

DEVELOPMENT OF CLASSIFICATION and ASSESSMENT PROTOCOLS FOR SWAMP WATERS IN VIRGINIA

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Swamp Waters in Virginia

From VA Water Quality Standards (9 VAC 25-260):

"**Swamp waters** means waters with naturally . . . low pH and low dissolved oxygen caused by . . . low flow velocity . . . and . . . decomposition of vegetation"



Swamp Waters in Virginia

“...waters with naturally . . . low pH and low dissolved oxygen. . .”

- DO and pH minimum standards for streams not appropriate
- VA Coastal Plain Macroinvertebrate Index (VCPMI) not appropriate



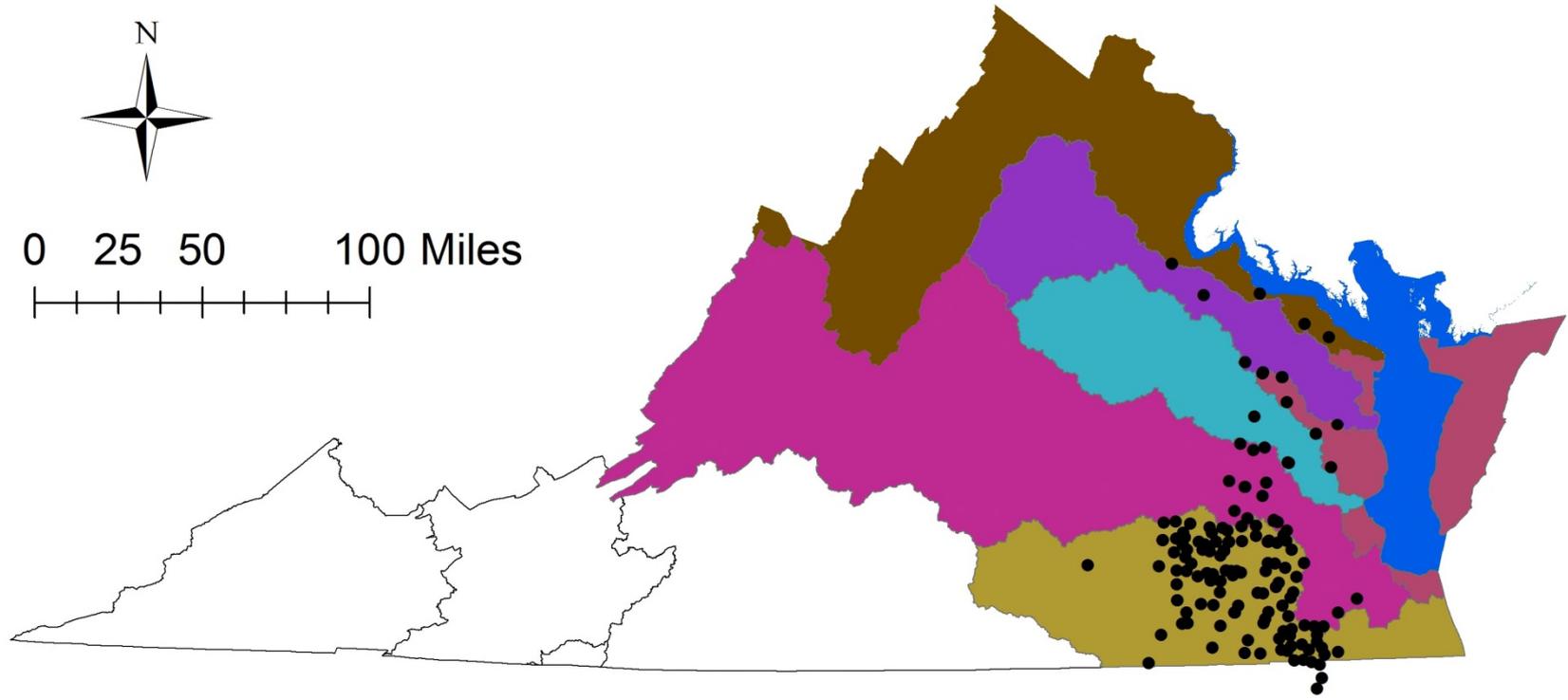
Objectives- to develop:

- 1) A rapid habitat protocol to classify swamp waters
 - **Blackwater Habitat Protocol (BHP)** - Rapid, visual habitat evaluation protocol

- 2) Biotic index for swamp waters
 - **Blackwater Condition Index (BCI)** - rapid bioassessment protocol specialized for swamps
 - Hypothesis: least-disturbed reference **swamp sites** with a **characteristic fish assemblage**



