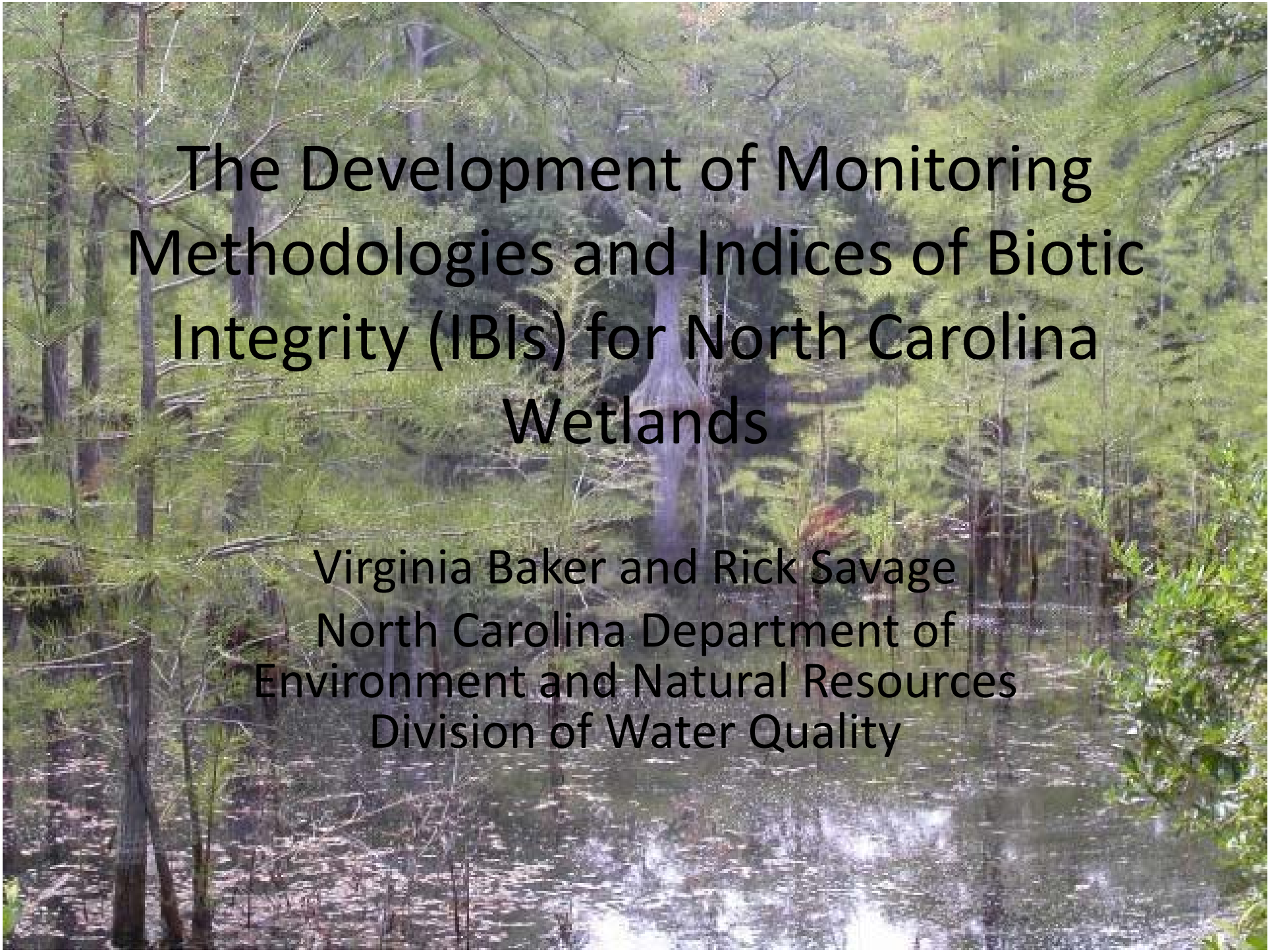

The Development of Monitoring Methodologies and Indices of Biotic Integrity (IBIs) for North Carolina Wetlands

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Wetlands Monitoring Objectives

