The Development of Monitoring Methodologies and Indices of Biotic Integrity for Headwater Wetlands in North Carolina

North Carolina Division of Water Quality

Virginia Baker – virginia.baker@ncmail.net

Rick Savage – rick.savage@ncmail.net

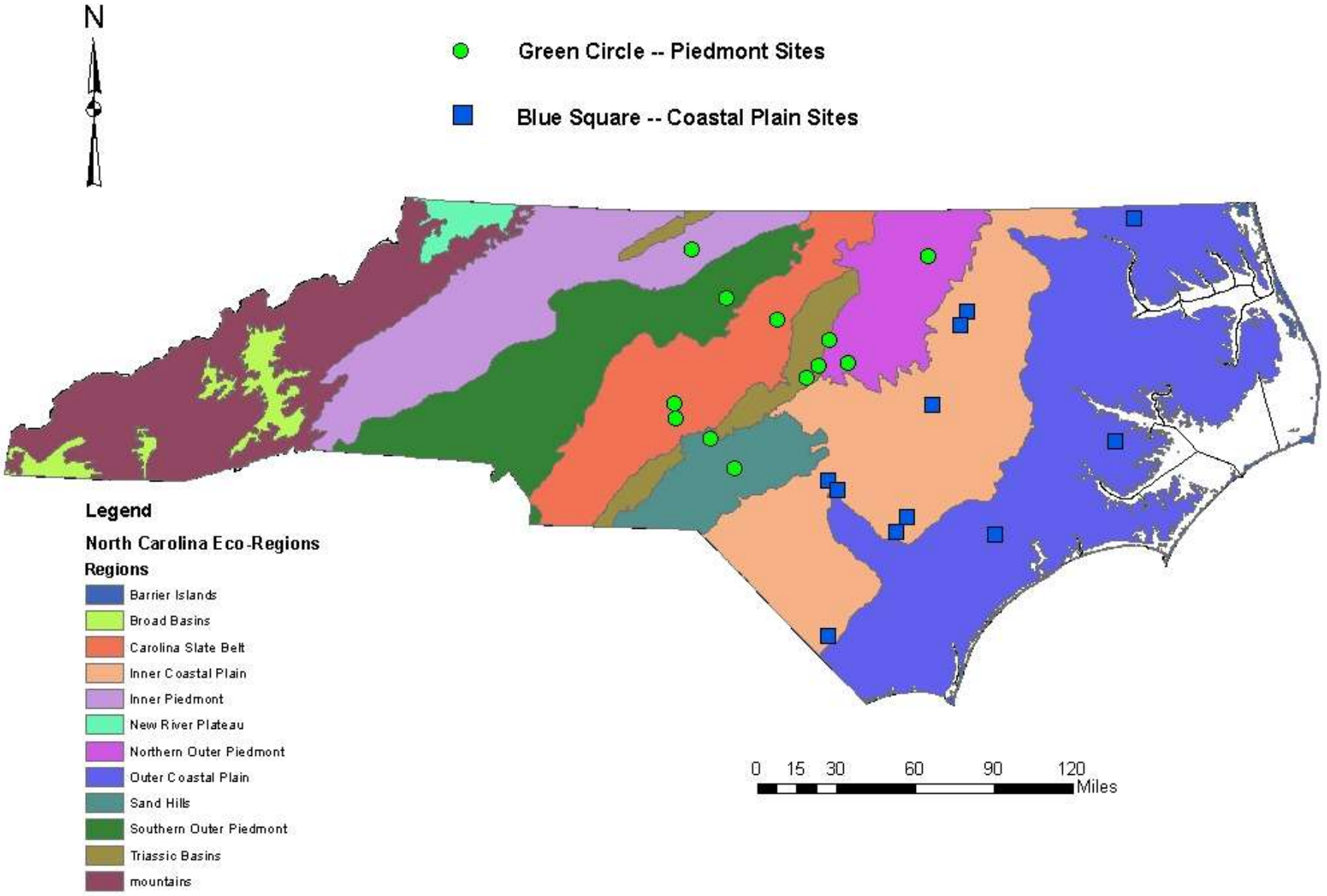
Objective

To determine the differences and similarities among amphibians, macroinvertebrates, and plant communities along a gradient of human disturbance within Headwater Forest Wetlands.

Goals

To develop separate amphibian, macroinvertebrate, and plant methodologies and Indices of Biotic Integrity (IBIs) that can be used for North Carolina Coastal Plain and Piedmont headwater wetlands.

