrestrial capability vs. those confined to channel
- Pathways end at **drainage divides**
- Allows for migration upland but very limited latitudinal shifts



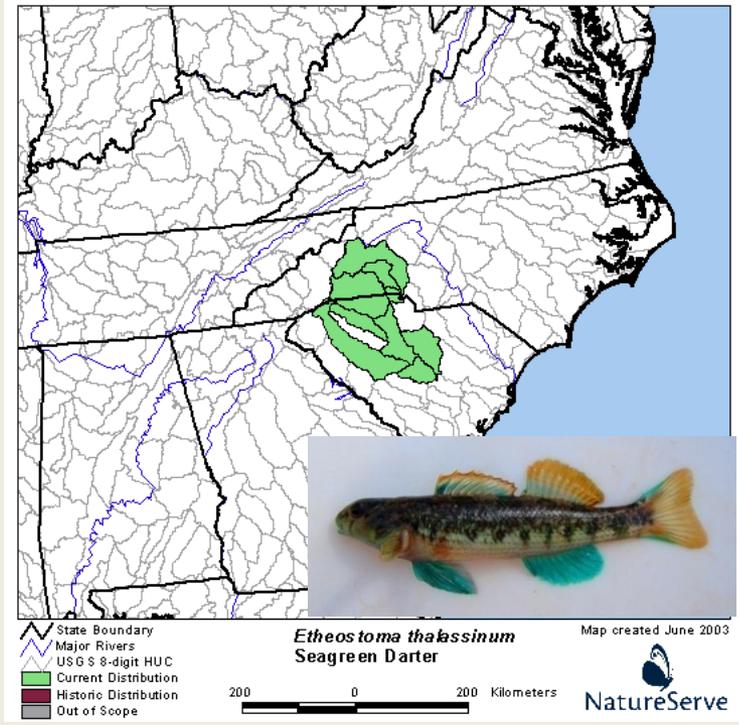
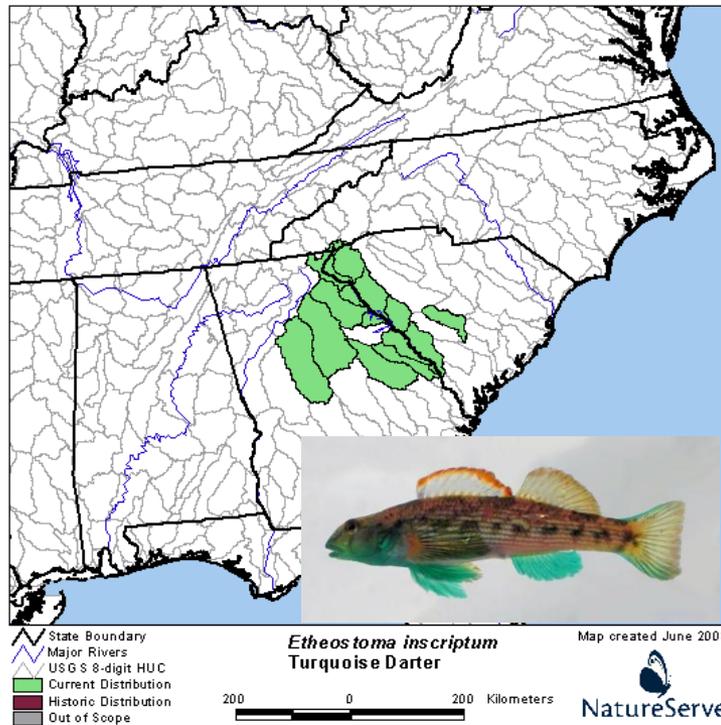
Barriers to connectivity within a drainage



