The Response of Fish Habitat to Environmental Flows in the Albemarle-Pamlico Watershed

Rashleigh, B., L. Prieto, S.T. Purucker, L. Suárez, M.C. Barber, and R.B. Ambrose, Jr.

U.S. Environmental Protection Agency, Athens, GA

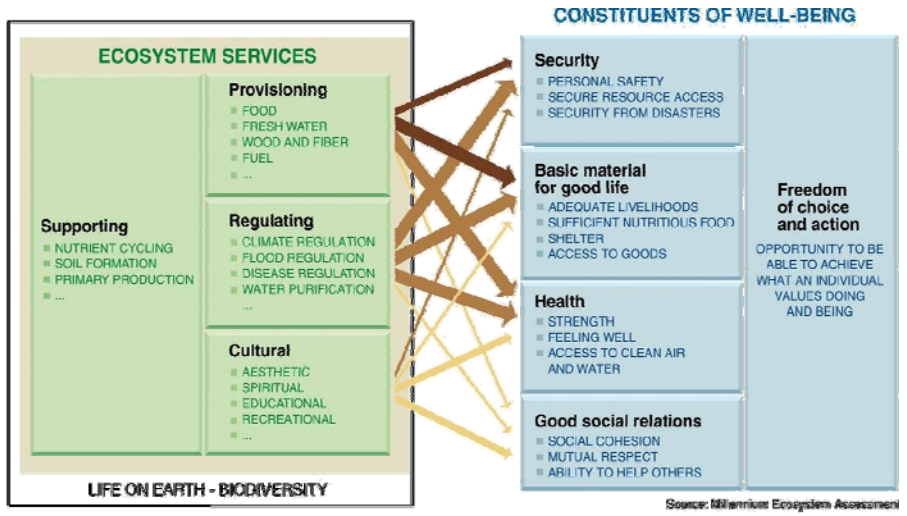
U.S. Environmental Protection Agency
Office of Research and Development

Introduction

- The provision of habitat for fish is an important service provided by rivers
- Future land development and climate change will likely alter several aspects of habitat, including flow
- Tools for the assessment of flow alteration in the context of multiple stressors can support watershed management

Core Ecosystem Services

- ***Supporting Services***
  - Carbon storage
  - **Habitat/maintenance of biodiversity**
- ***Regulating Services***
  - Nutrient cycling
  - Flood reduction
  - Storm-surge protection
- ***Provisioning Services***
  - Food, Fiber, Fuel
  - Water provisioning
- ***Cultural Services***
  - Recreation
  - Sense of place



Questions

- Are flow and velocity important in predictive habitat models for fish in the Albemarle-Pamlico basin?
- What is the response to flow and velocity variables in the models?

