



# Assessment of Aquatic Biological Communities Along a Gradient of Urbanization in the Willamette Valley Ecoregion, Oregon and Washington

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**National Water-Quality Assessment (NAWQA) Program**

# Urban Intensity Index

- Multimetric index based on population density, infrastructure, socioeconomic factors, land-use, and land-cover variables (McMahon and Cuffney 2000)\*.
- AFS Book *“Effects of Urbanization on Stream Ecosystems”* 2005
- Provides a consistent and objective indicator of urban intensity for site selection and data analysis.
- *\*<http://water.usgs.gov/nawqa/ecology/pubs/index.html>*

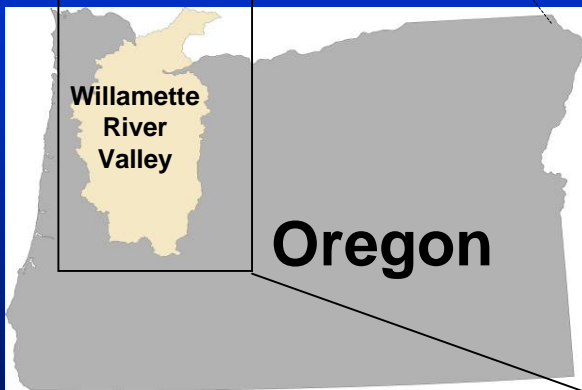
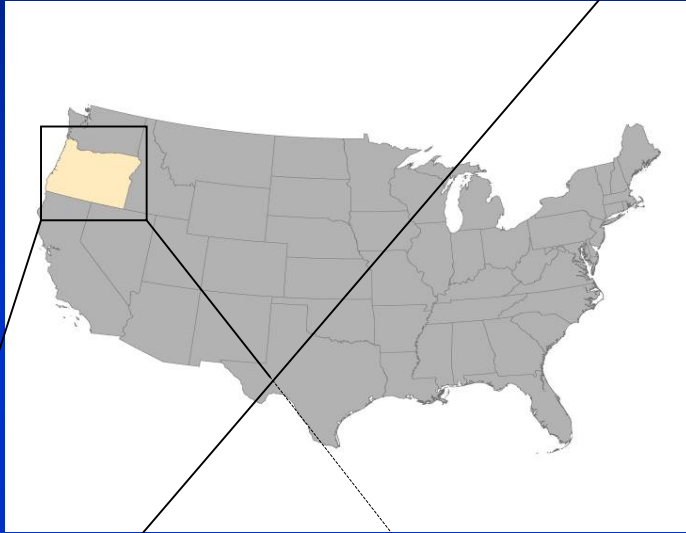


**Location of Studies**

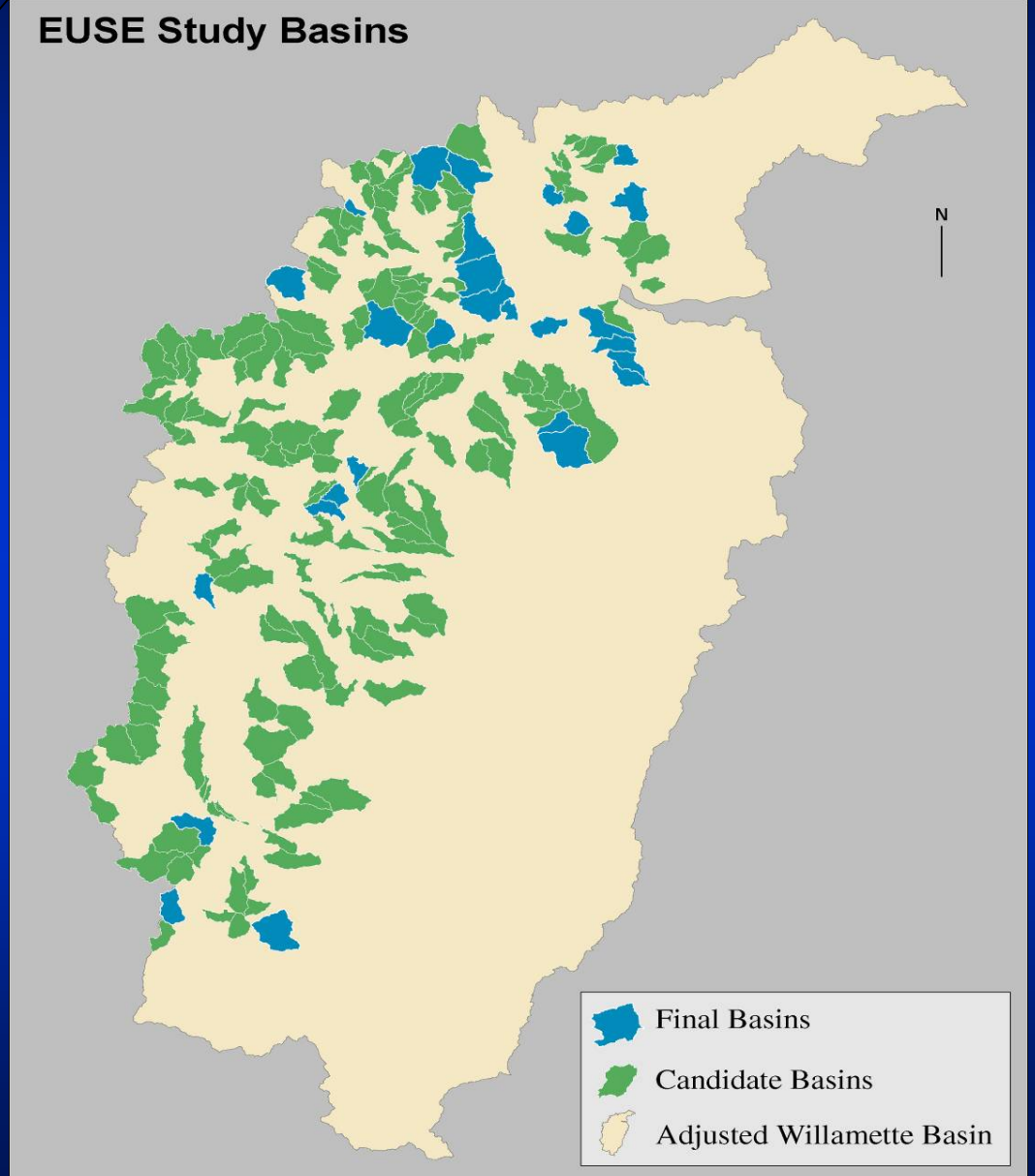
- Studies Completed
- Studies Underway
- Planned Studies