Coastal Virginia Study Sites

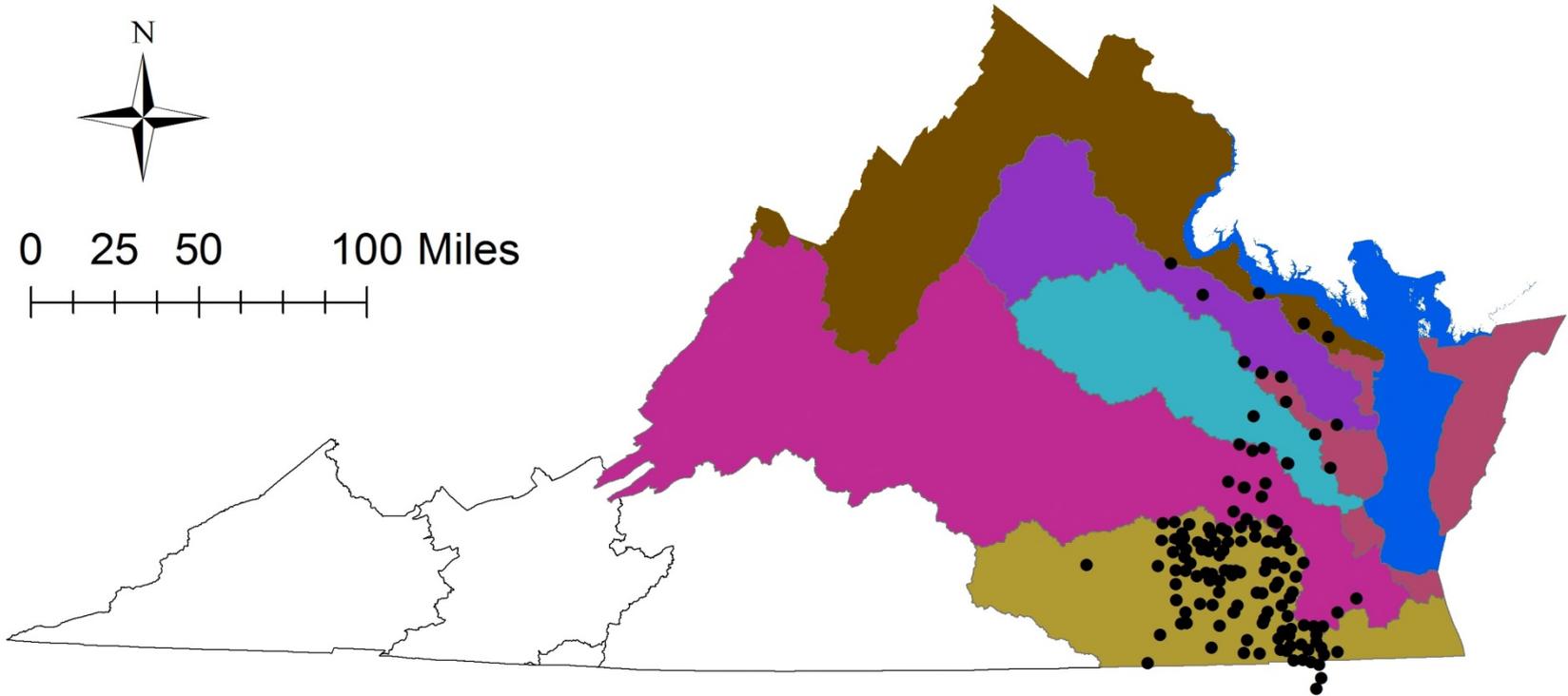


- Existing data:
 - Virginia Commonwealth University (<http://gis.vcu.edu/instar/>)
 - Virginia DEQ
- New data currently being collected

Coastal Virginia Study Sites



0 25 50 100 Miles
|-----|-----|-----|-----|



River Basin

-  Chowan N = 104
-  Chesapeake (drains directly)
-  James
-  Potomac
-  Rappahannock
-  York N = 33
-  Non-Coastal Basins
-  Study Sites



Classifying sites as swamp waters

Initial development

- Initial recon: subjectively classified sites as streams or swamps



- 18 characteristics evaluated

- Water color, chemistry, channel morphology, hydrology, riparian zone characteristics, vegetation, bottom substrate.

Site Description: Round Hill swamp subsection of C14

Date: 16 Nov 2012 Time on site: 4:30 Time off site:

Investigators: Tony, Dick

Lat: 36.84748 Long: 76.92093 Datum: WGS84

Has rain occurred recently? Comments on recent rain events:

Air Temperature: 85°F

Notes on weather conditions: Sunny, clear

Subjective classification of system: Bluewater swamp (original 'Bromwater')

Water Level: below normal (normal above normal) (assessments conducted during high water levels may be less reliable)

Section 1) Water Physicochemistry (indicate units where appropriate):

pH: 5.86 DO: 5.68 Cond: 94 and 100 (normal)

Temp: 21.82 Others (indicate parameters and units):

Water color: 1.41 (normal 1-4) Turbidity: 2.54 (normal 1-3) Chl a: 3

Water clarity (clear, slightly turbid, very turbid):

Section 2) Channel and flow characteristics:

2a Study reach length: 100 (m)

2b Channel morphology: Indicate the percentage of the study reach occupied by:

Single, defined channel with clearly-defined banks and streambed: 20%

Multiple, defined channels (i.e. braided system): 0%

If multiple channels present indicate approximate number of channels or range, if highly variable

Undefined bed and banks: 80% (if undefined banks predominate, metrics 2c, 2d may be difficult to evaluate)

2c Bank stability:

Percent of bank area with signs of erosion: Left 0% Right 0%

2d Sinuosity Ratio (stream channel length/straight-line distance): 1.0

2e Flow velocity:

No perceptible flow: 40% % of reach

Sluggish flow: 40% % of reach

Moderate, laminar flow: 20% % of reach

Rapid, laminar flow: 0% % of reach

Rapid, turbulent flow: 0% % of reach

Other (explain): 0% % of reach

2f Flow direction and definition

One, clearly-defined flow vector/area where flow predominates: 70% % of reach

Several, clearly-defined flow vector/areas where flow predominates: 30% % of reach

No clearly defined areas where flow predominates:

2h Canopy cover (percent cover above wetted area): 60

2i Bottom Substrate types:

Type	Percent
Sand	60%
Rock	20%
Soft/loose	20%

2j Percentage of wetted area comprised of pools: 5%

2k Pool depth variability: (max, min, commonness of deep pools, number of pool size classes present - to be revised based on field obs. if V. low, depth ~ 0.5-75)

Section 3) Riparian Zone Characteristics

3a Riparian vegetation type (note major veg types and widths from stream channel)

Left bank (descending): Bottom land hardwood forest > 100'

Right bank (descending): Bottom land hardwood forest > 100' from stream far beyond Bank.