Fish Sampling Locations

Methods – Fish Species

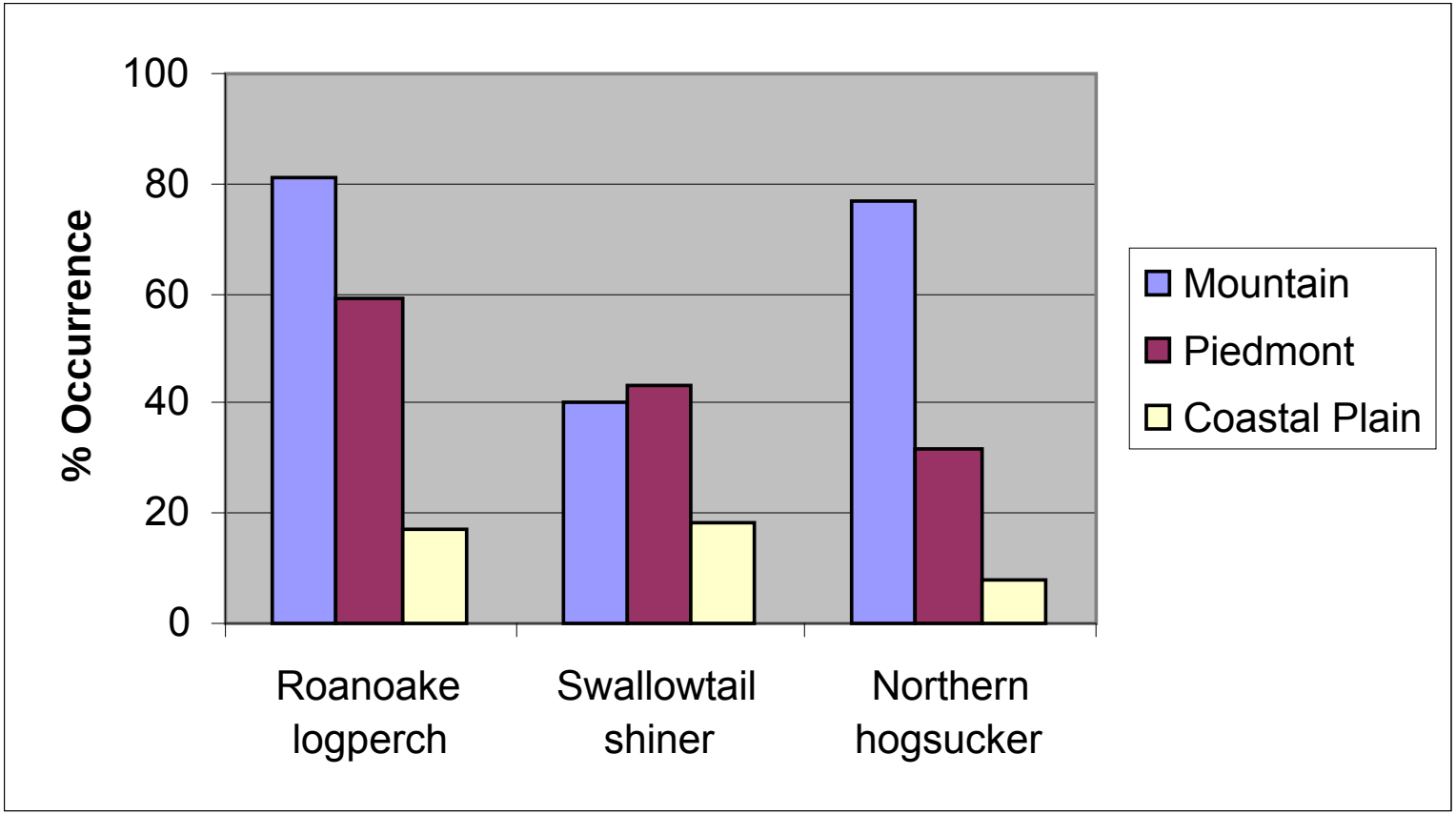
- 3 Surrogate species
  - Minnow – Swallowtail shiner (*Notropis procne)*

  - Sucker - Northern hogsucker (*Hypentilium nigricans)*

  - Darter – Roanoake darter (*Percina roanoaka)*

http://nc.water.usgs.gov/albe/Pics/pics_biology2/Fish/pages/Roanoke.darter.html

Fish Species by Ecoregion



Methods - Statistics

- Hierarchical models to predict the presence of fish species within the Albemarle-Pamlico basin

  - Random intercept that varies by Ecoregion (3 levels)
    - **Mountains** (Blue Ridge/Ridge and Valley)
    - **Piedmont**
    - **Coastal Plain** (Middle Atlantic Coastal Plain/Southeastern Plains)

  - Multiple Logistic Regression

    $r = b0_i + b1*X1 + b2*X2 + ... + bp*Xp$

    $p = 1/(1+e^{-r}),\ 0 \leq p \leq 1$

Methods – Environmental Measures

Predictors were taken from:

- USGS/EPA NHDPlus dataset

  - Flow
  - Velocity
  - Temperature
  - Slope

- NLCD 2001 Land cover (forest, agr, devel, wetlands)