# NAWQA Urban Gradient Studies

# Willamette River Valley, Oregon



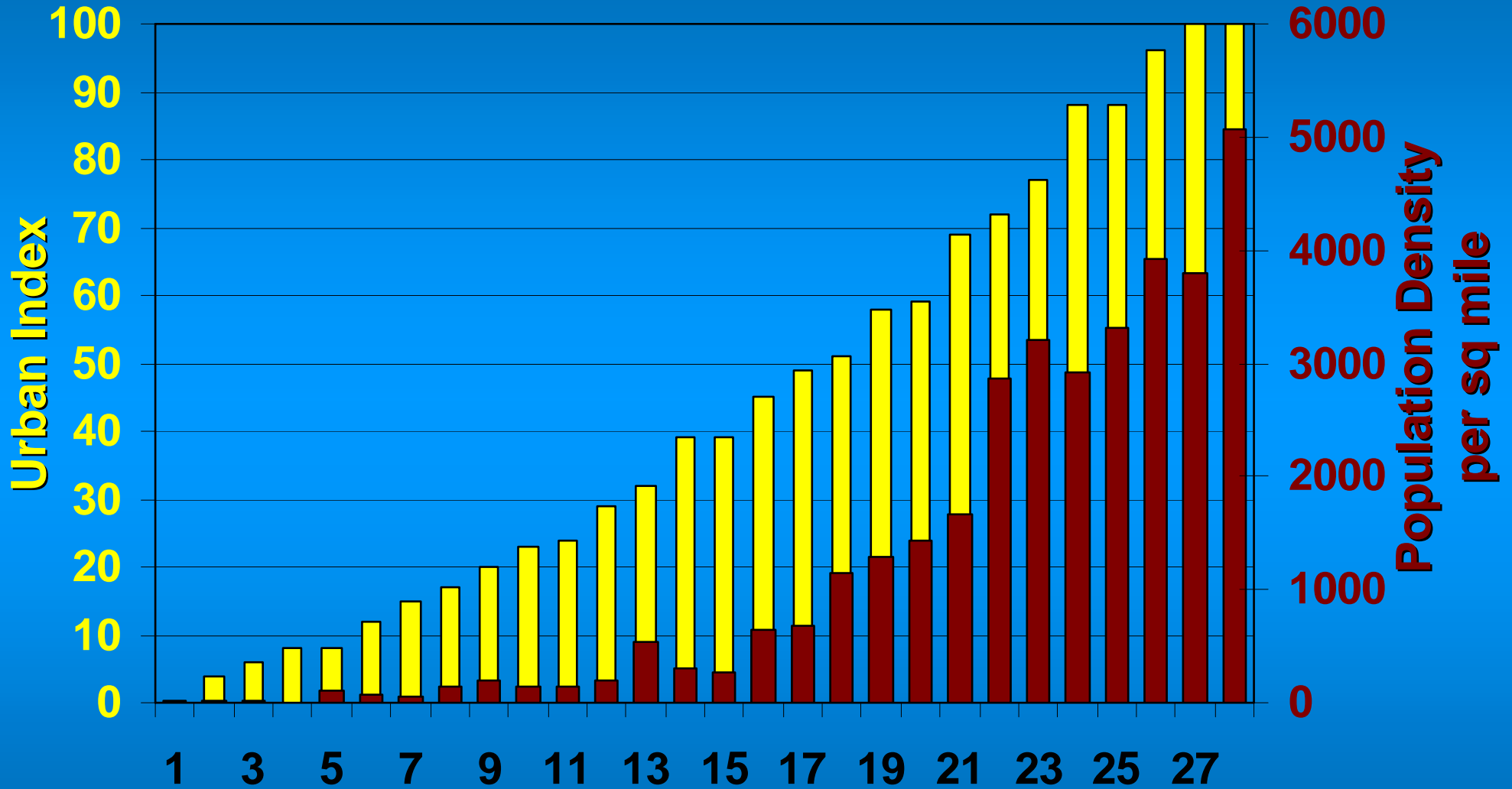
EUSE Study Basins



# Urban Intensity Index - variables

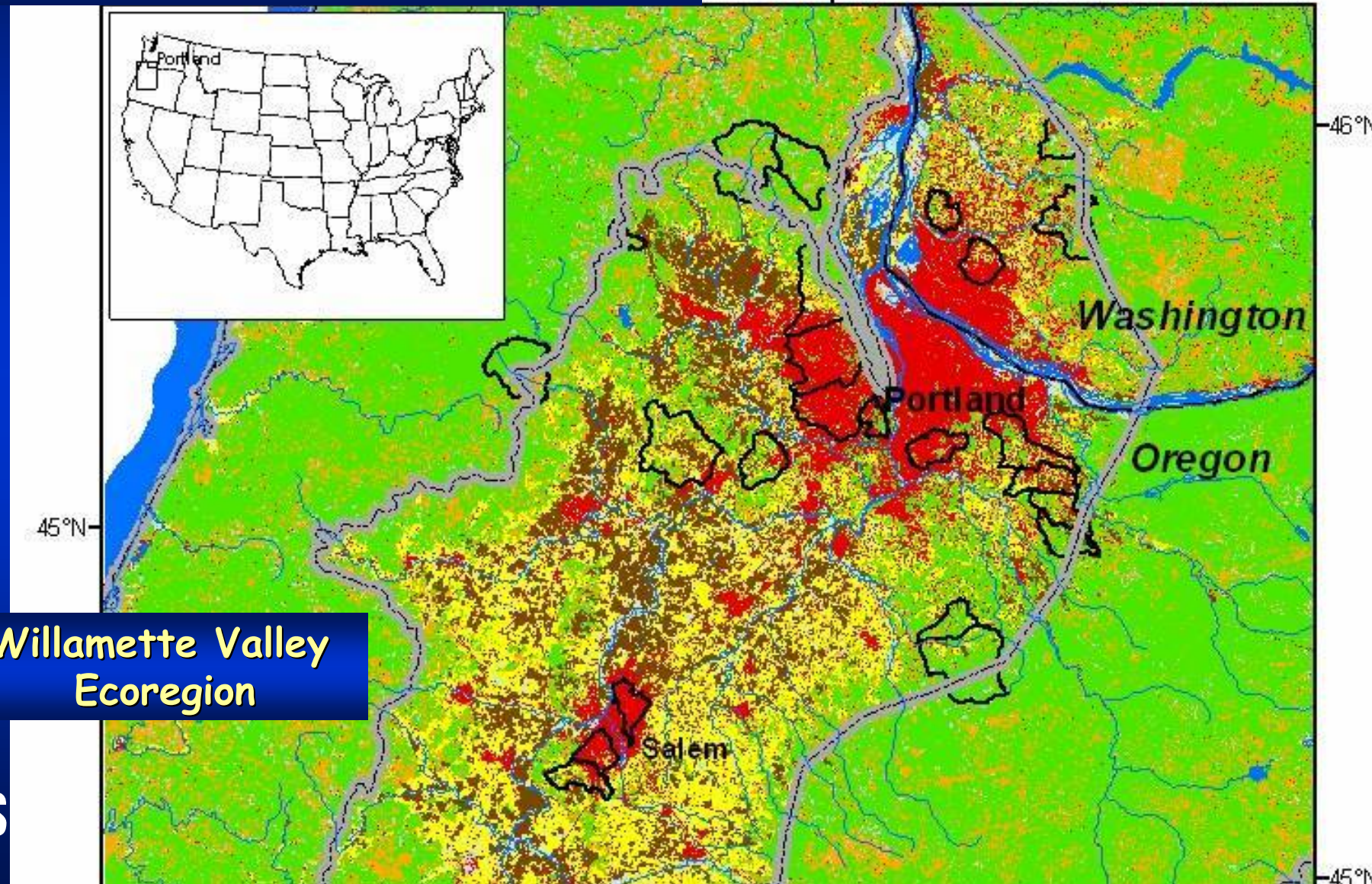
- Population density (people/sq km: 2000 census block)
- Household density (occupied housing units per sq. km)
- Percent impervious surface in basin (NLCD 2001)
- Road density (km/sq km: TIGER 2000 roads)
- Percent urban in basin (NLCD92e)
