Modeling Biological Stream Condition in Highly Urbanized Southern California

Larry Brown USGS, Jason May USGS, Andy Rehn ABL, Peter Ode SWRCB

USGS

Background

- Evolved from a USGS effort to model stream condition (individual metrics)
  - SoCal was one study area
- This talk will
  - Review previous results
  - Present the new model

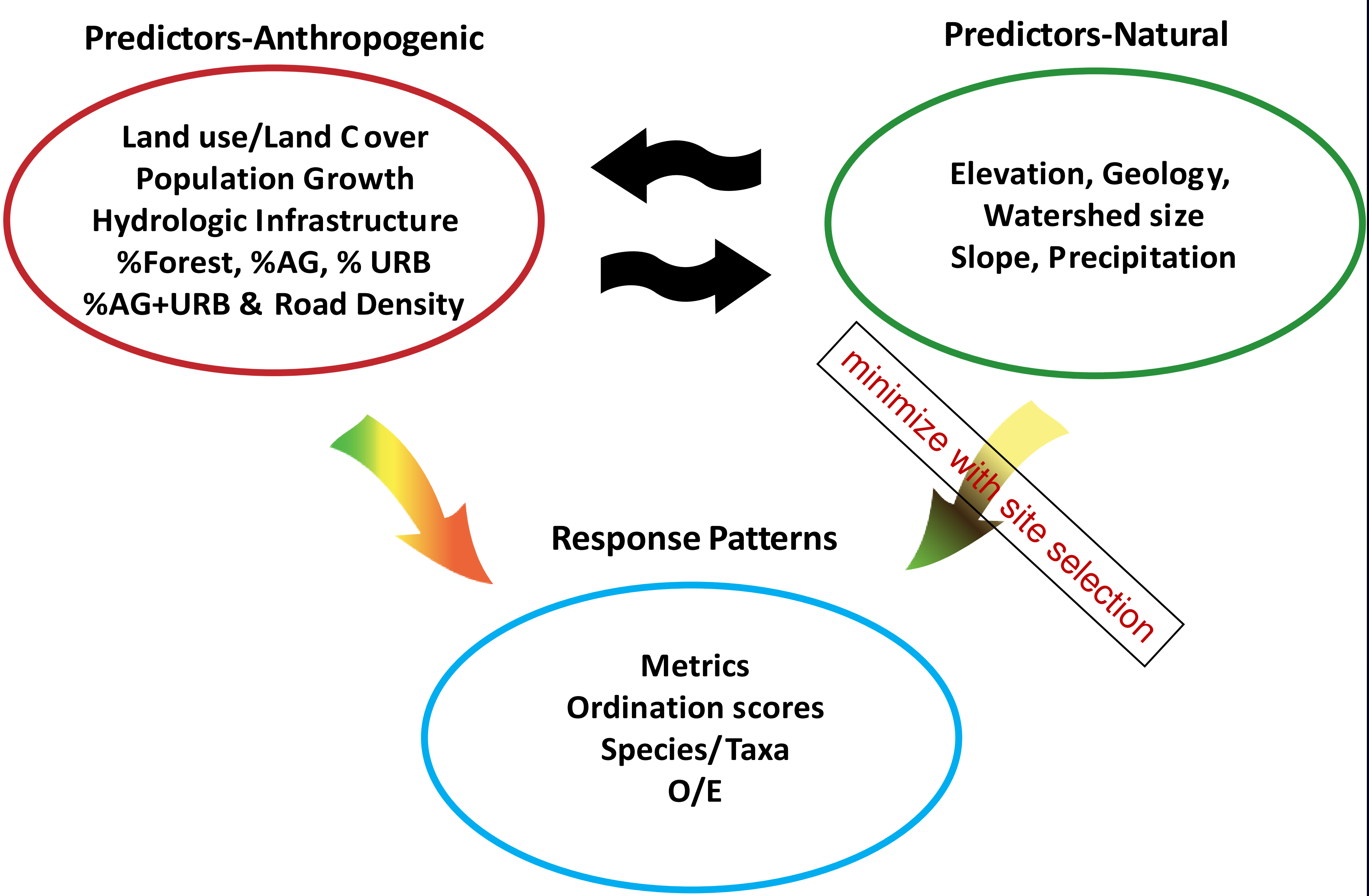
Objective of Earlier Study

- Can we develop simple, predictive models of biological condition at unsampled sites using land use, land cover and hydrologic infrastructure?

Methods

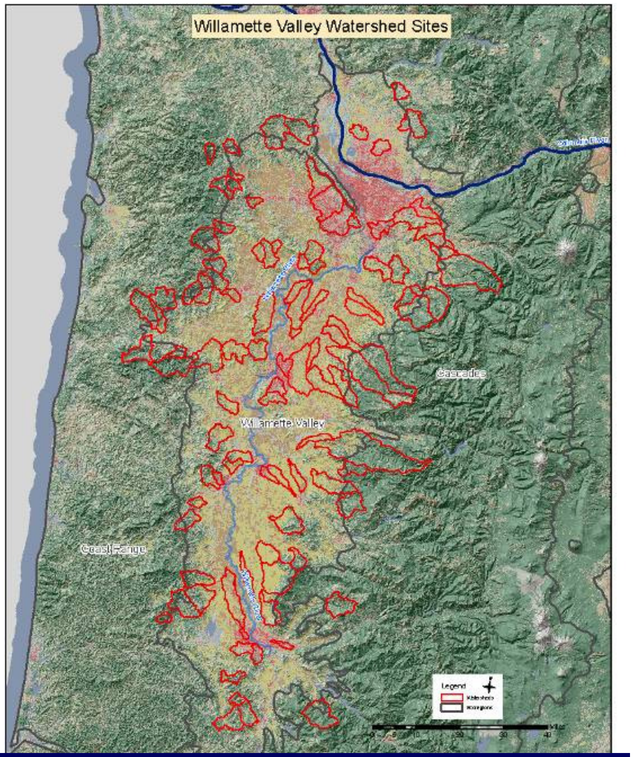
- Primary approach: simple multiple linear regression models
  - Response variables (invertebrate metrics like EPT richness and %noninsect taxa)
- Land use predictor variables
  - human impact (e.g., population density, %Ag, %Urban)
  - natural gradients (e.g., elevation)