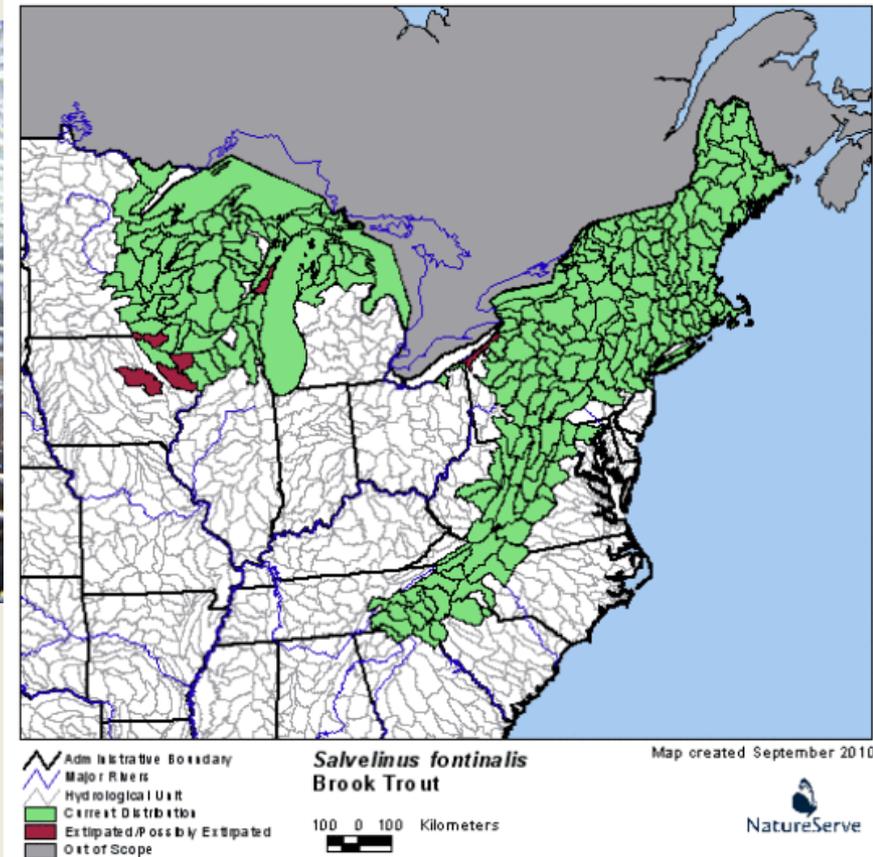
Translocation has been discussed as management tool to conserve species affected by climate change

Sister species are common due to isolation and speciation in the Southeast

- they pose special problem for shifting species' ranges across complex interacting landscape



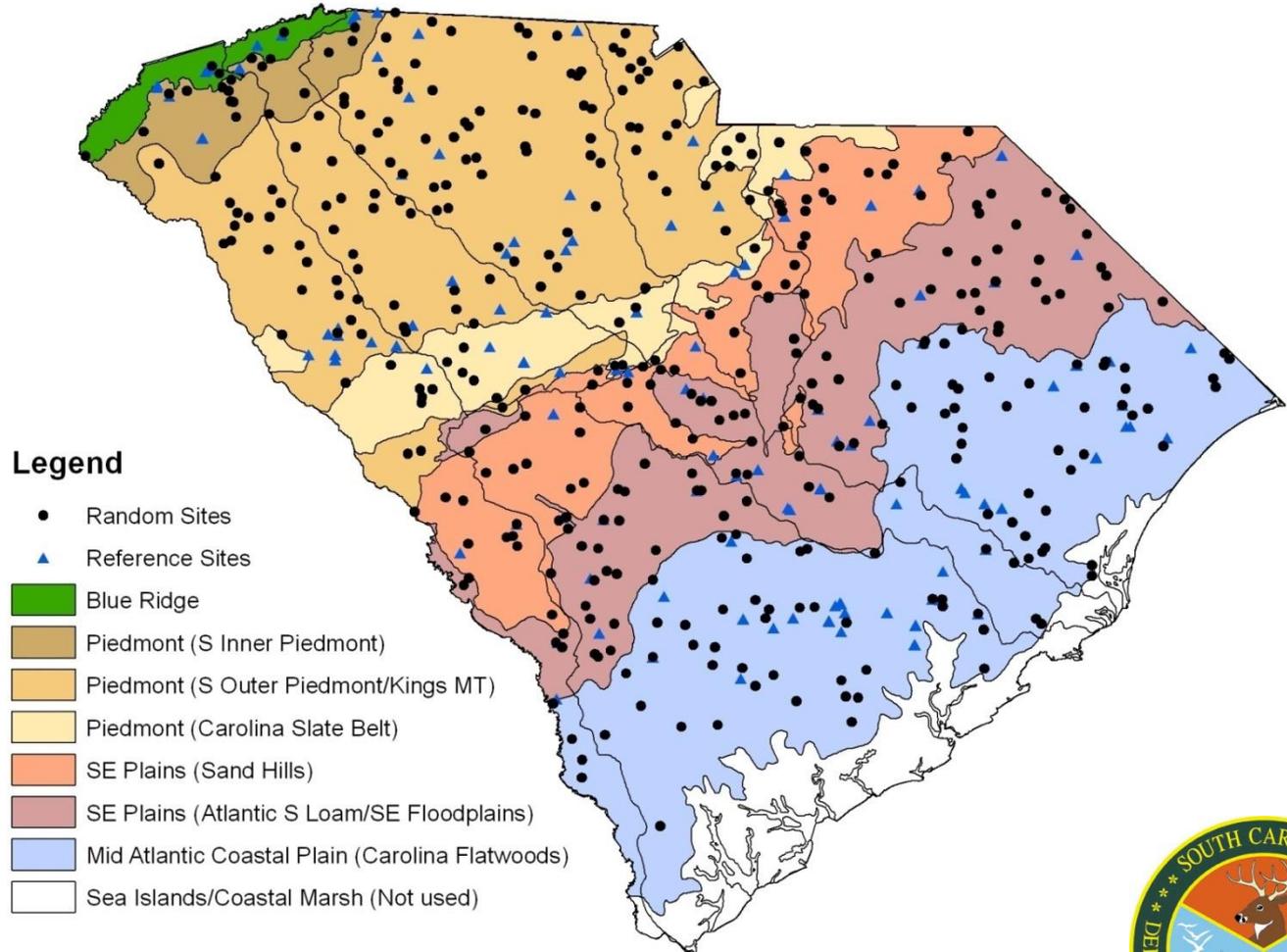
Eastern Brook Trout *Salvelinus fontinalis*