Results – Model Fits*

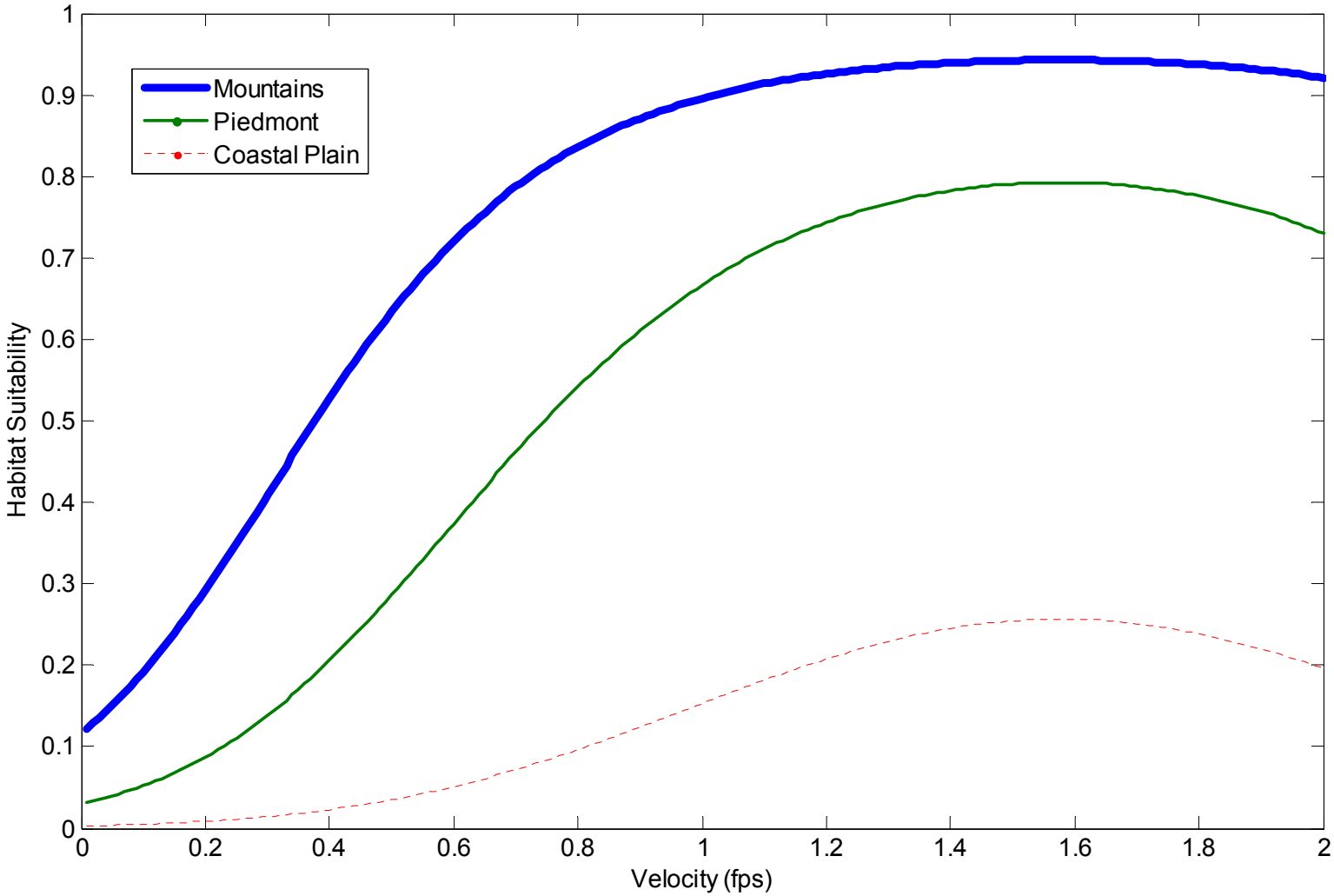
Species	% Correct n=548 (test data n=134)		
	Presence	Absence	Overall
Swallowtail shiner	41 (55)	85 (87)	**70 (75)**
Northern hogsucker	55 (49)	89 (85)	**78 (74)**
Roanoake darter	75 (73)	84 (82)	**80 (78)**