- Road Traffic Index
- Socioeconomic Index

# Willamette Urban Intensity Index



Sites Ordered by Urban Index

# Willamette Urban and Ag



Willamette Valley  
Ecoregion

# Tickle Creek near Boring, Oregon



**Urban Index = 32**



# Urban Streams



Claggett Creek



Amazon Creek



Pringle Creek

**Urban Index = 77 - 100**

Invertebrate

Water chemistry

Algal

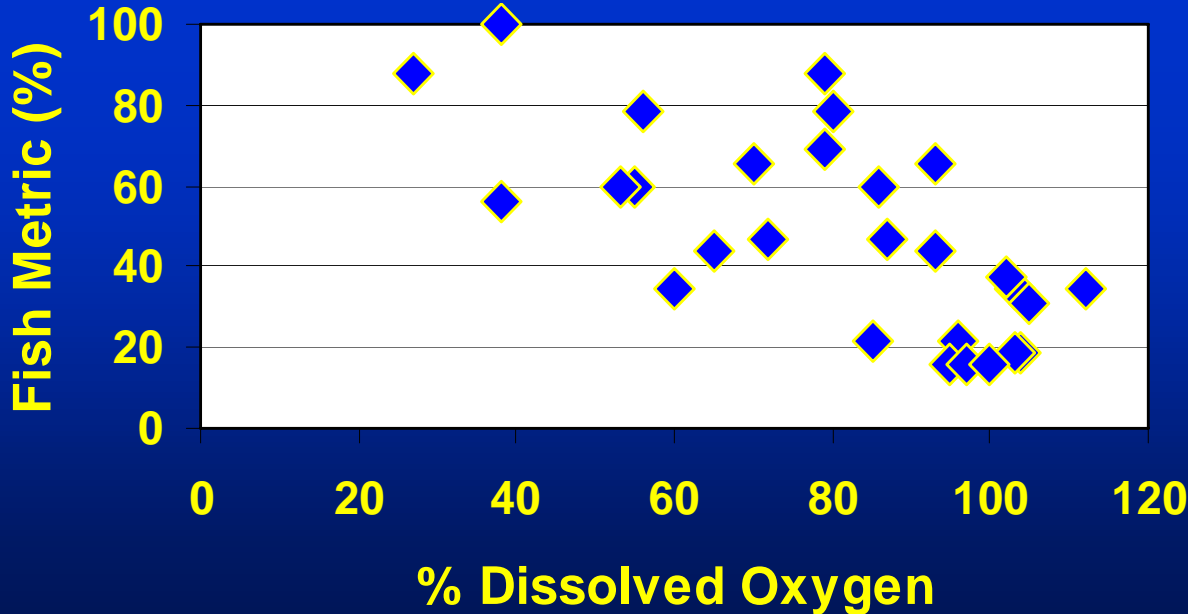
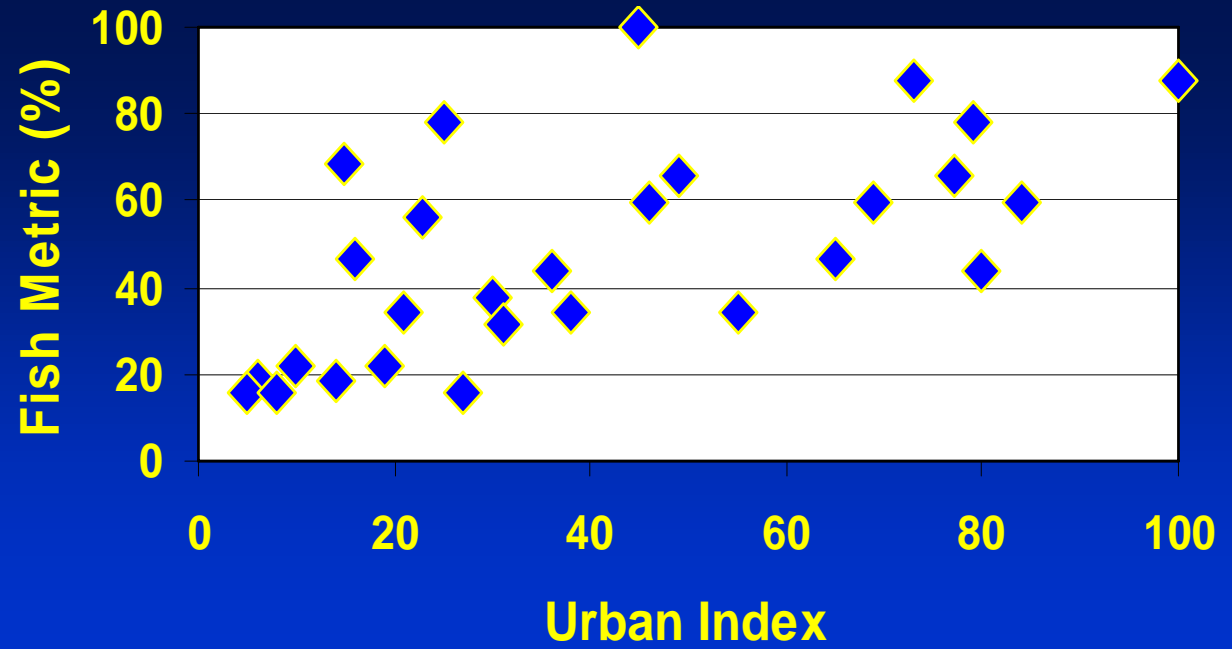
Fish assemblages