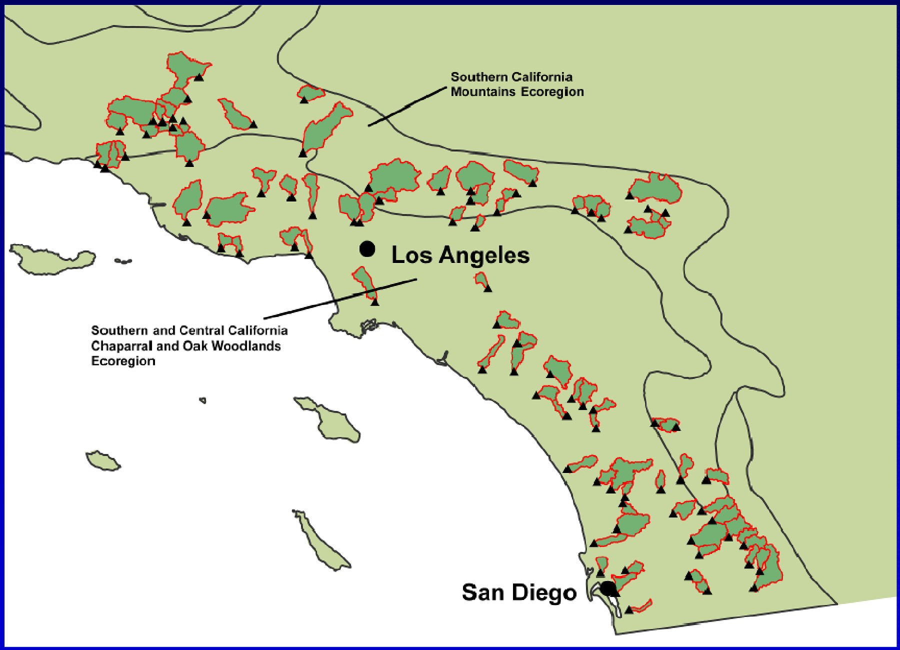
Conceptual Model

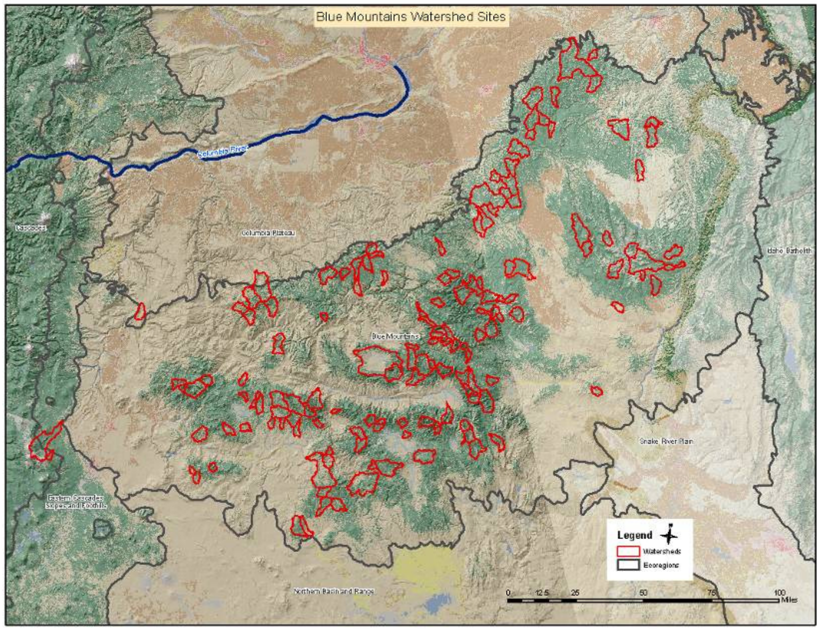


Geographic Regions:

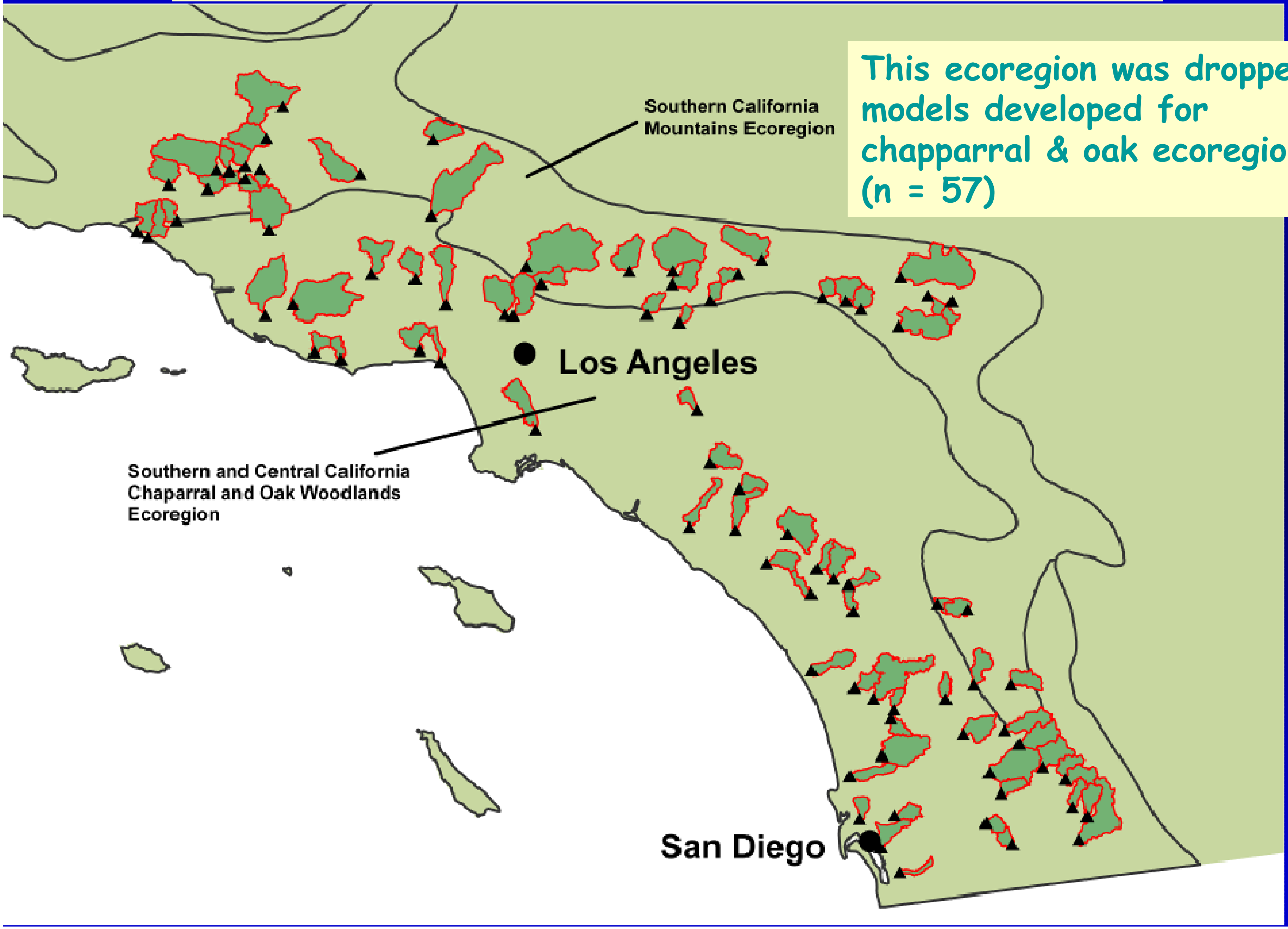
- **Will-V (96)**
- **BlueMtns (147)**
- **SoCal (87)**







Southern California Urban Region



This ecoregion was dropped: models developed for chapparral & oak ecoregion (n = 57)

Methods – Environmental Variables

- GIS effort
  - Jim Orlando (CA) verified delineated of every watershed
  - calculated 100+ summary statistics
- Invertebrates sampled 2000-2006
- Land use data 2001
- Census data 2000