Headwater Wetland Monitoring Sites



Monitoring Methods

1. GIS Analysis
2. Rapid Assessment Method
3. Intensive Surveys

Biological Surveys

- Amphibians
- Aquatic Macroinvertebrates
- Plants

Physical and Chemical Surveys

- Water Quality
- Soils
- Hydrology

What are Indices of Biotic Integrity?

IBIs are a numeric index which is composed of 5-10 metrics derived from biological attributes (e.g. species richness, evenness, percent predators etc). IBIs are used to represent a wetland's condition and provide a simple way to interpret the results of multiple biological attributes.

IBI Development

1. Identify Candidate Metrics

   (Biological attributes – e.g. Species richness, percent tolerant species, percent sensitive species etc)

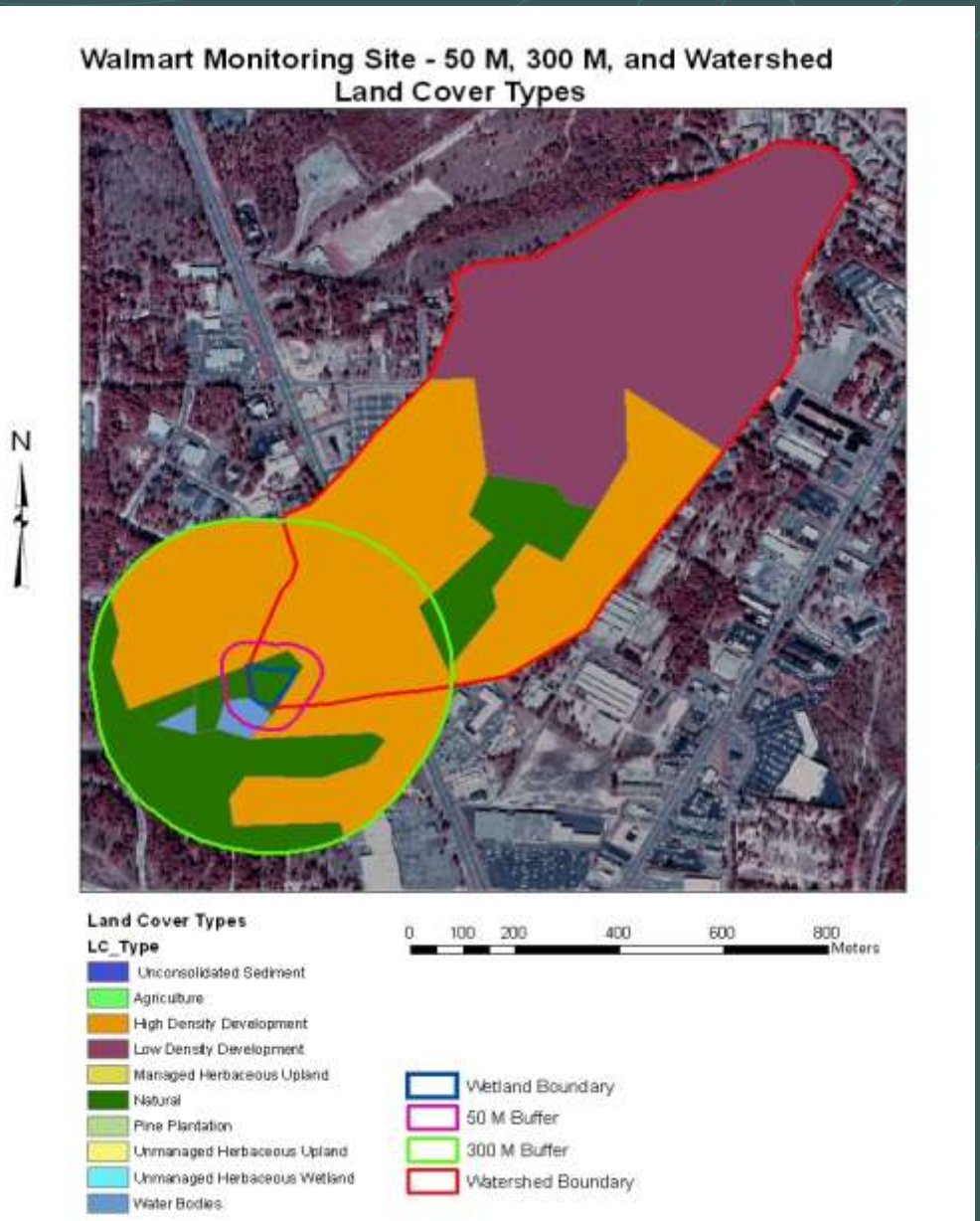
2. Test Candidate Metrics by statistically correlating with disturbance measurements