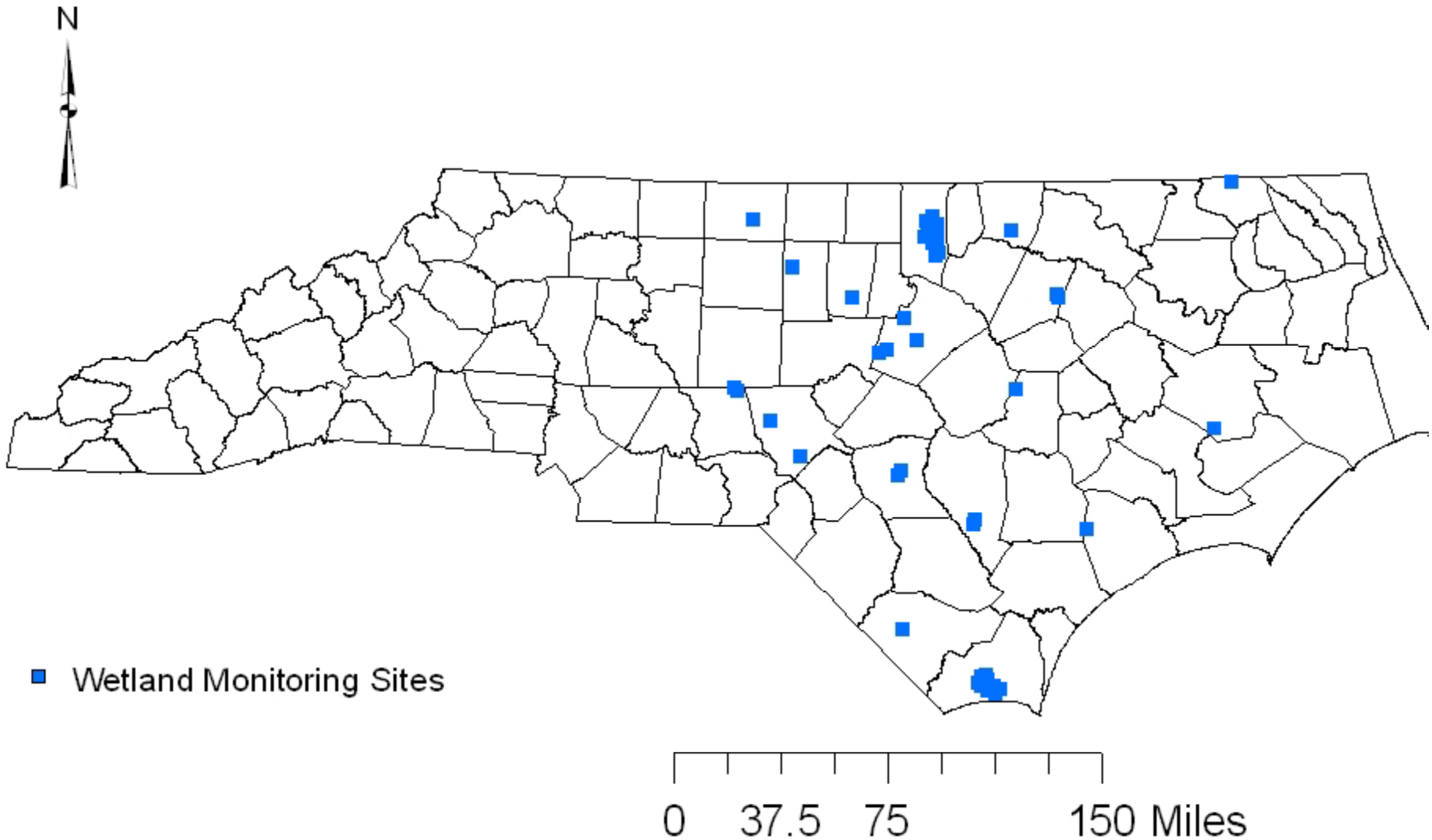
- Design and implement a wetland monitoring program for NC which assesses the change of wetland quality and function along a disturbance gradient.

