Riparian Development and Effects on Littoral Fish and Habitat, and Developing a Statewide and Regional Context for Lakes Assessment Data

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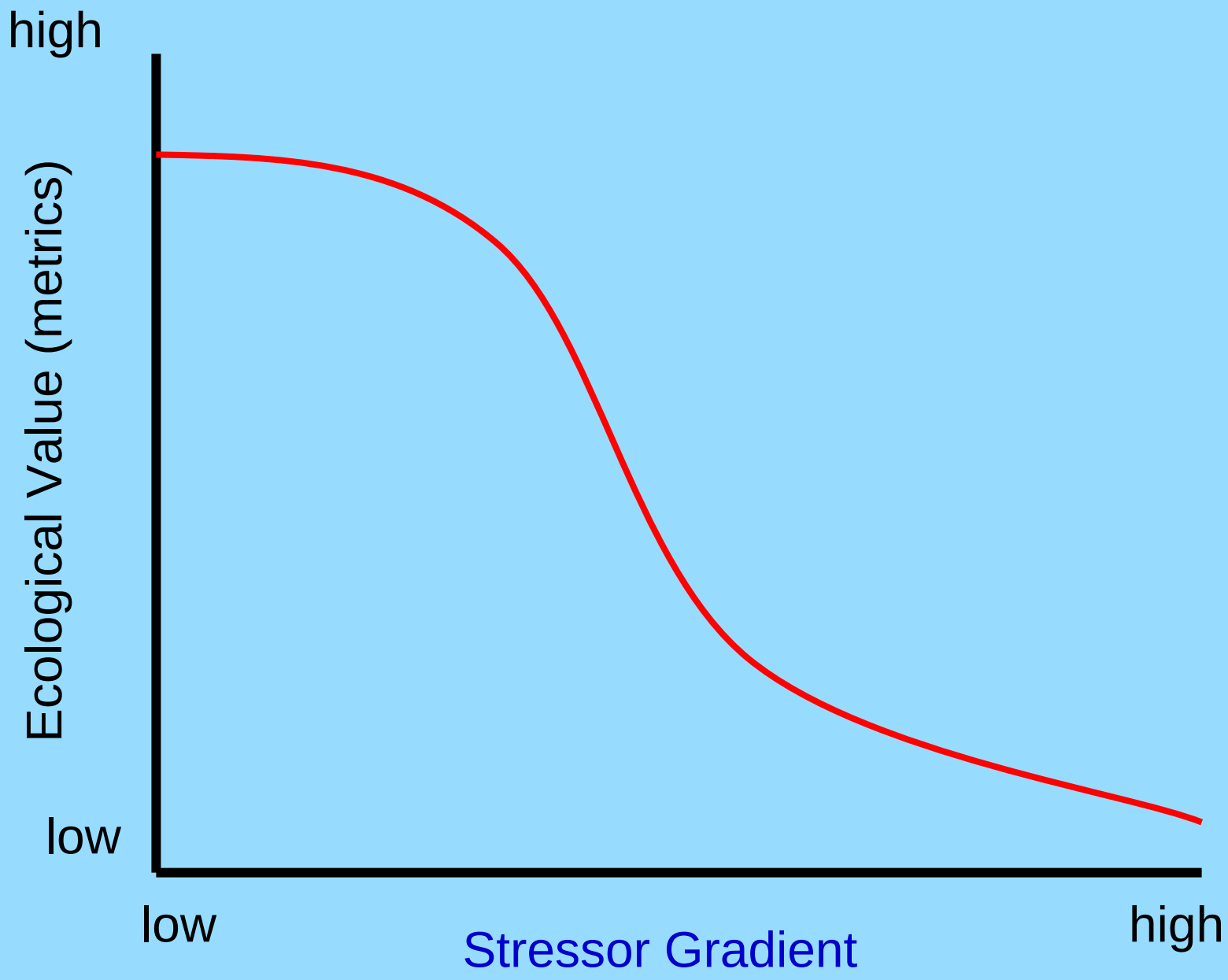
Stressors in Lakes in Wisconsin

- For our purposes:
  - Human induced perturbations in the
  - Landscape = Land-Use

- Three Scales of Perturbation:
  - Riparian Area Site Level Disturbance
  - Whole Lake Cumulative Effect
  - Watershed/Catchment Scale Land-Use Changes


high
Ecological Value (metrics)
low
low
Stressor Gradient
high

PRESENTATION OUTLINE

- Lakes Classification as a framework for ecological assessment and monitoring
- Application of lakes classification to real biological data across a stressor gradient of human development at multiple scales

Why Classify Lakes?

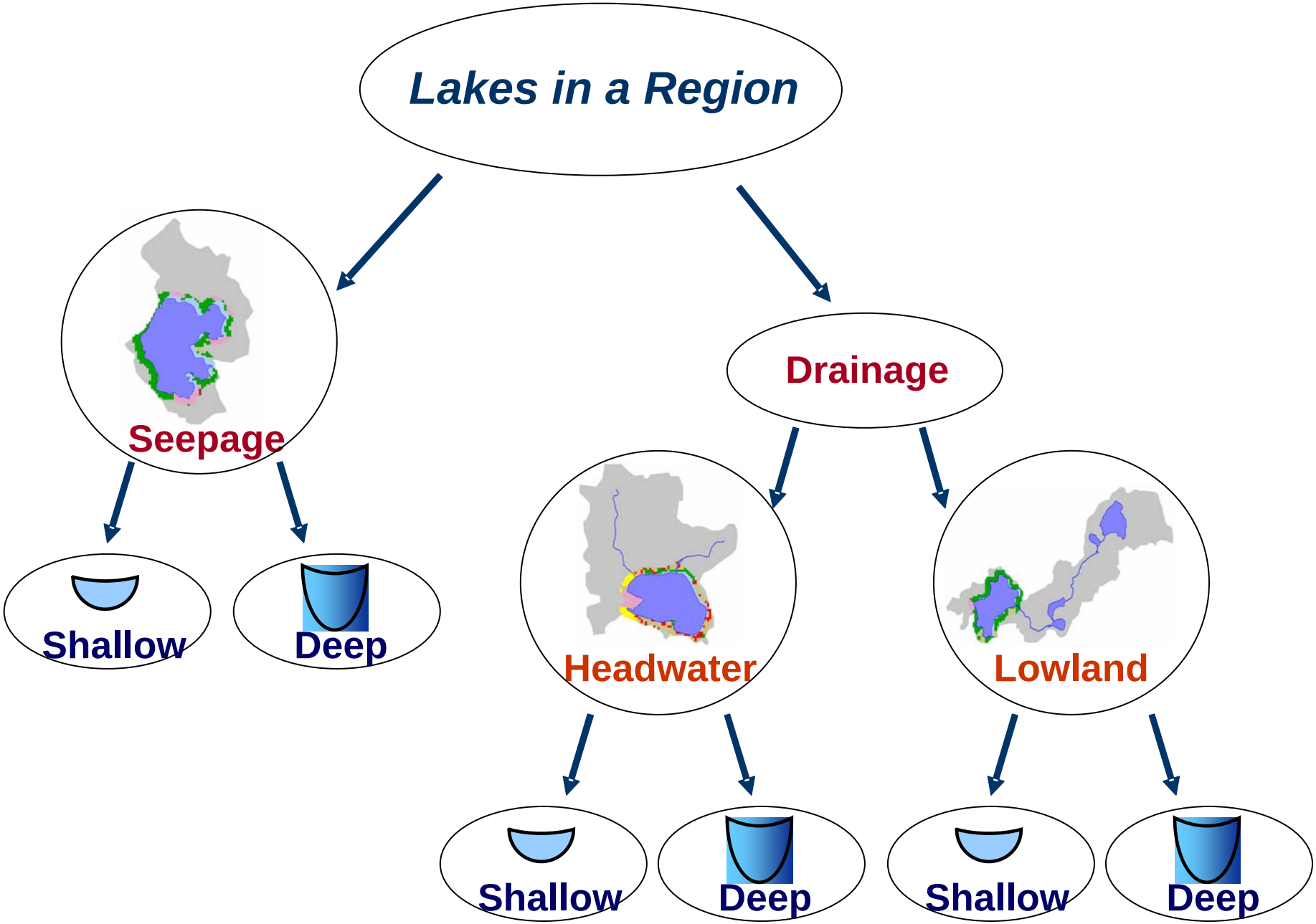
- Lakes differ from each other in physical and chemical composition
- Physical and chemical characteristics constrain biology
- Grouping similar lakes simplifies management
- Recognizing important differences allows flexibility

Approach to Lake Classification

- Data driven
  - Maximize similarity on conservative parameters
- Ultimately we will use lake classes to examine change in response variables across a range of human-induced lake conditions.

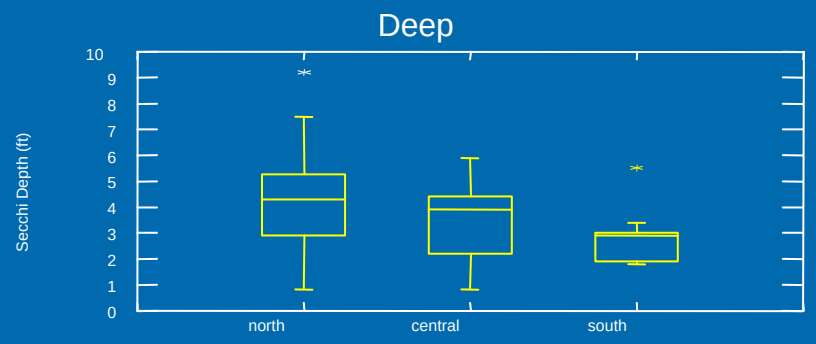
CLASSIFICATION CRITERIA

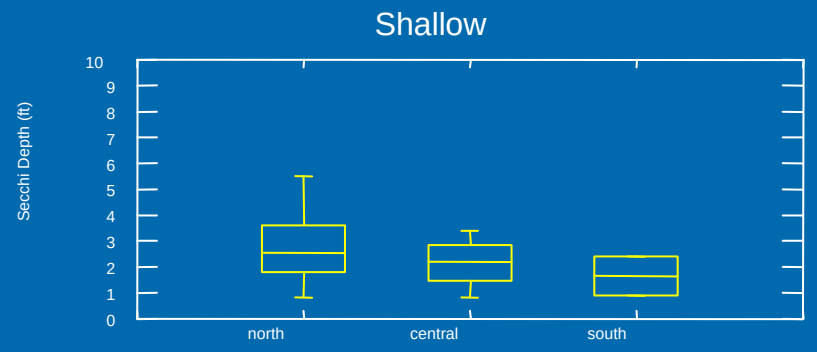
- Surface Area
- Depth
- Landscape position
- Alkalinity, Calcium, Magnesium, Chloride
- pH
- Transparency, Turbidity
- N:P ratio


Lakes in a Region
Seepage
Drainage
Shallow
Deep
Headwater
Lowland
Shallow
Deep
Shallow
Deep