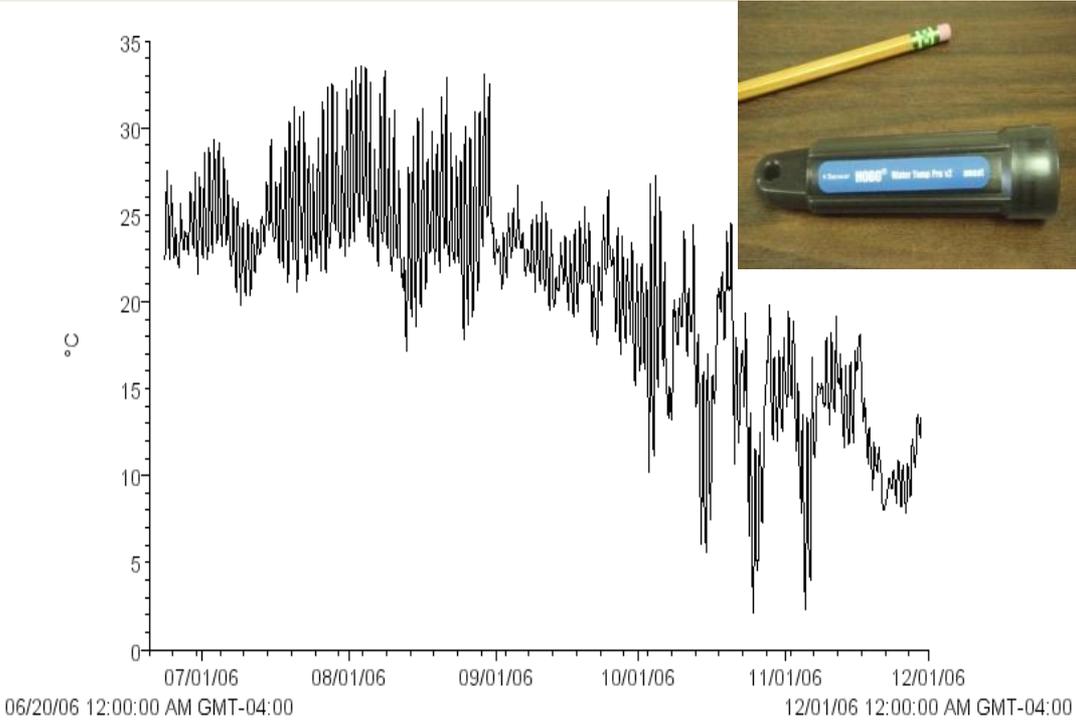
- Southern strain identified as genetically unique in the southern Appalachians
- Eastern Brook Trout Joint Venture has sponsored ongoing habitat projects in hopes of conserving only native member of salmon family
- Temperature preference is 55°F to 65°F – survival a matter of hours at >75°

SC Stream Assessment Sites

- Standardized sampling methods same for reference (N=80) and random sites (N=397)



Stream Assessment Database includes continuously logged temperature at each site



STREAM TEAM

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Dr. Rockie English
Dr. John Grego
Dr. Steve Klaine
Dr. Peter van den Hurk