Habitat





poor condition ↑



## % Fish Metric

Includes 4 Metrics

- % Salmonids
- % Native (other species)
- % Reticulate Sculpin
- % Introduced or Exotic

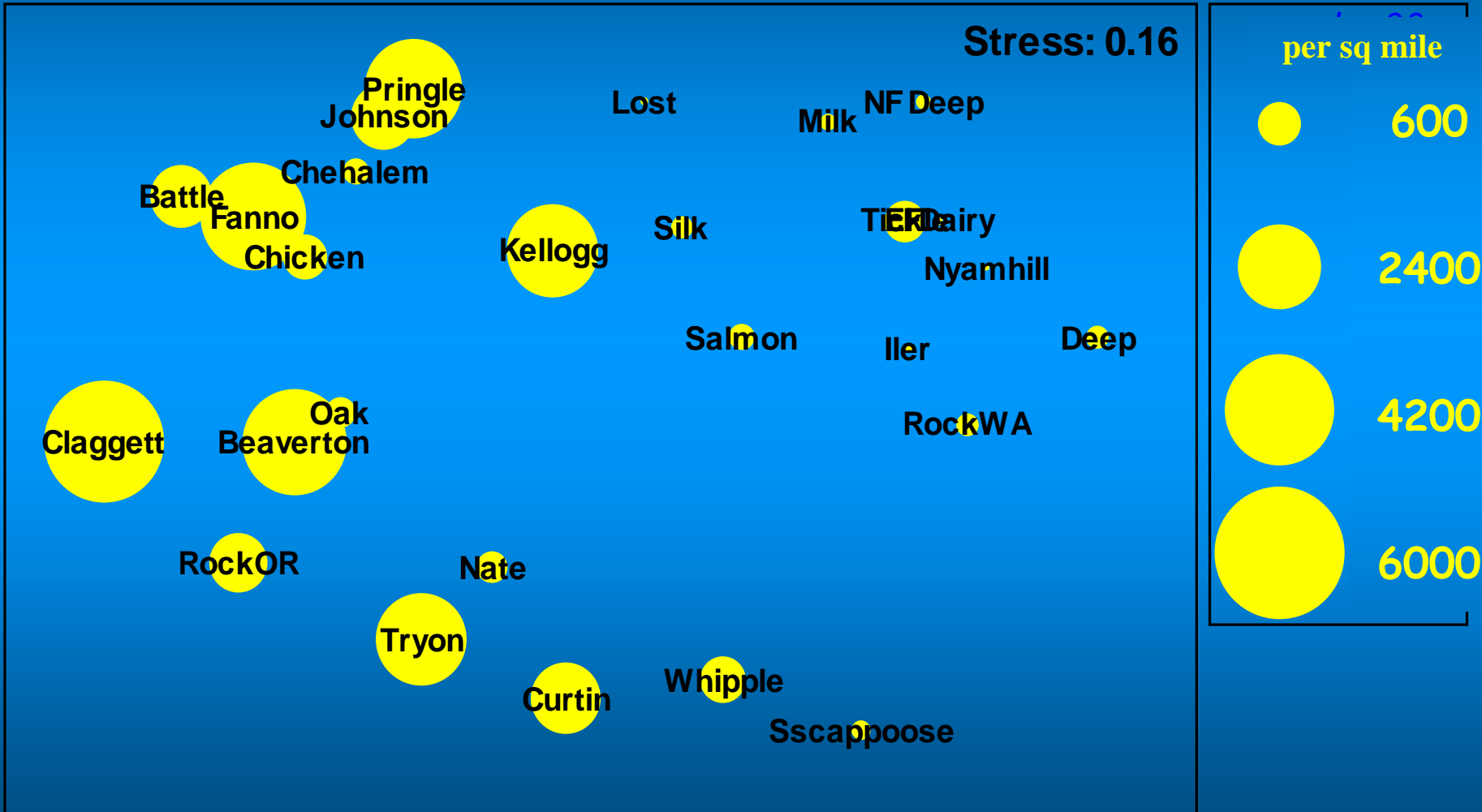
# Exotic Species

**“What do you  
mean cooties,  
no cooties on  
me.”**

FZ



# nMDS Ordination of Fish Abundance (Log X+1) with overlay of Population Density



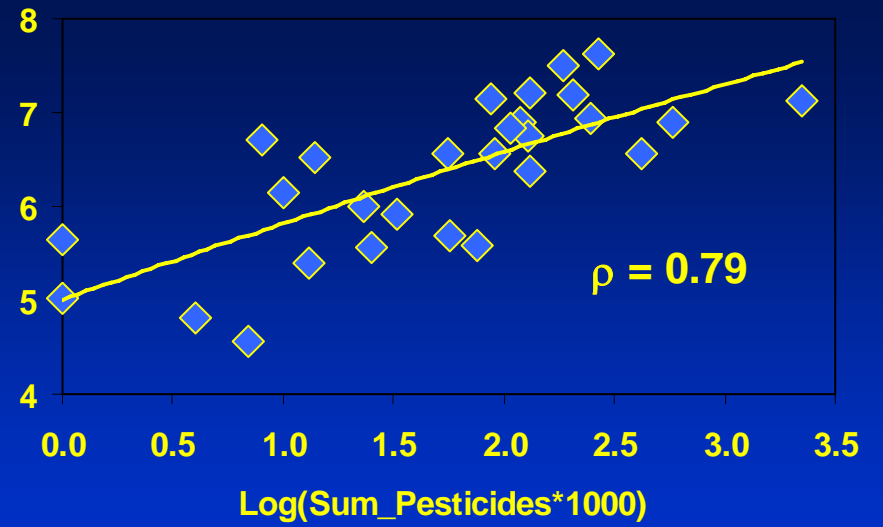
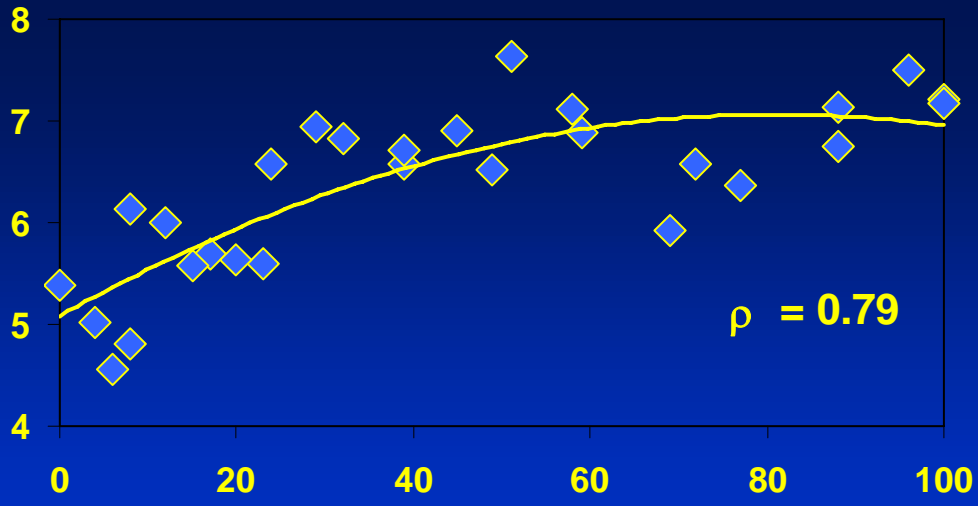