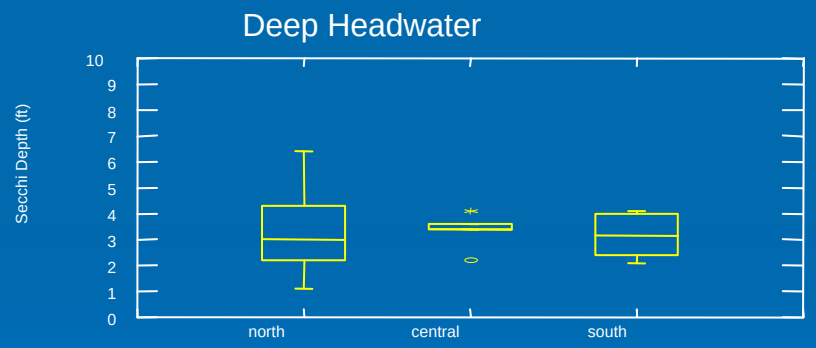
Box plots of Secchi Depth in Wisconsin

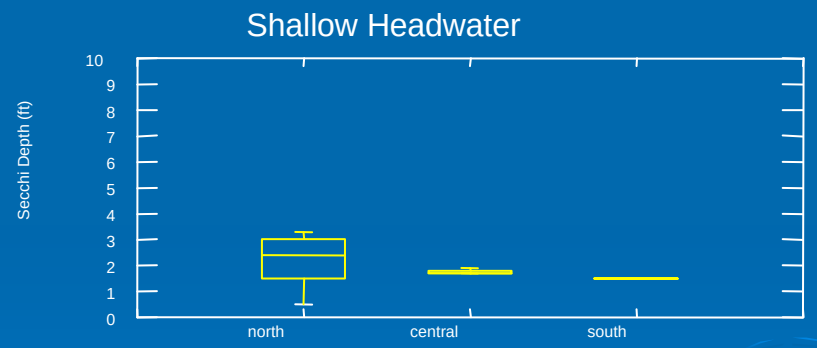
Seepage Lakes

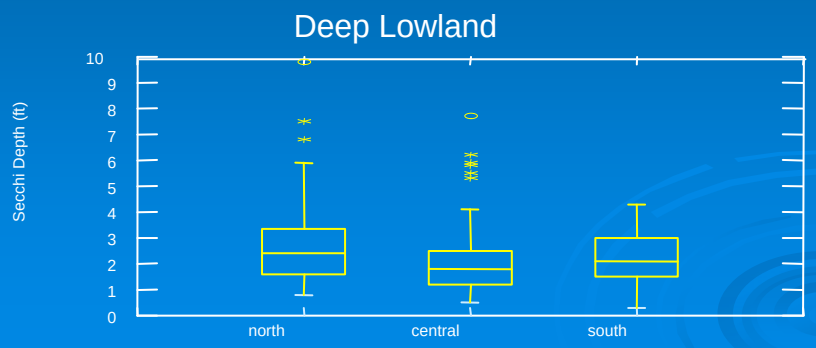


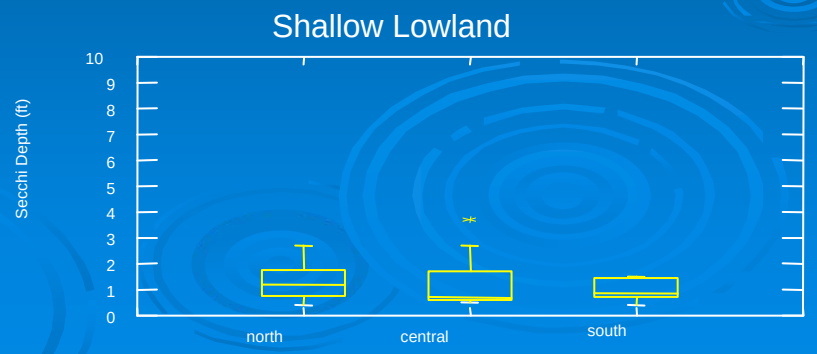


Drainage Lakes



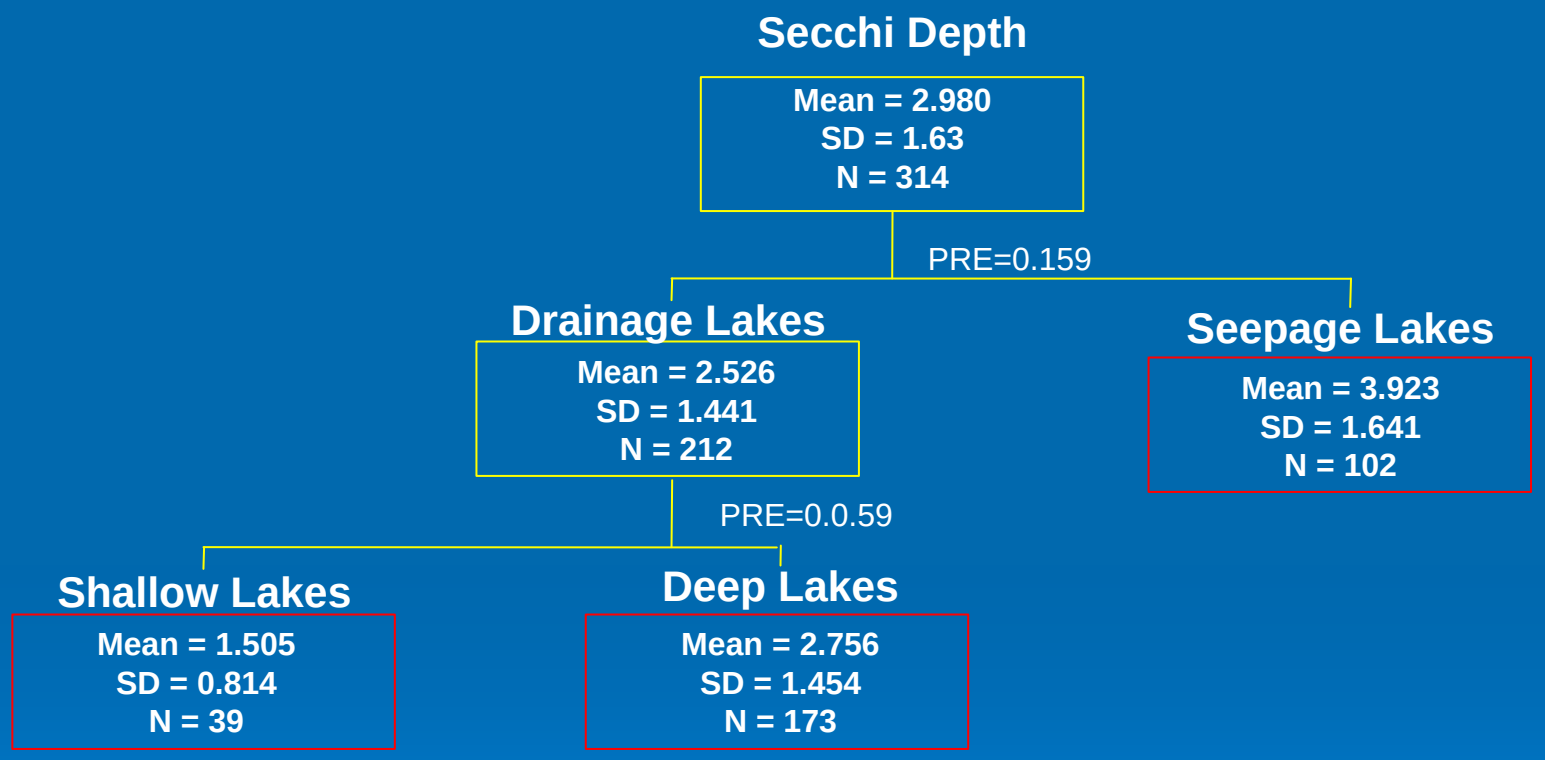




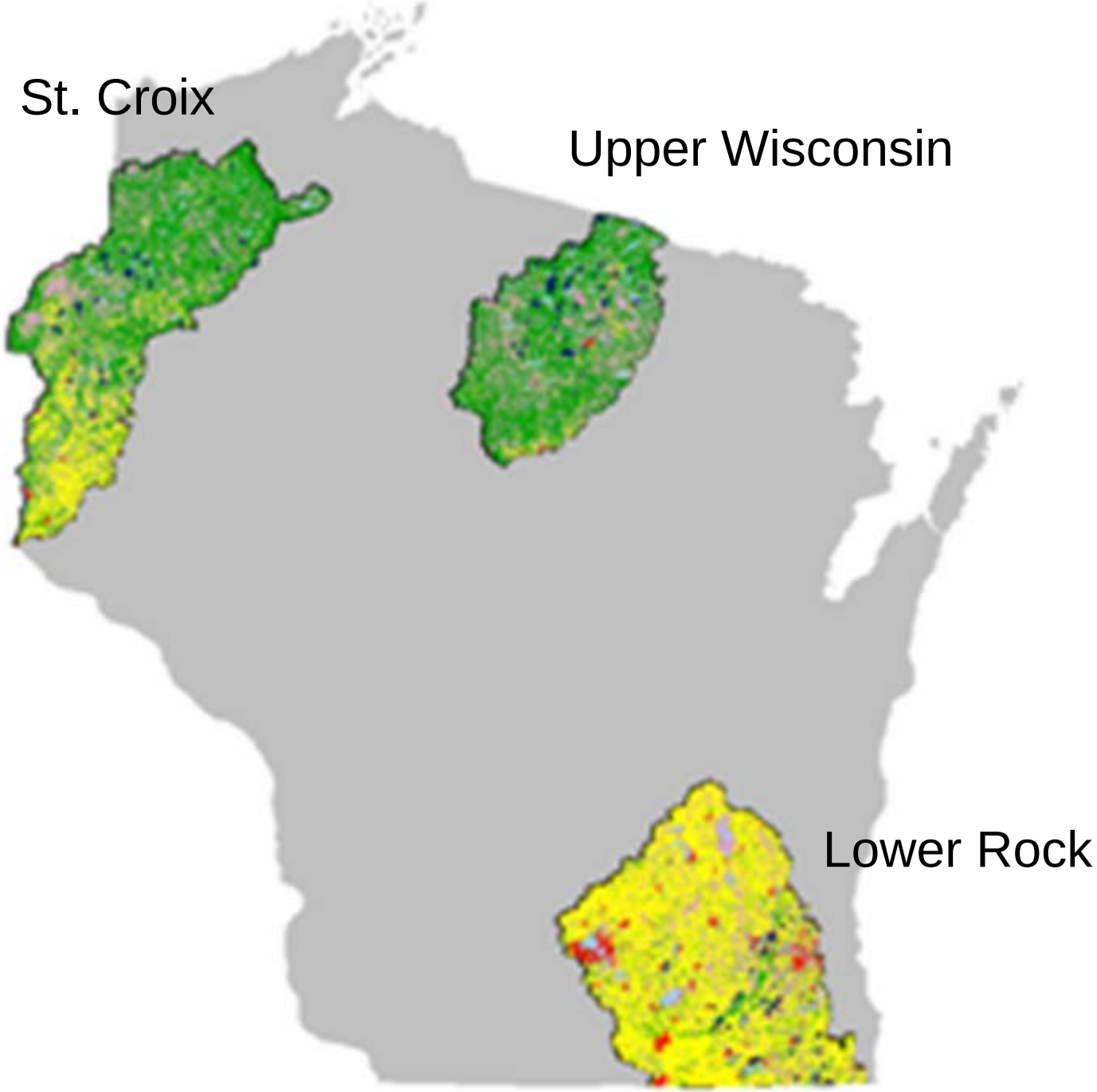


Regression Tree of Secchi Depth in Northern Wisconsin.

