

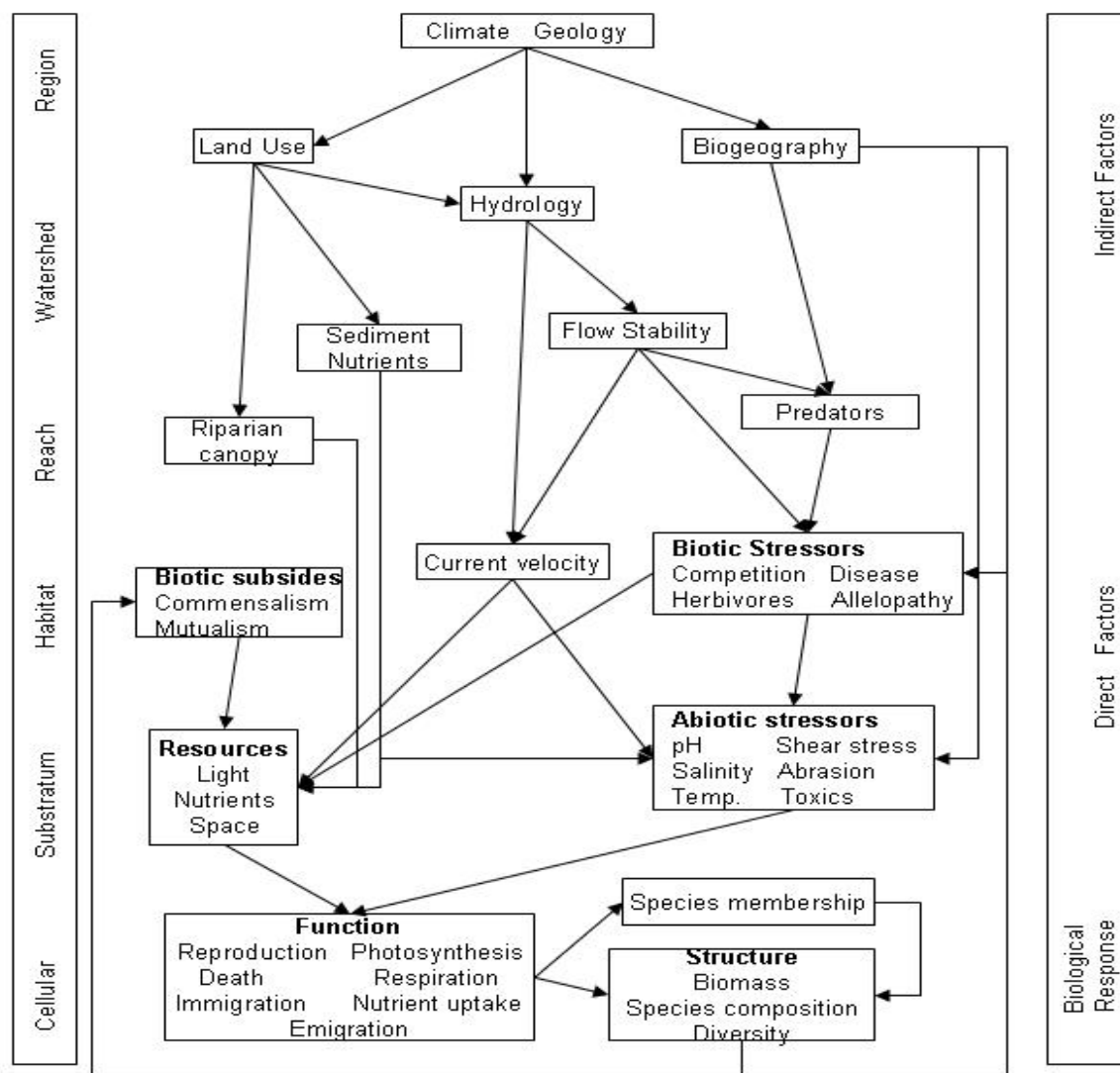
Response of benthic algae communities to nutrient enrichment in agricultural streams: Implications for establishing nutrient criteria

R.W. Black¹, P.W. Moran¹, and J.D. Frankforter²
National Water Quality Assessment Program
(NAWQA)