- To develop wetland monitoring and analysis methods for assessing the biological, physical, and chemical characteristics of NC wetlands.

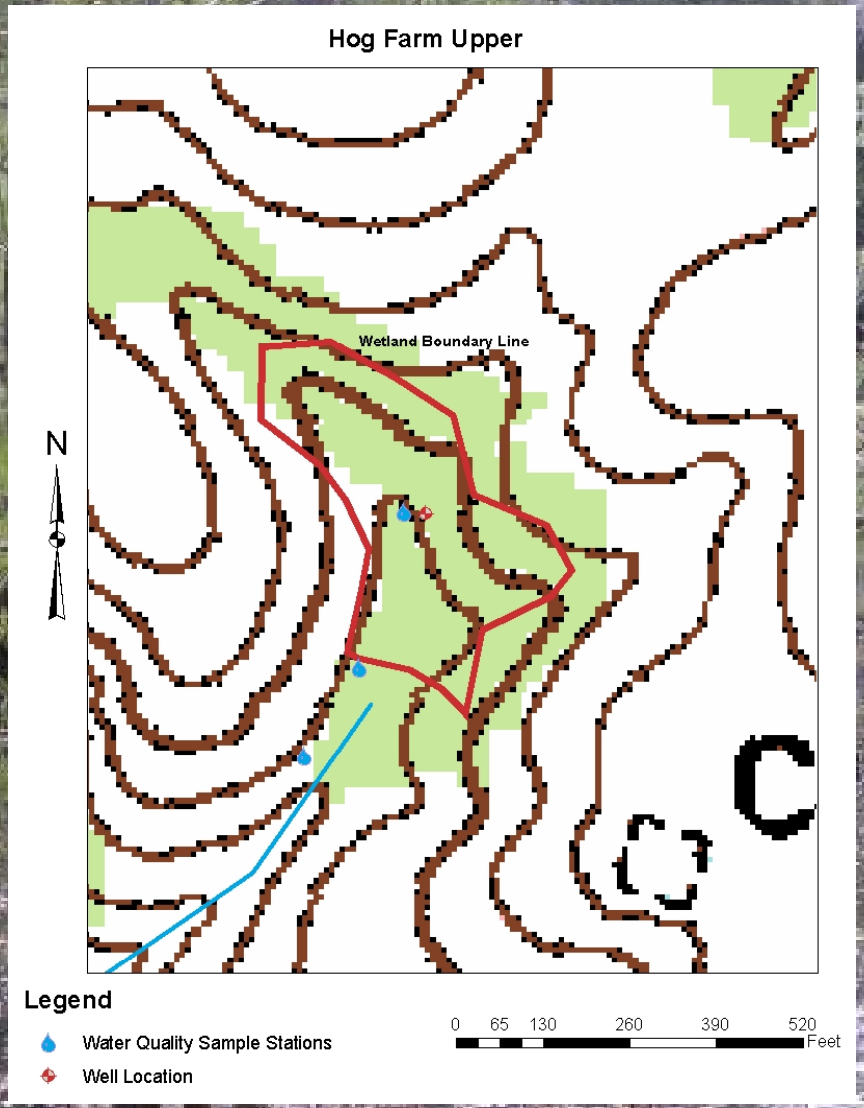
  - Develop Indices of Biotic Integrity (IBIs) specific for NC wetlands types for amphibians, aquatic macroinvertebrates, and plants.
  - Assess the water quality, soils, and hydrology of NC wetlands and how human impacts affect these characteristics.

- Determine ways the wetland monitoring methods and IBIs can be applied to the NC 401 Regulatory program.

Wetland Monitoring Sites



Headwater Wetland Study
23 Coastal Plain and Piedmont Sites 2004-2006



Riverine Swamp Forest (7), Bottomland Hardwood Forest (6), and Basin (12) wetland sites in a Coastal Plain and Piedmont Watershed, 2006-2008

Bottomland Hardwood Forest

Piedmont Basin Wetland

Riverine Swamp Forest

Coastal Plain Basin Wetland

Wetland Monitoring Methods

- Level I - GIS mapping – Land Development Index (LDI) for site watershed and buffer.
- Level II – Rapid on the ground wetland assessments: Ohio Rapid Assessment Method (ORAM) and the North Carolina Wetland Assessment Method (NCWAM).
- Level III – Intensive, long-term, on the ground survey methods.
  - Biological – Amphibians, Aquatic Macroinvertebrates, and Plant communities.
  - Physical and Chemical – Water Quality, Hydrology, and Soils.