Depth as Categorical (cutoff = 18 feet)

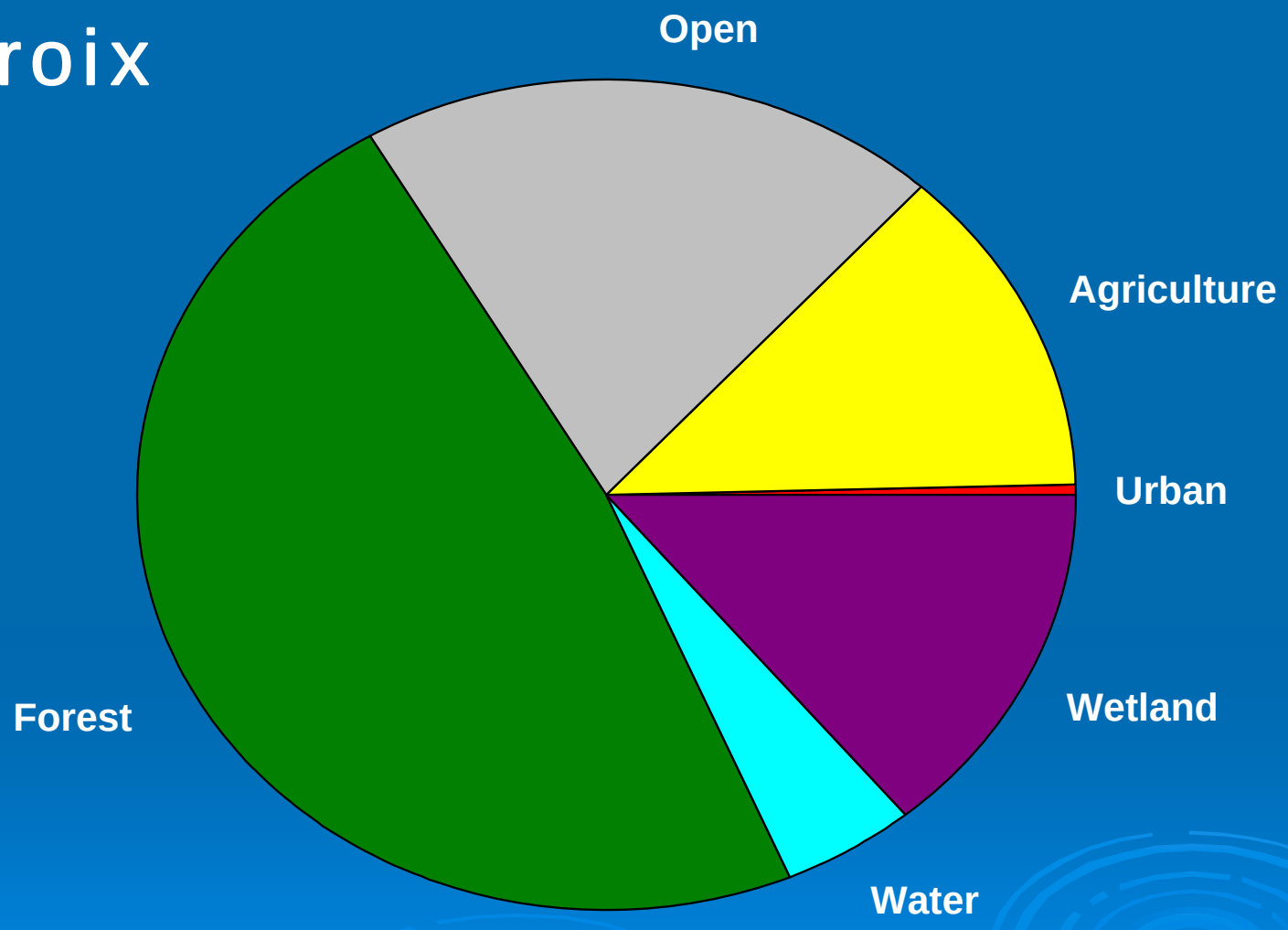


Overall PRE=0.218


St. Croix
Upper Wisconsin
Lower Rock

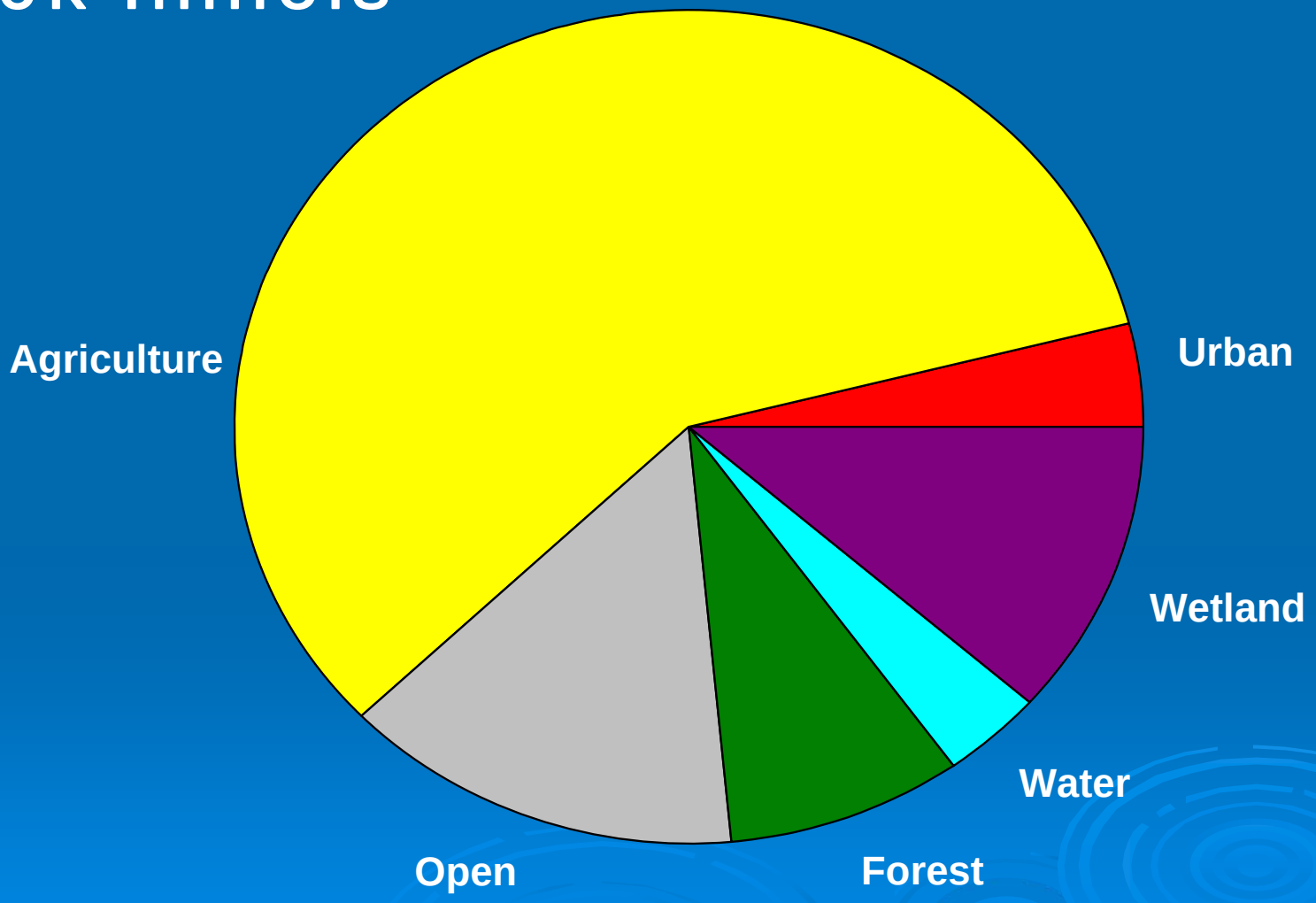
Land-Use Types

St. Croix



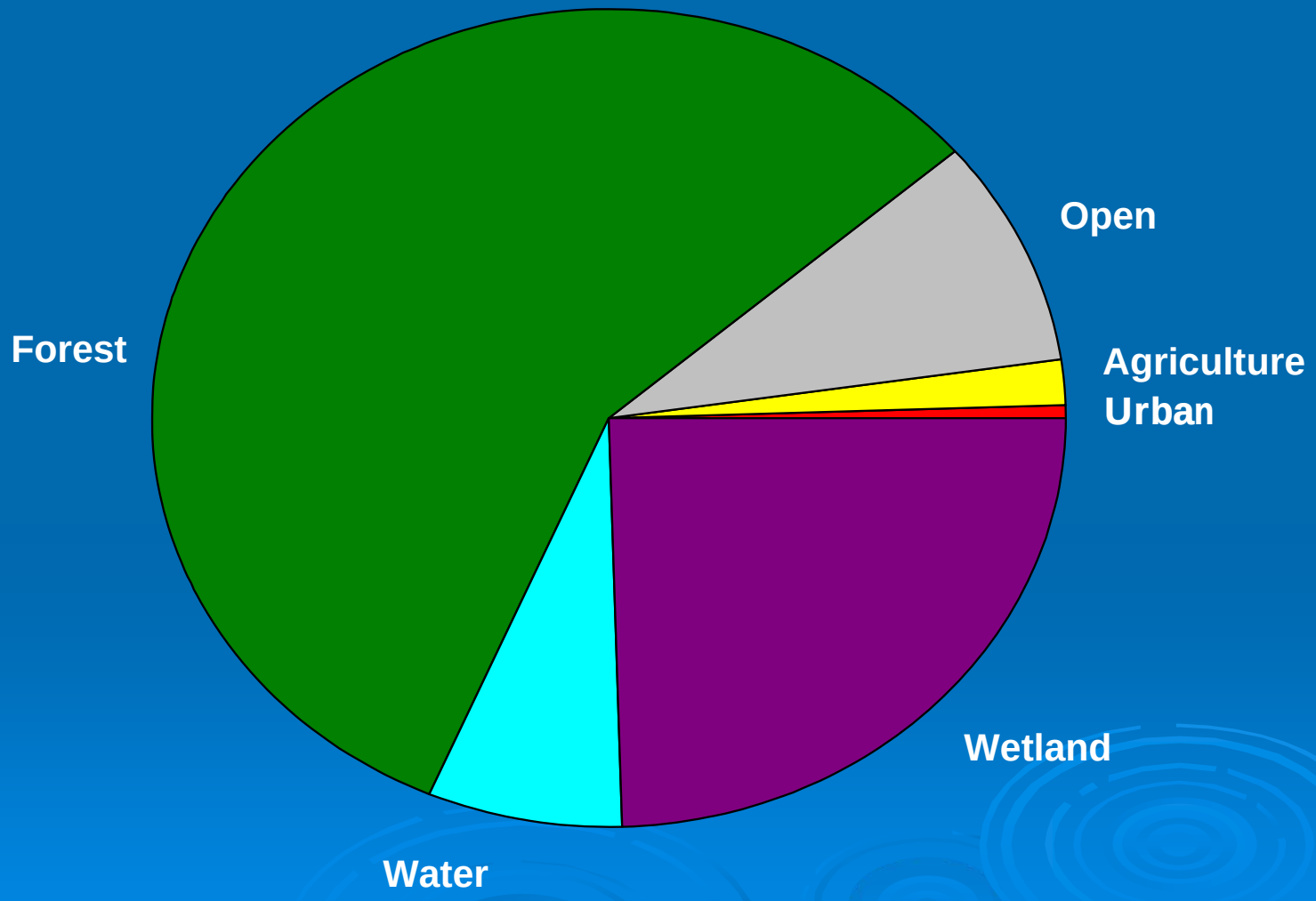
Land-Use Types

Rock Illinois

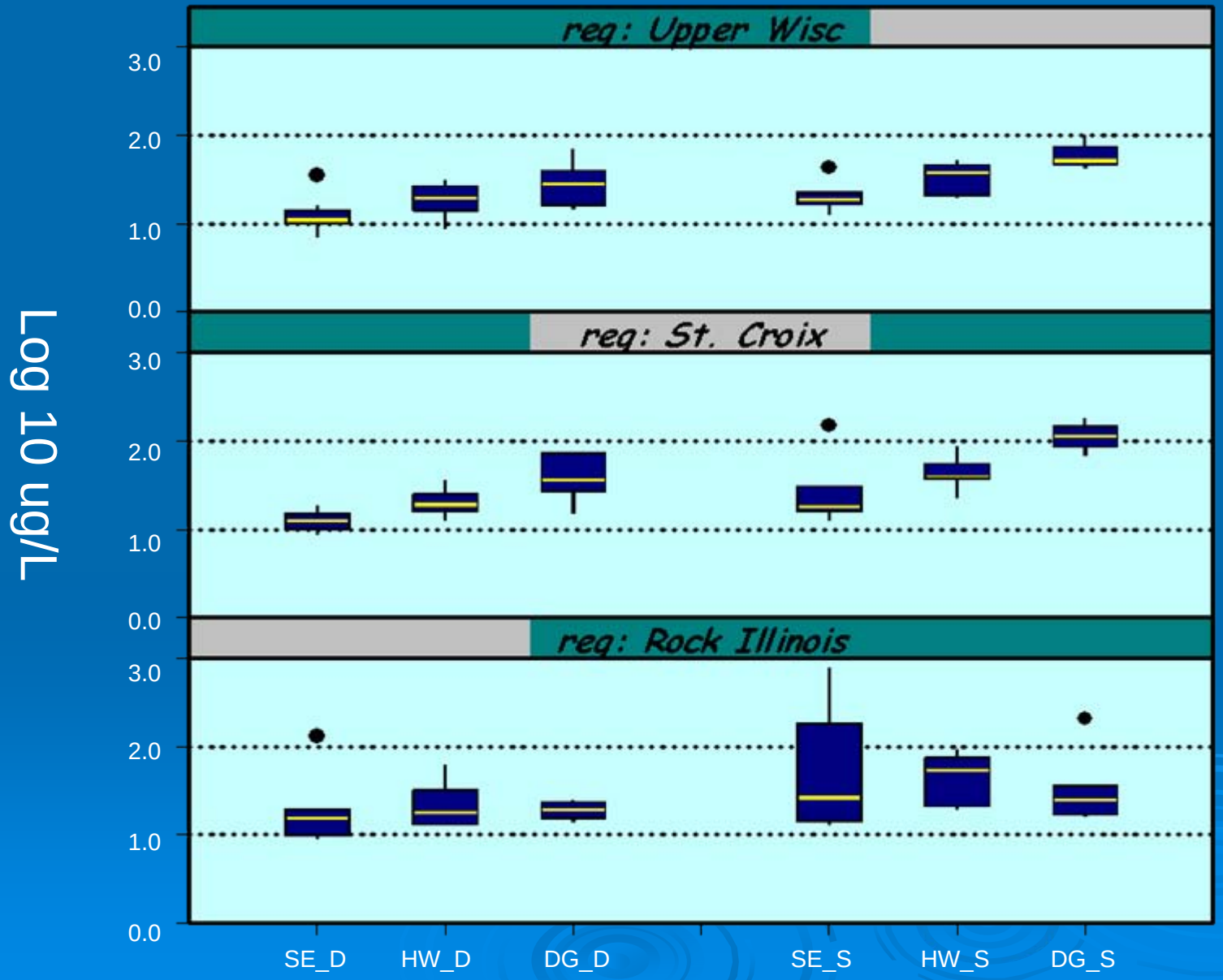


Land-Use Types

Upper Wisconsin



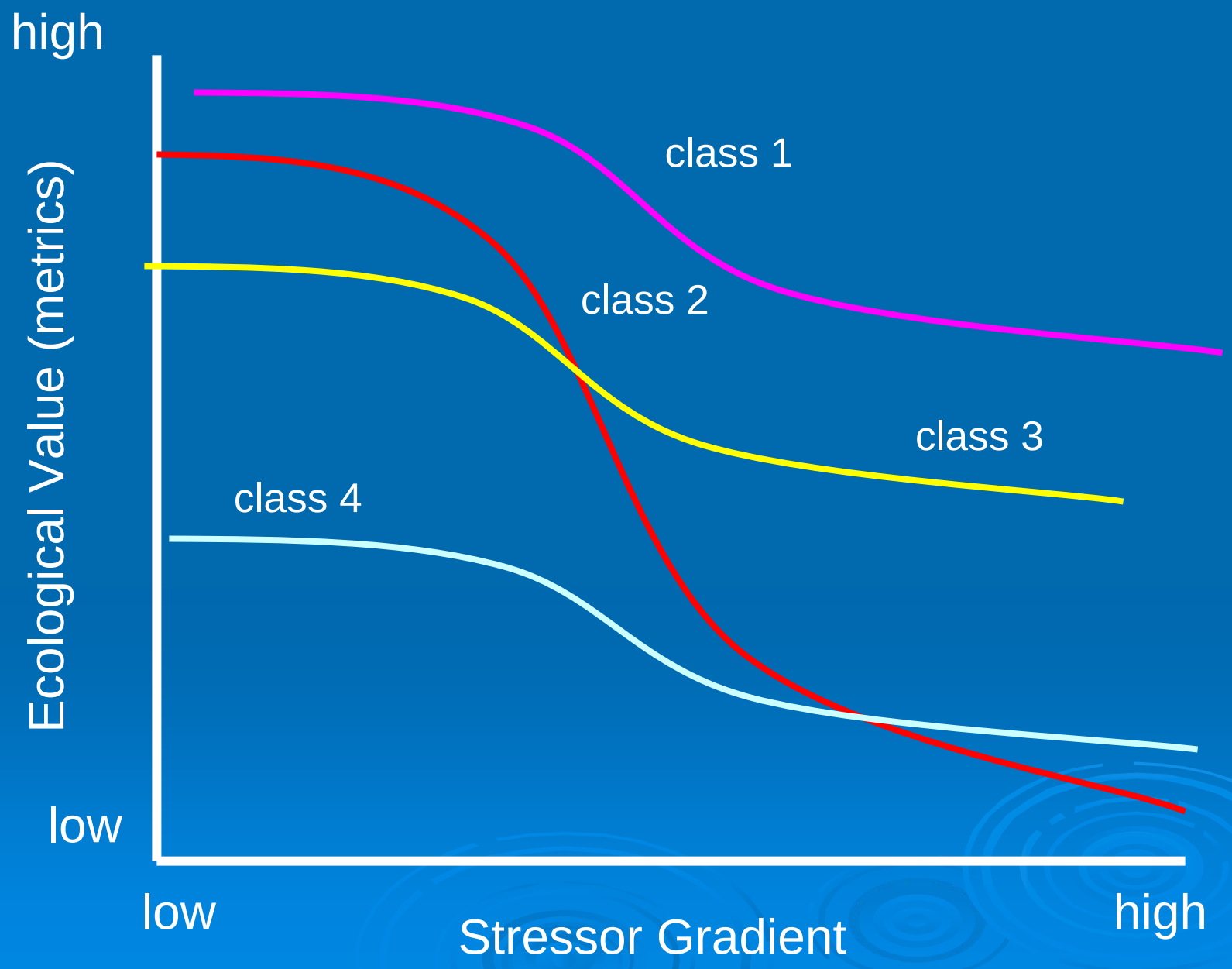
Log Total Phosphorus



Type	Response Variable	R^2	Region	Depth	Hydrology
Geochemical	Calcium	0.775	<0.001	NS	<0.001
Nutrients	Chlorophyll a	0.152	NS	-<0.05	<0.01
	TP	0.225	NS	-<0.01	<0.01
	TN	0.464	<0.001	-<0.001	<0.01
	DOC	0.172	<0.05	-<0.001	NS
Morphometric	Total Watershed Area	0.238	NS	NS	<0.001
Land Cover	% Agriculture	0.689	<0.001	NS	<0.01
	% Forest	0.533	-<0.05	NS	-<0.01
	% Wetland	0.170	-<0.05	NS	-<0.05

LAKES CLASSIFICATION

- Provides appropriate context for assessing impacts--Reference Conditions
- Allows objective, realistic management goal-setting
- Scale of classification units consistent with monitoring and assessment tools
- Scale of classification units consistent with scale of management


high
Ecological Value (metrics)
low
class 1
class 2
class 3
class 4
low
Stressor Gradient
high

PRESENTATION OUTLINE

- Lakes Classification as a framework for ecological assessment and monitoring
- Application of Lakes Classification – Northern Wisconsin Seepage Lakes
  - Littoral habitat, riparian development, and land-cover in Northern Wisconsin lakes
- Fish assemblages and riparian development
- Macrophyte communities and riparian development

LITTORAL HABITAT STUDY: OBJECTIVES

- Identify features of littoral zone affected by residential development
- Assess contribution of site-level, and lake-scale impacts on littoral zone
- Assess relation between littoral habitat and watershed land-cover

APPROACH

- Measure physical habitat and macrophytes in lakes with similar natural features
- Compare sites with and without residential development
- ANCOVA with density of residential development as covariate
- Measure habitat relation to watershed land cover across multiple lakes