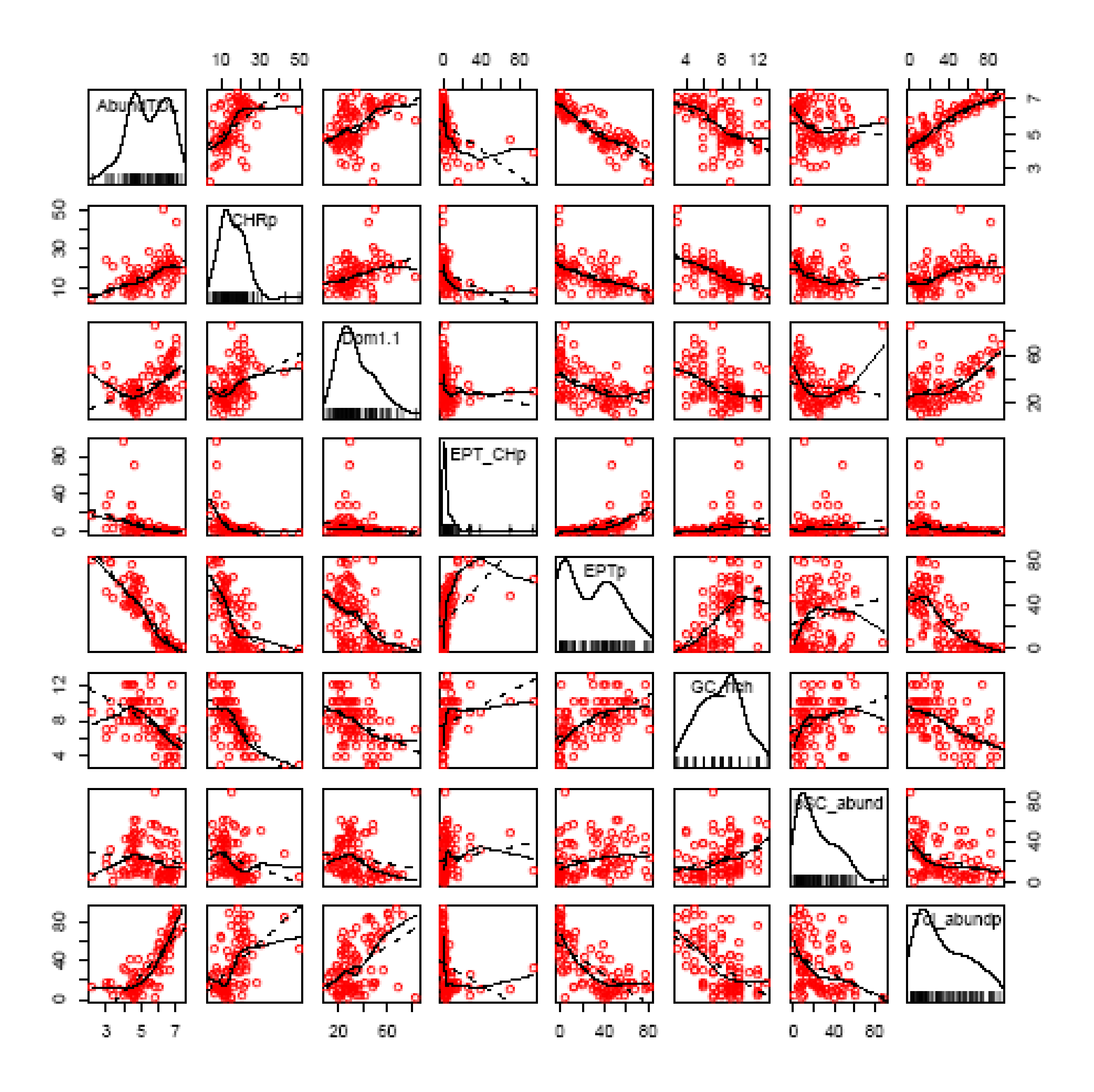
Methods – Response Variables

- Invertebrate data obtained from
  - Federal programs (NAWQA, EMAP)
  - State programs (Oregon, California)
- Standardize taxonomy
- Calculate 100+ metrics

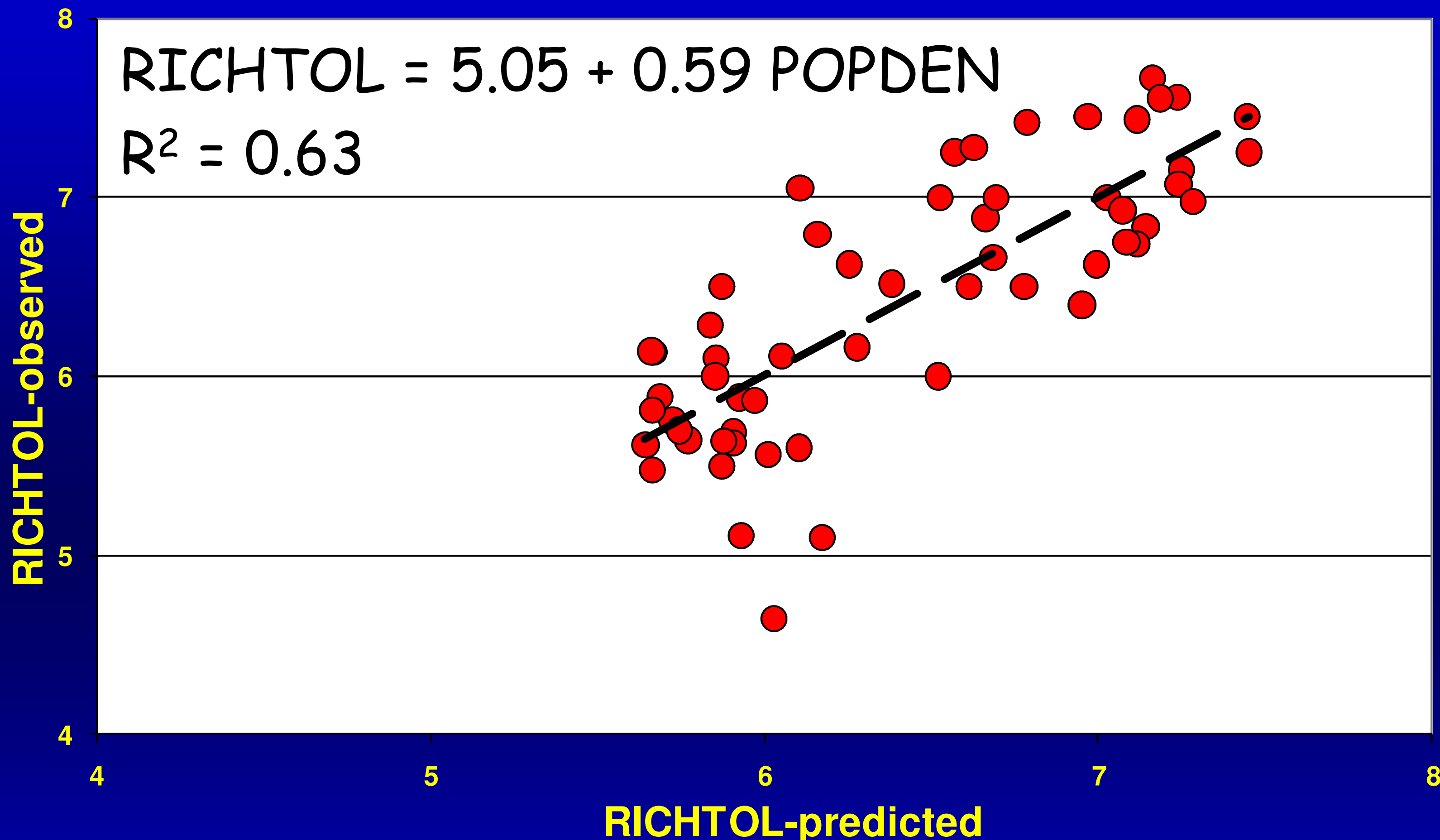
Methods – Final Data Selection

- Exploratory Analysis
  - Range tests
  - Normality
  - Scatter Plots
  - Outlier Analysis
  - Correlations

Lots of Scatter Plots!