Eastern United States Forested landscapes

- Stable hydrology
- Stable channels
- Low rates of sedimentation
- Moderate temperature
- Allochthonous energy for trophic system (OM)
- Coarse substrates (uplands)
- Wood as important habitat structure



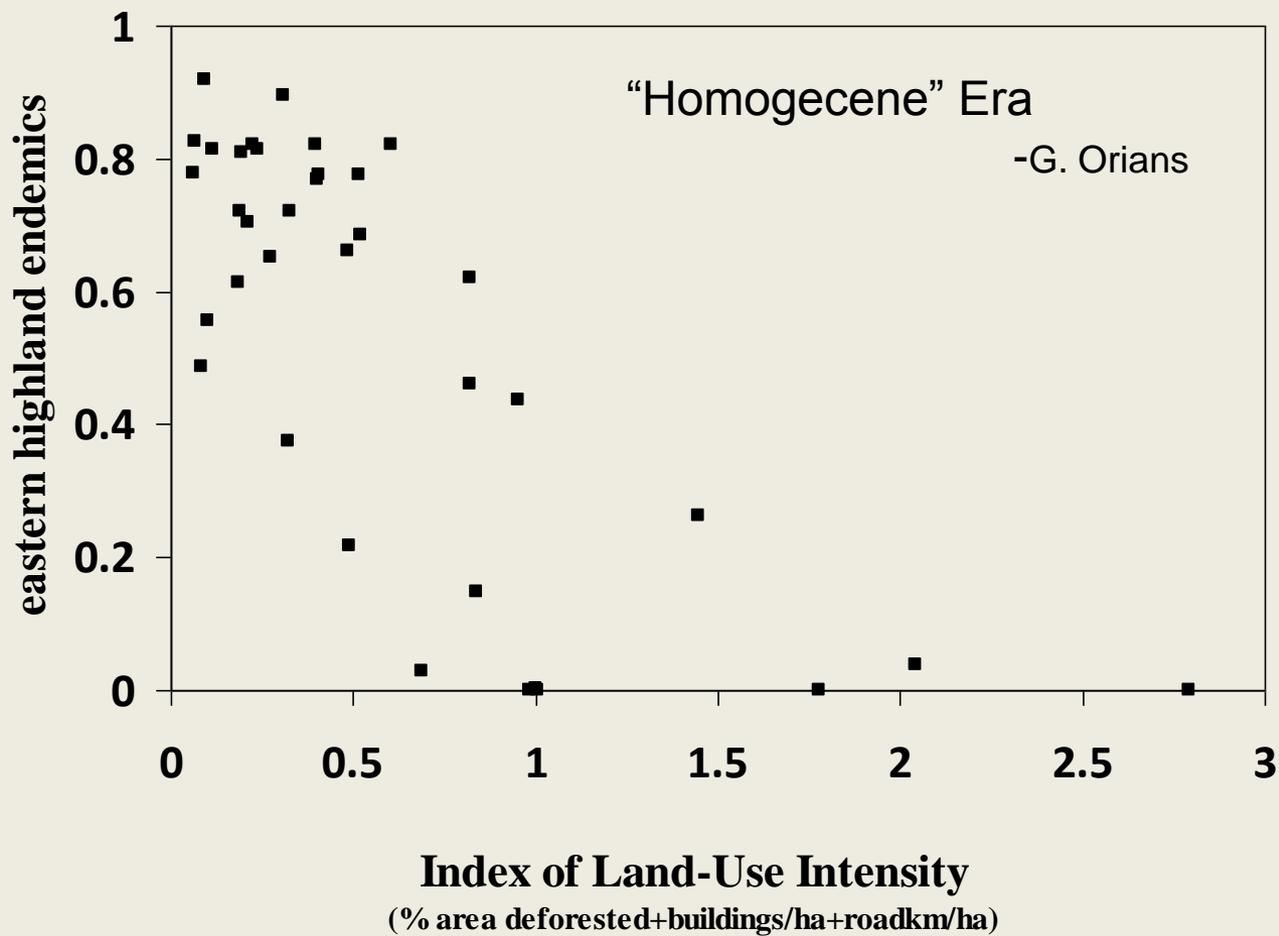
Human-dominated landscapes

- Unstable hydrology
- Unstable channels
- High rates of sedimentation
- Elevated and variable temperature regime
- Finer substrates
- Organic matter inputs reduced
- Dissolved nutrients increased
- Contaminants





Relative abundance of fishes endemic to eastern highlands in relation to catchment land use



