INDEX OF BIOTIC INTEGRITY MODELS FOR EVALUATING ECOLOGICAL RESTORATION IN HARDWOOD BOTTOMLAND SITES

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Bottomland Hardwood (BLH) Forests

- **Forested wetlands in floodplains**
- **Habitat**

    - **birds**
    - **amphibians**
    - **mammals**
    - **fish**

- **Ecosystem services**
    - **Filter contaminants**
    - **Store sediments**
    - **Stabilize riverbanks**
    - **Flood control**
    - **Produce biomass, sequester carbon**
- **Historically common in SE**
- **Currently, >70% of original BLH destroyed**

Bottomland Restoration

Wetlands Reserve Program (WRP)

NRCS Natural Resources Conservation Service

- Established 1990 under farm bill
- Voluntary program for landowners
- Retires agricultural land from production in flood-prone areas
- Restorations consist of replanting, hydrology

Tennessee

- Began restoration under WRP in 1994
- Mostly in western 1/2 of state
- 90% hardwood bottomlands
- Currently 4,014 ha enrolled in TN

2004

Monitoring

- **Currently 779,000 ha enrolled in WRP nationwide**

- **$ 4.9 billion since 1990**

Currently no monitoring protocol

- **Monitoring important to ensure restoration goals are reached**

  - for WRP, restoration of ecological function

- **Can lead to adaptive management**

Bioassessments

- **Use community composition of plants and animals to measure health of system**
  - Advantage: Measure effects of multiple stressors at once
  - Drawback: Requires knowledge of taxa being measured

- **Index of Biological Integrity (IBI)**
  - Measures ability of site to support balanced community similar to undisturbed sites in region
  - Uses community metrics of several taxa to give a summary score

Objective

Develop IBI models for vegetation, amphibian and avian communities to be used for monitoring the state of ecological restoration in hardwood bottomlands

Methods

Study Sites

- **17 Randomly selected restoration sites**

  Multi-stage sampling approach
  - First level: 1st year of restoration

    (1987, 1995-2006)
  - Second level: Size - large (>45 ha) 9 sites
    - small (<45 ha) 8 sites

- **4 Reference sites located in Hatchie NWR**
  - Longest unchannelized tributary of Mississippi river
  - Medium-aged stand: appropriate target for restorations
  - Mean stand age 49, 58, 41, and 55 years old
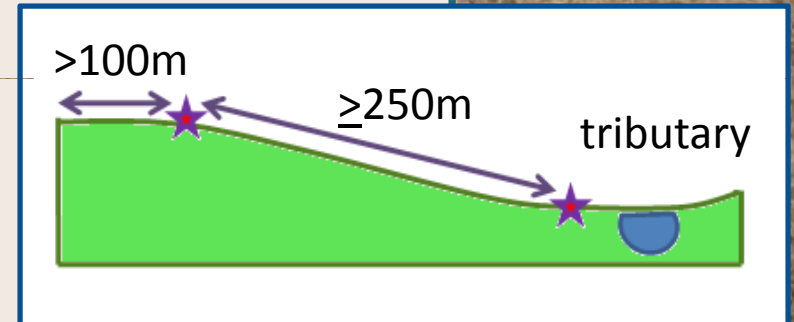
  🔴 Restoration sites