*Most parsimonious model based on AICc

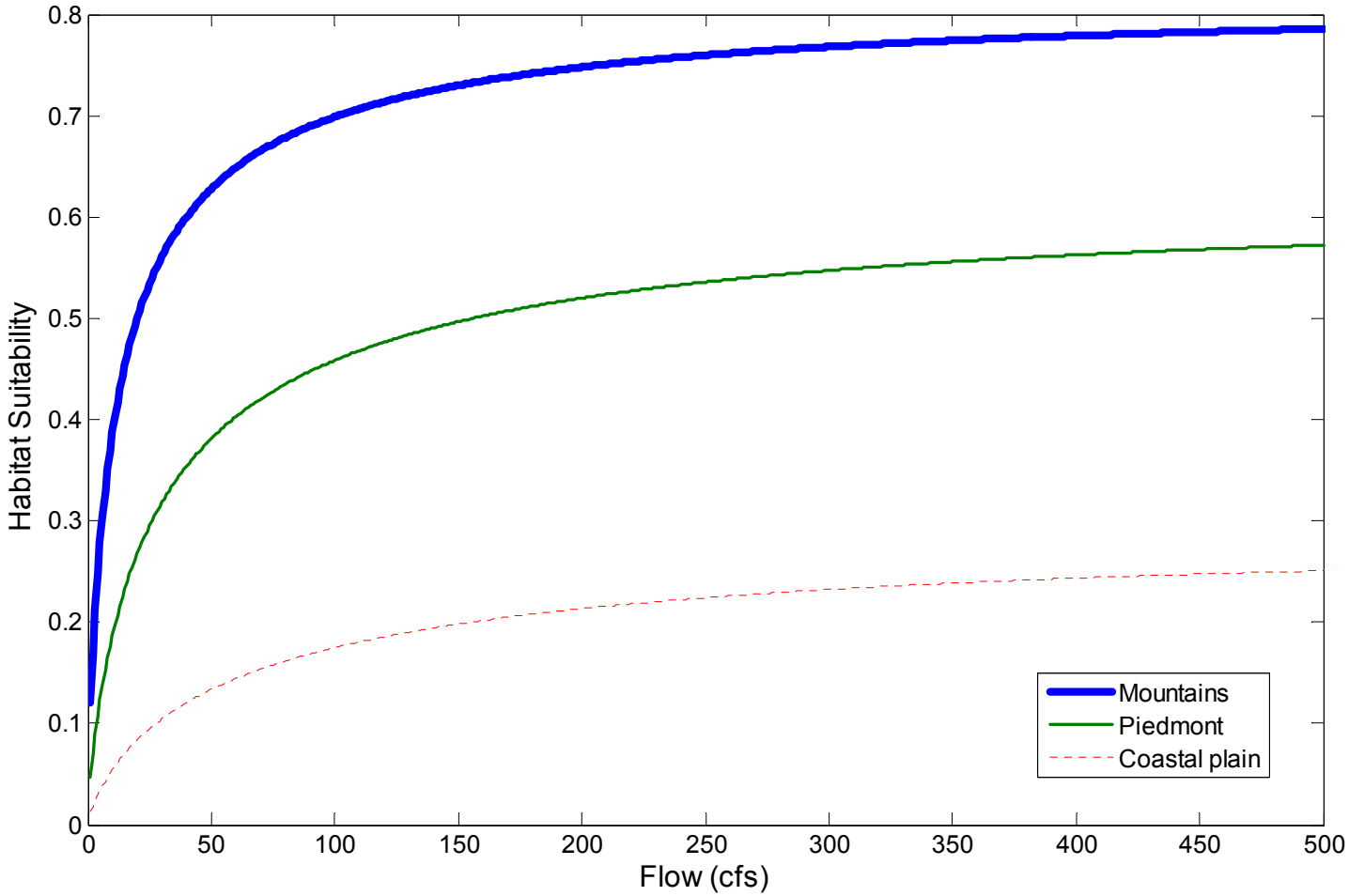
Results – Response to Parameters

Fish Species	Flow	Velocity	Temp	Forest	Slope
Swallowtail shiner		+/-	+		-
Northern hogsucker	+/-			+	
Roanoake darter	+/-	+/-	-		