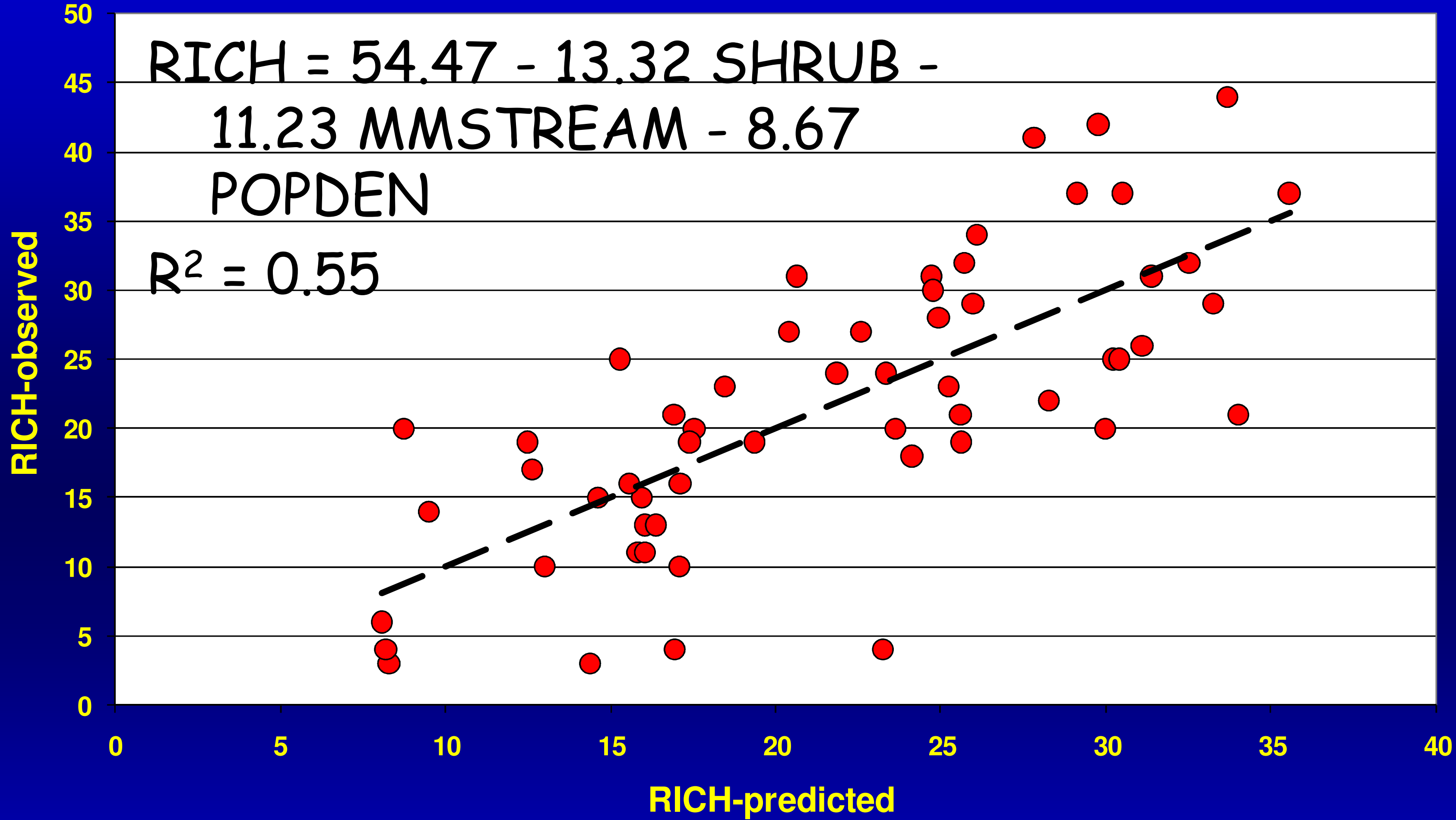


SOCAL RICHTOL Observed vs. Predicted

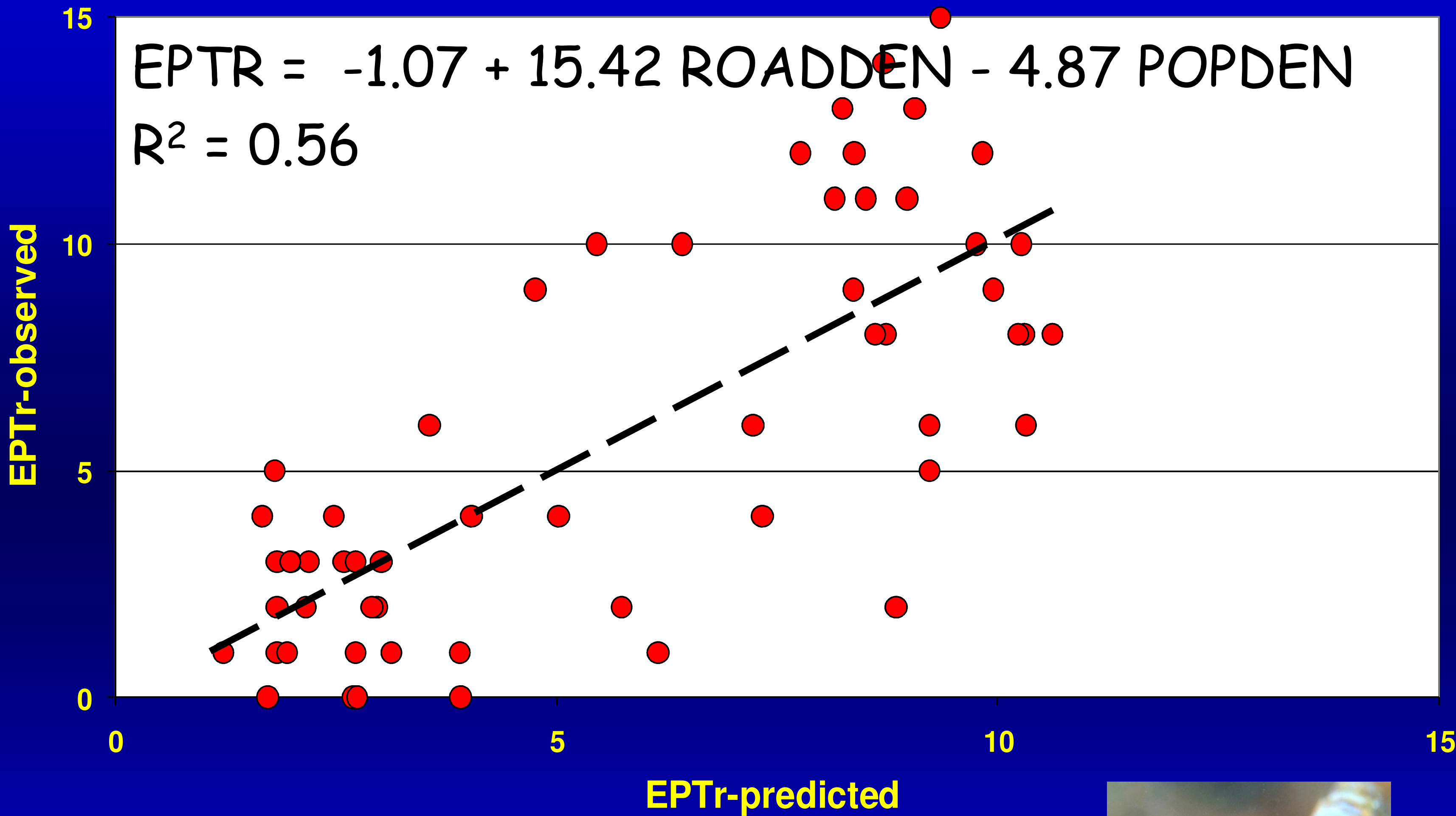


RICHTOL = average EPA defined tolerance (1-10) for all taxa found at a site

SOCAL Richness observed vs. predicted



SOCAL EPTr observed vs. predicted



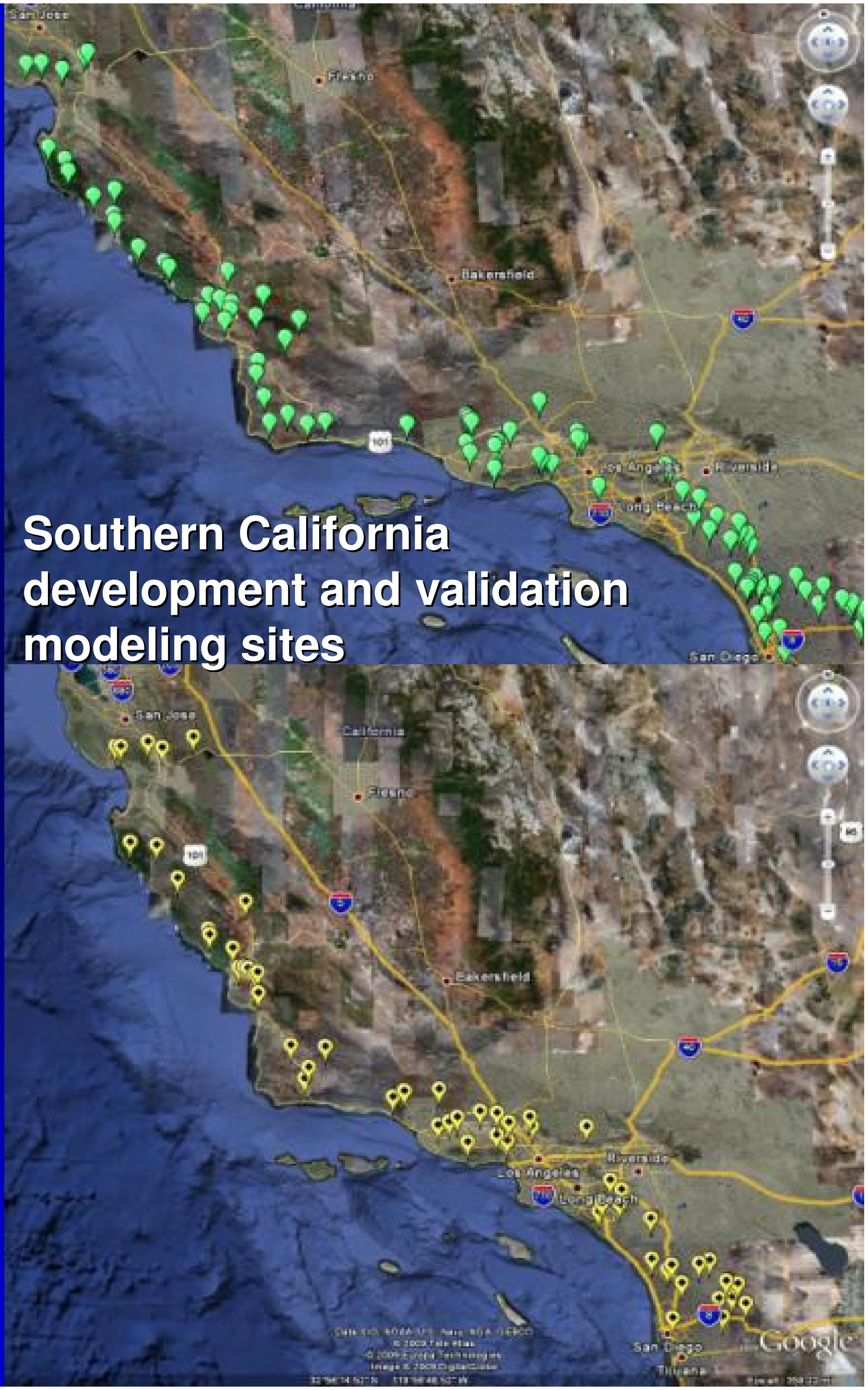
Comparison of watershed disturbance predictive models for stream benthic macroinvertebrates for three distinct western ecoregions

Ian R. Waite, Larry R. Brown, Jonathan G. Kennen, Jason T. May, Thomas F. Cuffney, James L. Orlando and Kimberly A. Jones

Submitted to: Ecological Indicators

Southern CA IBI Modeling effort

- Initial effort promising
- Followup: develop additional MLR model of IBI scores (Ode et al 2005)
- Larger data set: 100 development sites and 59 validation sites within the SoCal Chaparral Ecoregion



Objectives of SoCal Model

- Develop a simple, predictive model of SoCal-IBI at unsampled sites using land use, land cover and hydrologic infrastructure.
- Such a model could be used to:
  - Prioritize sites for sampling
  - Identify potential reference sites
  - Identify potentially impacted sites

Explanatory Variables Considered

Final Selections for Modeling

Variable	Development	Validation
Watershed Factors		
Elevation (m)	99 (3-1503)	141 (1-1292)
Population density (persons/km^2)	27 (0-4643)	14 (1-4480)
Urban (%)	8 (0-99)	7 (0-98)
Agriculture (%)	0 (0-45)	<1 (0-45)
Agriculture + urban (%)	9 (0-99)	11 (0-98)
Forest (%)	9 (0-93)	9 (0-84)
Shrubland (%)	38 (<1-93)	36 (1-100)
Road density (km/km^2)	2 (0-12)	2 (0-12)
Man-made channel density (km/km^2)	0.01 (0-0.61)	0.01 (0-0.35)
Mean annual precipitation (cm)	65 (31-159)	69 (34-155)