¹Washington Water Science Center, US Geological
Survey, Tacoma, WA, USA,

²Nebraska Water Science Center, US Geological
Survey, Lincoln, NE, USA





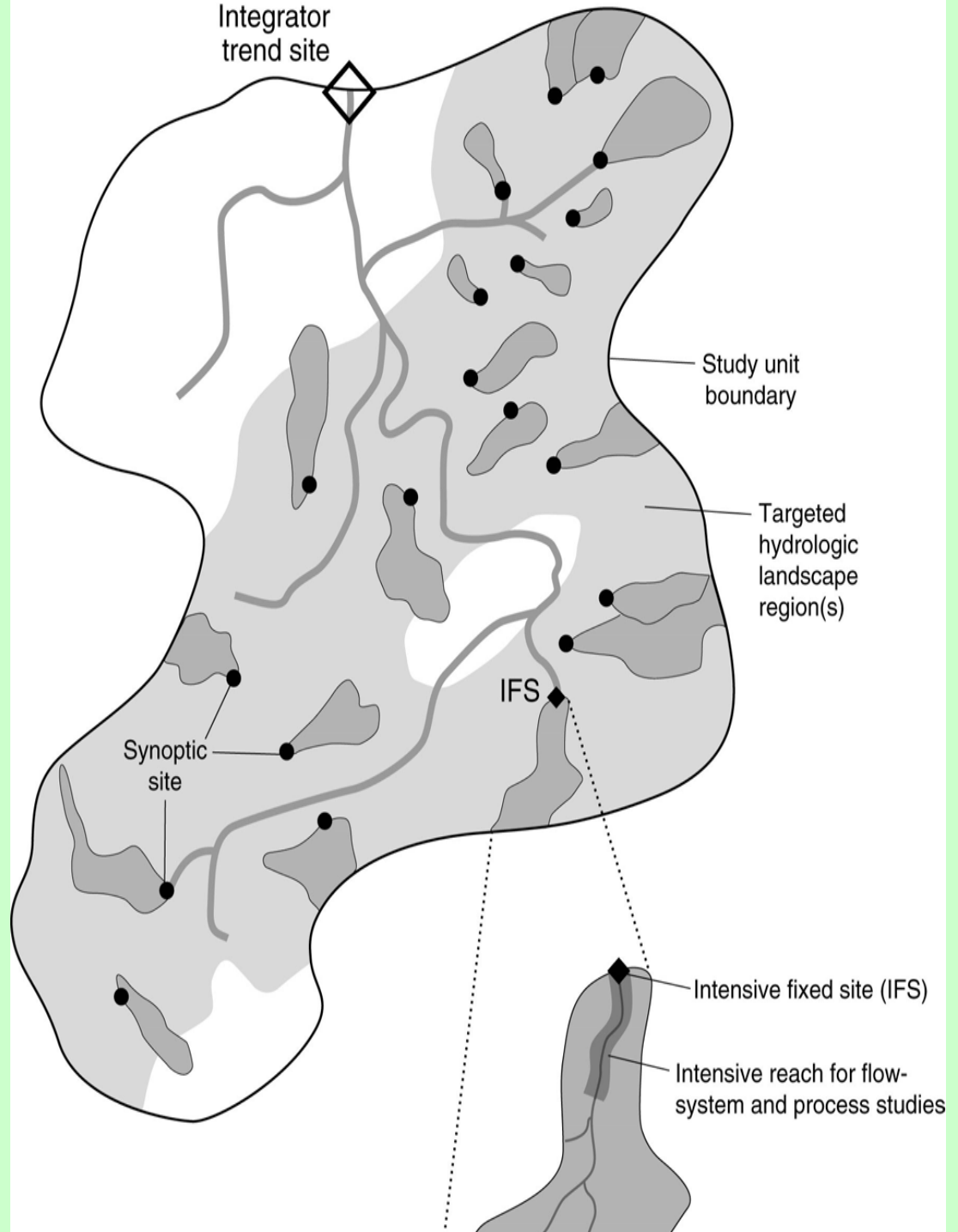
From R.J. Stevenson. 1997. Scale-dependent determinants and consequences of benthic algal heterogeneity. *Journal of the North American Benthological Society*. 16:248-262.