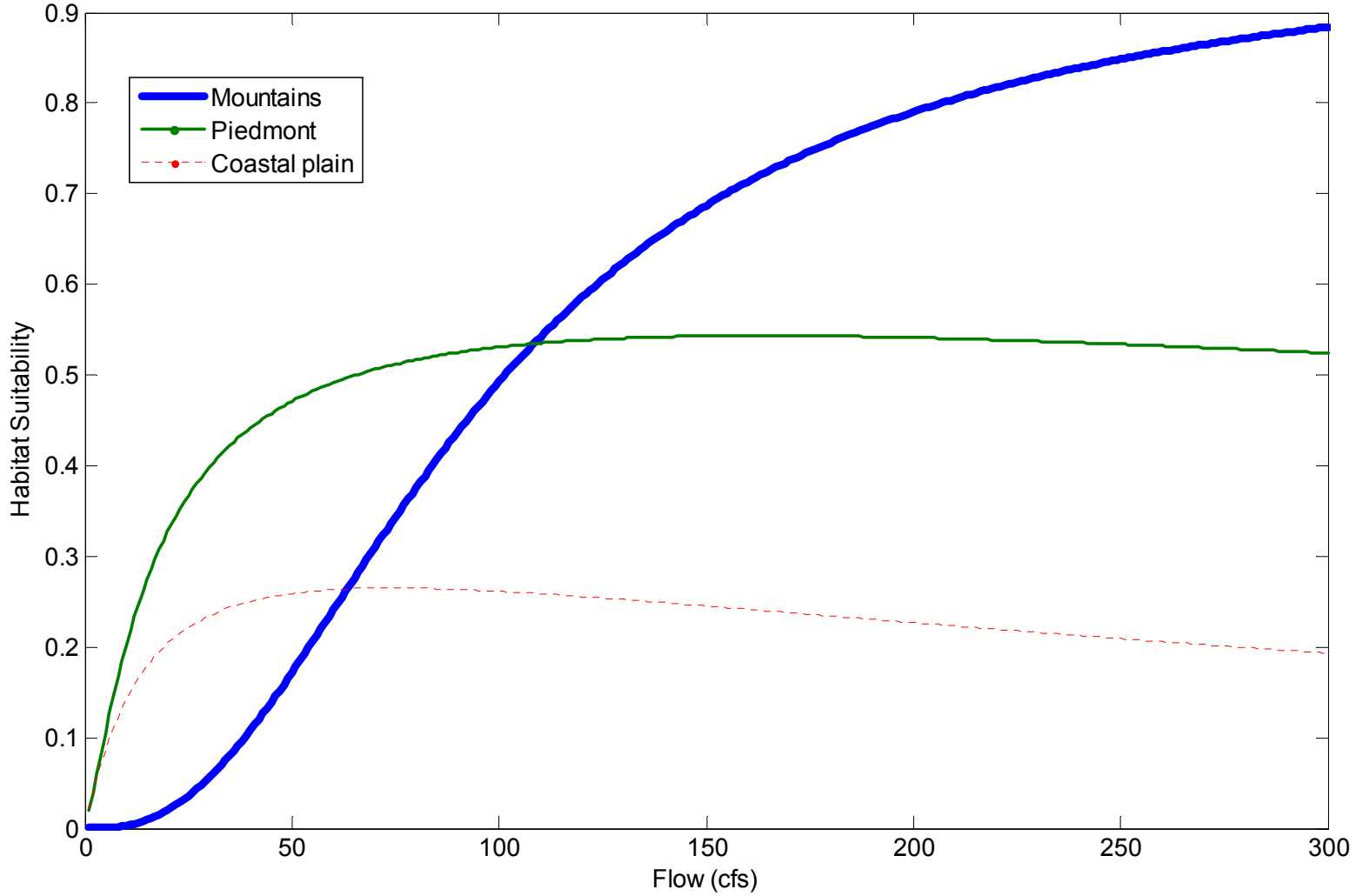
Results – Swallowtail Shiner



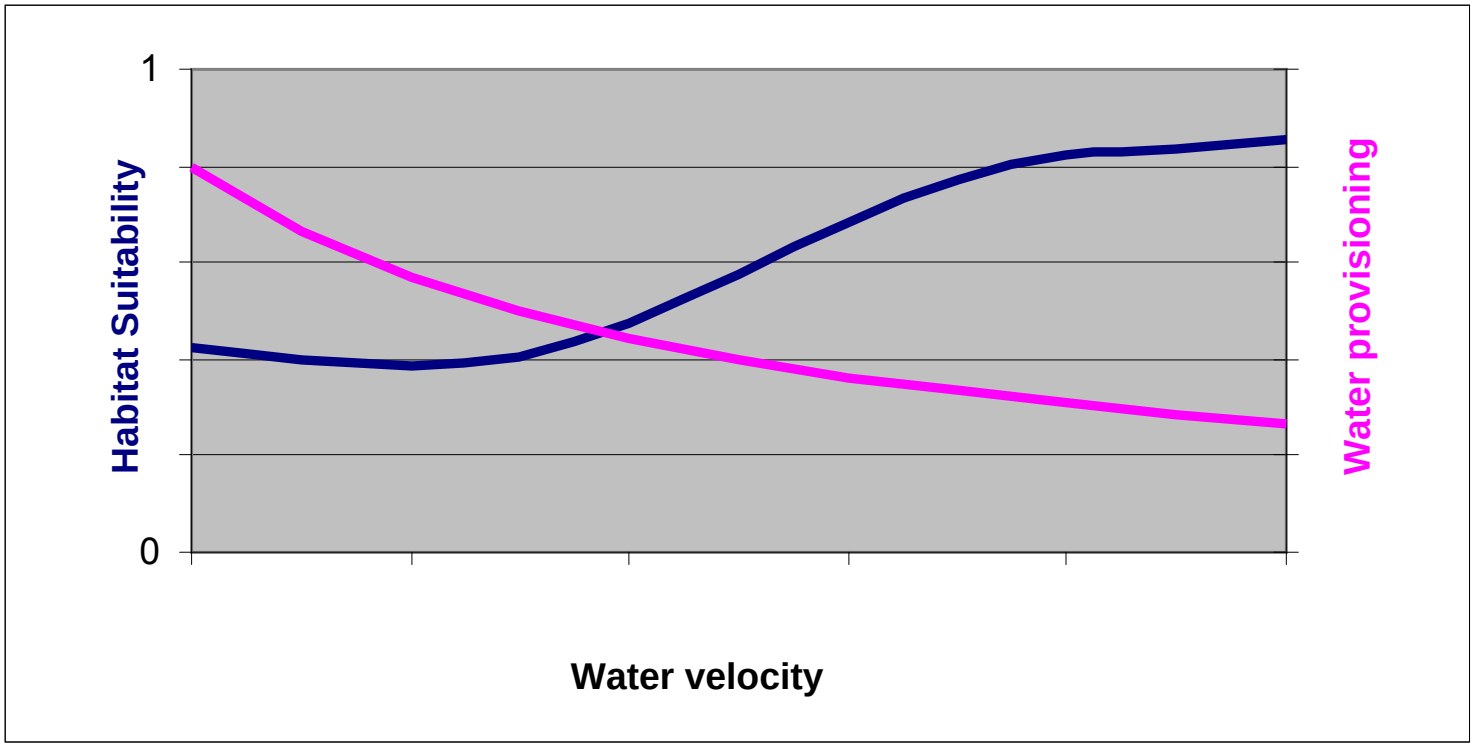
Results - Northern Hogsucker



Results – Roanoake Darter

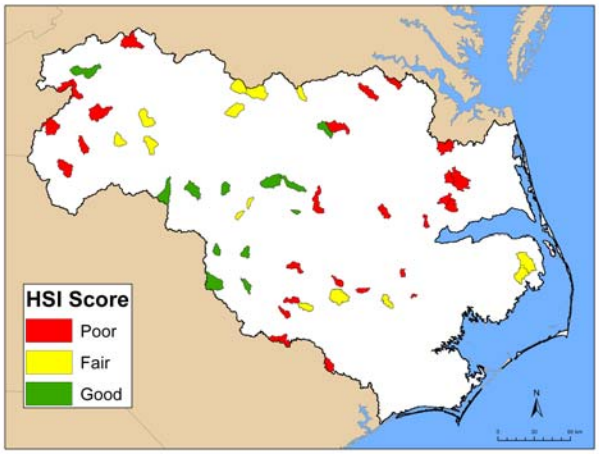


Ecological Trade-Off Functions

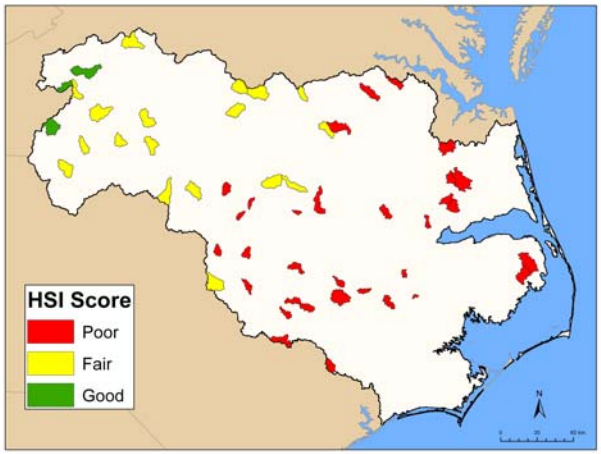


Application to Randomly Selected HUCs

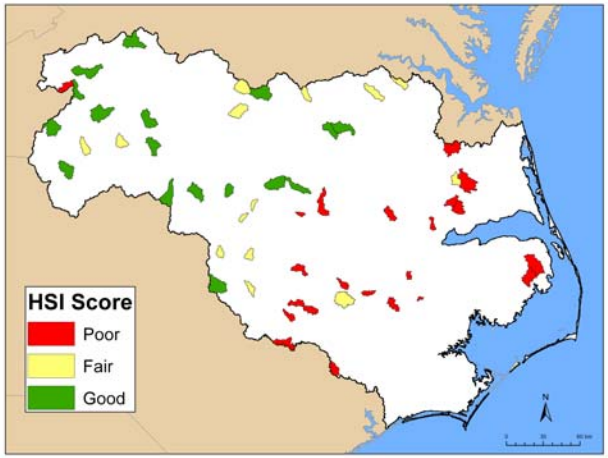
Swallowtail shiner



Northern hogsucker