Explanatory Variables Considered

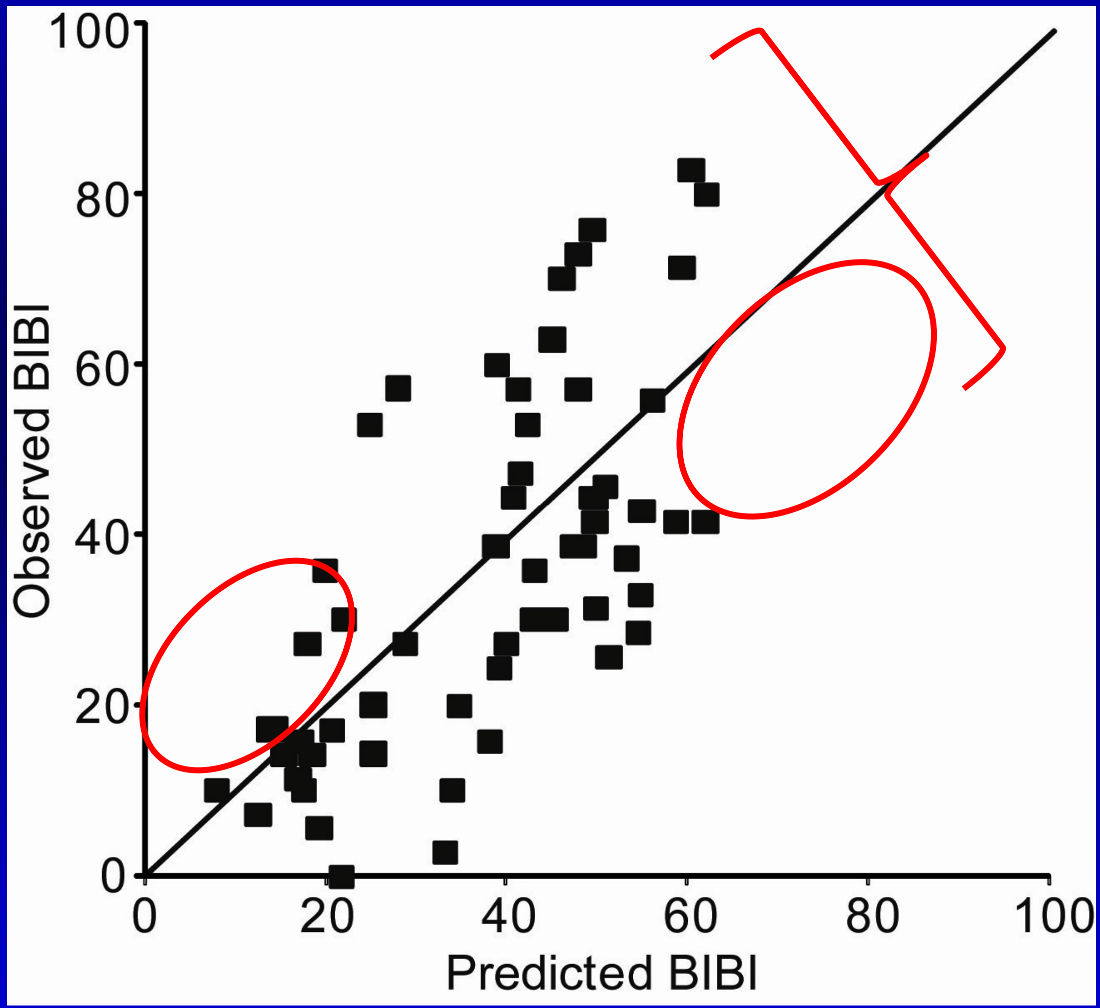
Final Selections for Modeling

Variable	Development	Validation
Riparian buffer		
Urban (%)	24 (0-100)	29 (0-100)
Agriculture (%)	0 (0-90)	0 (0-93)
Agriculture + urban (%)	36 (0-100)	36 (0-100)
Shrubland (%)	21 (0-98)	23 (0-100)
Road density (km/km^2)	3 (0-16)	3 (0-12)
Man-made channel density (km/km^2)	0 (0-6)	0 (0-6)
Slope (%)	9 (<1-33)	10 (<1-29)

Final Model

BIBIa = 63.51 – 11.35(logPOPDEN) - 7.09(logRIPAGURB)

$R^2 = 0.48$



Validation sites (N = 59)

Why Isn't The Model Better?

- Intermittent streams
- GIS/Census data slightly out of date for some sites
- Site specific factors
  - Make low scoring sites worse
  - Make high scoring sites better
- Variability in IBI from individual metrics

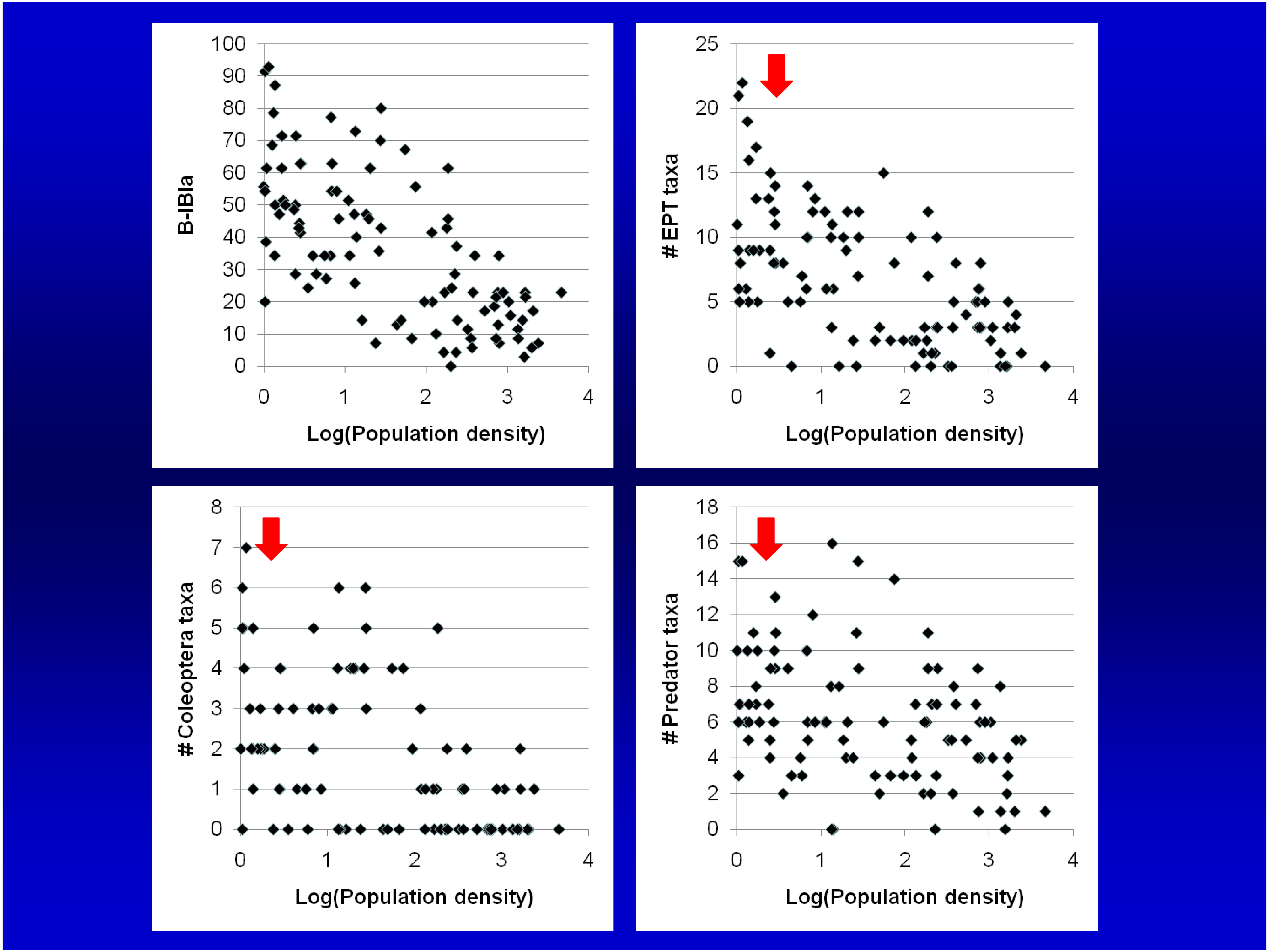
Responses of Individual Metrics
Model BETTER for B-IBI