3b Riparian vegetation protection (note percentages of natural land cover and width from channel)

Left bank (descending): Heavy tree growth understorey sparse

Right bank (descending): No tree strip US = green trees - grass

Riparian zone topography (approx elevation above stream bank - if variable, a diagram may be appropriate)

Left bank (descending): ~ 0.5 - 1m without channel

Right bank (descending): low (from left, ~ 0.2 - 1m with channel)

Section 4) Stream/waterbed disturbance

4a Channel alteration (if present, note type):

no

4b Riparian land use (if multiple, note percentages): Forest

4c Other indicators of anthropogenic disturbance: None

Section 5) Stream cross section draw a typical stream cross section and indicate normal flow depth/width, normal high flow depth and width, and extreme high flow depth/width (i.e. dimension of total stream incision - see example figure)

Notes Regarding site conditions and other:

Remotely-derived data (not collected on-site)

Watershed land use/land cover (note types)

Moisture indices at time of investigation:

USGS Gauge Data: Nearby Stream

Notes on comparability of gauge data:

Classifying sites as swamp waters

Working protocol

- Discrimination between *apriori*-assigned classes
- Simplicity
- Agreement among investigators

- 1) Channel Development
- 2) Flow velocity
- 3) Flood plain elevation
- 4) Sub./emergent vegetation*
- 5) Benthic organic matter
- 6) Forest type
- 7) Riparian wetland width
- 8) Canopy cover*

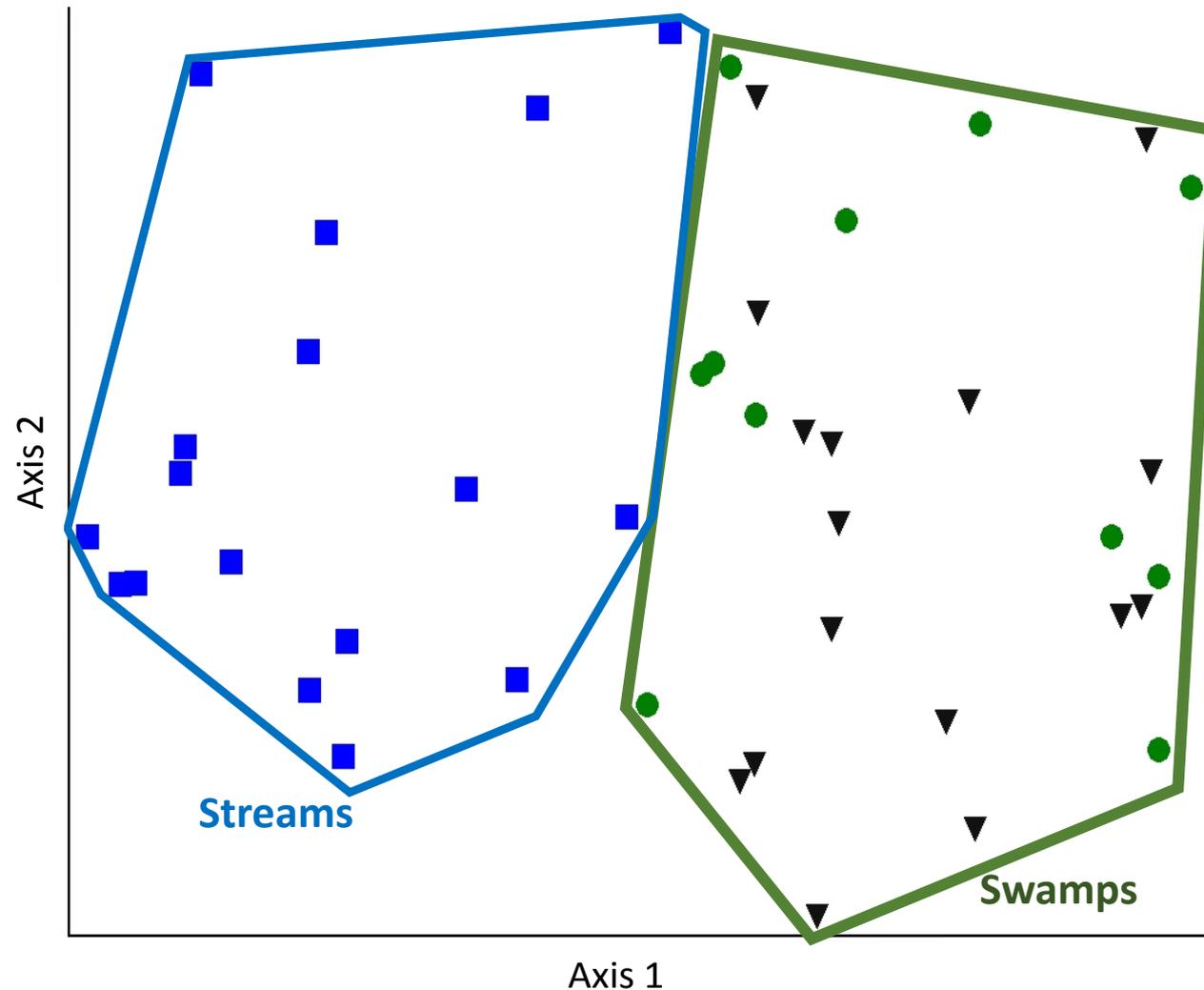


Blackwater Habitat Protocol Sheet					
Site name:		Date:			
Site code:		Time on:			
Field crew members:		Time off:			
Location description:		Shoes/glasse			
Metric	Subcategories (metrics 1 and 2)	Raw values	Weights	Scoring	
1) Channel Development		Percentage of channel	Weight	Percentage* weight	
	One defined bed/bank flow path		2		
	Multiple defined bed/bank flow paths		1		
	No defined bed/bank flow paths		0		
Comments:		Total weighted percentage:		Metric score:	
2) Flow Score		Percentage of channel	Weight	Percentage* weight	
	No perceptible flow /flow extremely sluggish		0		
	Slow flow (see reverse for description)		1		
	Moderate, laminar flow (approx 0.1-0.2 m/s)		2		
	Rapid, laminar flow (>0.2 m/s)		3		
	Rapid, turbulent flow		4		
Comments:		Total weighted percentage:		Metric score:	
3) Flood plain elevation		Value (cm):		Metric score:	
4) Submerged and emergent vegetation	abs: 0, rare:1, common:2, abundant: 3			Metric score:	
5) Benthic organic matter		Percentage:		Metric Score:	
6) Forest type	see criteria on reverse			Metric score:	
Dominant tree/vegetation cover species:		Comments:			
7) Wetland width		Percentage of 200-m area as wetland:		Metric score:	
Comments:					
8) Canopy		Percentage of overhead cover:		Metric score:	
Comments:					