ANCOVA MODELS

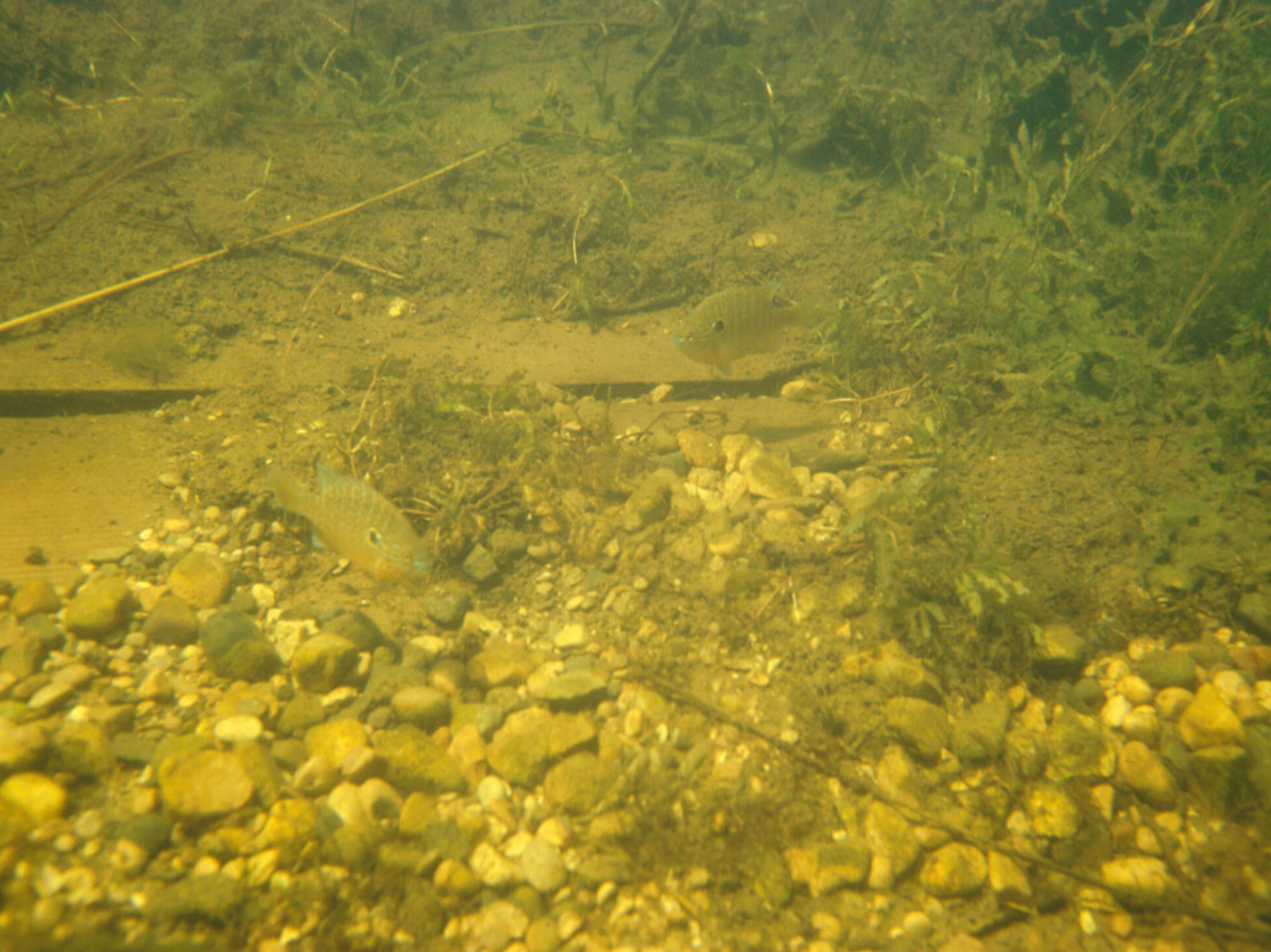
- Evaluate effects at site and whole lake scale
- Lake=random effect in mixed effects model
- Dependent variables transformed with log +1, or arcsin-square root for proportions
- Analyses performed in SAS mixed procedure

LARGE WOODY DEBRIS

- More wood at undeveloped sites (p=.026)
- More wood in lakes with fewer residences/km shoreline (p=.004)
- Significant interaction, with least wood found at developed sites in highly developed lakes (p=.030)

MEDIUM WOODY DEBRIS

- Less wood in developed lakes (p=.003)
- No significant site-level effect



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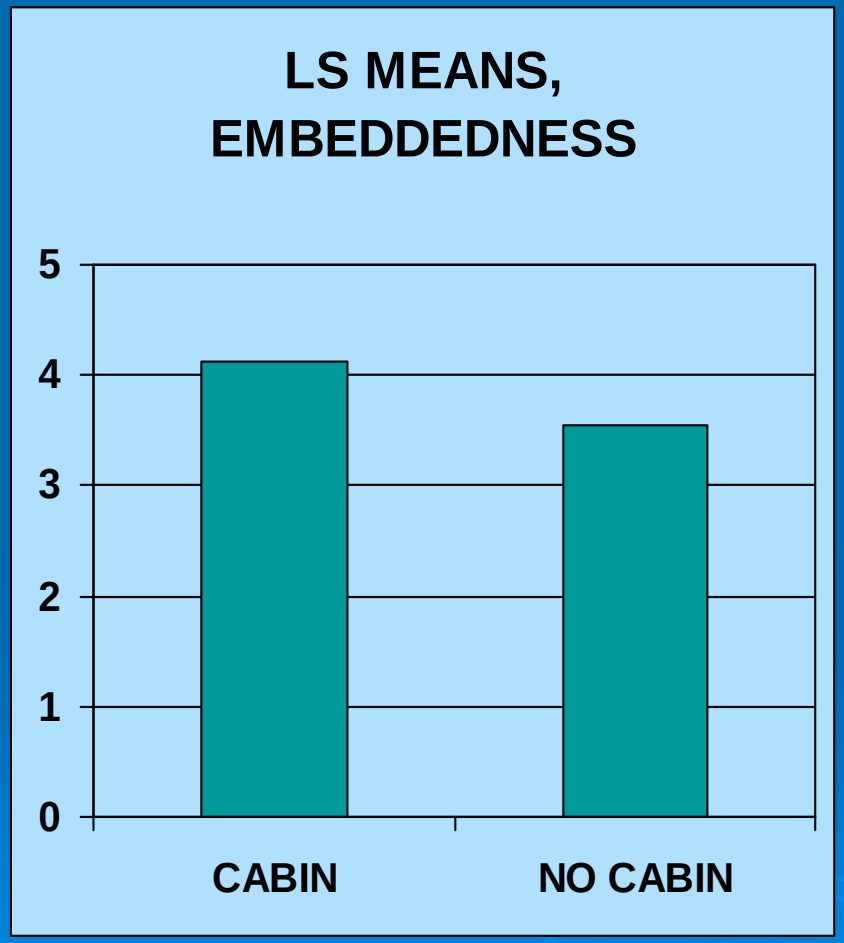
SUBSTRATE



- Local effect (p=.0003)
- Lake-wide density effect (p=.0004)
- Interaction NS

EMERGENT VEGETATION

- Significant site effect (p=.002)
- Significant lake-wide density effect (p=.006)
- LS Means comparison indicates 20% reduction in emergent vegetation at developed sites

FLOATING-LEAF VEGETATION

- Significant site effect (p=.0001)
- Significant lake-wide density effect (p=.0001)
- Significant interaction (p=.0001)
- Least floating-leaf vegetation at developed sites in developed lakes

PCA SUMMARY

Watershed Land-Cover	Component 1	Component 2
Forest	0.883	-0.049
Wetland	-0.283	0.727
Ag/Grassland	-0.366	-0.684
Barren	-0.041	0.004
Shrub	-0.024	-0.004
Open-Water	-0.046	0.035
% Variance Explaned	0.665	0.262
Cumulative Variance Exp.	0.665	0.927

HABITAT VERSUS LAND-COVER

Habitat Characteristic	Forest Land Cover	Wetland (+) Ag Land Cover (-)
Substrate	-	-
% Emergent	+	NS
% Floating	+	+
% Submergent	+	+
L. Woody Debris	+	NS
M. Woody Debris	NS	+
S. Woody Debris	+	NS

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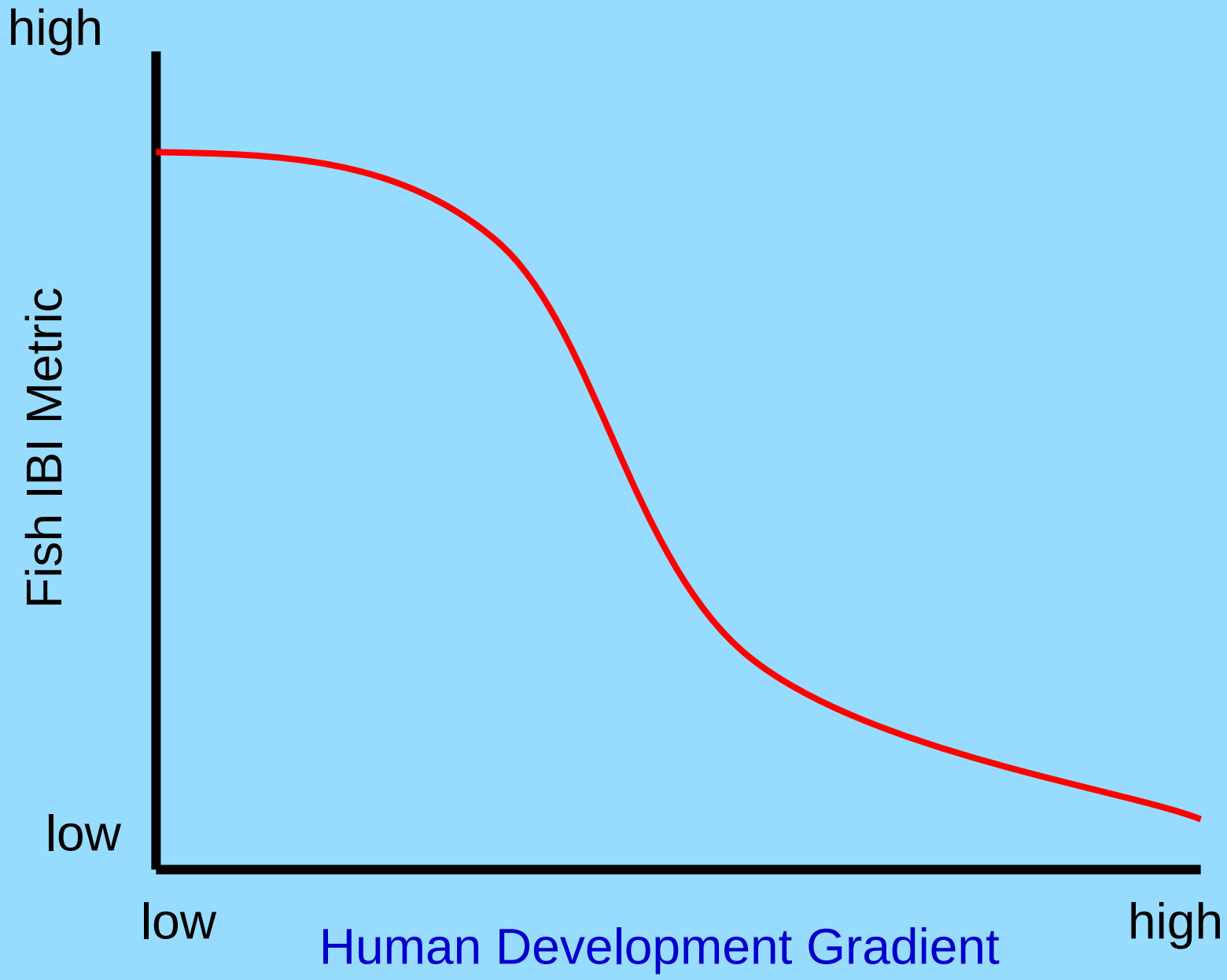
BIOLOGICAL INTEGRITY