  🟦 Reference sites
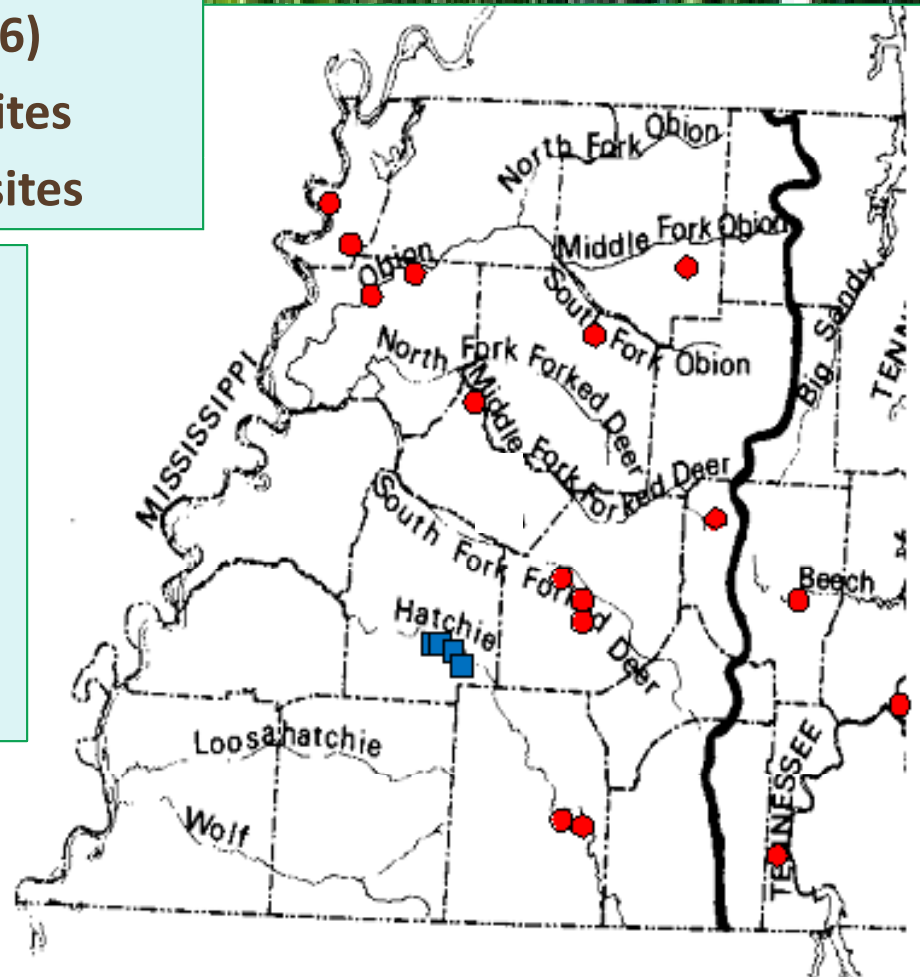
Sampling Plot Placement