Validation

- Discrimination of least-disturbed swamps from least-disturbed streams (biota).
- Independence from human disturbance.

PCA ordination based on 8 BHP metrics

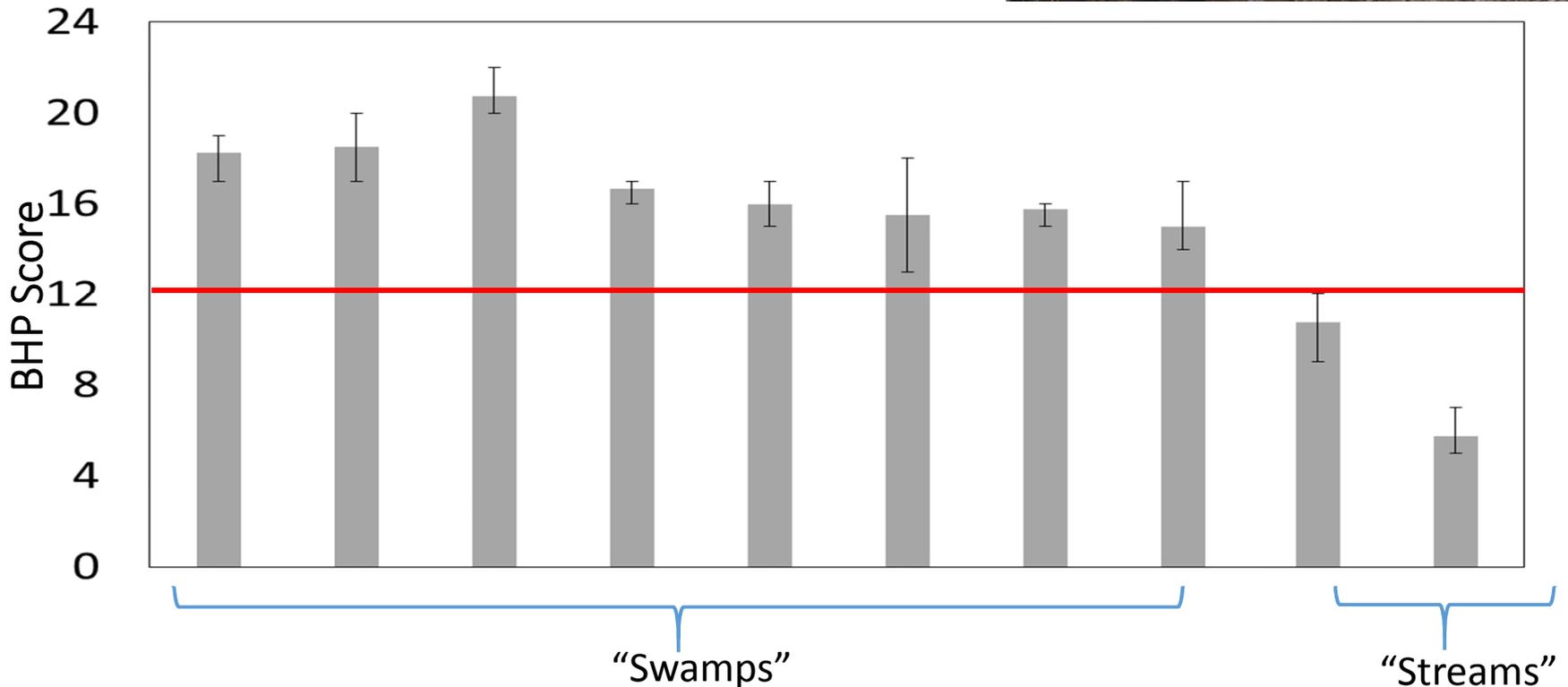


organic matter substrate, riparian wetland width, cypress + tupelo trees

channel development, flow velocity, floodplain elevation

BHP: Consistency Among Investigators

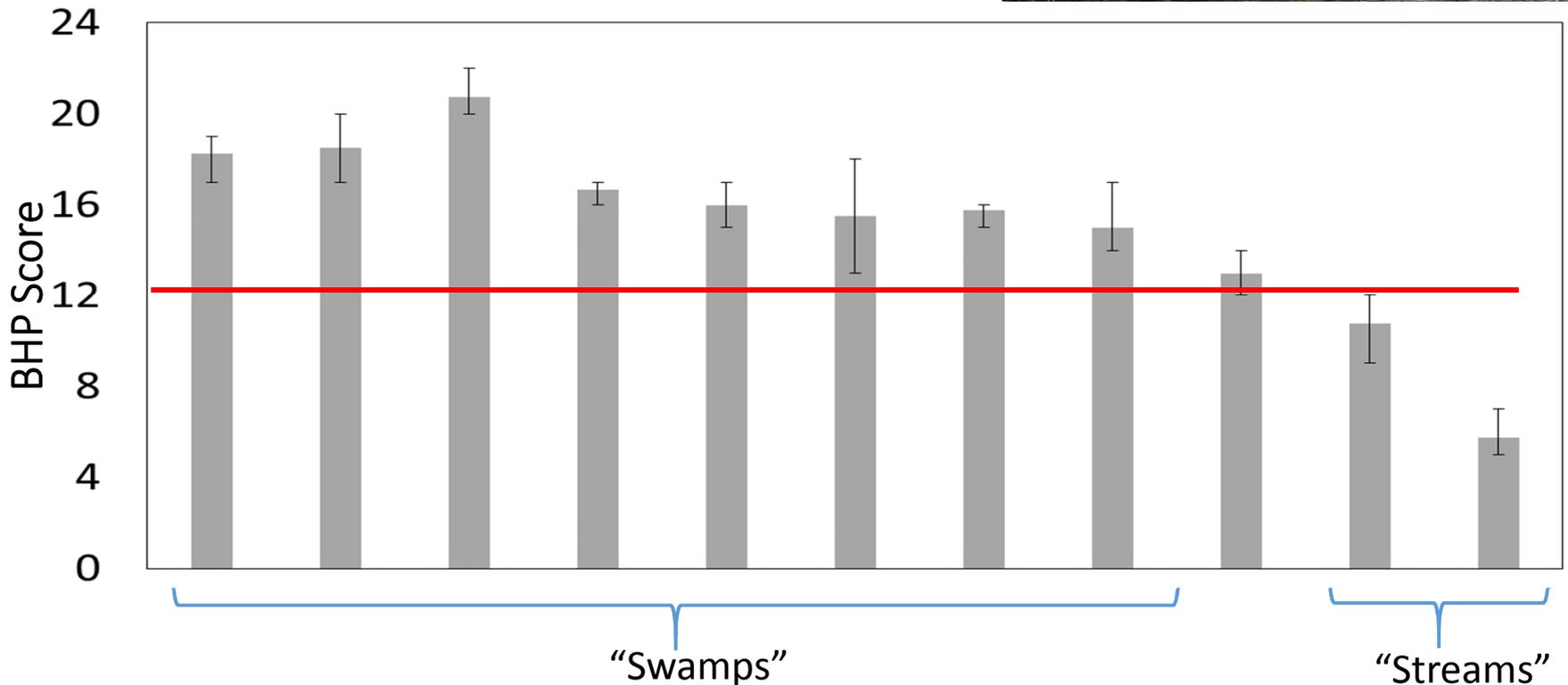
