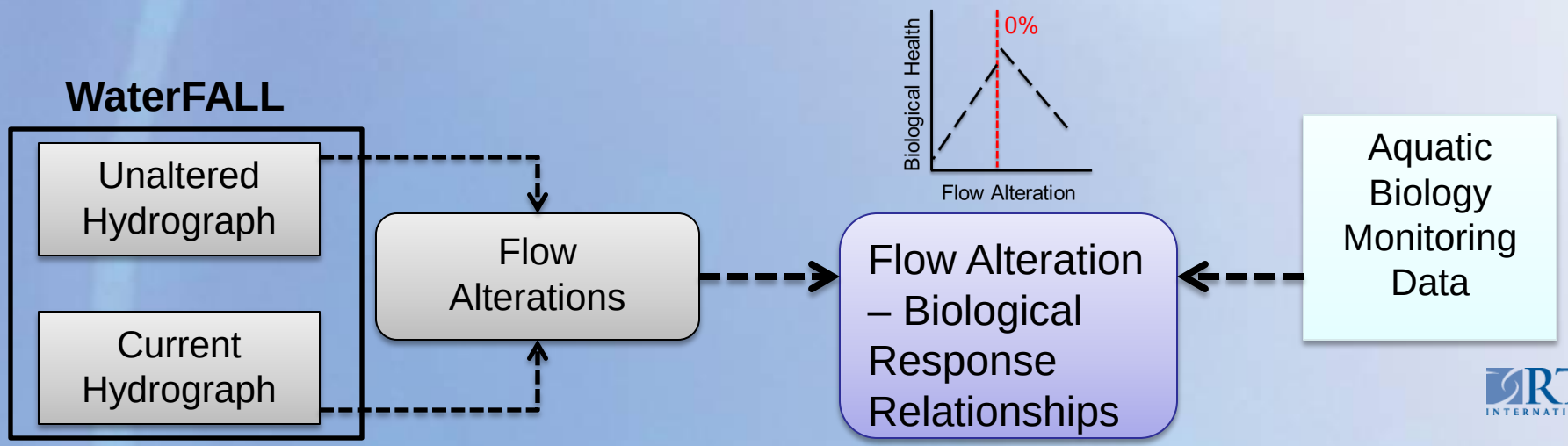
Flow Alteration – Biological Response Relationships: *Proof of Concept of a Proposed Methodology*

RTI Internal Research and Development Project

Objectives

- To develop and test a space-for-time/cross-sectional analysis approach to determine flow alteration – biological response relationships:
  - to support determination of ecological flows
    - e.g., Step 2 of BEC project
  - that are useful to water resource managers



Methods

- Flow alteration
  - Data:
    - WaterFALL™ hydrologic data at each biological monitoring station
    - unaltered (Potential Natural Vegetation - PNV) and current (2006 NLCD + instream flow alterations) hydrologic conditions – expressed as % change
    - 40-year climate period (1967-2006)
  - Metrics:
    - Based on TNC Indicators of Hydrologic Alteration (IHA) and Ecodeficit metrics
    - Focused on reductions/decreases in flow (management focus)
    - Originally 67 metrics, now 23 metrics due to high degree of correlation between metrics
      - magnitude, timing, and duration components of flow