Two plots at each site

- minimum 250 m apart
- Located in highest and lowest contours

--OR--

>100m

≥250m

tributary

One plot at center of site

sites too small for 250 m separation

Vegetative Composition

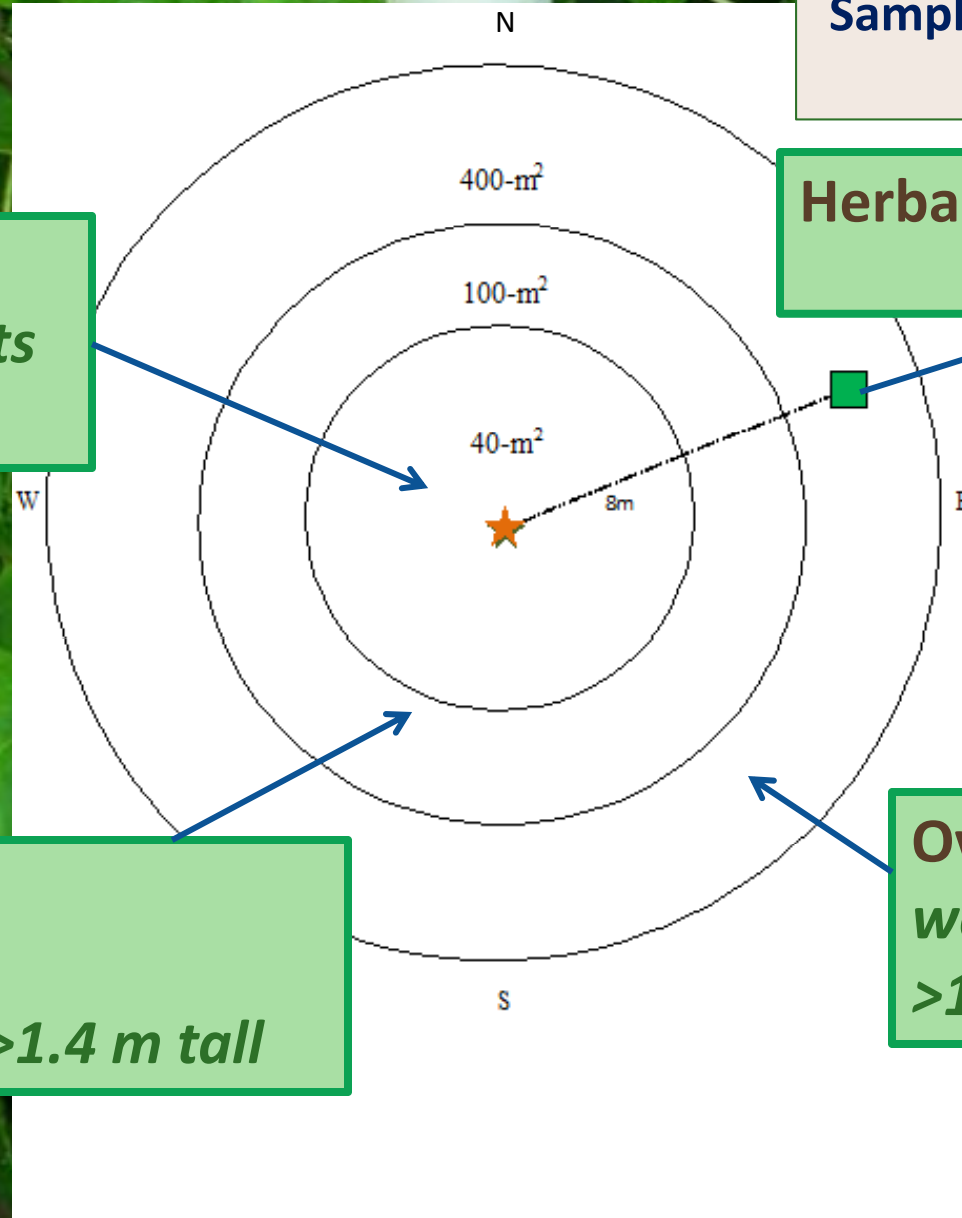Sampled at 1 random plot per site

Herbaceous vegetation
(Jun, Aug)

Understory
woody plants < 1.4 m tall

Midstory
woody plants <11.4 cm DBH, >1.4 m tall

Overstory
woody plants >11.4 cm DBH

400-m^2

100-m^2

40-m^2

8m

N

W

E

S

Vegetative Composition

Sampled at 1 random plot per site

- **Vertical structure (0-2 m above ground)**
- **Canopy closure**

Measured 2x (Jun, Aug)

- **Overstory height**

  (nearest tree to plot center)

- **Logs (>11.4 cm dia)**
- **Snags (>11.4 cm dbh)**
- **Tree Basal Area**

Measured once (Jun)

Amphibian Sampling Design

Once every 2 wks
Mar – Aug 2008

1 random plot

All plots

Recorders
Treefrog tubes
Cover boards
Area search

Bird Composition

Point Counts

- Morning after amphibian recorders put out
- Ten minute count at each plot
- 50-m radius
  - Tested detectability using recordings
  - Detectability similar among sites

Amphibian & Bird Community Metrics

- **Species richness**
  - **Total # of species per 2-month period**
  - **Mar – Apr, May – Jun, Jul – Aug**