Objective: Determine the relations between algal communities and nutrient, habitat and macroinvertebrate conditions in streams from agricultural settings in Washington and Nebraska.

- Large N spatial study (57 sites)
- Stable flow period
- Habitat assessment
- Chemical: Nutrients, DOC, POC, SS (2 sampling events)
- Biological: algae and invertebrates, algal (seston and benthic) biomass, macrophyte cover/biomass

Washington and Nebraska Study Design and Characteristics

- 28 to 29 wadeable stream sites/study unit
- Independent basins
- 50-1500 sq. km
- Significant agricultural areas
- Semi-arid to arid regions
- Significant hydrologic modifications of most streams due to irrigation



EPA Nutrient Indicators

- **Algal biomass**
- **Chlorophyll *a***
- **AFDW**
- **Community composition**
- **Community metrics**
- pH
- DO
- Hydrologic studies
- TN, DIN
- TP, SRP
- Nutrient ratios
- Sediment composition
- Temperature
- Transparency/TSS

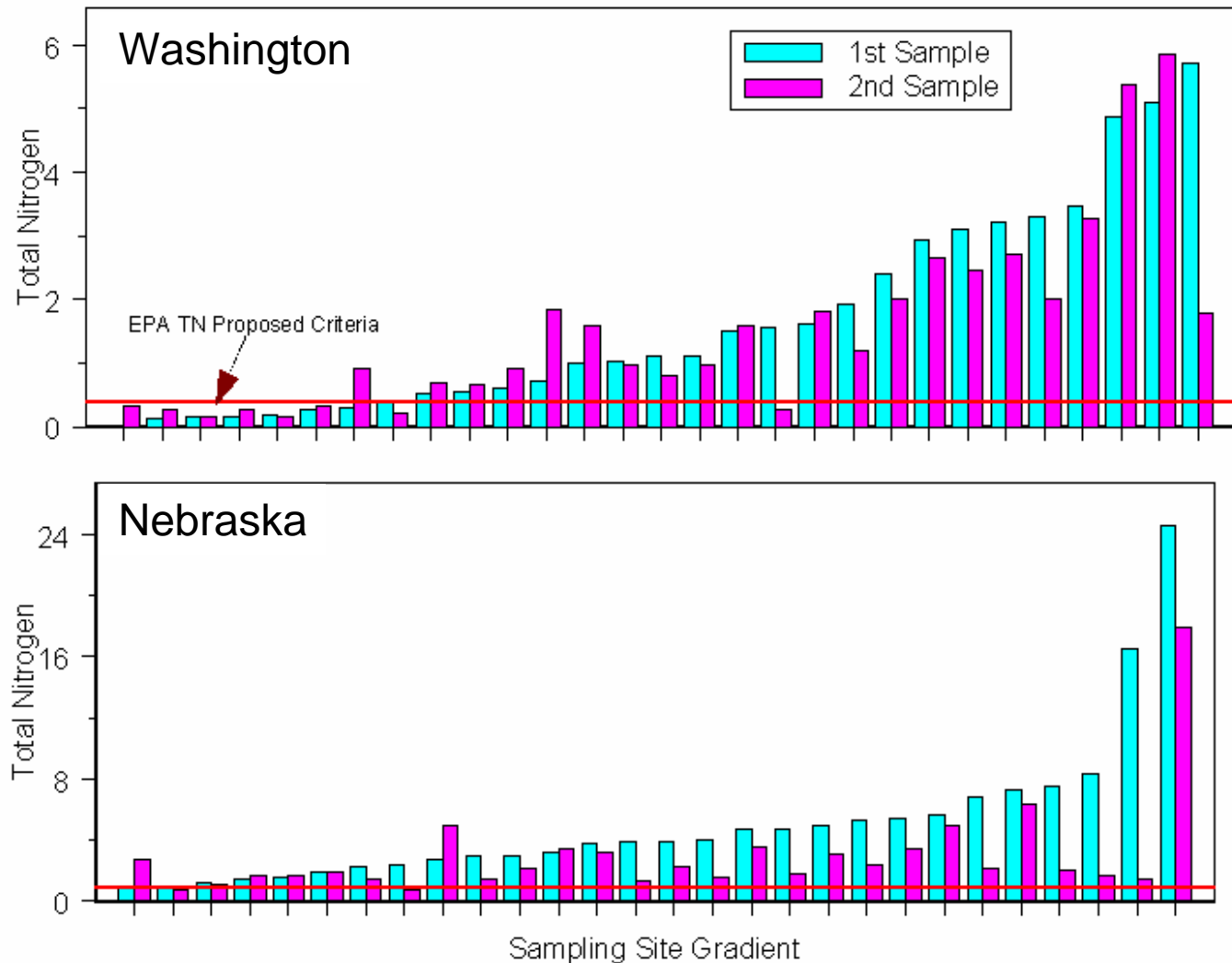
Are algal communities related to nutrients, macroinvertebrates and/or habitat conditions in Washington and Nebraska agricultural streams?