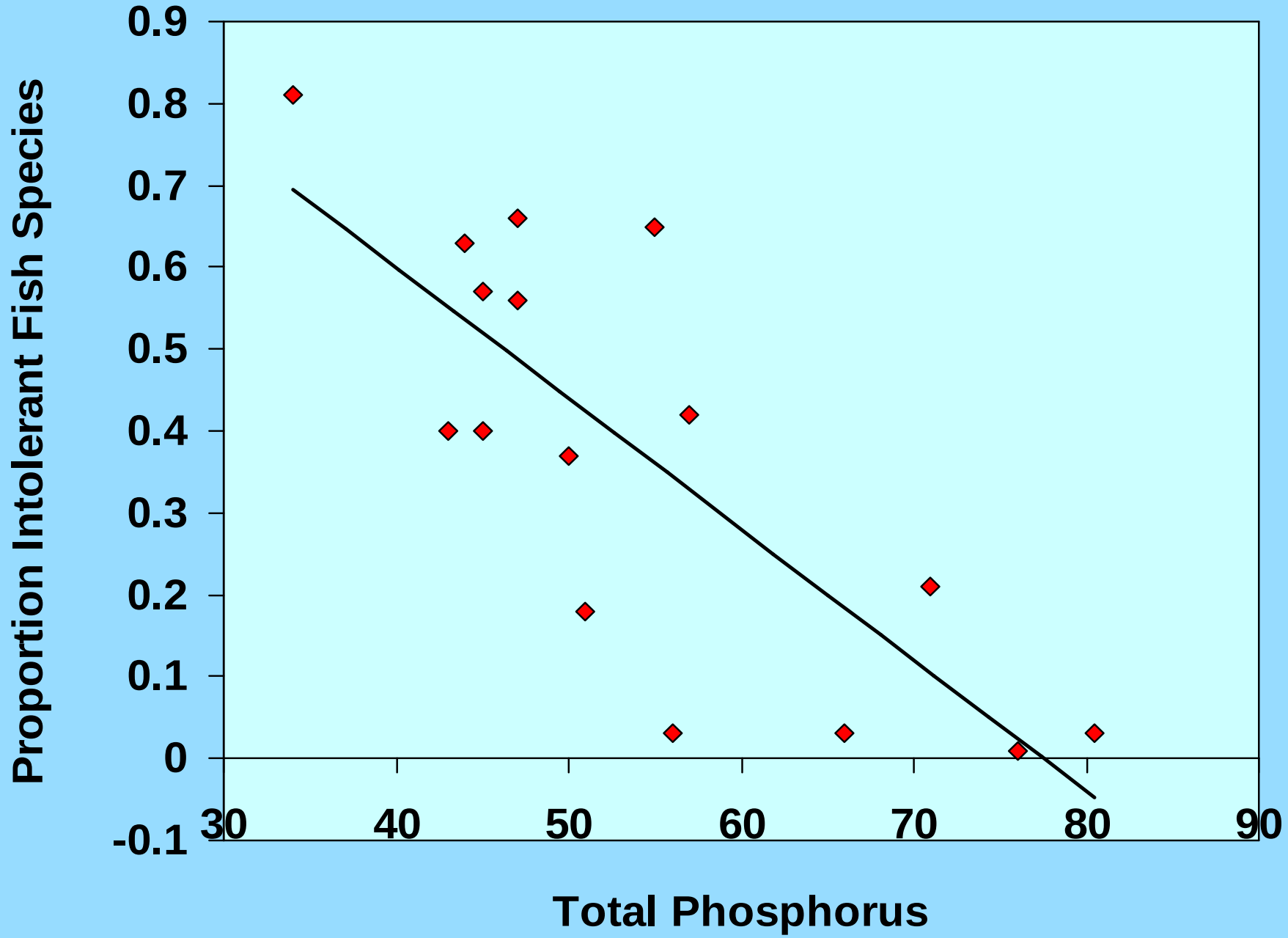
Capability of supporting
and maintaining a balanced,
integrated, adaptive community
of organisms having a
species composition, diversity,
and functional organization
comparable to natural habitats
of the region

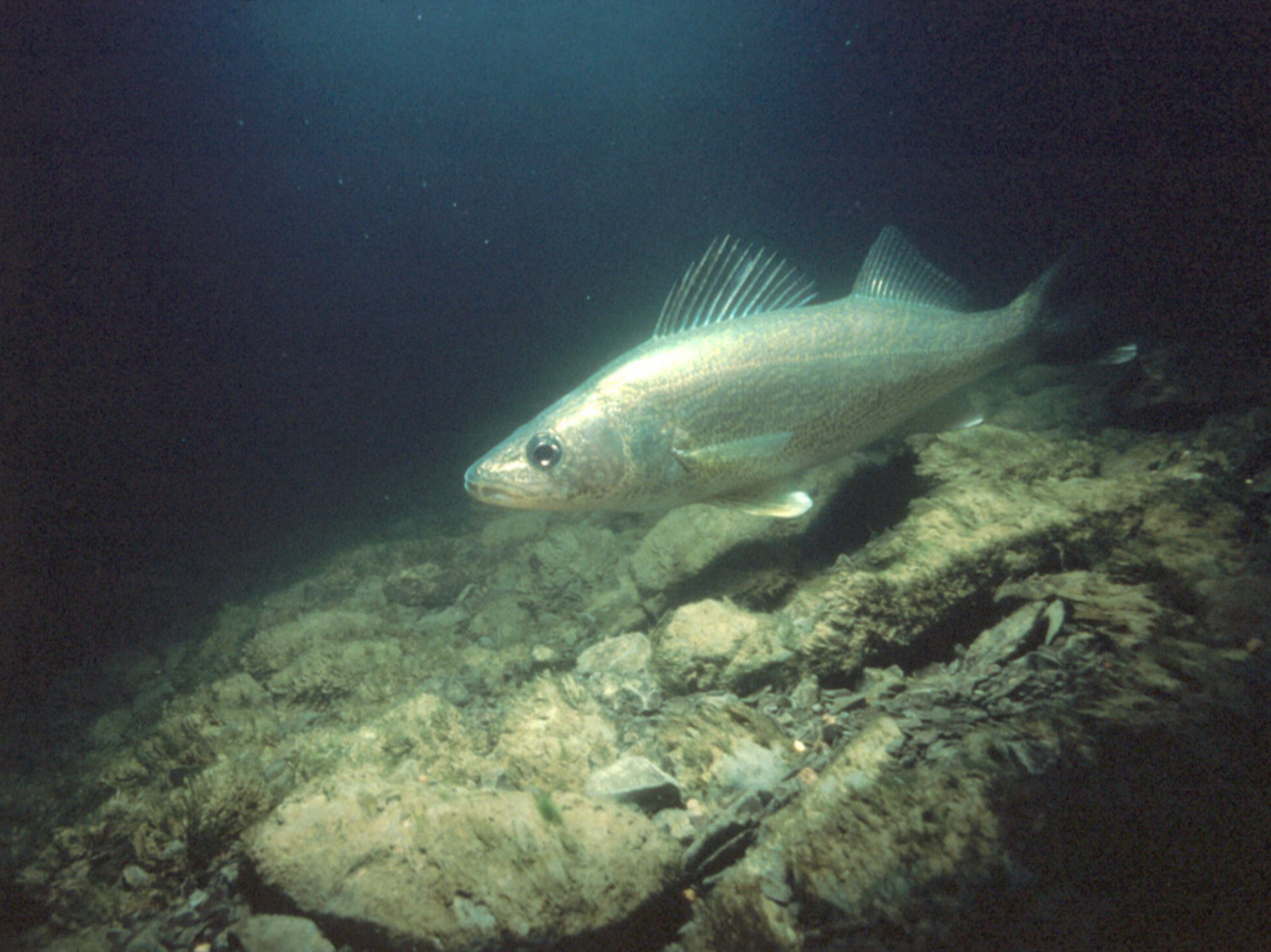
-Karr and Dudley (1981)

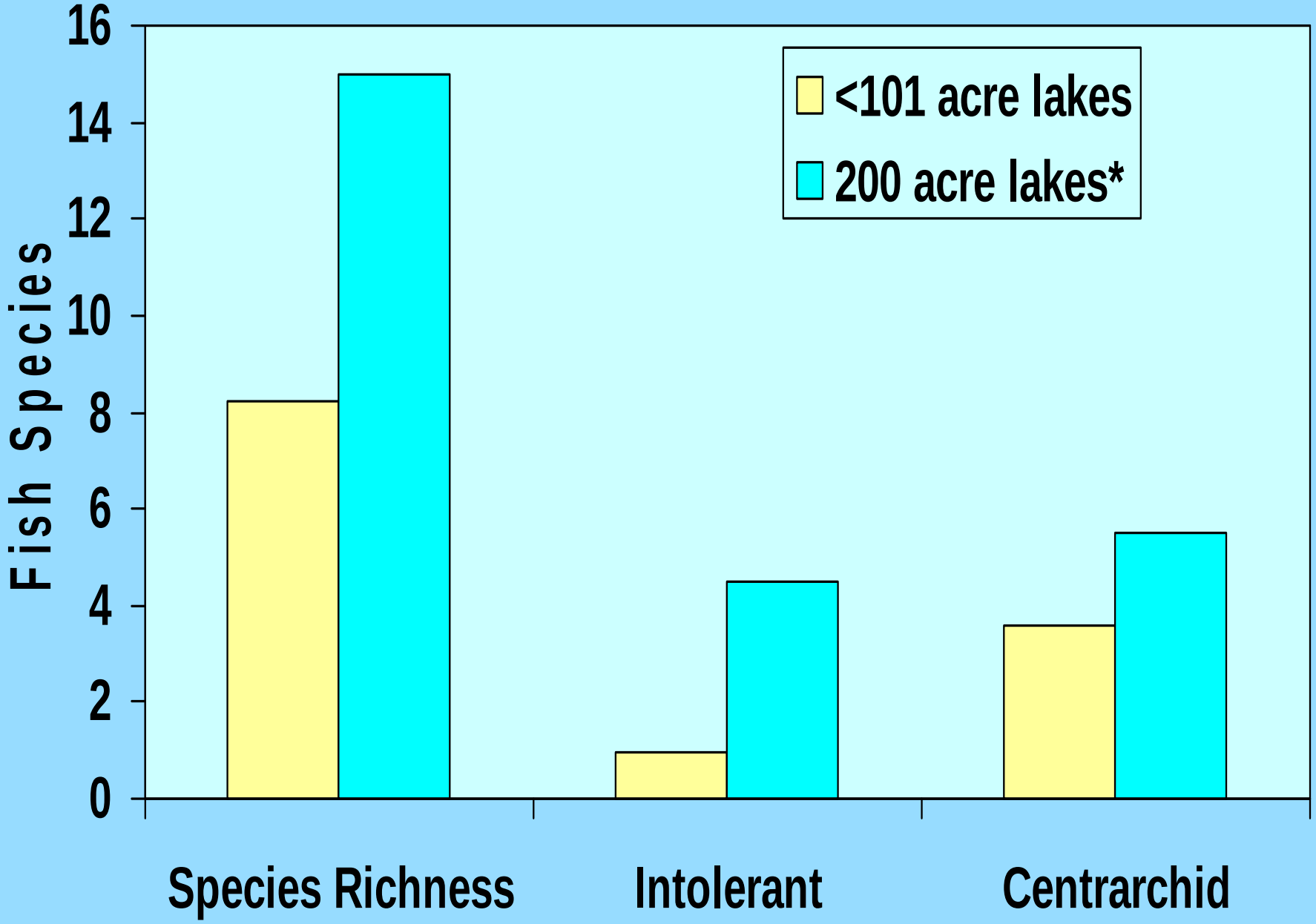
INDEX OF BIOTIC INTEGRITY

- Use biota to assess condition of water resources
- Taxonomic and functional metrics
- Modified for region and type of system


high
Fish IBI Metric
low
low
Human Development Gradient
high


Proportion Intolerant Fish Species
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
30
40
50
60
70
80
90
Total Phosphorus