- **Shannon-Wiener species diversity**

- **Abundance**

  Averaged over each 2-month period

  - **5 Amphibian families**

  - **Bird habitat use guilds**
    4 feeding guilds
    5 nesting guilds

Bird Habitat Use Guilds

DeGraaf and Chadwick 1984

Feeding Guilds
Air

Ground

Canopy

Nesting Guilds
Cavity
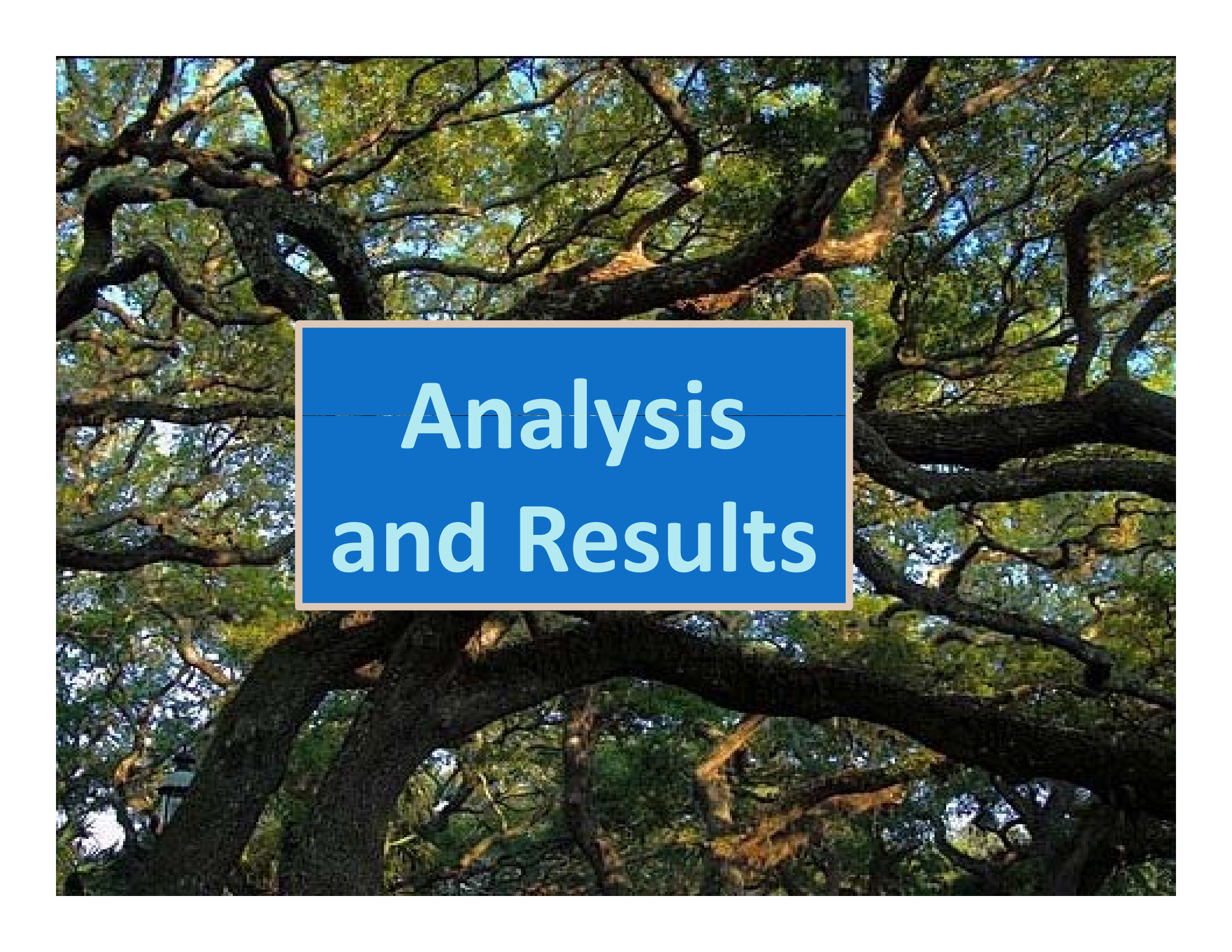
Shrub

Ground

Branch

Twig
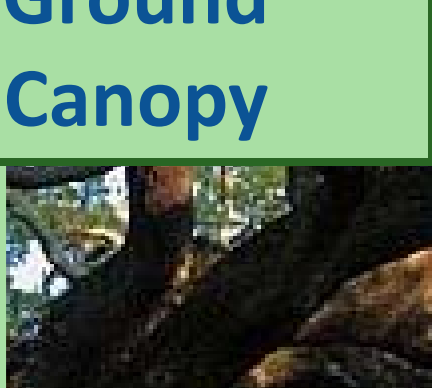
Analysis and Results

IBI Model Development

1) **Identified community metrics which vary along a disturbance gradient: time since restoration**

   0 years