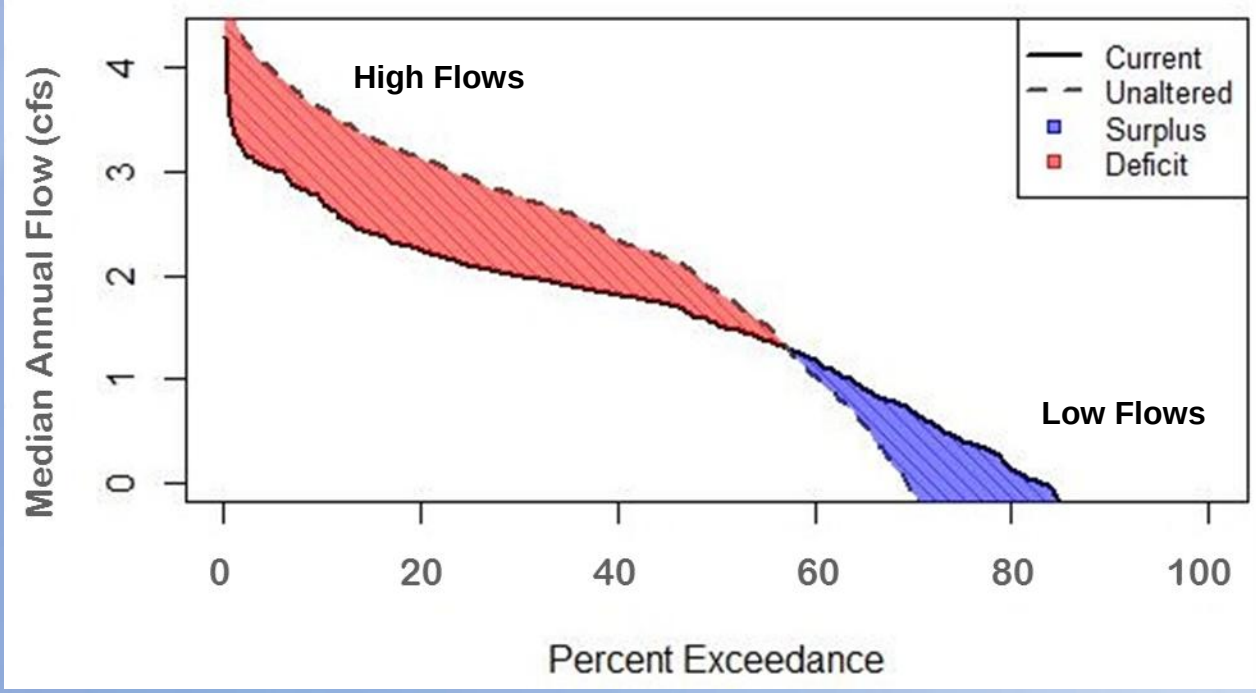
Methods

- Flow alteration metrics

Metric Group	Time Step (months)	Description	Number of Metrics	Flow Regime Component
EcoDeficit	Annual Winter (12-3) Spring (4-6) Summer (7-9) Fall (10-11)	Deficit in flow duration curves between unaltered and altered conditions	5	Magnitude Timing
Minimum Flow Durations	Annual Winter (12-3) Spring (4-6) Summer (7-9) Fall (10-11)	3-, 7-, 30-, and 90-day average minimum flows (90 days not present in fall)	19	Magnitude Duration Timing
Total			**23**	

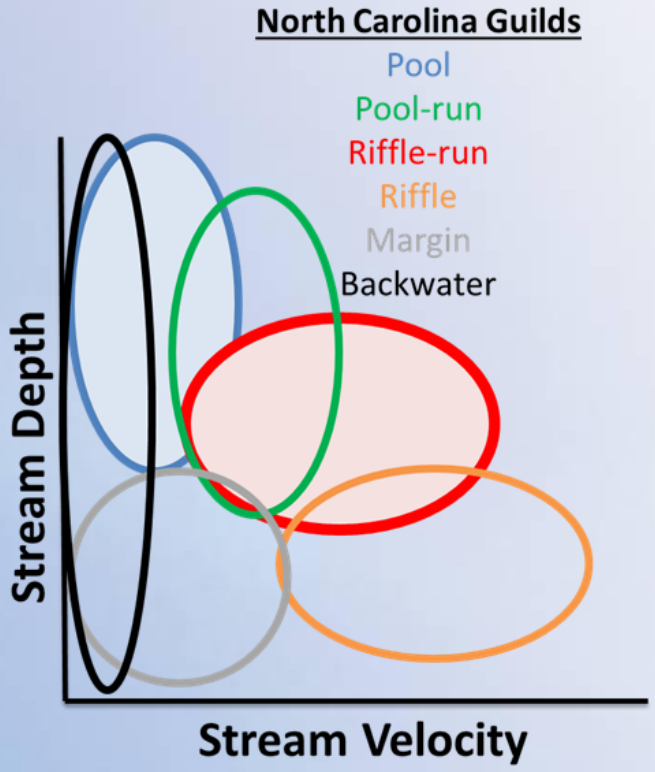
Methods

- EcoDeficit and Ecosurplus
  - From Vogel et al. (2007) and Gao et al. (2009)