   - GIS Analysis (LDI)
   - Rapid Assessment Method (ORAM)
   - Chemical & Physical Intensive Survey Summary Results

GIS Analysis Disturbance Measurement
Land Development Index (LDI)

$$LDI_{Total} = \sum \%Lu_i * LDI_i$$

- LDI_{Total} = LDI Ranking for landscape unit
- $\%Lu_i$ = percent of the total area of influence in the land use i
- LDI_i = landscape development intensity coefficient for land use



Rapid Assessment Method Disturbance Measurement ORAM

Ohio Rapid Assessment Method (ORAM) v. 5.0

1. Wetland Area
2. Upland buffers and surrounding land-use
3. Hydrology
4. Habitat Alteration and Development
5. Plant Communities, Interspersion, and microtopograpy

Intensive Survey Summary Results
Disturbance Measurements

Summary Soil Results

Average wetland soil core results for pH, Cu, Zn

Summary Water Quality Results

Average surface water results

Dissolved Oxygen, Temperature, Specific Conductivity, pH, Fecal Coliform, Nutrients (Phosphorous, Ammonia, NO_2+NO_3, TKN), Metals (Cu, Pb, Zn, Mg, Ca), TSS, Turbidity, TOC, DOC.

Combination Disturbance Measurements - Relative Average

Relative Nutrients (Phosphorous + Ammonia + NO_2+NO_3 + TKN)

Relative Metals (Cu + Pb + Zn)

Relative Combo – Metals + Nutrients + Fecal coliform + TSS + Specific Conductivity

Amphibian Survey Methods

- Systematically surveyed amphibian microhabitats- streams and pools, woody debris, moss hammocks, leaf cover
- Recorded visual and auditory observations of eggs, larvae, juveniles, and adults
- D-shaped sweep nets, potato rakes, tape recorder
- Quantitative survey done with funnel traps in conjuction with Macroinvertebrate survey in March 2006

Rana sphenocephala

Hemidactylium scutatum

Rana sphenocephala

Hemidactylium scutatum

Amphibian Candidate Metrics

7 Candidate Metrics tested, 5 Metrics chosen

1. Species Richness
2. % Tolerant (Species with C of C $\leq$ 3)
3. % Sensitive (Species with C of C $\geq$ 6
4. % State Listed
5. % Headwater-Ephemeral-Seepage HW-EW-SW
6. % Ureodela (Salamander)
7. Amphibian Qualitative Assessment Index (AQAI)

C of C = Coefficient of Conservatism

Amphibian Results (X = significant result)

Water Quality Disturbance Measurements	DO	Fecal Coliform	Ammonia	NO_2+NO_3	Phophorous	TKN	Cu	Zn	Pb	Ca	Mg	TSS	Turbidity	TOC	DOC	Relative Nutrients	Relative Metals	Combo	Specific Condo	Temp	pH
Species Richness	x									x	x										
% HW - EW - SW		x		x												x					
% Sensitive		x	x		x			x								x		x			
% Tolerant	x																				x
% Urodela			x		x			x	x			x	x				x				
% State Listed																					
AQAI	x		x		x									x	x						x
LDI, ORAM, and Soils Disturbance Measurements	**LDI 300 M**	**LDI Watershe**	**LDI 50M**	**Oram**	**Soils pH**	**Soils Cu**	**Soils Zn**														
Species Richness	x	x		x	x	x	x														
% HW - EW - SW		x			x																
% Sensitive					x																
% Tolerant																					
% Urodela					x																
% State Listed																					
AQAI					x																

Amphibian Score Assignment and IBI Results

Metric Score Assignment for Amphibians

Metric	0	3	7	10
AQAI	<3	<5	<7	≥7
% Sensitive	<5	<10	<25	≥25
% HW-EW-SW	<20	<50	<75	≥75
% Urodela	<10	<30	<50	≥50
Species Richness	<3	<5	<8	≥8