## Overview of Abundance and Taxonomy

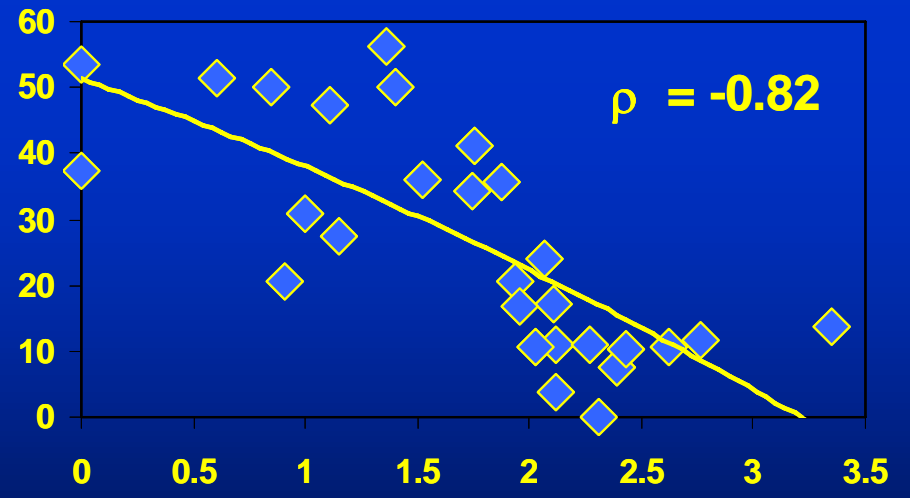
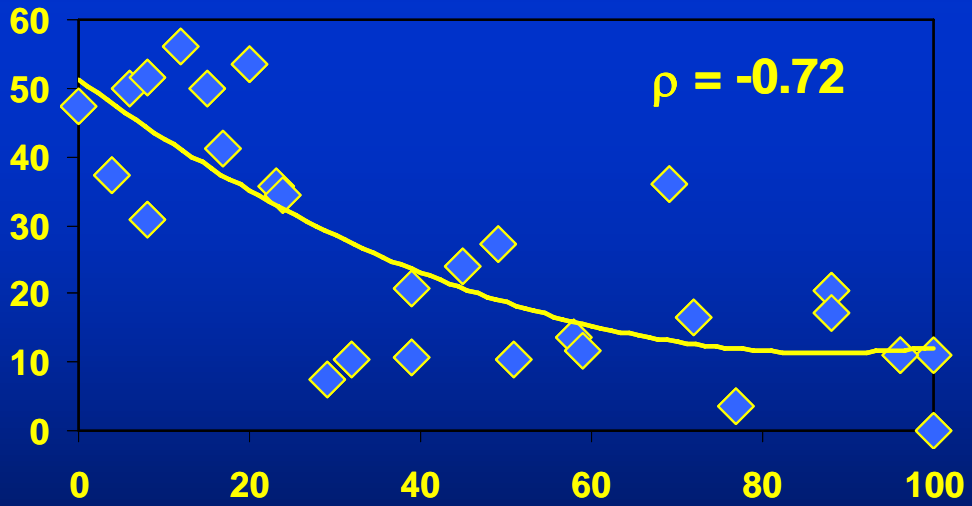
Order	No. Unique Taxa	Most Abundant Taxa and their Maximum Abundance (m2)	
Ephemeroptera	19	Heptageniidae	2943
Plecoptera	14	<i>Zapada cinctipes</i>	4851
Trichoptera	26	<i>Cheumatopsyche</i> sp.	4208
Diptera	67	Simuliidae	10584
Chironomidae	45	<i>Cricotopus bicinctus</i>	3226
Coleoptera	11	<i>Optioservus</i> sp.	1546
Noninsects (17 orders)	30	<i>Fluminicola</i> sp.	14274
<b>Total</b>	<b>172</b>		