Metric	PopDen	RAgUrb	R^2
Coleoptera taxa (#)	-0.42	NS	0.25
EPT taxa (#)	-0.46	NS	0.37
Predator taxa (#)	-0.32	NS	0.16
Collector individuals (%)	NS	0.36	0.14
Intolerant individuals (%)	-0.26	-0.27	0.21
Noninsect taxa (%)	0.60	NS	0.40
Tolerant taxa (%)	0.49	NS	0.23

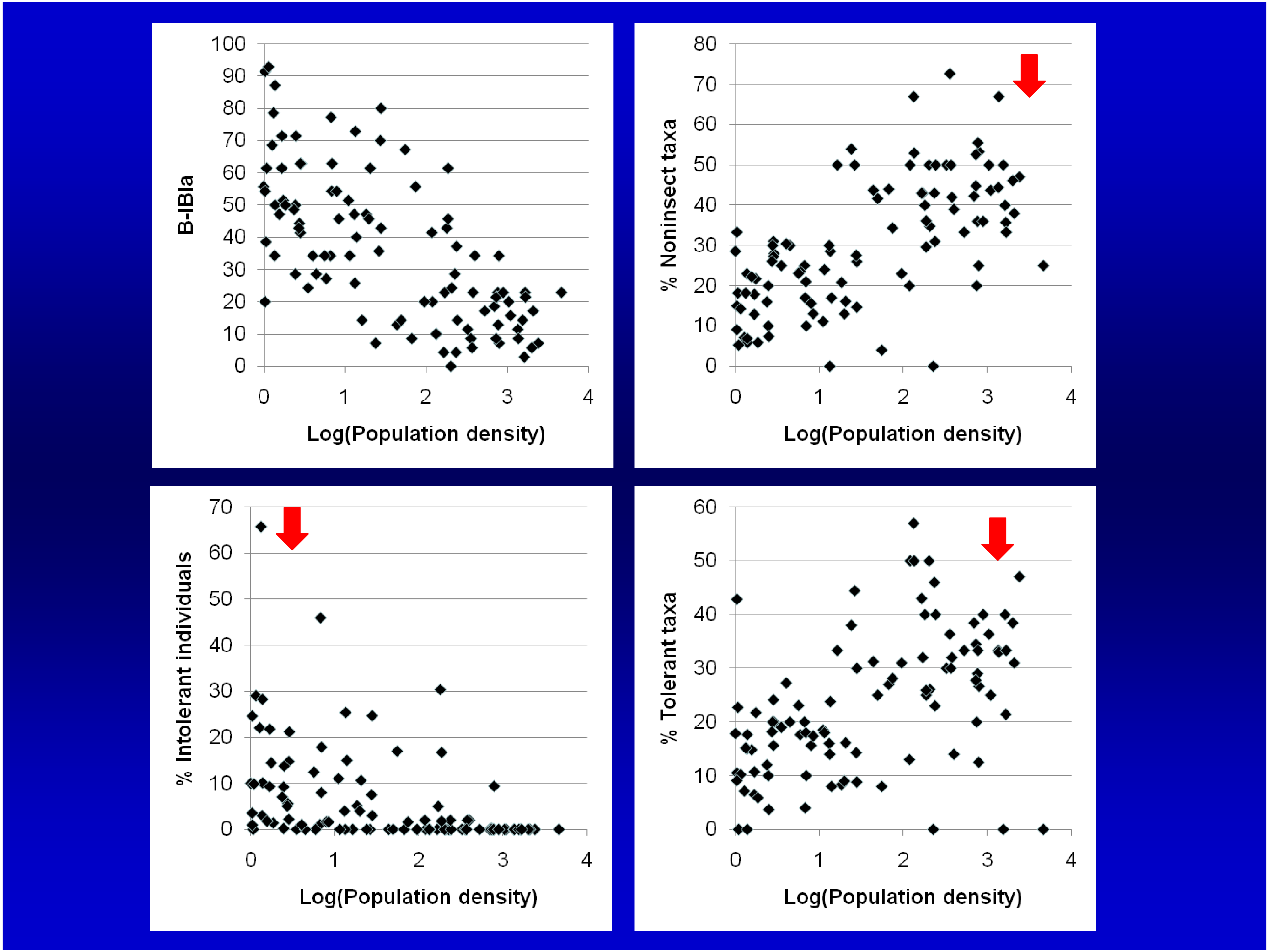
Development sites (N = 100)