Region	Site Name	Metric Results					Metric Scores					IBI
		AQAI	% Sensitive	% HW-EW-SW	% Urodela	Species Richness	Metric AQAI	Metric % Sensitive	Metric % HW-EW-SW	Metric % Urodela	Metric Score Species Richness	Amphib IBI
Piedmont	Moonshine	2.7	0.0	0.0	8.5	5.0	0	0	0	0	7	7
	Kelly Rd	2.1	0.0	18.1	0.0	8.0	0	0	0	0	10	10
	Fire Tower	2.0	14.3	14.3	28.6	3.0	0	7	0	3	3	13
	Pete Harris	3.5	2.4	68.7	2.4	4.0	3	0	7	0	3	13
	Umstead	2.3	8.8	25.4	8.8	8.0	0	3	3	0	10	16
	Troxler	4.1	6.3	93.9	0.5	4.0	3	3	10	0	3	19
	Black Ankle Powerline	3.9	1.7	93.1	1.7	7.0	3	0	10	0	7	20
	Black Ankle Non-Powerline	3.9	2.4	90.2	4.0	8.0	3	0	10	0	10	23
	East of Mason	4.0	2.3	95.1	2.3	11.0	3	0	10	0	10	23
	Spring Garden	3.9	4.8	84.8	16.0	5.0	3	0	10	3	7	23
	Walmart	7.0	100.0	16.7	100.0	2.0	10	10	0	10	0	30
	Duke Forest	6.0	52.8	69.3	52.8	4.0	7	10	7	10	3	37

Aquatic Macroinvertebrate Survey Methods

Funnel Trap

Sweep Net

Stove Pipe Sampler

Aquatic Macroinvertebrate Candidate Metrics

36 Candidate Metrics tested

- Taxonomic Richness
- Taxonomic Composition
- Trophic Structure
- Tolerant / Sensitive

Aquatic Macroinvertebrate IBI Results

6 Coastal Plain Metrics Chosen

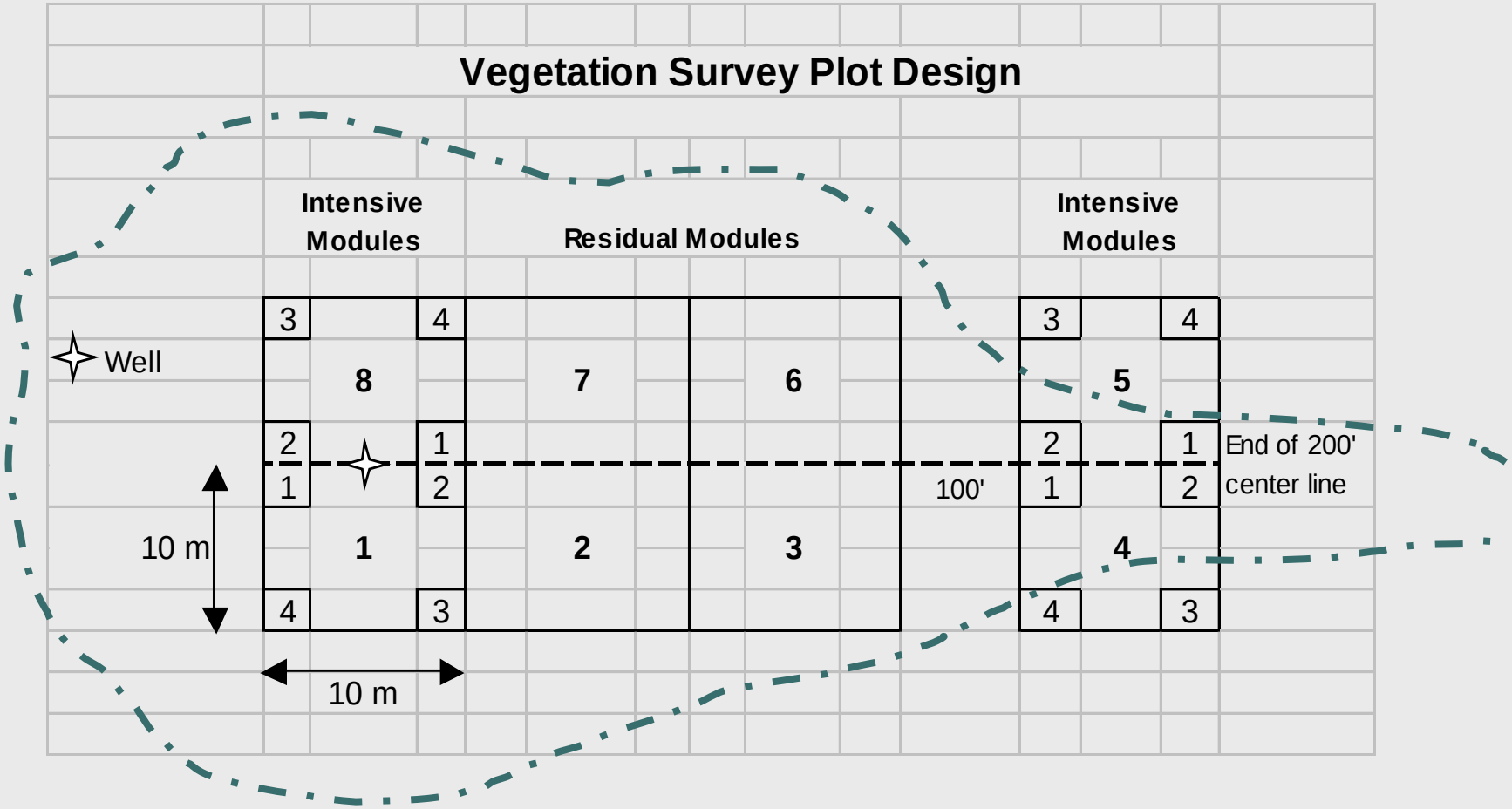
% Coleoptera, % Crustacea, % Diptera, % Orthocladiinae, % POET (Plecoptera, Odonata, Ephemeroptera, Trichoptera), POET Richness