Amphibian Monitoring

- Qualitative timed survey in late winter and spring.
- Systematically surveyed entire site and surrounding buffer with potato rakes and sweep nets.
- Searched microhabitats- streams and pools, woody debris, moss hammocks, and leaf cover.
- Recorded visual and auditory observations of eggs, larvae, juveniles, and adults.

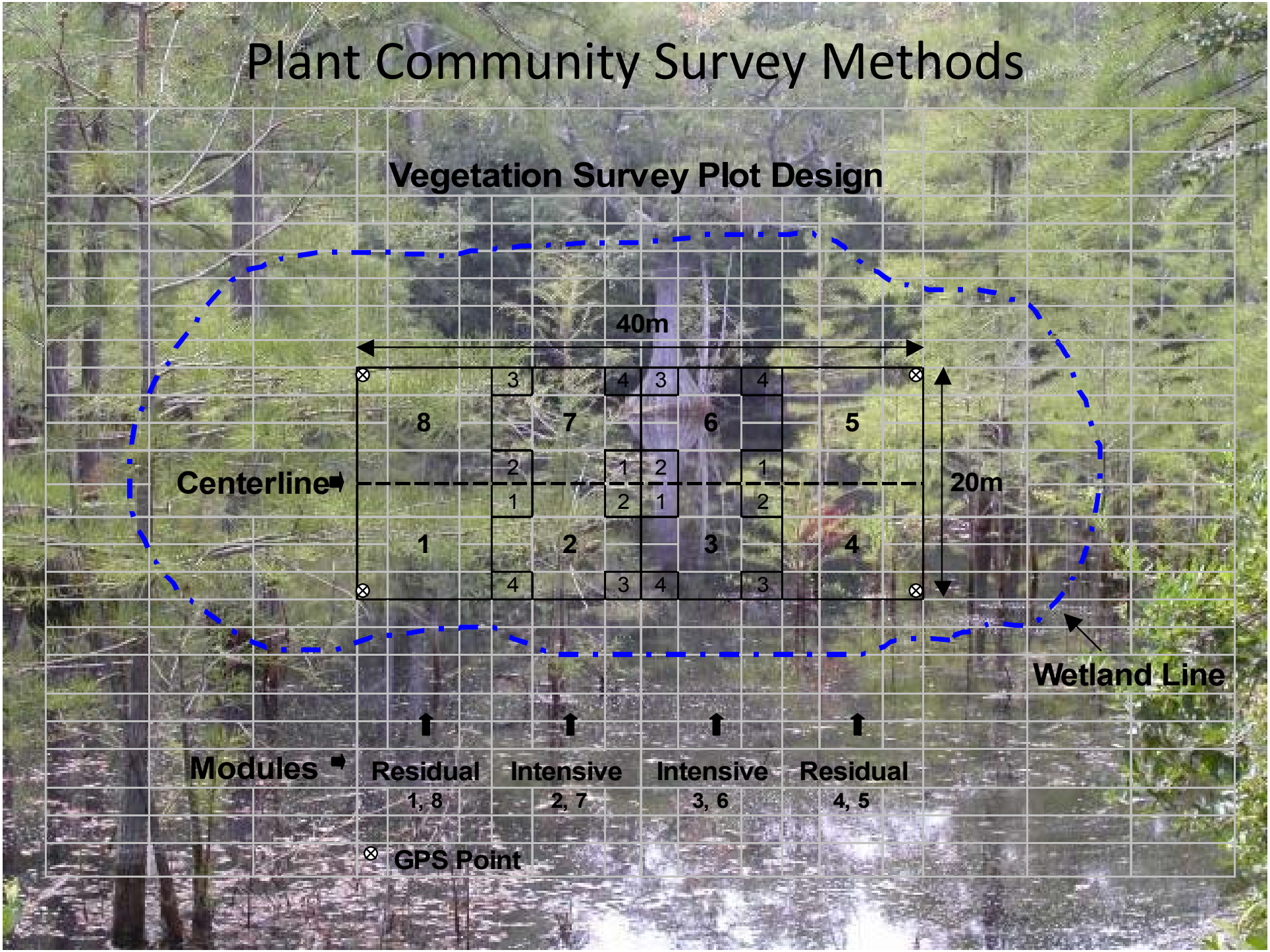
Aquatic Macroinvertebrate Survey

- All wetland types surveyed in late winter, at 5 stations.
- Sweep nets used to sweep different microhabitats.
- Funnel Traps deployed for approximately 24 hours.
- Stovepipe method used in Headwater wetlands only.
- ≤ 200 taxa randomly picked on gridded tray.
- Headwater wetland samples identified and analyzed.

Plant Community Survey Methods

- Delineated study site and generated species presence/absence.
- Used Carolina Vegetative Survey Protocol (Peet et al) as template for plant survey design.
- Plot Design - Array of 2x4 modules (10x10m each).
- Surveyed
  - Cover (cover classes 0-1% ….95-100%)
  - DBH of woody species (size classes 0-1cm ….30-35cm, >35 cm)
  - Presence

Plant Community Survey Methods



IBI Development

- Identify Candidate Metrics

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

- Test Candidate Metrics by statistically correlating with disturbance measurements

  Level 1 - GIS Analysis (LDI)

  Level 2 - Rapid Assessment Method (ORAM)

  Level 3 - Chemical & Physical Intensive Survey Summary Results (water quality and soils)

- Spearman's Rho and Pearson's Correlation Coefficient

Amphibian Candidate Metrics

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

Wetland Types – HW-Headwater, BLH-Bottomland Hardwood, RS-Riverine Swamp, EW-Ephemeral Wetland, SW Seepage Wetland, C of C = Coefficient of Conservatism