Methods

- Biological response metrics
  - NC DWQ Fish community dataset:
    - Most recent record (1990-2011)
    - 858 monitoring stations
  - Fish species (156) grouped by habitat guild:
    - Pool (44 species / 675 stations)
    - Pool-run
    - Riffle-run (44 species / 650 stations)
    - Riffle
    - Margin
    - Backwater
  - Metric
    - Species diversity
    - Abundance (total count)
    - Shannon Weaver Index



Methods

- Biological response metrics

90th percentile of biologic metrics for riffle-run guild by basin

Basin	n	Abundance	Species	Shannon
Broad	43	169	5	1.31
Cape Fear	72	95	4	0.89
Catawba	66	342	6	1.43
French Broad	73	674	10	1.76
Hiwassee	19	767	9	1.58
Little Tennessee	60	552	9	1.52
Lumber	12	15	1	0.00
Neuse	47	194	4	1.05
New	31	1512	11	1.62
Roanoke	37	419	11	1.84
Savannah	2	115	3	0.42
Tar	34	131	5	1.29
Watauga	19	625	5	1.09
Yadkin	136	419	7	1.44

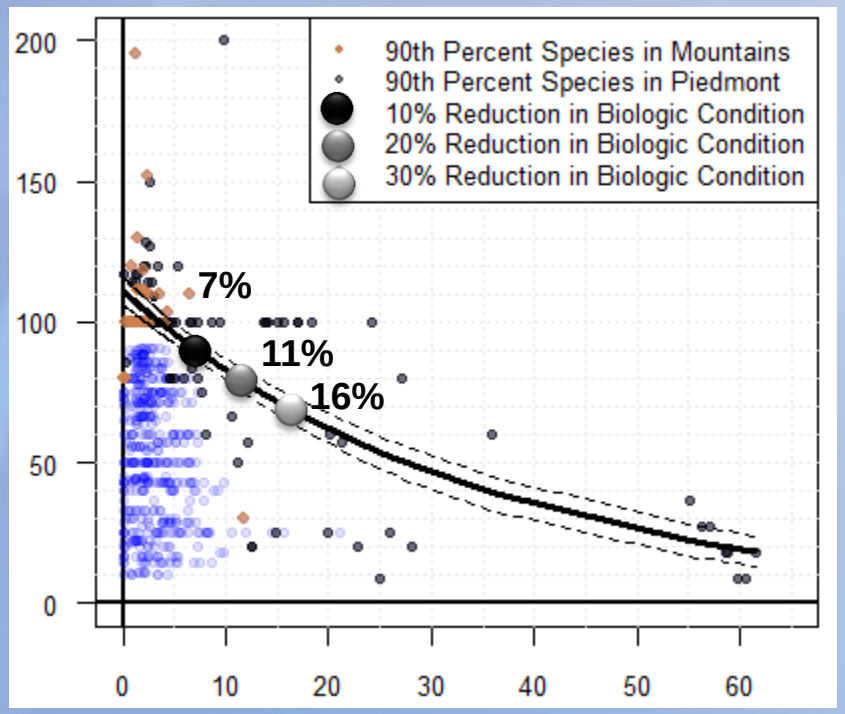
- Metrics normalized by 90th percentile value for each basin (i.e., “maximal biological condition” in each basin)