Order	Taxa	Percent of Sites	PNW Tolerant Value
Noninsect - Water Mite	Acari	96	6
Diptera	Simuliidae	93	6
Noninsect - Snail	<i>Juga</i> sp.	89	7
Ephemeroptera	<i>Baetis tricaudatus</i>	82	7
Noninsect - Worm	Naididae	79	8
Diptera - Chironomidae	Orthoclaadiinae	75	5
Noninsect - Worm	Lumbriculidae	71	7.5
Trichoptera	<i>Cheumatopsyche</i> sp.	68	8
Diptera - Chironomidae	<i>Polypedilum</i> sp.	68	6
Diptera - Chironomidae	<i>Paraleptophlebia</i> sp.	64	5
Diptera - Chironomidae	Chironominae	64	6
Diptera - Chironomidae	<i>Thienemannimyia</i> group sp.	61	6
Diptera - Chironomidae	<i>Rheotanytarsus</i> sp.	57	6
Diptera - Chironomidae	<i>Eukiefferiella</i> sp.	57	8
Noninsect - Snail	<i>Ferrissia</i> sp.	57	7
Coleoptera	<i>Optioservus</i> sp.	57	9
Coleoptera	<i>Zapada cinctipes</i>	54	4
Noninsect - Worm	Tubificidae	54	10
Noninsect - Crayfish	<i>Pacifastacus leniusculus</i>	54	7
Noninsect - Snail	<i>Fluminicola</i> sp.	50	7
Trichoptera	<i>Ceratopsyche</i> sp.	50	5
Ephemeroptera	Heptageniidae	50	4
Trichoptera	Hydropsychidae	50	6
Ephemeroptera	Leptophlebiidae	50	2





Urban Index  
**Y-Axis Invertebrate Tolerance (Weighted Abundance)**



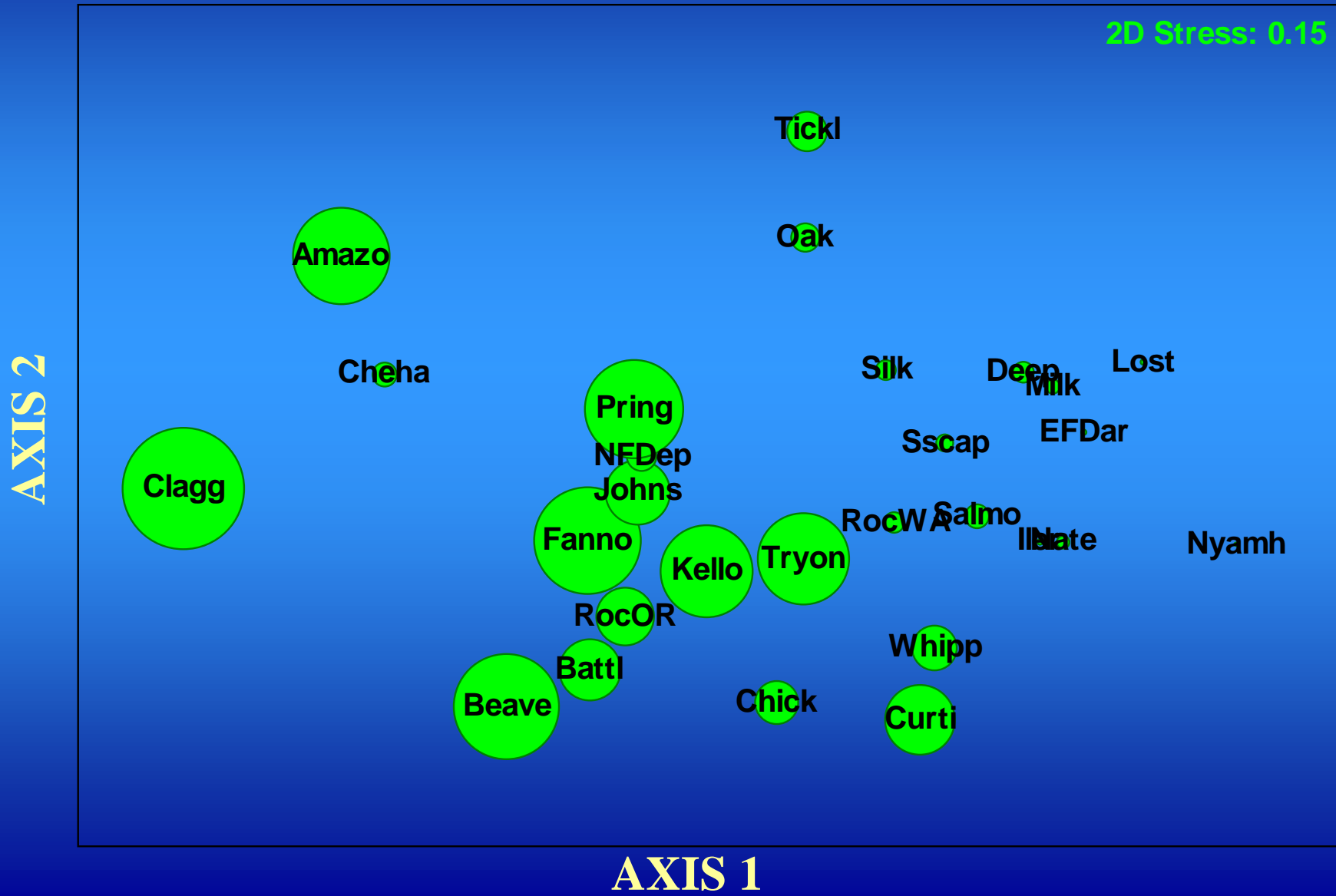
Urban Index  
**Y-Axis % Ephemeroptera Plecoptera Trichoptera Richness**