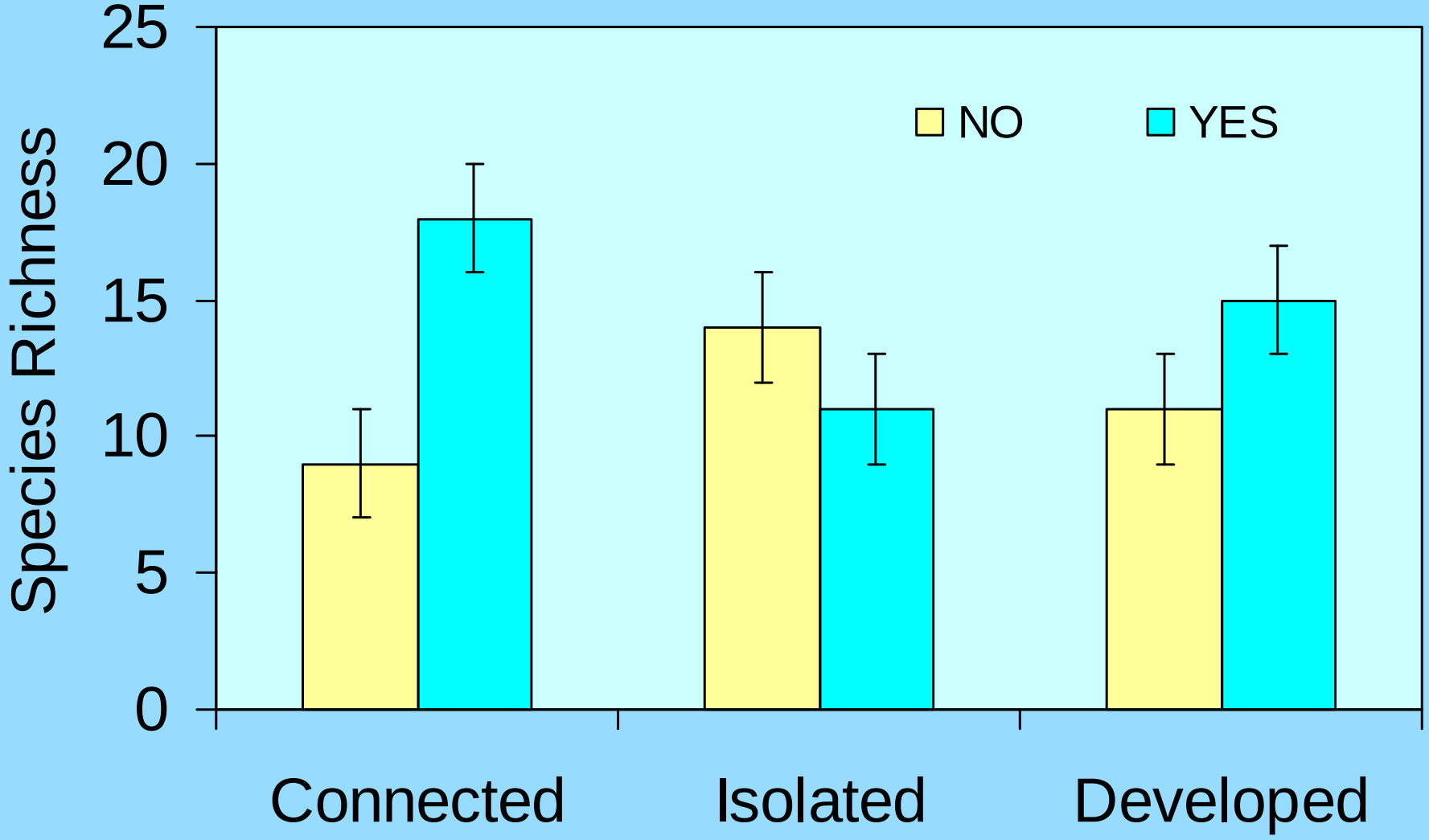



16
14
12
10
8
6
4
2
0
Fish Species
<101 acre lakes
200 acre lakes*
Species Richness
Intolerant
Centrarchid

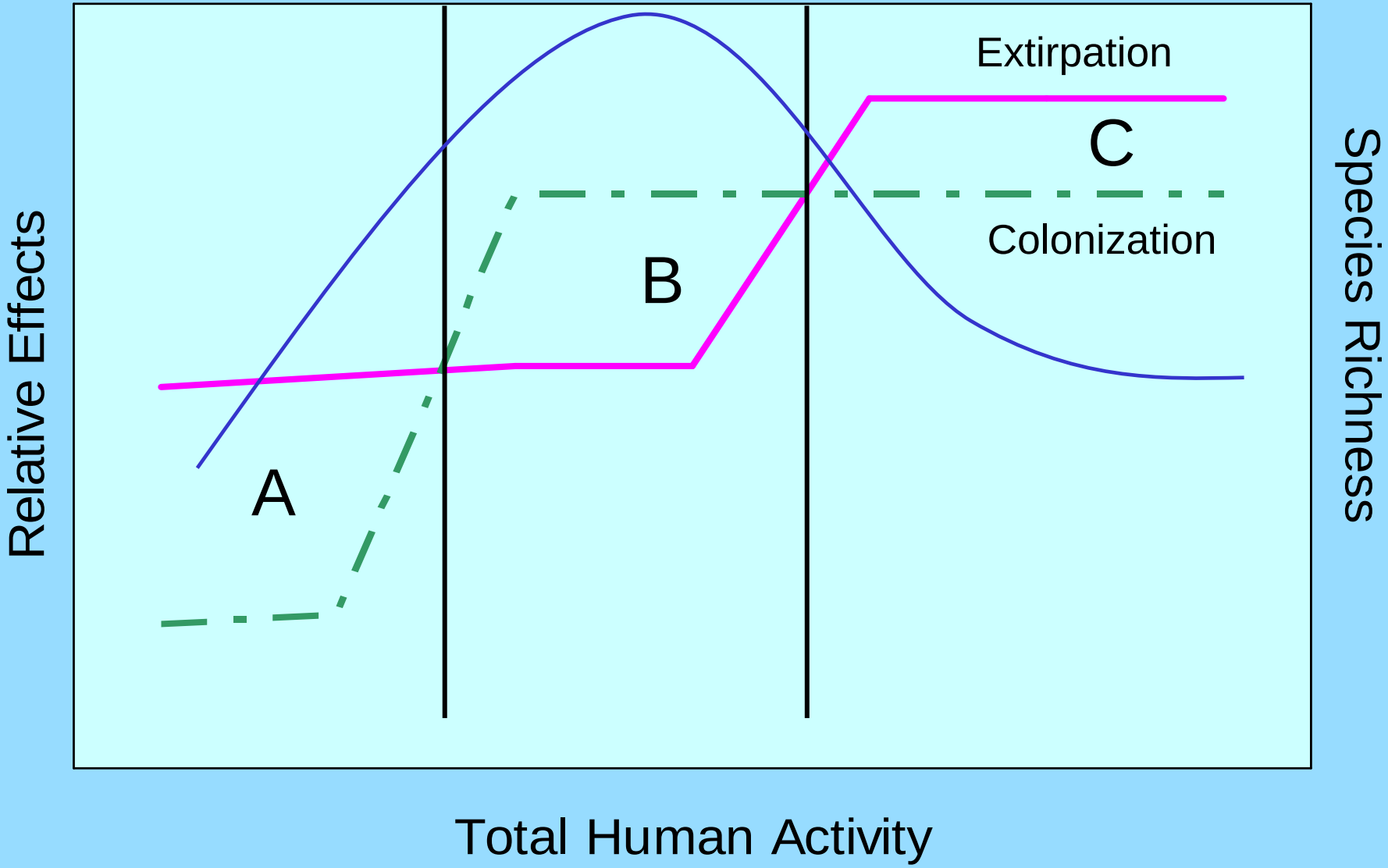
ANCOVA, Total Species Richness vs. Colonization/Extirpation Variables

Effect	Parameter	P
Connectivity	+	<.0001
Development	+	.0072
Isolation	-	.0145
Lake Area	+	.0335

Comparison of Least-Square Means



Hypothesized Relative Effects of Colonization and Extirpation on Species Richness