- Visited 11 Coastal Plain sites
 - Field notes indicated potential swamp conditions
- Made initial judgement of swamp/stream status
- Then evaluated 8-metric BHP
 - Ca. 30min on-site
 - Laser range-finder and meter stick



Bars= means, whiskers = range among 4 investigators

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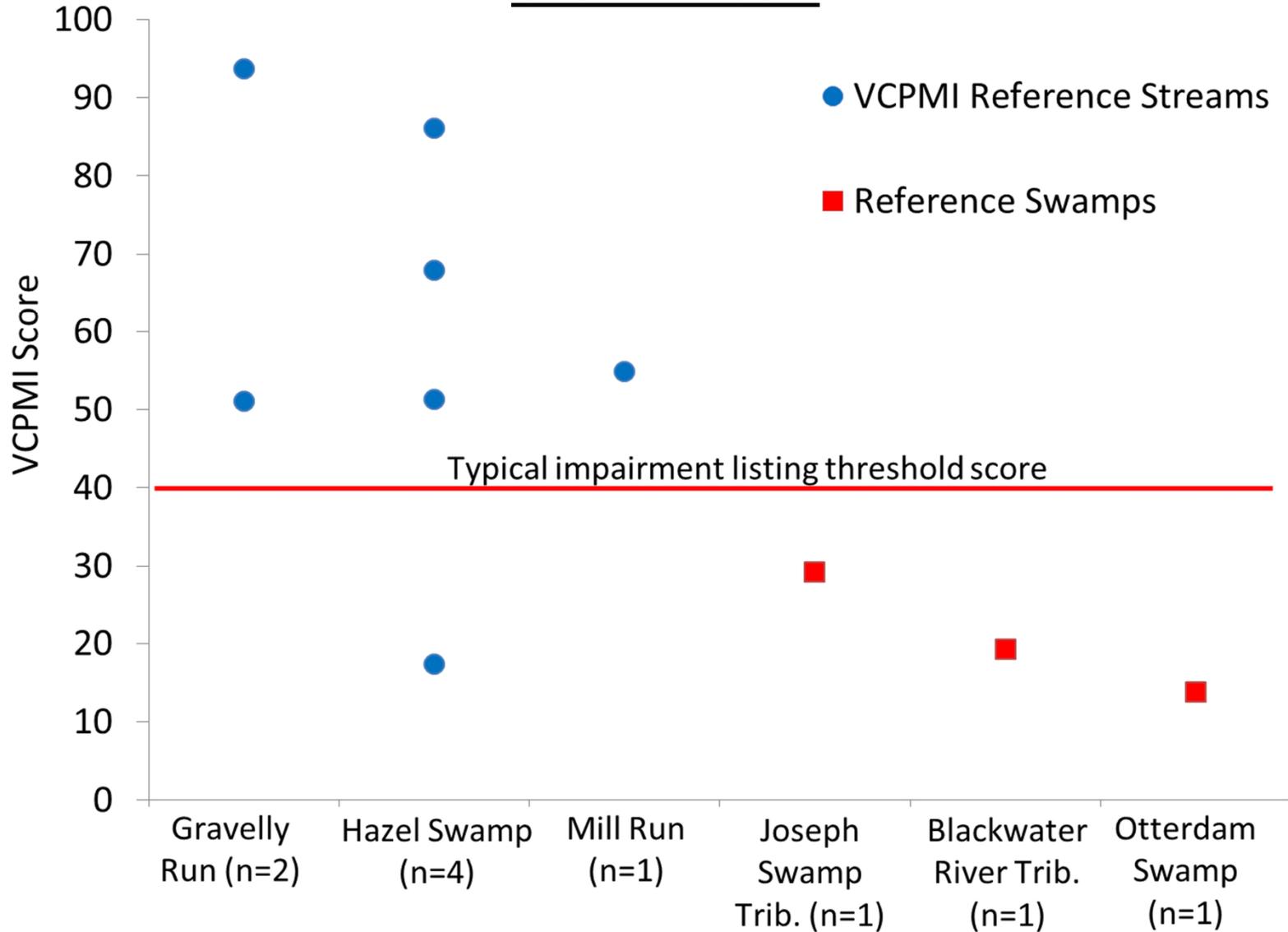
Quantifying Disturbance: Chowan Basin Reference