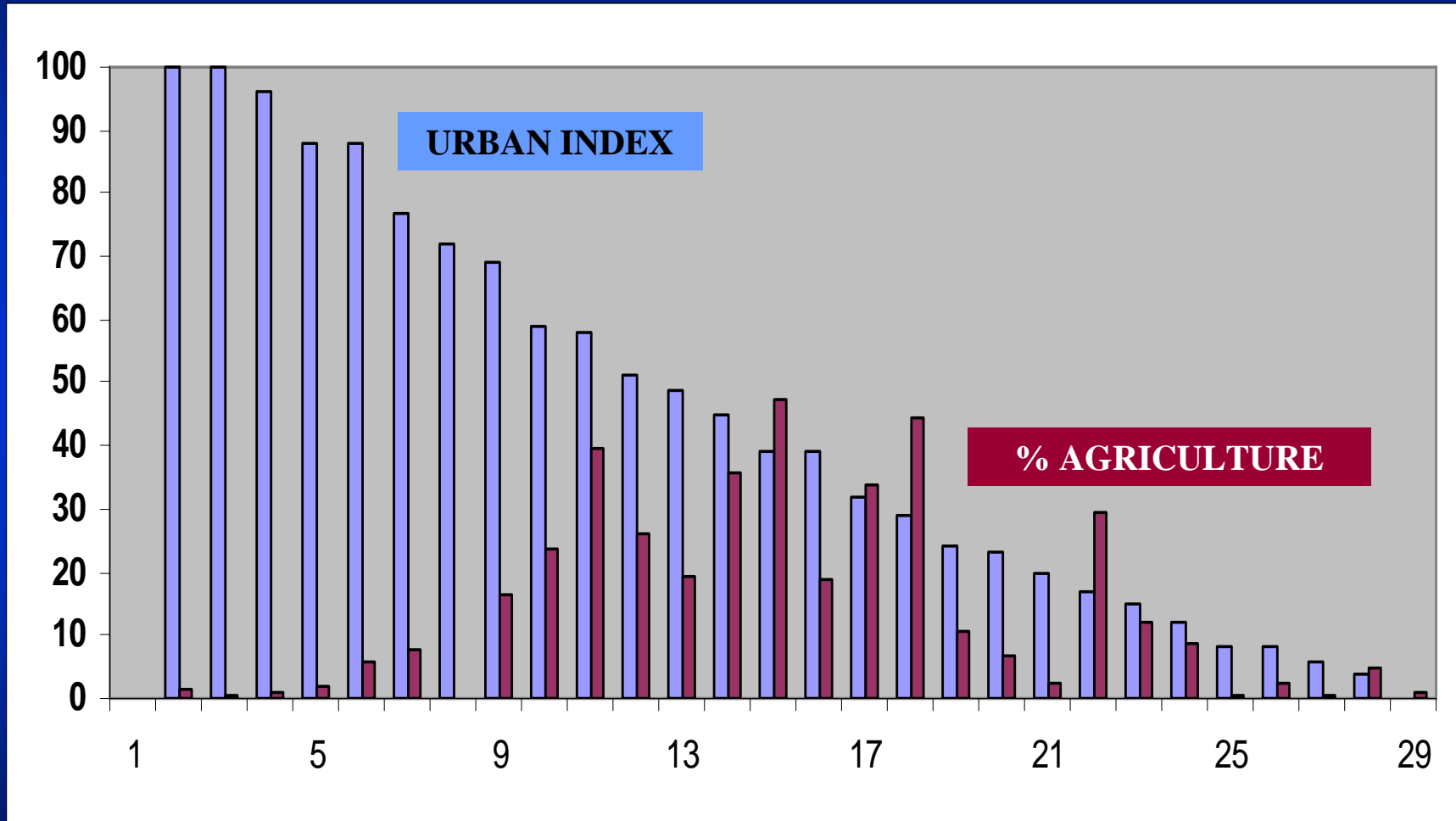
# Dominance, Tolerance and EPT Richness along the Urban Gradient -- Is Dominance all it's cracked up to be?