Amphibian Results - Bottomland Hardwood Forest

Candidate Metric	Disturbance Measurement	Correlation / Spearman ρ	p-value	Analysis
%EW-HW-Seep	100M	**-0.7924**	**0.0602**	Pearson's Correlation
%EW-HW-Seep	Calcium	**-0.8484**	**0.0327**	Pearson's Correlation
%EW-HW-Seep	Dissolved Oxygen (%)	**0.8704**	**0.0241**	Pearson's Correlation
%EW-HW-Seep	Dissolved Oxygen (mg/L)	**0.8017**	**0.0551**	Pearson's Correlation
%EW-HW-Seep	Magnesium	**-0.9673**	**0.0016**	Pearson's Correlation
%EW-HW-Seep	Magnesium	**-0.7714**	**0.0724**	Spearman's Rho Correlation
%EW-HW-Seep	Specific Conductivity	**-0.7711**	**0.0726**	Pearson's Correlation
%Sensitive	Lead	**-0.7995**	**0.0563**	Pearson's Correlation
%Sensitive	Magnesium	**-0.8286**	**0.0416**	Spearman's Rho Correlation
%Sensitive	ORAM Mean	**0.7714**	**0.0724**	Spearman's Rho Correlation
%Sensitive	Total Suspended Residue	**-0.7307**	**0.0990**	Pearson's Correlation
%Sensitive	WQ Combo	-0.6658	0.1488	Pearson's Correlation
%Tolerance	Copper	0.7143	0.1108	Spearman's Rho Correlation
%Tolerance	Fecal Coliform	0.7143	0.1108	Spearman's Rho Correlation
%Tolerance	Magnesium	0.7143	0.1108	Spearman's Rho Correlation
%Tolerance	ORAM Mean	-0.6889	0.1301	Pearson's Correlation
%Tolerance	TOC	0.7143	0.1108	Spearman's Rho Correlation
%Tolerance	Total Suspended Residue	**0.7714**	**0.0724**	Spearman's Rho Correlation
%Tolerance	WQ Combo	0.7143	0.1108	Spearman's Rho Correlation
%Urodela	Lead	**-0.8147**	**0.0483**	Pearson's Correlation
%Urodela	Magnesium	**-0.8286**	**0.0416**	Spearman's Rho Correlation
%Urodela	ORAM Mean	**0.7714**	**0.0724**	Spearman's Rho Correlation
%Urodela	Total Suspended Residue	**-0.7309**	**0.0989**	Pearson's Correlation
%Urodela	WQ Combo	-0.6678	0.1472	Pearson's Correlation
%Urodela	Zinc	-0.6646	0.1499	Pearson's Correlation