   - Linear Regression
   - Included seasonal period (1, 2, 3)

   Reference

2) **Chose metrics based on strength of relationship with site age**

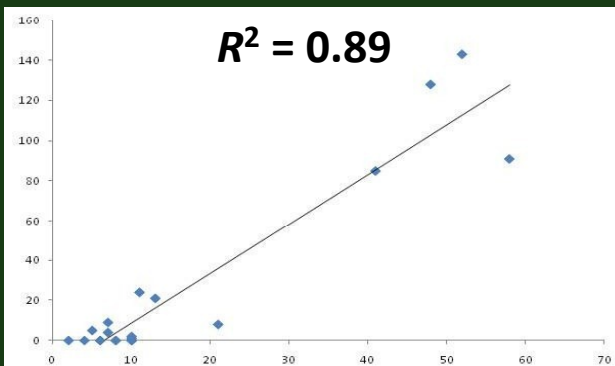   - Decision rule: $R^2 \geq 50\%$ of maximum for a given community

3) **Assigned scores to final metrics**

   - Used observed range of values across all sites for given metric
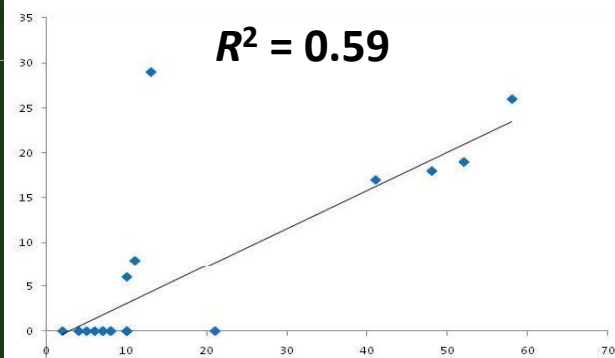   - Divided range into quartiles

Percentile	Score
0 – 25	1
26 – 50	2
51 – 75	3
76 – 100	4

Results: Vegetation
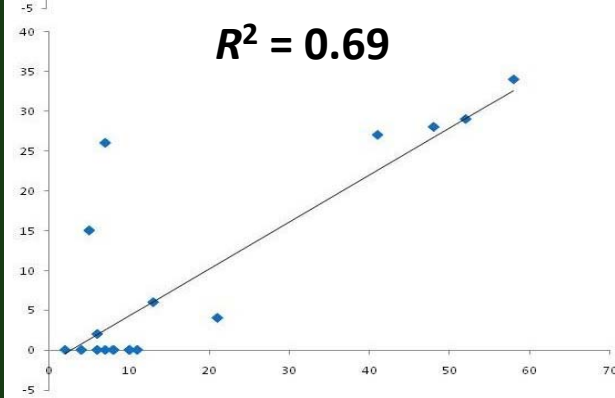
Results: Birds and Amphibians