7 Piedmont Metrics Chosen

% Tolerant, % Mollusk, % Coleoptera, POET Richness, Family Richness, Chironomidae Richness, Predator Richness

Plant Community Survey Methods

Carolina Vegetative Survey Protocol using 2x4 Array of Modules



Plant Community Metrics

41 Candidate Metrics tested - 10 Metrics chosen

Community Balance

- Native Species Evenness Metric

Floristic Quality

- Floristic Quality Assessment Index (FQAI) Metric
- Average C of C Metric
- Invasive Shrub Cover Metric

Wetness Characteristics

- Native Wetland Plant Richness Metric

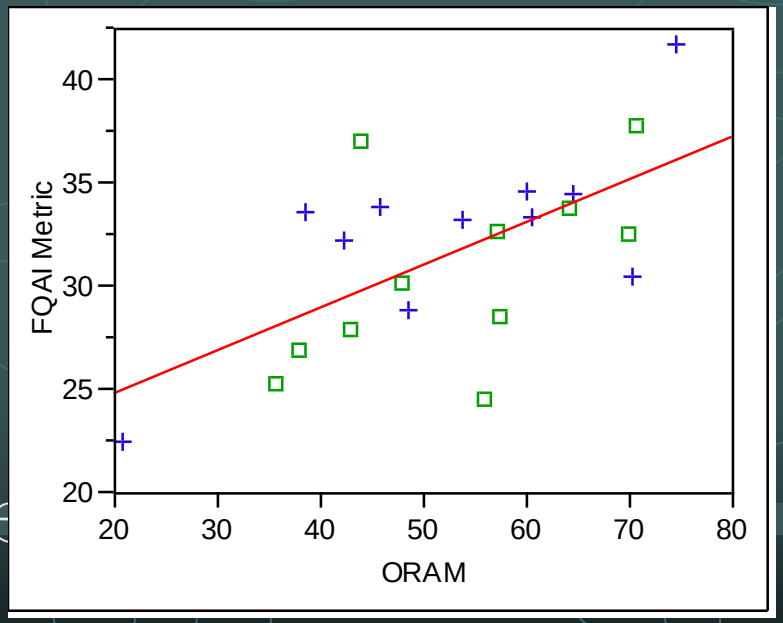
Functional Group

- Poaceae, Cyperaceae, and Juncaceae Cover Metric

Community Structure

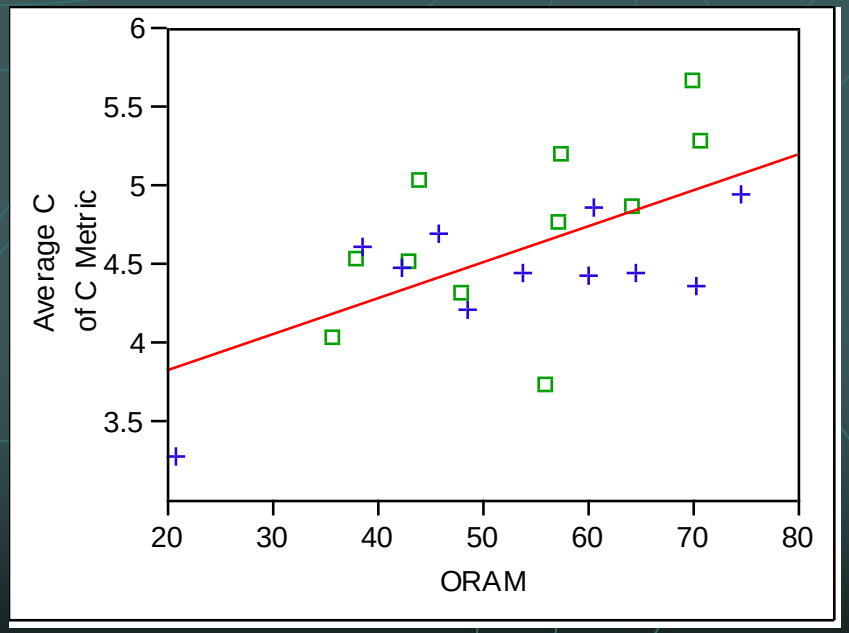
- Native Herb Richness Metric
- Shade Metric
- Pole Timber Density Metric
- Average Importance Shrub Metric

Plant Community Metric Results-FQAI, C of C, and Invasive Shrub Cover by ORAM



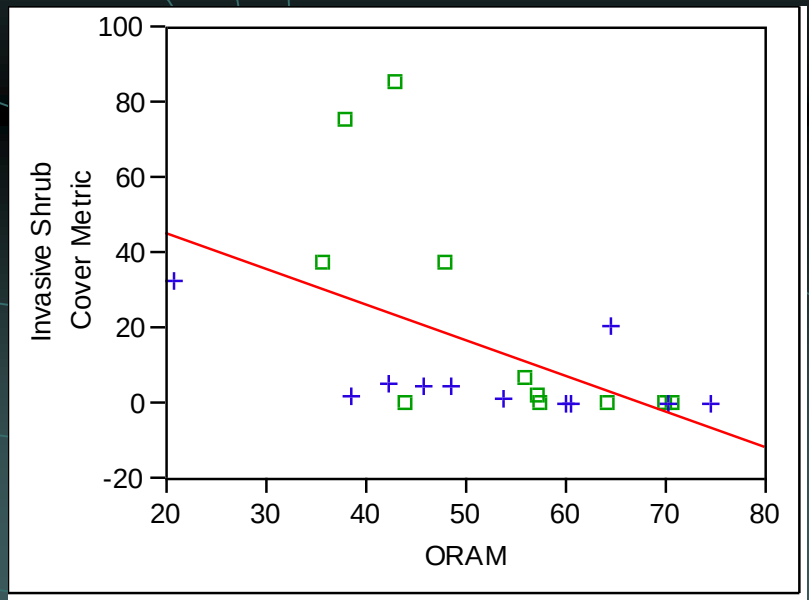
FQAI vs ORAM

p=0.007, r2=0.56



Ave C of C vs ORAM

p=0.03, r2=0.47



Invasive Shrub Cover vs ORAM

p=0.0002, r2=-0.72

Final Conclusions

- The Amphibian and Macroinvertebrate IBI metric correlation analysis results showed that these communities respond more directly to water quality and soil chemistry than the more the ORAM general wetland GIS (LDI) and rapid assessment (ORAM) disturbance measurements.
- The Plant IBI metric correlation analysis showed that there is a significant correlation between the condition of plant communities and the rapid assessment (ORAM) and GIS (LDI) disturbance measurements.

Future Work Plans

- Further testing of survey methods and Amphibian, Macroinvertebrate, Plant IBIs in different North Carolina wetland community types – bottomland hardwood, riverine swamp, basin wetlands.
- Further testing of the NC rapid assessment – NC Wetland Assessment Method (NCWAM) by correlating with wetland IBI results.

Thank you

U. S. Environmental Protection Agency
Alan Weakley, University of North Carolina
Alvin Braswell, NC Natural History Museum
North Carolina Division of Water Quality-
Larry Eaton
John Dorney
Alicia Duclos
Caroline Reddy
Mike Turner

Virginia Baker – virginia.baker@ncmail.net
Rick Savage – rick.savage@ncmail.net