Bold Red = Probility ≤ 0.05 and **Bold Blue** = Probility > 0.05 and ≤ 0.10

Amphibian Results - Bottomland Hardwood Forest

Candidate Metric	Disturbance Measurement	Correlation / Spearman ρ	p-value	Analysis
Abundance	100M	-0.6667	0.1481	Spearman's Rho Correlation
AQAI	Calcium	**-0.8930**	**0.0166**	Pearson's Correlation
AQAI	Calcium	**-0.9429**	**0.0048**	Spearman's Rho Correlation
AQAI	Magnesium	-0.7188	0.1075	Pearson's Correlation
AQAI	Magnesium	**-0.9429**	**0.0048**	Spearman's Rho Correlation
AQAI	ORAM Mean	**0.9159**	**0.0103**	Pearson's Correlation
AQAI	ORAM Mean	**0.8857**	**0.0188**	Spearman's Rho Correlation
Species Richness	Fecal Coliform	-0.6833	0.1346	Pearson's Correlation
Species Richness	Fecal Coliform	**-0.8407**	**0.0361**	Spearman's Rho Correlation
Species Richness	Lead	**-0.7903**	**0.0613**	Pearson's Correlation
Species Richness	Soils Mean(pH)	0.6736	0.1425	Pearson's Correlation
Species Richness	Soils Mean(pH)	**0.7537**	**0.0835**	Spearman's Rho Correlation
Species Richness	TKN	-0.6957	0.1248	Spearman's Rho Correlation
Species Richness	TOC	**-0.8580**	**0.0288**	Pearson's Correlation
Species Richness	TOC	**-0.8407**	**0.0361**	Spearman's Rho Correlation
Species Richness	Total Suspended Residue	**-0.7997**	**0.0562**	Pearson's Correlation
Species Richness	Total Suspended Residue	**-0.8117**	**0.0499**	Spearman's Rho Correlation

Bold Red = Probility ≤ 0.05 and **Bold Blue** = Probility > 0.05 and ≤ 0.10

Amphibian Results - Bottomland Hardwood Forest

BLH Candidate Metric Results

Site Name	Species Richness	Abundance	%Tolerance	%Sensitive	%Urodela	AQAI	%EW-HW-Seep
Fairport	**9**	41.8	**17.94**	**31.82**	**34.21**	**4.96**	**65.19**
Gray	**4**	42	**95.24**	**0**	**0**	**2.62**	**4.76**
Hancock	**10**	500.35	**89.14**	**4.53**	**5.77**	**1.56**	**7.18**
Kim-Brooks	**8**	34	**91.18**	**4.71**	**8.82**	**1.48**	**0.00**
Munn	**7**	51.2	**28.32**	**66.8**	**66.8**	**6.1**	**34.96**
Powers	**9**	77.55	**17.02**	**26.24**	**26.24**	**4.83**	**68.44**

Bold Red = Metrics to be used in Bottomland Hardwood IBIs, %EW-HW-Seep = %Ephemeral Wetland-Headwater Wetland-Seep

BLH Metric Score Assignments

Metric	0	3	7	10
Species Richness	<5	<7	<9	≥9
%Tolerance	≥50	<50	<30	<20
%Sensitive	<5	<30	<50	≥50
%Urodela	<10	<30	<50	≥50
AQAI	<2	<4	<6	≥6
%EW-HW-Seep	<5	<30	<50	≥50