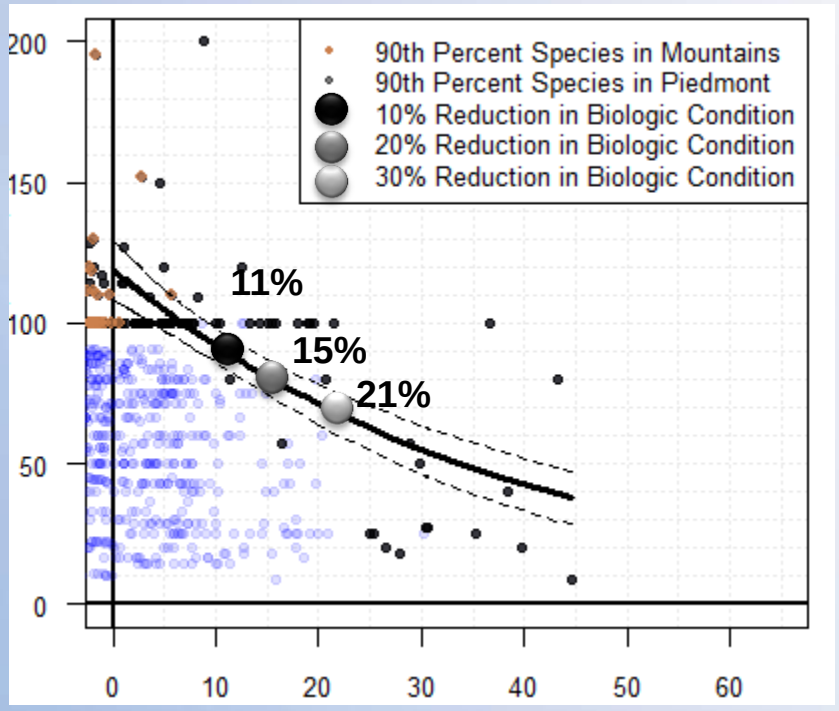
Methods

- Statistical Analyses:
  - Focused on 90th percentile of data (to represent upper limit of response attributable to flow alteration)
  - Normalized data by basin
  - Analyzed at state level
  - Linear vs. non-linear response function
    - best fit determined by residual deviance
- Thresholds of biological response:
  - Flow alteration associated with 10, 20 and 30% reduction in “biological condition”