- Algal communities in each study area were related to a different suite of environmental variables and in some cases not nutrients.
- Models relating traditional measure of eutrophication to nutrients were insignificant.
- Non traditional measures of algae composition show promise

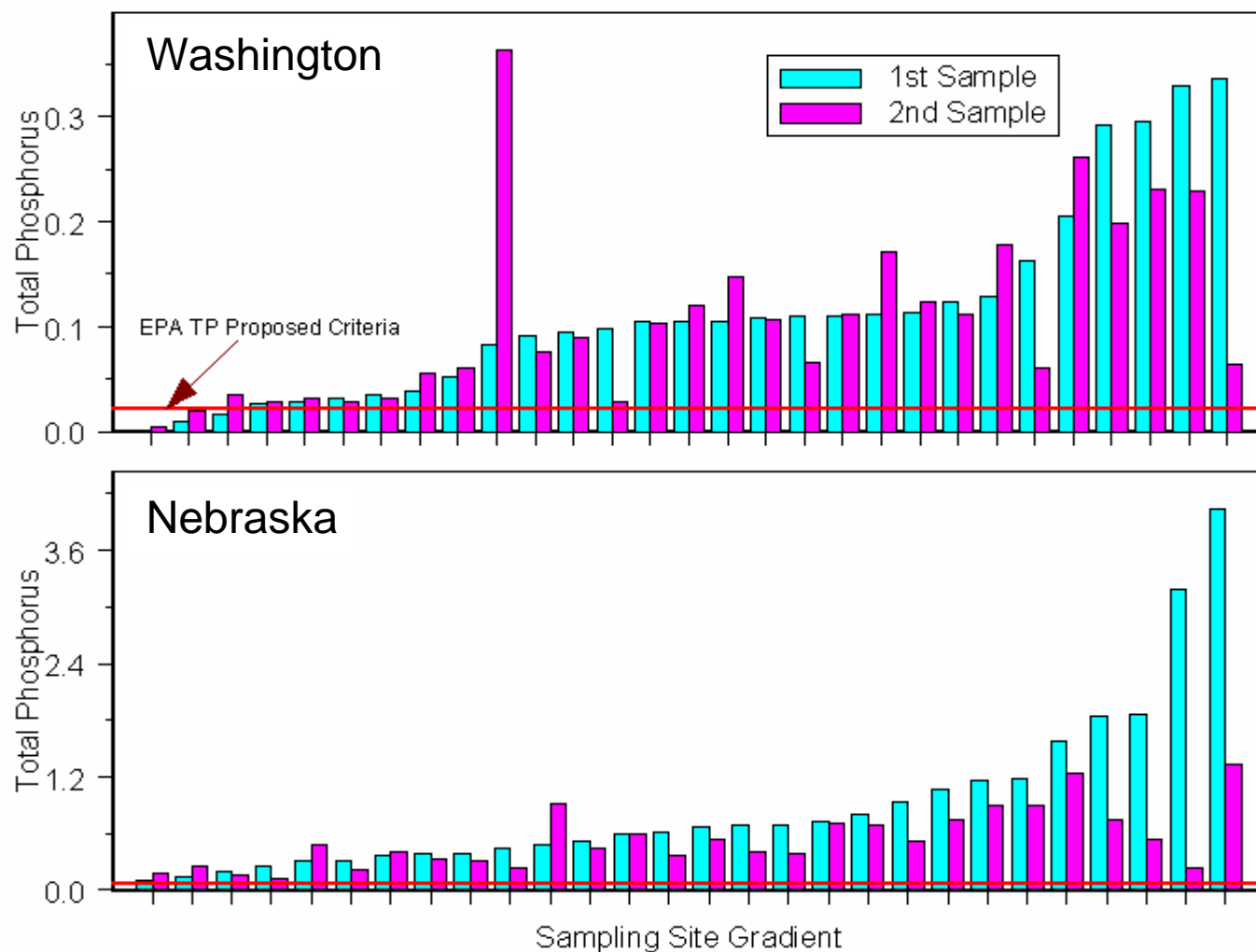
Analyses

- Multivariate statistics (MDS)
 - Monitoring sites are grouped together based on similarity of algae/invertebrate communities AND collected environmental variables
- Nonparametric Multiplicative Regression
 - Ecologically relevant benefits over traditional regression
- Metrics and indices
 - Opportunity to standardize response measures over temporal and spatial scales

Total Nitrogen Concentrations by Study Unit



Total Phosphorus Concentrations by Study Unit