Birds

Amphibians

Bark Feeders — $R^2 = 0.76$

Branch Nesters — $R^2 = 0.44$

Twig Nesters — $R^2 = 0.83$

Site Age

Ambystomatidae — $R^2 = 0.30$

Plethodontidae — $R^2 = 0.37$
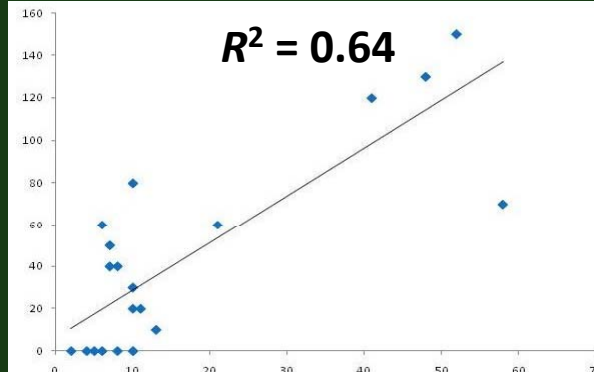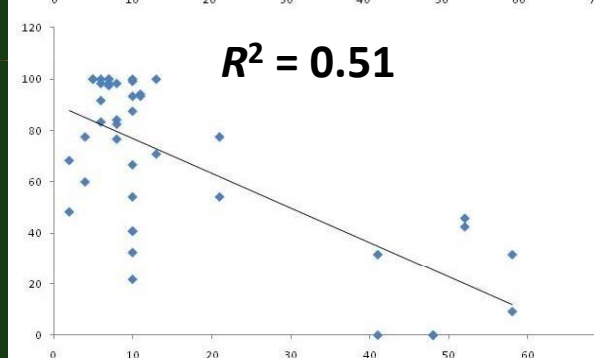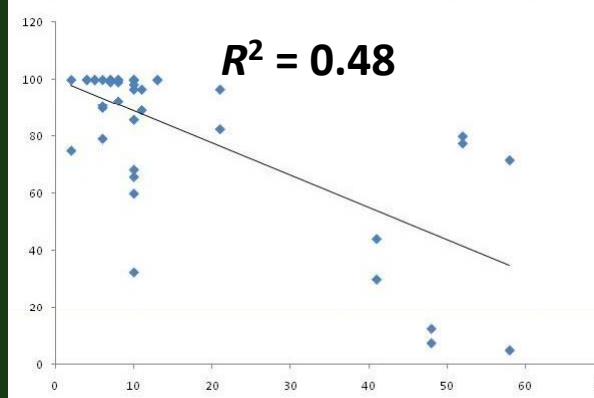
Site Age

IBI Model: Vegetation

Metric	Field Measurement	IBI Restoration Score
Logs	0	1
(3.14-ha plot)	1 - 2	2
	3 - 21	3
	>21	4
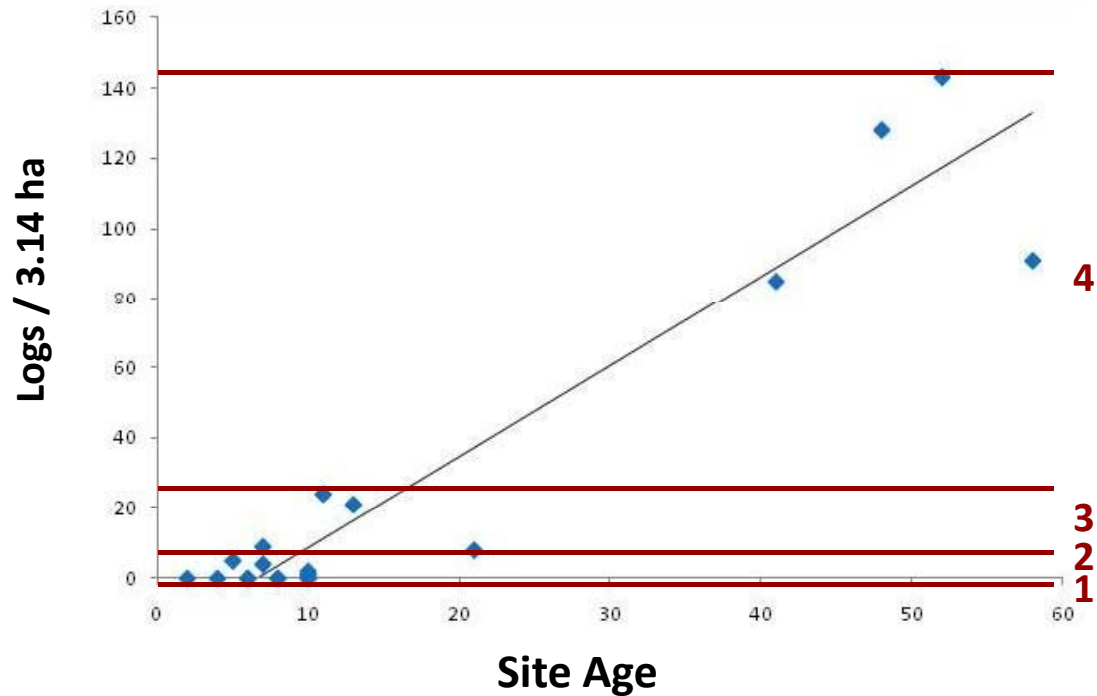
Sum for final score