Results

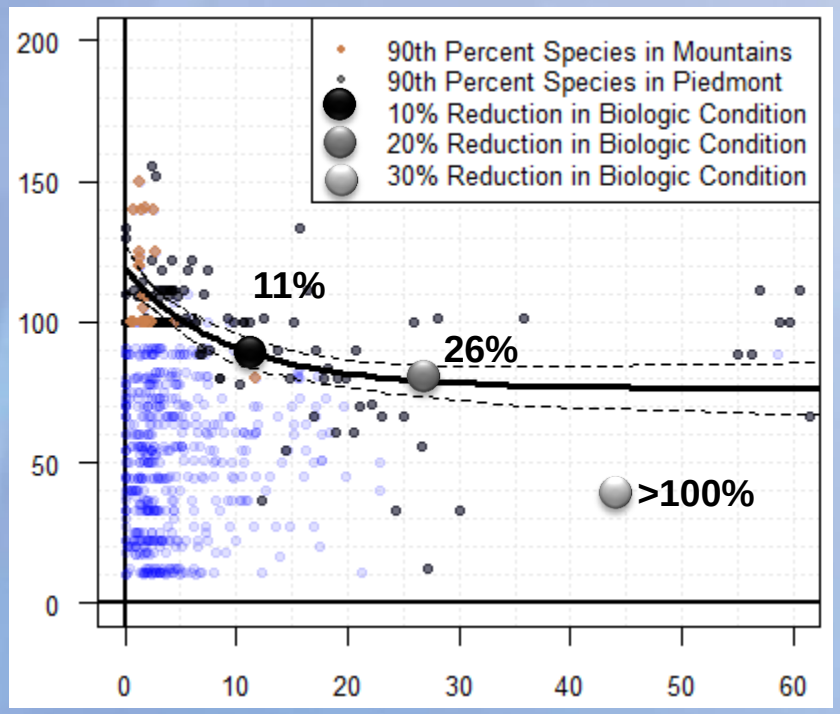
- Riffle-run guild

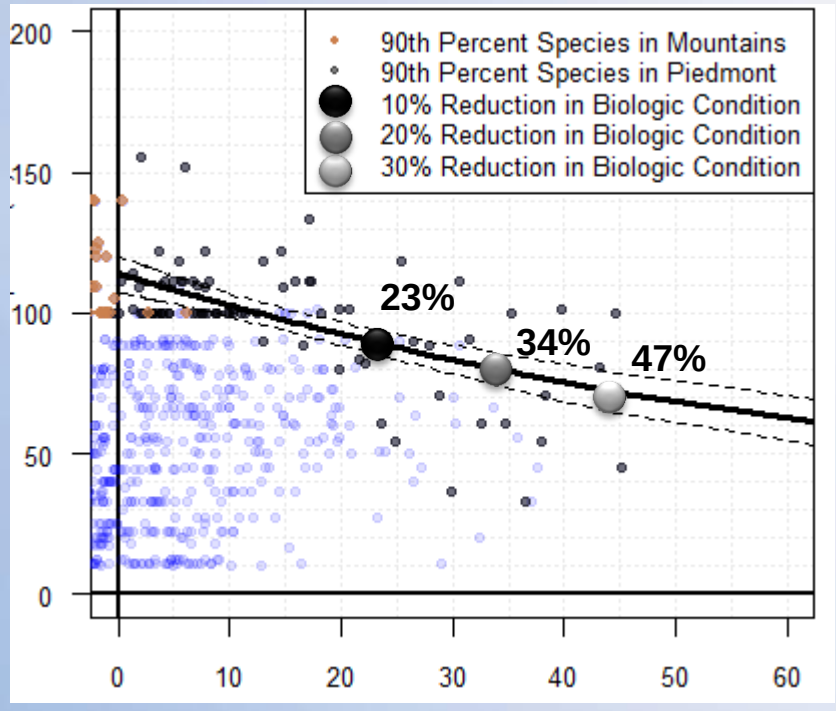




Results

- Pool guild





Results

- Riffle-run guild

Changes in flow associated with a 10% decrease in the maximum biologic condition

Exponential Decay Model

Generalized Linear Model

NS Not significant ($p < 0.05$)

Flow Metrics	Abundance	Species	Shannon
Annual Deficit	6	7	5
Winter Deficit	6	7	5
Spring Deficit	6	7	6
Summer Deficit	8	9	8
Fall Deficit	11	10	10
Annual 3 Day	10	11	11
Annual 7 Day	8	NS	5
Annual 30 Day	13	13	11
Annual 90 Day	12	11	10
Winter 3 Day	9	9	8
Winter 7 Day	8	9	4
Winter 30 Day	9	10	8
Winter 90 Day	9	10	8
Spring 3 Day	9	11	8
Spring 7 Day	8	8	9
Spring 30 Day	11	12	13
Spring 90 Day	11	11	12
Summer 3 Day	10	13	12
Summer 7 Day	9	NS	6
Summer 30 Day	14	14	12
Summer 90 Day	17	14	15
Fall 3 Day	12	12	8
Fall 7 Day	12	13	10
Fall 30 Day	12	12	10
Average	10	11	9
Deviation	2.7	2.1	2.9

Results

- Pool guild

Changes in flow associated with a 10% decrease in the maximum biologic condition.

Exponential Decay Model

Generalized Linear Model

NS Not significant ($p < 0.05$)