BLH Amphibian IBI Scores

Site Name	Species Richness	%Tolerance	%Sensitive	%Urodela	AQAI	%EW-HW-Seep	Total
Kim-Brooks	7	0	0	0	0	0	**7**
Gray	0	0	0	0	3	0	**3**
Hancock	10	0	0	0	3	3	**16**
Powers	10	10	3	3	7	10	**43**
Fairport	10	10	7	7	7	10	**51**
Munn	7	7	10	10	10	7	**51**

Amphibian Results – Headwater Wetlands, Riverine Swamps, and Basin Wetlands

- Headwater Wetlands – 5 Metrics, IBI Range 0-37
  Species Richness, %Urodela, AQAI, % Sensitive,
  % HW-EW-SW
- Riverine Swamp Forests – 3 Metrics, IBI Range 7-23
  Species Richness, % Urodela, Abundance,
- Basin Wetlands
  3 Coastal Plain Metrics, IBI Range 7-23
  Species Richness, % Urodela, % Tolerance
  2 Piedmont Metrics, IBI Range 13-17
  Abundance, % EW-HW-Seep

Blue – Metrics with signficant results in All Wetland Types

Headwater Wetland 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, IBI Range 3-50

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

7 Piedmont Metrics Chosen, IBI Range 6-57

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

Plant Community Metrics

40 Candidate Metrics tested

- Community Balance Metrics
  - e.g. Evenness, Simpson's Diversity, Dominance, Species Richness etc.
- Floristic Quality Metrics
  - e.g. Floristic Quality Assessment Index (FQAI), Percent Sensitive, Invasive Species Coverage etc.
- Wetness Characteristic Metrics
  - e.g. Wetland Plant Species Richness, FAQWet Cover, Wetland Shrub Cover etc.
- Functional Groups
  - e.g. Cryptogram Richness, Bryophyte Coverage, Sedge-Grass-Rush Richness etc.
- Community Structure
  - e.g. Large Tree Density, Sapling Density, Total Herb Coverage, Standing Snag Importance etc.

Plant Community Results

Wetland Type	Community Balance	Floristic Quality	Wetness Characteristics	Functional Groups	Community Structure
Headwater Wetland 10 Metrics IBI - 6-84	**Evenness**	**FQAI**, Ave C of C, **Invasive Shrub Cover**	**Native Wetland Species Richness**	**Grass, Sedge and Rush Cover**	**Native Herb Richness**, **Pole Timber Density**, Shade, Ave Shrub Importance
Riverine Swamp Forest 7 Metrics IBI 12-61	**Herb and Shrub Dominance**		FAQWet Equation 3, **Wetland Species Richness**	**Carex Richness**, Dicot Cover	**Total Herb Richness**, **Pole Timber Density**
Bottomland Hardwood Forest 8 Metrics, IBI 29-55	**Dominance**		FAQWet Cover, **Wetland Shrub Cover**	Bryophyte Cover, **Carex Richness**, **Grass, Sedge and Rush Cover**	**Native Herb Richness**, **Standing Snag Importance**
Basin Wetland 7 Metrics IBI 3-67	**Evenness**	**FQAI Cover**, **Invasive Cover**	**Wetland Shrub Richness**		Sapling Density, Large Tree Density, **Standing Snag Imporance**

Blue = Similar Metrics with significant results in 2 wetland types

Observed Trends

- The Amphibian and Aquatic 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).

- The IBIs were also correlated with the NCWAM for purposes of verification and calibration. Correlation was observed with (1.) Riverine Swamp Forest and Basin wetland Plant IBIs and the NCWAM Overall Score and Habitat Function and (2.) Bottomland Hardwood Forest Amphibian IBIs and the Overall NCWAM Score and Water Quality Function.

- NCWAM is planned to be implemented into the NC 401 permitting program.

Future Projects Goals

Continue to build the NC Wetland Monitoring Program by improving IBIs and further calibration of NCWAM

- 12 Additional impacted Headwater wetlands have been surveyed.
- 16 additional Basin wetlands are in the process of being surveyed.
- 20 Randomly chosen Piedmont and Coastal Plain Wetlands will be used for an "Intensification" study with the NWCA and NC wetland monitoring methods next year.

Thank you!

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