Filters

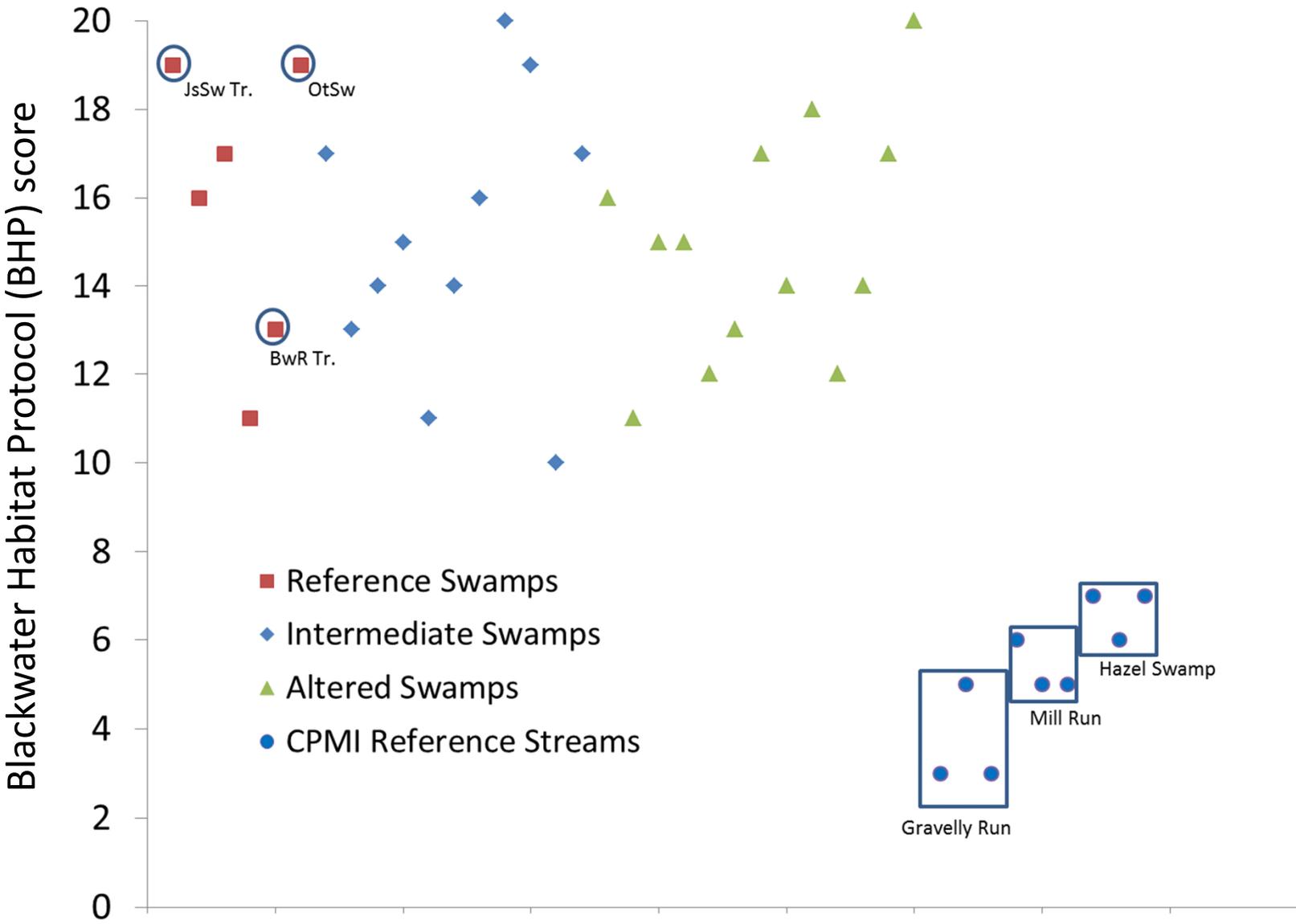
Parameter	Reference threshold	Altered threshold
Specific Conductance	<150 μ S/cm	>350 μ S/cm
Total N	<1.5 mg/l	>3mg/l
Total P	<0.05 mg/l	>0.1mg/l
pH	<6.5	>7.5
Other	No other measured parameters indicate site should be 303d listed	Other chemical stressors present that are likely to affect community
GIS Land use/land cover	>70 percent natural land cover in watershed	<50 percent natural land cover
Intact Riparian Vegetation	>50m from both banks	<10m, either bank, or <25m from both banks
Point sources/others	No NPDES sites within watershed	NA*
Site Recon Land use/land cover	No extensive development in watershed	NA*
Visible system impairment	No visible signs of direct alteration to the water body	NA*

Macroinvertebrate index: Reference Swamps vs. Reference Streams

Chowan Basin



Habitat scores (BHP): Chowan Basin Swamps vs. Reference Streams



Assessing human disturbance in swamp waters: The Blackwater Condition Index (BCI)