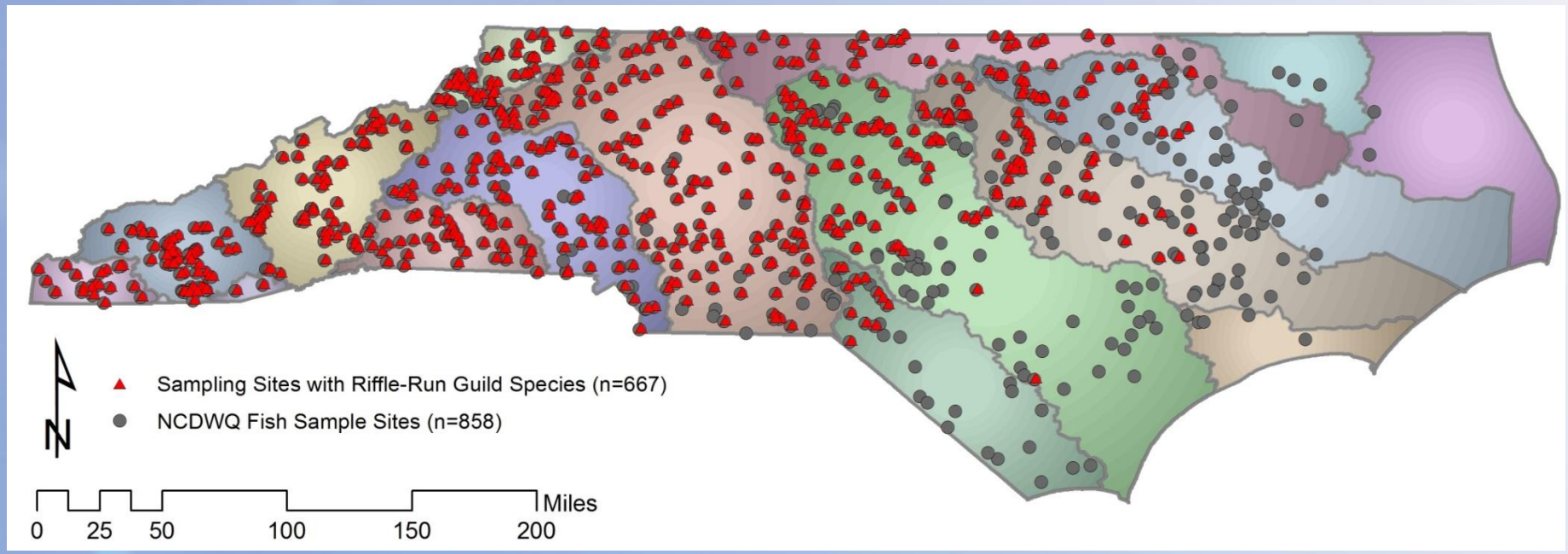
Flow Metrics	Abundance	Species	Shannon
Annual Deficit	25	11	13
Winter Deficit	31	11	13
Spring Deficit	22	11	13
Summer Deficit	21	15	14
Fall Deficit	28	21	25
Annual 3 Day	20	16	17
Annual 7 Day	17	11	15
Annual 30 Day	NS	26	29
Annual 90 Day	NS	23	24
Winter 3 Day	38	33	31
Winter 7 Day	28	NS	31
Winter 30 Day	NS	16	19
Winter 90 Day	NS	16	18
Spring 3 Day	NS	16	20
Spring 7 Day	28	14	14
Spring 30 Day	31	19	21
Spring 90 Day	31	21	24
Summer 3 Day	23	17	19
Summer 7 Day	14	NS	19
Summer 30 Day	NS	24	31
Summer 90 Day	36	22	28
Fall 3 Day	26	14	17
Fall 7 Day	32	24	27
Fall 30 Day	30	22	21
Average	27	18	21
Deviation	6.3	5.7	6.1

Potential applications:

- Develop these relationships for each stream class
  - i.e., BEC system
- Adopt these relationships for all “monitorable” streams (i.e., stream classification may not be necessary):
  - Riffle-run guild:
    - Mountains and Piedmont
  - Pool guild:
    - Mountains, Piedmont, and Coastal Plain