Small Scale Environmental Variables That Significantly Explain Depositional Algae (MDS) Community Organization by Study Unit

Washington

(3d-Stress =0.13, Rho=0.56, p=0.17)

pH_(2nd sample)

Mean Water Width

% Abund. Filtering-Collectors

% Abun. Gathering-Collector

Max. % Embed.

Water Temp (2nd sample)

CV Solar Path (MJ/m²/d)

% Substrate > Sand

% Abun. Scrapers

Nebraska

(3d-Stress=0.13, Rho=0.64, p=0.005)

Mean Water Width

% Barren, 50m buffer (reach)

Mean Algae Depth

NO₂ (2nd sample)

Diss. In. N (1st sample)

% Macrophyte cover

% Overhanging Veg. Cover

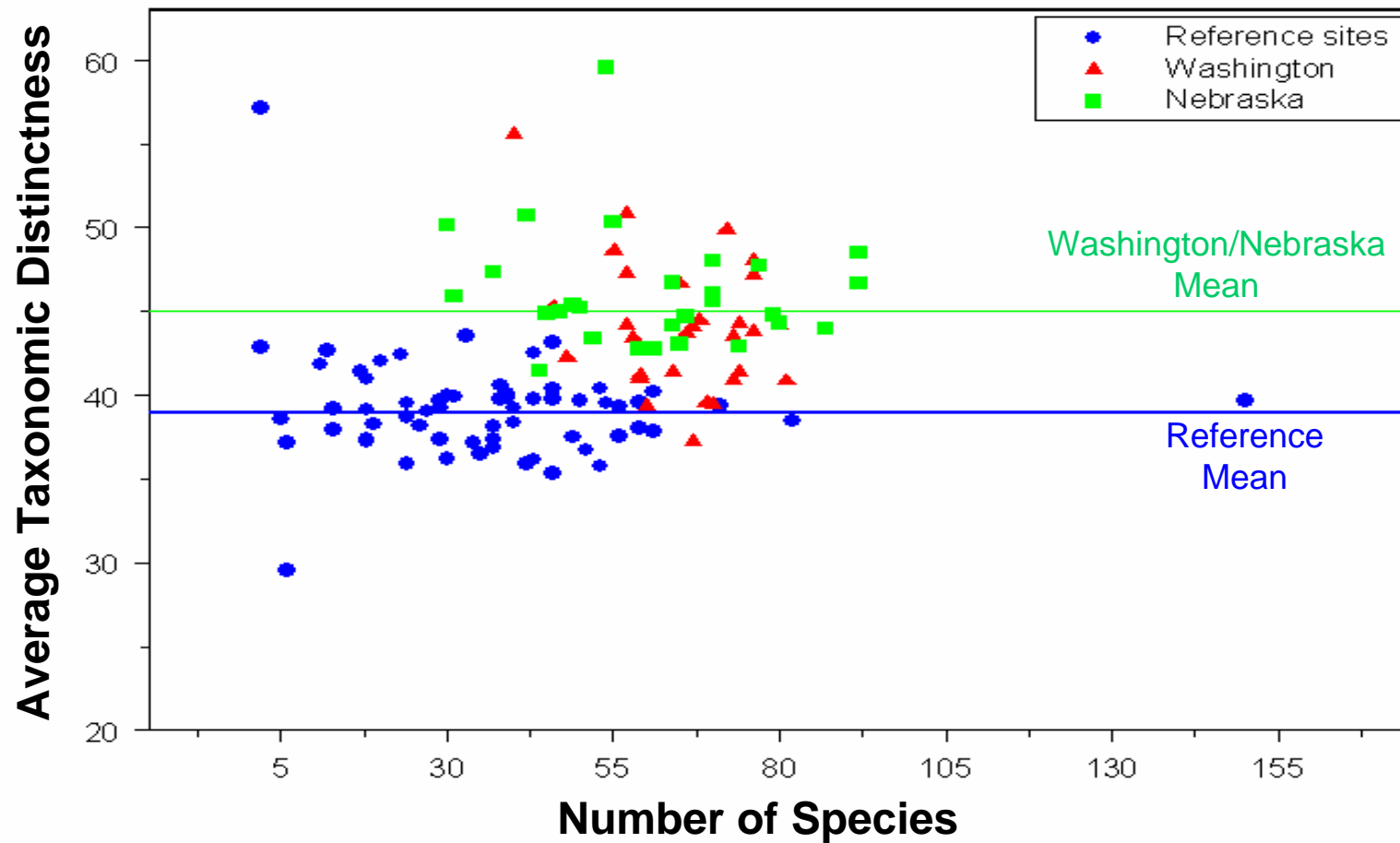
Significant Predictive Models for Depositional Algae and Small Scale Variables in Washington Using Nonparametric Multiplicative Regressions