- Calculated 41 fish metrics commonly used for bioassessment
 - Abundance, pollution tolerance, habit/habitat, condition of individual, diversity
 - Select combination that yields highest correlation with **% Natural land cover** (Schoolmaster *et al.* 2013)

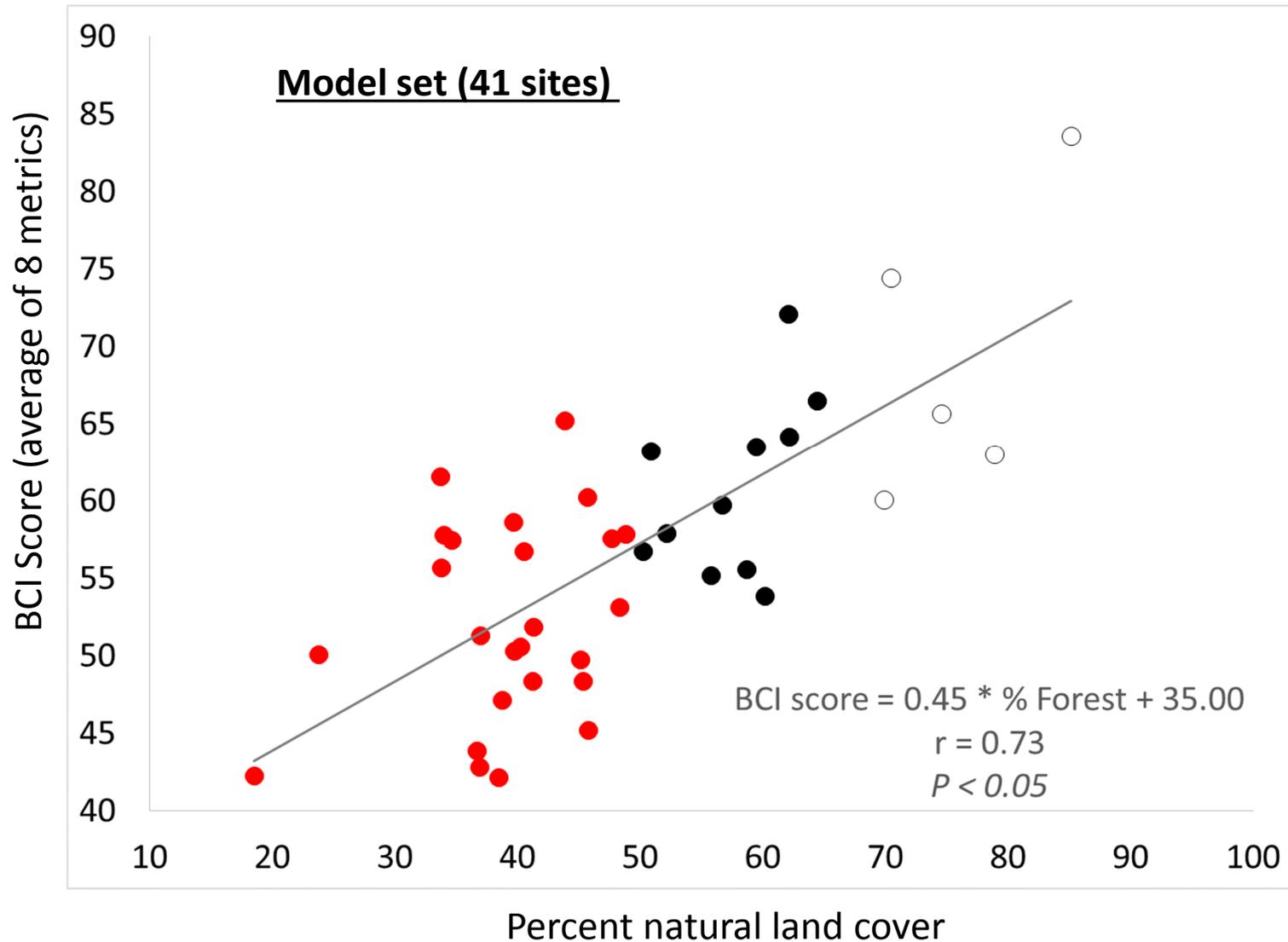


% Natural land cover in watershed

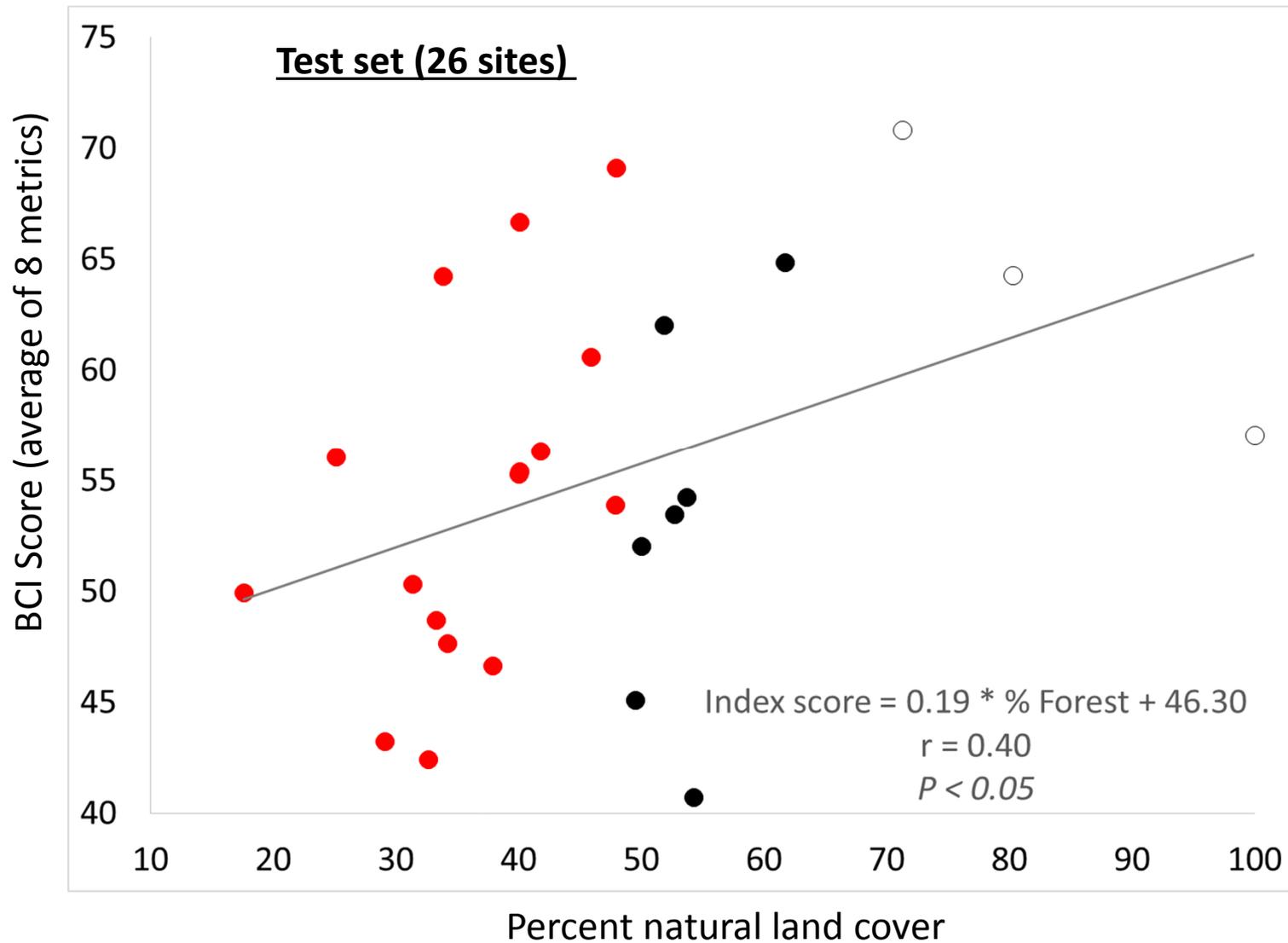


- **8-metric fish assemblage index (response to human disturbance)**
 - Percent opportunists (+)
 - No. opportunist species (+)
 - No. tolerant species (+)
 - No. omnivore species (+)
 - Pielou evenness (+)
 - Simpson evenness (+)
 - No. blackwater specialist species (-)
 - No. vegetation specialists (+)

Fish index (BCI) testing and validation



Fish index (BCI) testing and validation



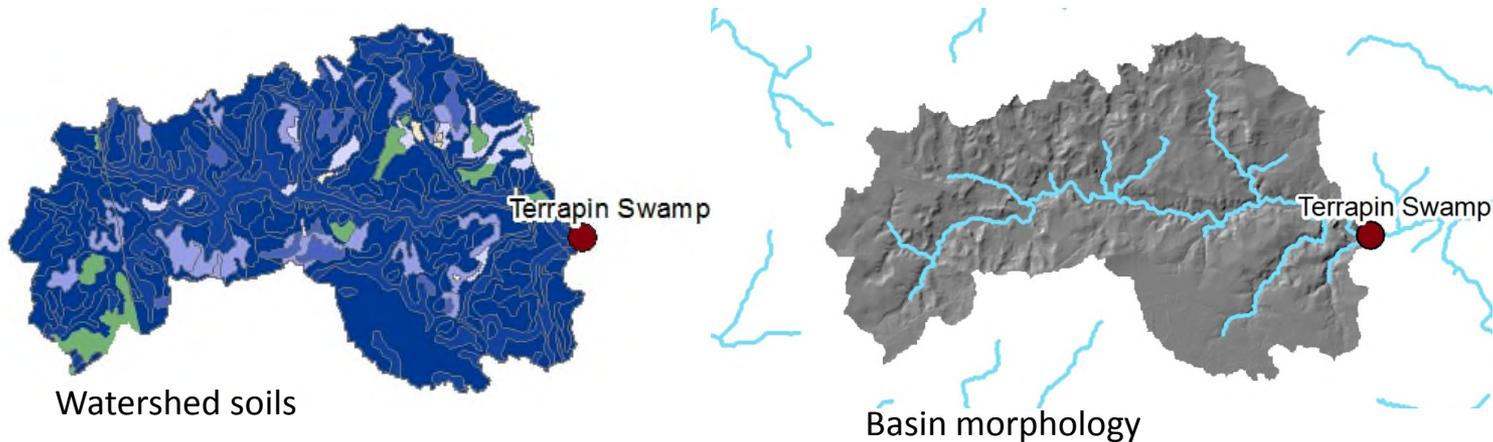
Conclusions

- Rapid habitat classification system for swamp waters (BHP)
 - **Preliminary validation:**
 - Effectively separates swamp waters from streams
 - Not confounded by anthropogenic disturbance
- Bioassessment methods for swamp waters
 - Fish-based bioassessment index (BCI)
 - Responsive to anthropogenic disturbance
 - Much additional work needed



Next Steps

- **Finalize Blackwater Habitat Protocol (BHP)**
 - Relationships of habitat metrics with biota
 - Relationships of habitat metrics with watershed disturbance
- **GIS-based classification of swamp waters**
 - Soils, slope, watershed and stream morphology



- **Later Phase: Finalize bioassessment protocols for swamps**
 - Confounding factors (spatial autocorrelation, spatial/temporal variability.....)
 - Macroinvertebrates as swamp bioindicator?