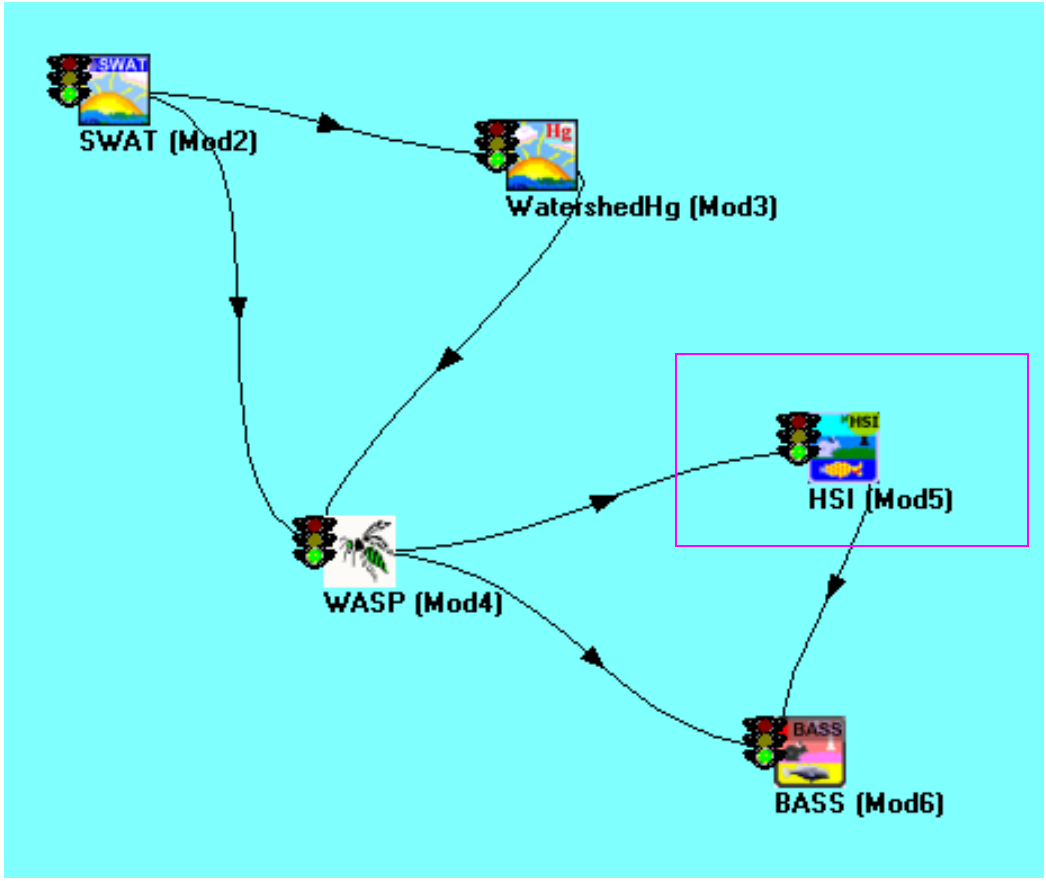
Roanoake darter



Modeling Framework

SWAT –
Soil &
Water
Assessment
Tool

WASP –
Water quality
Analysis
Simulation
Program



BASS –
Bioaccumulation &
Aquatic
System
Simulator

BASS Population Modeling

BASS assumes that a cohort's population dynamics will conform to the self-thinning power function relationship

$$N = aW^{-b}$$

A cohort's self-thinning exponent b is assumed to be a function of its species' habitat suitability index (HSI) for survival such that b is maximal when HSI = 0 and is minimal when HSI = 1:

$$b = \left(1 - HSI_{survival}\right)\left(b_{\min} - b_{\max}\right) + b_{\min}$$

Conclusions

- Reasonable models can be developed with NHDPlus data
  - ~75% correct for training and test data
  - Missing aspects of substrate and cover
  - Does not account for flow variability
  - Better for screening

Conclusions

- Flow and velocity are important predictors of suitability
  - Responses differ by species and ecoregion
  - Mid to high values are more suitable
  - Models can be used to consider trade-offs with other ecosystem services
  - Linked modeling systems can assess effects of flow alteration on fish (in the context of other stressors) under future scenarios

Acknowledgements

- We thank Gerry Laniak and the ERD MEERT Research Team for input