Response	xR2	Canopy Closure, Mean	NH3 (1st sample)	pH (2nd sample)	%Crop (25m buffer,reach)	%Shurb (50m buffer,reach)	Mean Gap Length, Non-woody (reach)	Mean Gap Length, Woody (reach)	Sus. Sed
Abundance of algal taxa tolerant to organically-bound nitrogen	0.57		x	x		x			
AFDW	0.24	x					x		x
Chl a	0.24			x	x			x	

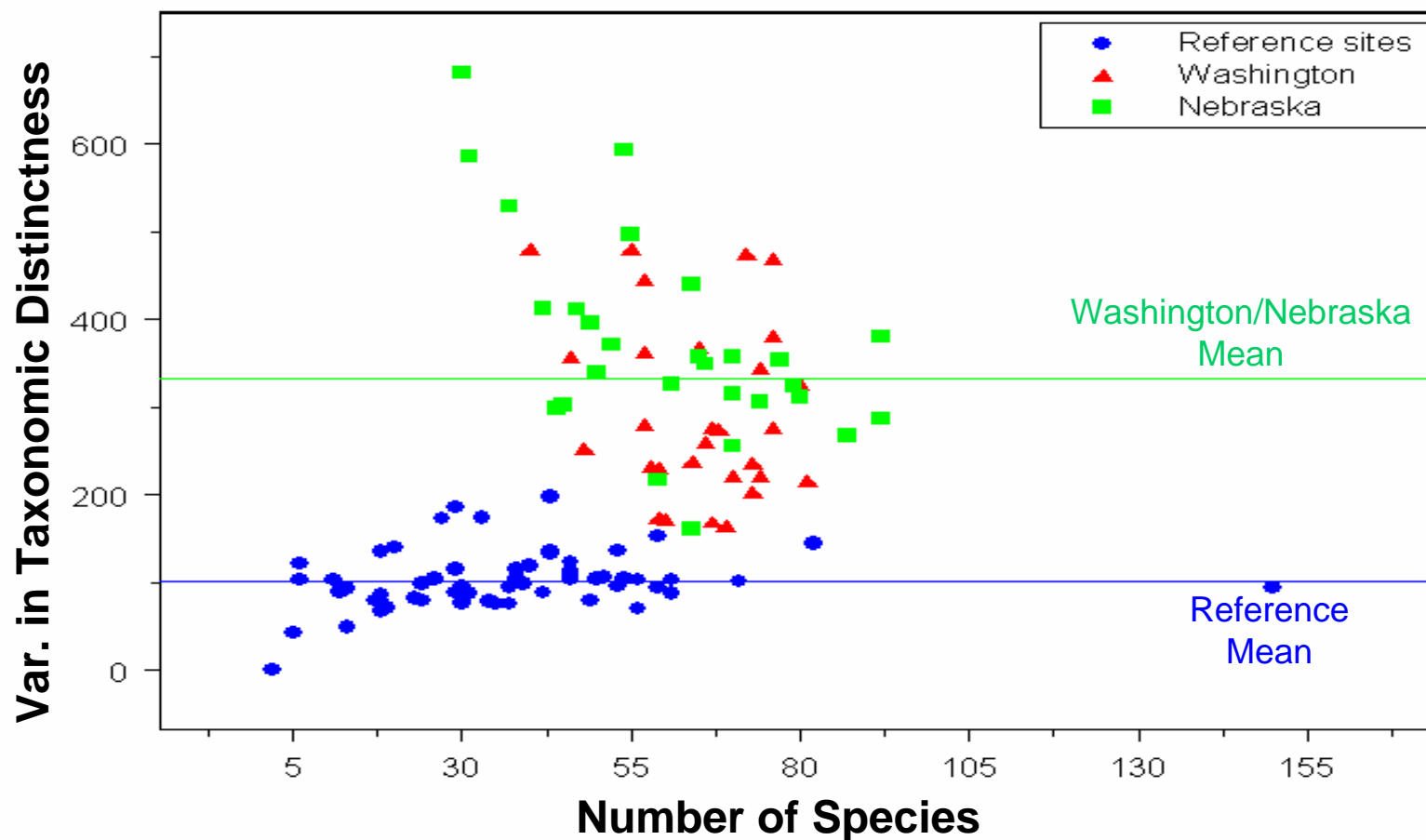
Significant Predictive Models for Depositional Algae and Small Scale Variables in the Nebraska Using Nonparametric Multiplicative Regressions