Aquatic ecosystem comprises the watershed

Freshwater ecosystem

- Hydrologic cycle driven by climate and geology/topography
- Mediated by soils and vegetation
- Transport and storage of water and sediment
- Biogeochemical cycling of dissolved and suspended carbon and nutrients
- **Watershed** (aka. catchment, drainage basin) as the basic ecosystem unit
- Entire landmass can be organized into scaleable watersheds



SC Stream Assessment

Initiated in 2006 - streams had not been surveyed since 1980s-90s

Objectives: Design & implement standardized sampling program that will

- Provide estimates of stream resource conditions
- Allow determination of primary factors influencing stream resource conditions
- Establish baseline conditions so resource trends can be monitored

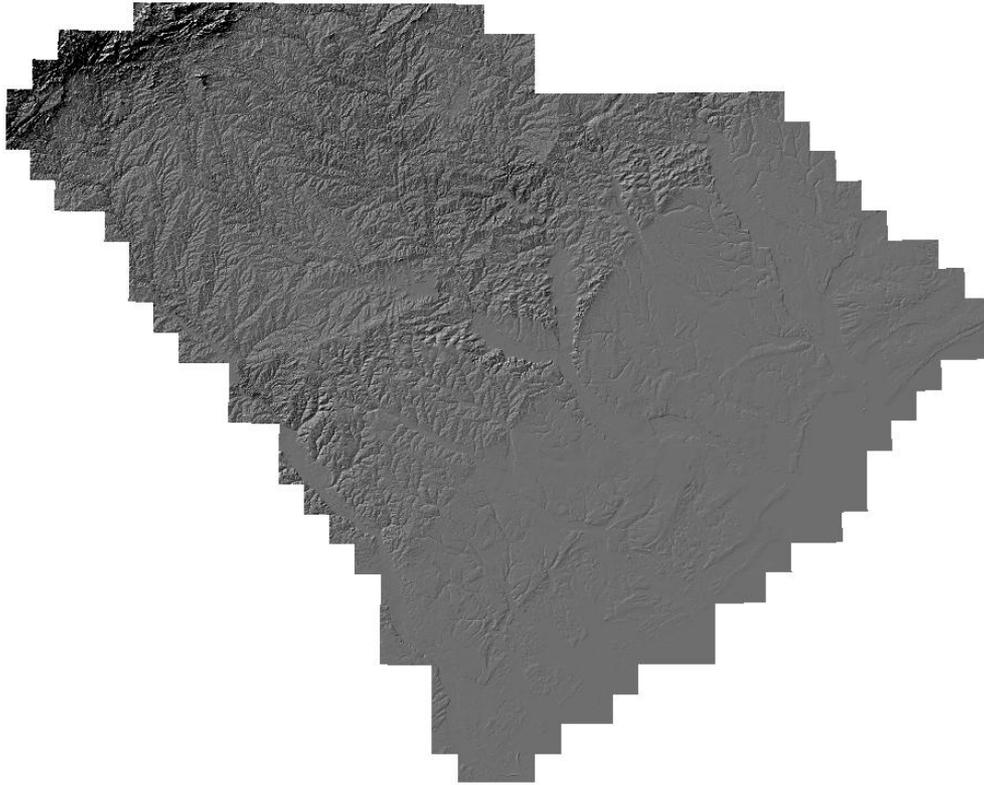
Wadeable streams targeted (draining 4 – 150km²)

Two-pronged approach to site selection:

- Fixed sites on “reference” streams to document natural spatiotemporal variability
- Probabilistic design with stratified random site selection allows parameter estimates and relationships among variables to be extrapolated to the statewide population of streams

SC Stream Assessment

Random Site Selection



- Statewide population of stream channels modeled from digital elevation model at 30m resolution – 37,888 stream km
- List frame of sampling points every 100m
- Stratified random sample selection
- Project collaboration with Dr. Chris Post, Dr. Megan Goddard, and Sam Esswein

Stream Assessment Database

Physical/Geomorphic

Channel dimensions: ratios of width to depth, bank height/angle, cross sectional area

Channel substrate particle size distribution

Mean wetted width (m)

Mean and standard deviation (STD) water depth (m)

Mean and STD water velocity (m/sec)

Percent occurrence of organic debris and wood in channel



Biological

Biomarkers indicating exposure to pollutants in sunfish individuals: EROD activity, bile fluorescence, and induction of metallothionein and vitellogenin

Indicators of sunfish health: hepatosomatic index, gonadosomatic index and splenosomatic index



Biological Community Structure:

aquatic insects

crayfishes

mussels

fishes

reptiles & amphibians (herpetofauna)