IBI Model: Birds

Metric	Field Measurement	IBI Restoration Score
Branch nesters	0 - 0.3	1
(0.79-ha plot)	0.4 - 1.0	2
	1.1 - 2.6	3
	>2.6	4
Twig nesters	0 - 0.1	1
	0.2 - 0.5	2
	0.6 - 1.0	3
	>1.0	4
Bark feeders	0	1
	0.1 - 0.3	2
	>0.3	3

IBI Model: Amphibians

Metric	Field Measurement	IBI Restoration Score
Ambystomatidae	Absent	0
	Present	1
Plethodontidae	Absent	0
	Present	1

Don't recommend using alone
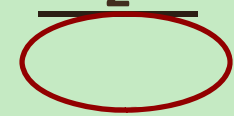
IBI Application

- **Use IBI models alone or sum for overall score**

- **Establish 100-m radius sampling plot at site center**
  - **measure vegetation once (May – Aug)**
  - **sample salamanders and birds ≥4 times, at least 1 week apart (Mar – Aug)**

State of Restoration	Vegetation Score	Bird Score	Amphibian Score	Summed Scores
Early	6 – 9	3 – 4	0	9 – 14
Mid	10 – 13	5 – 6	0	15 – 20
Late	14 – 17	7 – 8	0	21 – 26
Reference	18 – 21	9 – 11	1 – 2	27 – 34

Example: Vegetation IBI

Metric	Field Measurement	Example	BI Restoration	Example
Logs (3.14-ha plot)	0		1	
	1 - 2	2 logs	2	← 2
	3 - 21		3	
	>21		4	+
Snags	0		1	
	1 - 2	1 snag	2	← 2
	>2		3	+
Overstory trees (0.04-ha plot)	0		1	+
	1 -	ry	2	← 2
	>5		3	
Basal area (ft² / acre)	0 - 1		1	+
	2 - 30		2	
	30 - 60	40 ba	3	← 3
			4	
			1	+
			2	
		cover	3	← 3
			4	+
			1	
		cover	2	← 2
			3	

Late restoration

State of Restoration	Vegetation Score	Bird Score	Amphibian Score
Early	6 – 9	3 – 4	0
Mid	10 – 13	5 – 6	0
Late	14 – 17	7 – 8	0
Reference	18 – 21	9 – 11	1 – 2

Conservation Implications

-IBI models can be used as a tool to monitor hardwood bottomland restorations in TN
  -Elsewhere?
  -Recommend validation using independent data

-Models built using mature forest as reference standard
  -Don't apply if early successional species are a priority

Photo Credits

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Questions?