Response	xR2	Aquatic Macrophyte Cover (%)	NO3 (2nd sample)	% Abun. Parasites	Discharge	Undercut Bank Cover (%)
# Algae Taxa, Less Pollution Tolerant	0.51	X	X	X		
AFDW	0.34	X			X	X
Chl a	NS					

Average Taxonomic Distinctness of Depositional Algae by Study Unit



Variation in Taxonomic Distinctness for Depositional Algae by Study Unit



Significant Predictive Models of Algal Taxonomic Distinctness (Diversity) in Washington and Nebraska

Response	xR ²	Total N	Total P	% Gravel/Cobble	% Macrophyte	% overhead cover	Max. Velocity	Predators	Collector/Gatherer	Shredders	Soil erodability	% Forest	% Silt	Drainage area	Mean ann. Runoff
Var. in Taxanomic Distinctness	0.64	X					X	X	X	X					
Mean Taxanomic Distinctness	0.47	X		X	X			X							X
Without Invertebrates															
Var. in Taxanomic Distinctness	0.58		X	X		X						X	X	X	
Mean Taxanomic Distinctness	0.41	X		X		X					X	X			
				Reach Scale Control				Biological Control			Watershed Control				

Summary

- Nutrient levels in the agricultural streams of the Washington and Nebraska study units are well above the proposed EPA Criteria.
- Response variables (algal communities and metrics) generally related to variables other than nutrients.
 - Nutrient saturation, Physical and Biological (Top Down) control
 - Periodic Nutrient sampling vs. Annual Nutrient Loading
- Responses tended to be stronger in Nebraska – less plumbing?
- “Non-traditional” response measures are more significantly related to environmental variables.

Nutrient Criteria Implications

- Establishing nutrient criteria will need to utilize multiple response and predictor variables.
- Traditional response (if they work) and predictor variables may need to be regional/habitat specific
- Predictive models using scale independent response variables (Taxonomic Distinctness measures) to evaluate the response of streams to changes in nutrients and other watershed variables show promise

Contact Information

Robert Black and Patrick Moran
Washington Water Science Center
U.S. Geological Survey
Tacoma, WA
(253) 428-3600
rwblack@usgs.gov
pwmoran@usgs.gov

Jill Frankforter
Nebraska Water Science Center
U.S. Geological Survey
Lincoln, NE
402 328-4143
jdfrankf@usgs.gov