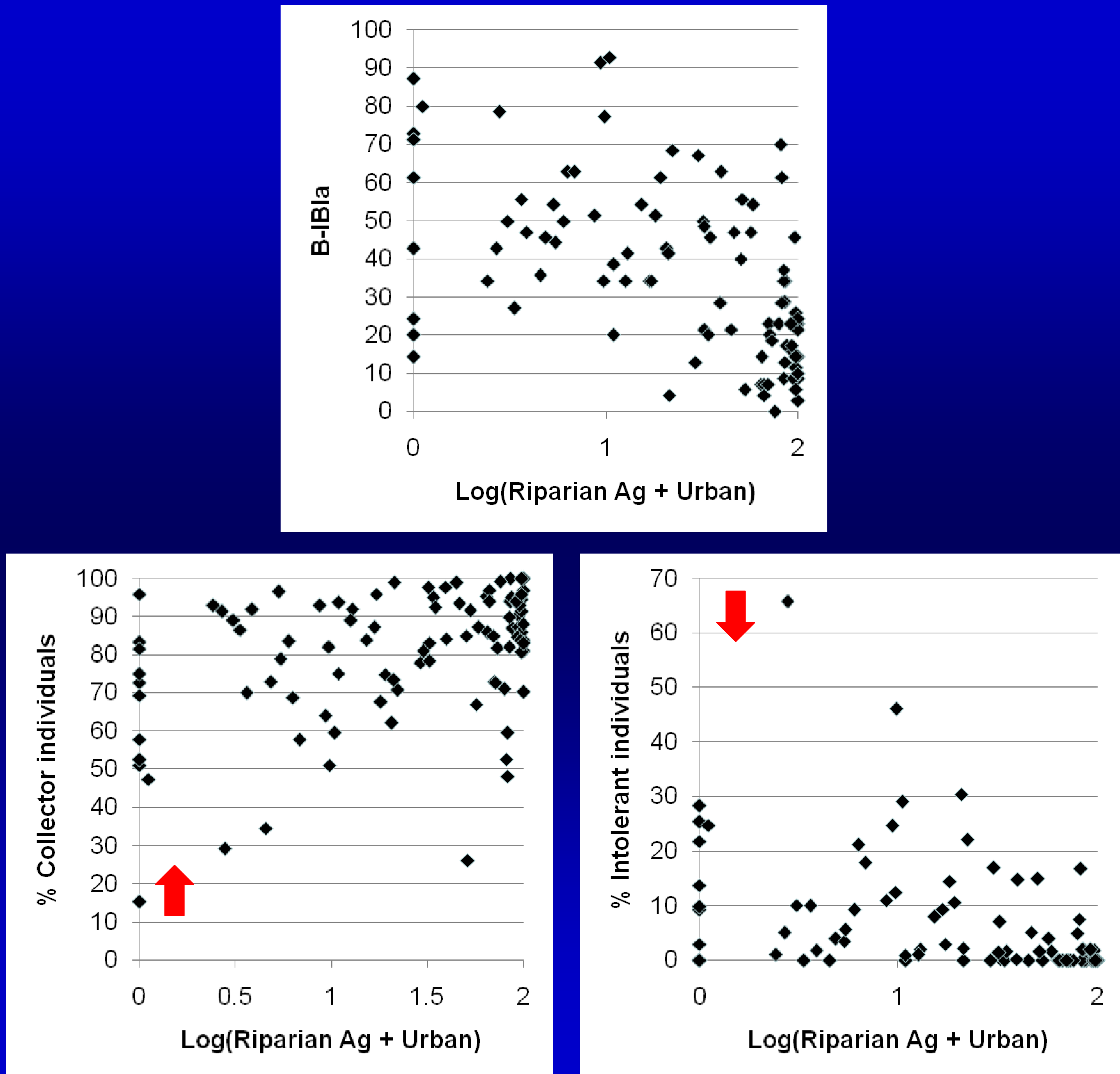
Plots for Individual Metrics

Development sites (N = 100)



B-IBIa
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
Log(Population density)
# EPT taxa
25
20
15
10
5
0
0
1
2
3
4
Log(Population density)
# Coleoptera taxa
8
7
6
5
4
3
2
1
0
0
1
2
3
4
Log(Population density)
# Predator taxa
18
16
14
12
10
8
6
4
2
0
0
1
2
3
4
Log(Population density)

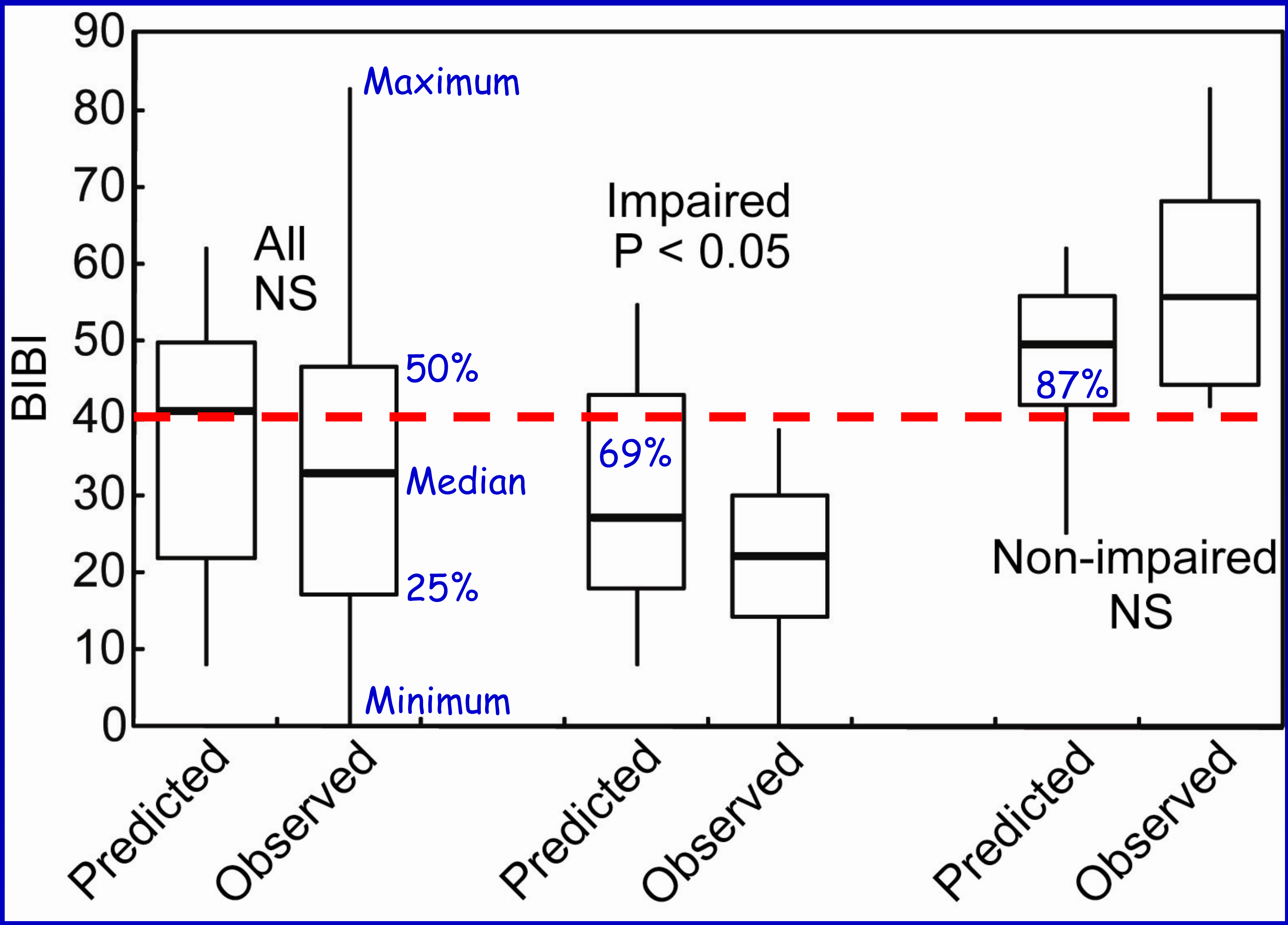

B-IBIa
% Noninsect taxa
% Intolerant individuals
% Tolerant taxa
Log(Population density)
Log(Population density)
Log(Population density)
Log(Population density)


B-IBIa
Log(Riparian Ag + Urban)
% Collector individuals
Log(Riparian Ag + Urban)
% Intolerant individuals
Log(Riparian Ag + Urban)

Improving the Model

- Probably difficult without site visit
  - Remote sensing (cost?)
  - More complex GIS analyses (probably not)
- Assess reasons for misclassifications
  - If mostly due to one factor may be able to correct (unlikely)

Is This a Useful Model?



Validation sites (N = 59)

Initial Objectives Met?

- Identify potential reference sites? YES
  - Prioritize for conservation assessment
- Identify potentially impacted sites? YES
  - Prioritize for restoration assessment
- Prioritize sites for sampling? YES
  - Stratify new sampling according to specific needs

Is This a Useful Model?

- Correctly classified impaired sites in 25 of 36 cases (69%)
- Correctly classified unimpaired sites in 20 of 23 cases (87%)