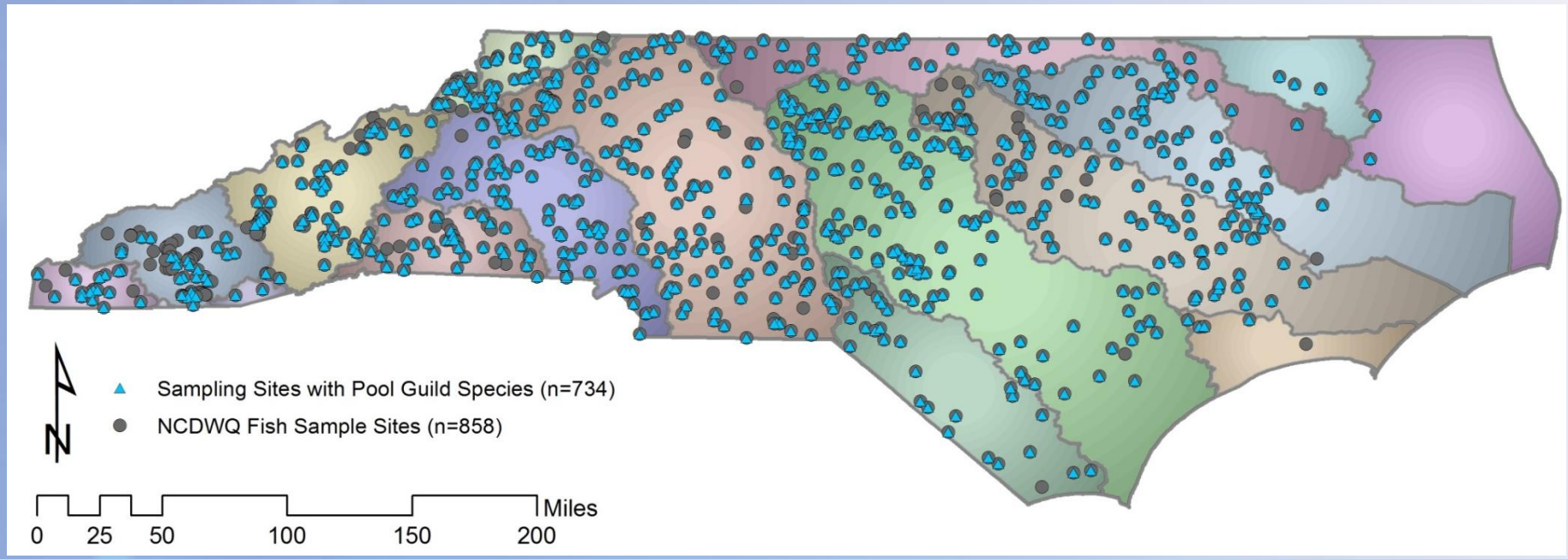
Potential Applications

- Monitoring sites with riffle-run guild present



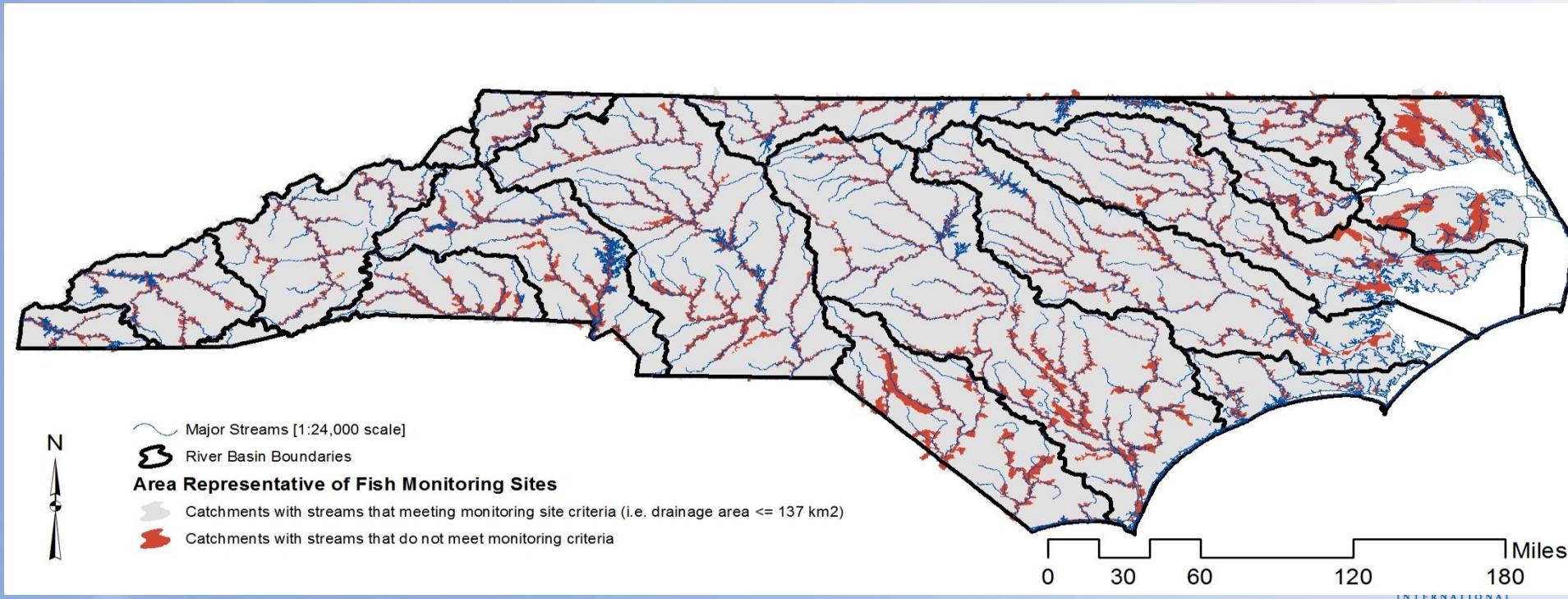
Potential Applications

- Monitoring sites with pool guild present



Potential Applications

- Where can the flow-biology relationships be applied?
  - To all streams that are “monitorable”
    - Maximum drainage area
    - Wadeable for stream length of 600 ft



Questions?

Fall Creek