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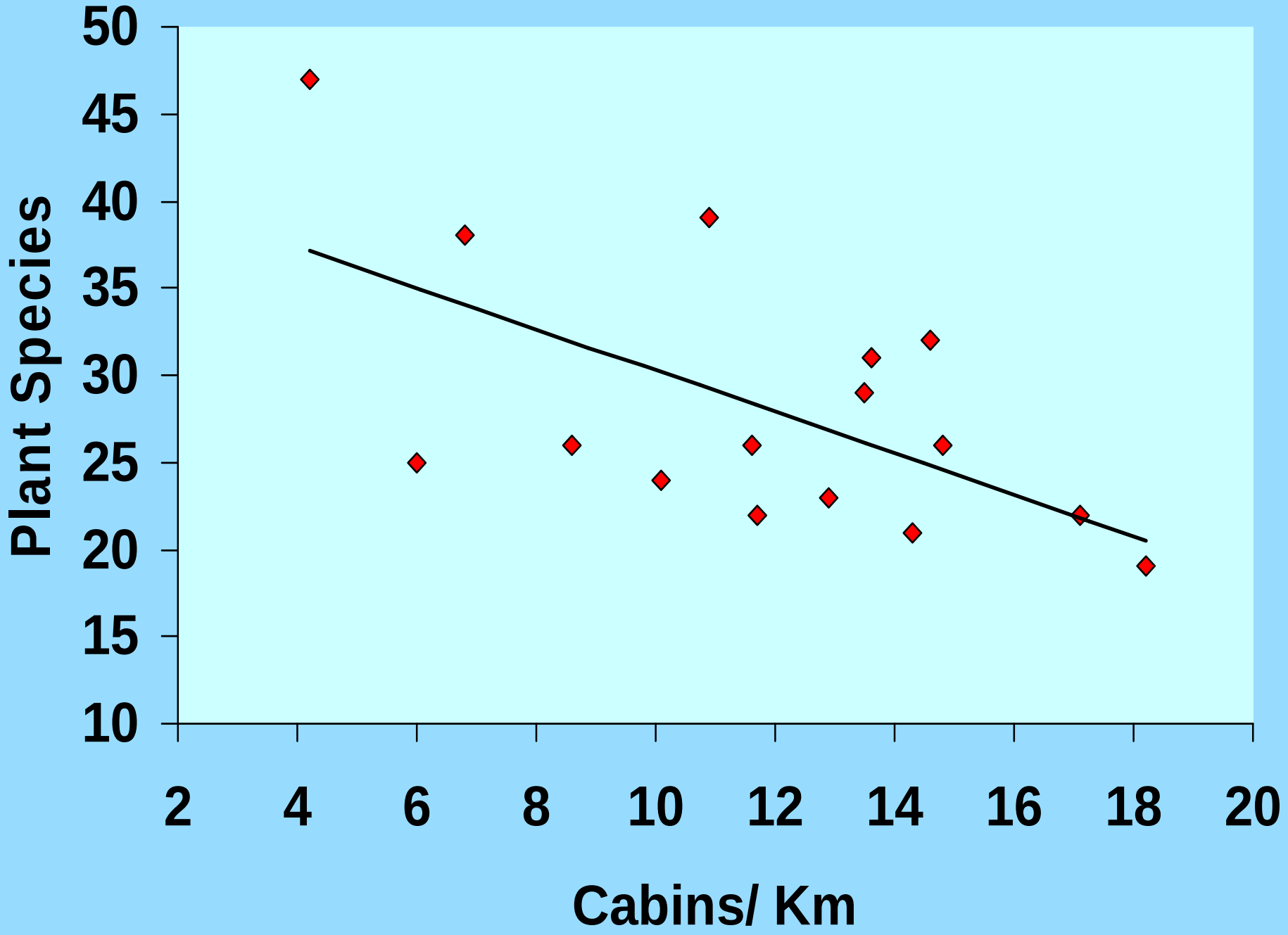
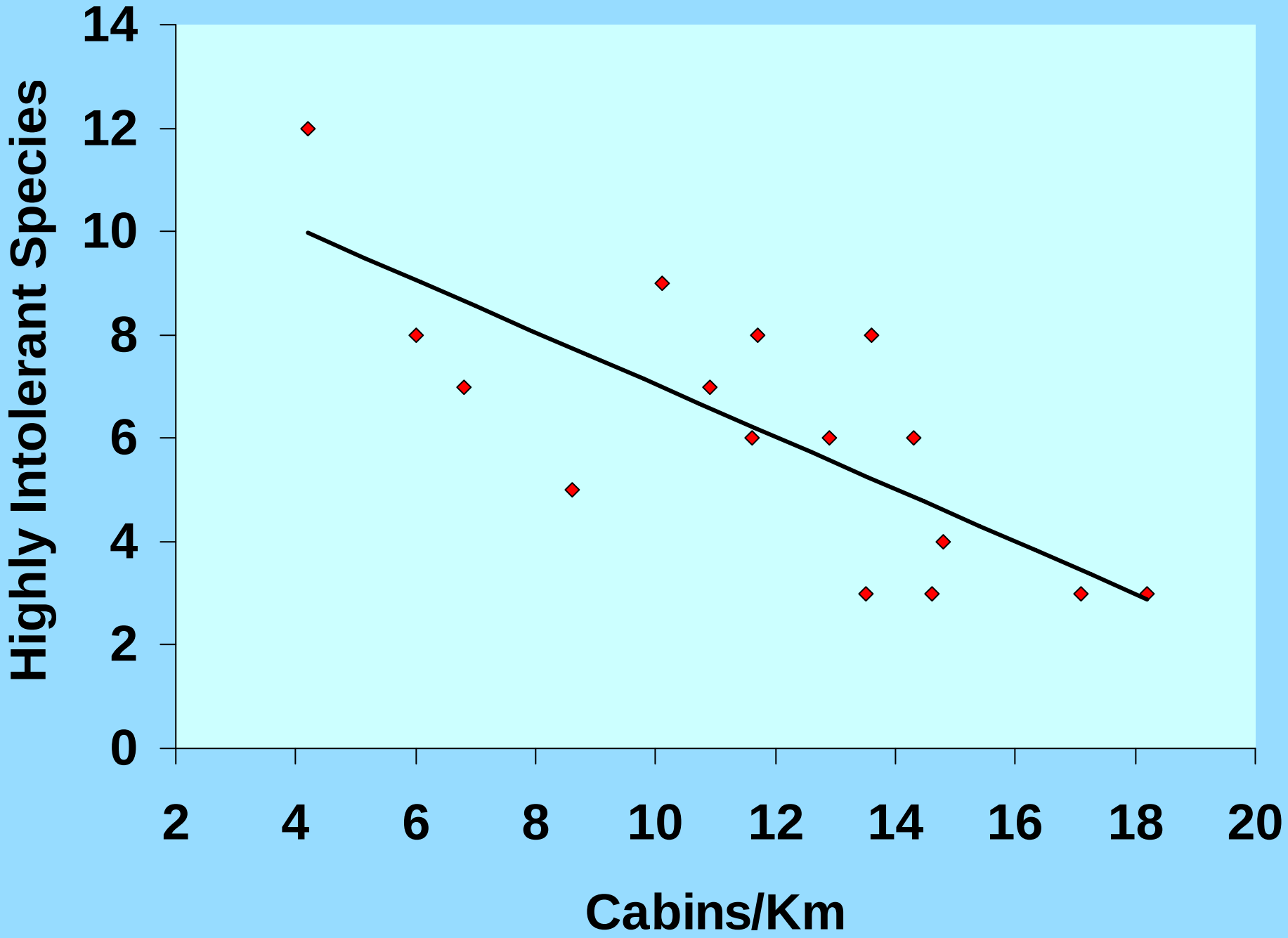
OBJECTIVES

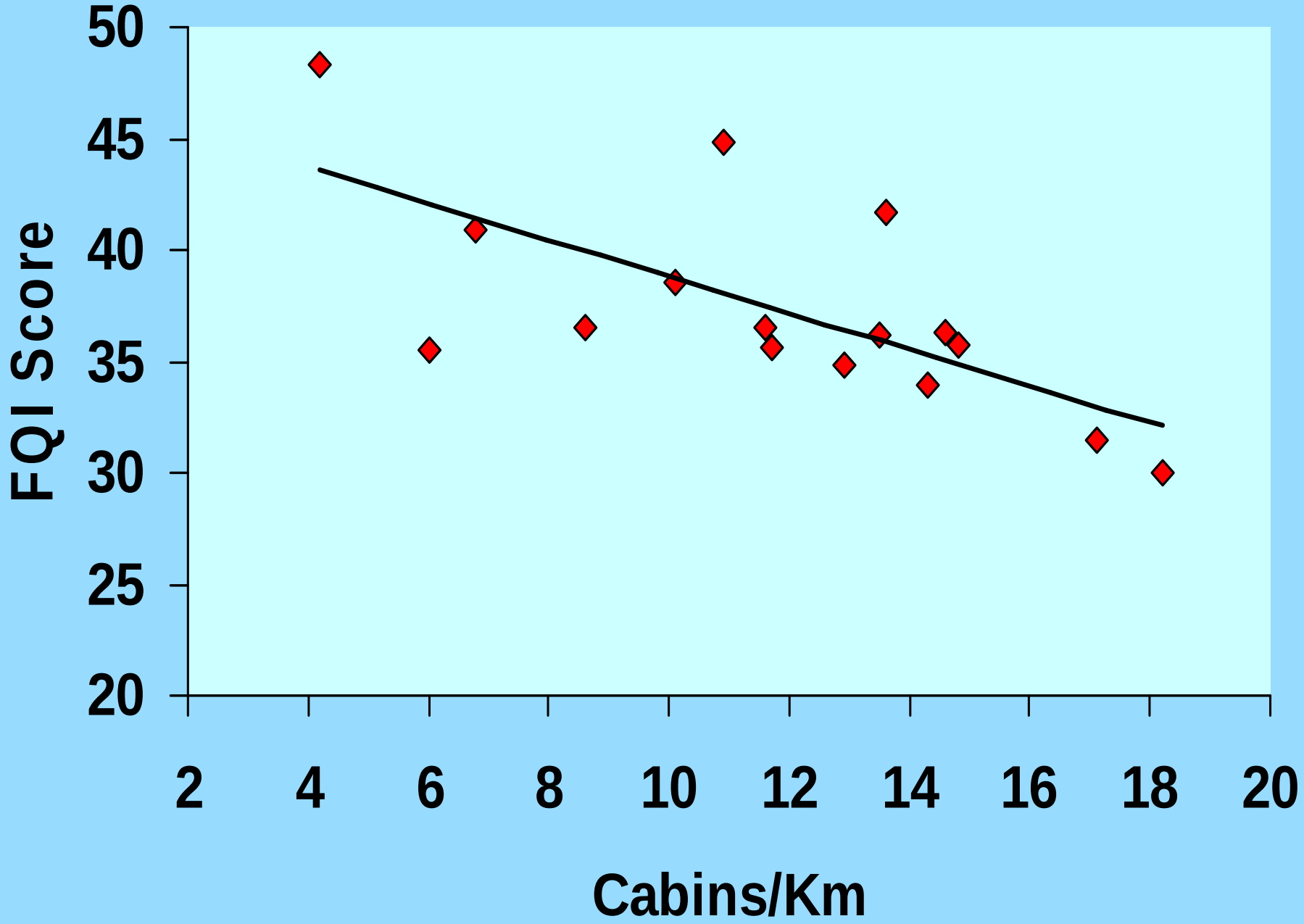
- Test Floristic Quality Index (FQI) for application as a monitoring tool in Wisconsin Lakes
- Provide preliminary assessment of lake condition within a class of lakes in northern Wisconsin
- Test null hypothesis of no relation between riparian development and macrophyte community

FQI APPROACH

- Based on species richness and "conservatism," a measure of sensitivity
- Lakes randomly selected within class based on objective limnological criteria


Plant Species
50
45
40
35
30
25
20
15
10
2
4
6
8
10
12
14
16
18
20
Cabins/ Km


Highly Intolerant Species
0
2
4
6
8
10
12
14
2
4
6
8
10
12
14
16
18
20
Cabins/Km


FQI Score
50
45
40
35
30
25
20
2
4
6
8
10
12
14
16
18
20
Cabins/Km

SUMMARY

- Development is associated with habitat changes at different spatial scales
- Sensitive fish species may respond to changes related to development but the response differs among lake type
- Preliminary macrophyte data suggests that community composition shifts in response to development

Summary Continued

- Classification and Metric Development are Linked
- Classification Scale must match the scale at which we measure and model our perturbation gradient
- Classification and metric development must be at the scale at which we make management decisions and at the scale at which we do assessment and monitoring