Urban Index	Percent Dominant	Dominant Taxa	Tolerant	EPTR	EPTRp
100	27	<i>Baetis tricaudatus</i>	7	2	11
100	42	Tubificidae	10	0	0
96	57	<i>Cheumatopsyche</i> sp.	8	3	11
88	27	<i>Cheumatopsyche</i> sp.	8	7	21
88	49	<i>Simulium canadense</i>	7	5	17
77	35	<i>Cricotopus bicinctus</i> group	7	1	4
72	30	<i>Baetis tricaudatus</i>	7	6	17
69	16	<i>Cheumatopsyche</i> sp.	8	14	36
59	29	<i>Cheumatopsyche</i> sp.	8	3	12
58	51	<i>Cheumatopsyche</i> sp.	8	3	14
51	37	<i>Cheumatopsyche</i> sp.	8	3	10
49	16	<i>Optioservus</i> sp.	9	9	27
45	38	<i>Cheumatopsyche</i> sp.	8	6	24
39	34	<i>Baetis tricaudatus</i>	7	3	11
39	31	<i>Ferrissia</i> sp.	7	6	21
32	67	<i>Simulium canadense</i>	7	2	11
29	51	<i>Fluminicola</i> sp.	7	2	7

Urban Index	Percent Dominant	Dominant Taxa	Tolerant	EPTR	EPTRp
24	28	<i>Simulium canadense</i>	7	12	34
23	14	<i>Paratanytarsus</i> sp.	6	15	36
20	27	<i>Rhithrogena</i> sp.	3	15	54
17	23	<i>Baetis tricaudatus</i>	7	14	41
15	30	<i>Rhithrogena</i> sp.	3	14	50
12	23	<i>Cheumatopsyche</i> sp.	8	18	56
8	36	<i>Ceratopsyche cockerelli</i>	5	18	51
8	20	<i>Rhithrogena</i> sp.	3	8	31
6	30	<i>Rhithrogena</i> sp.	3	16	50
4	26	<i>Rhithrogena</i> sp.	3	16	37
0	18	<i>Zapada cinctipes</i>	4	18	47
Ave. of sites > 25 Ur Index			8	4	15
Ave. of sites < 25 Ur Index			5	15	44

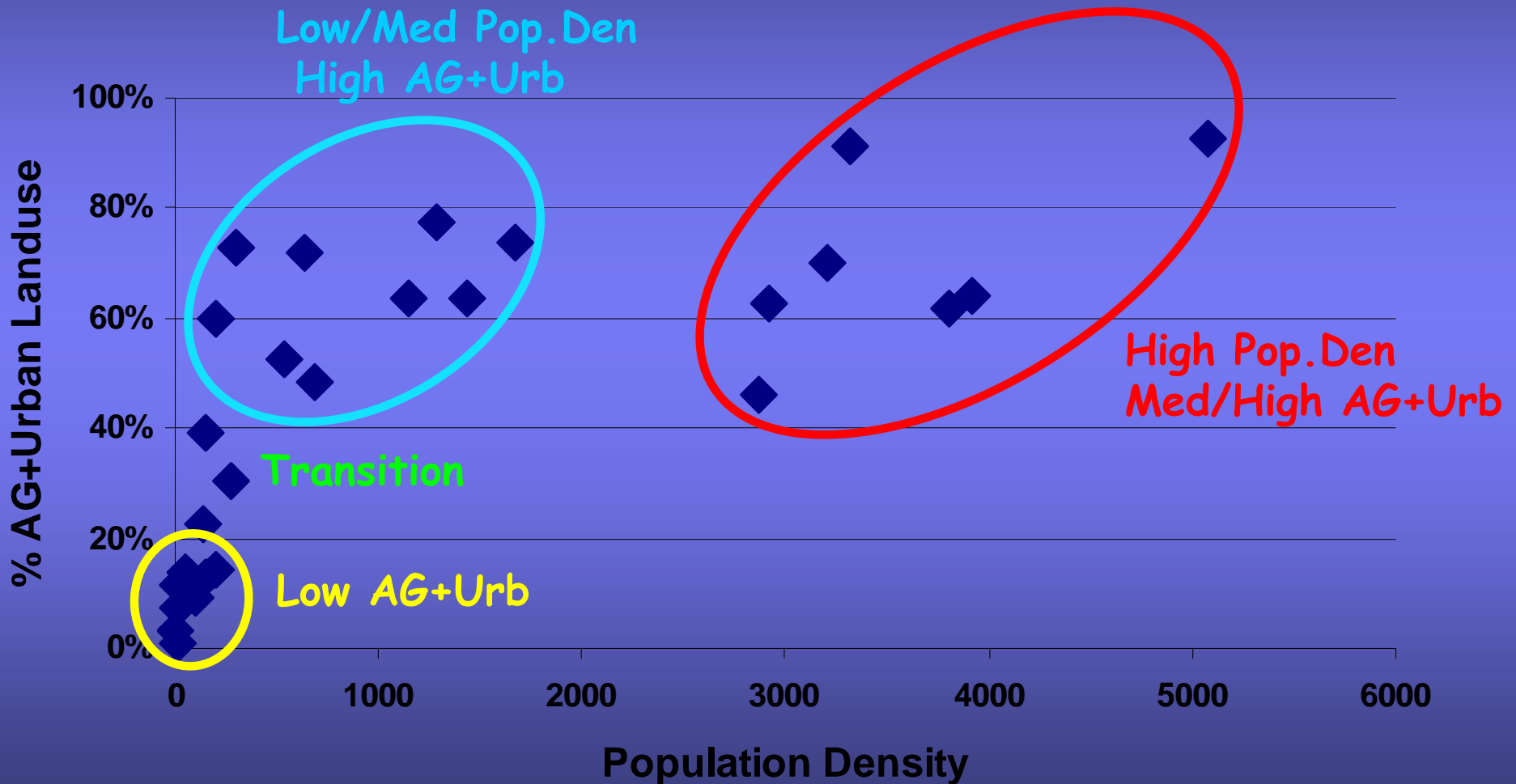
# nMDS Ordination of Invertebrate Density (Log X+1) w/ overlay of Population Density





Sites sorted by Urban Index (n = 28)

# Plot of Population Density vs. % AG+Urban Land Use (% disturbance)



# nMDS Ordination of Invertebrate Density Sites coded by %AG+Urban

*Invertebrate RTH (Density-Log(X+1))*

2D Stress: 0.15

## %AG+Ur Categories

< 15 %

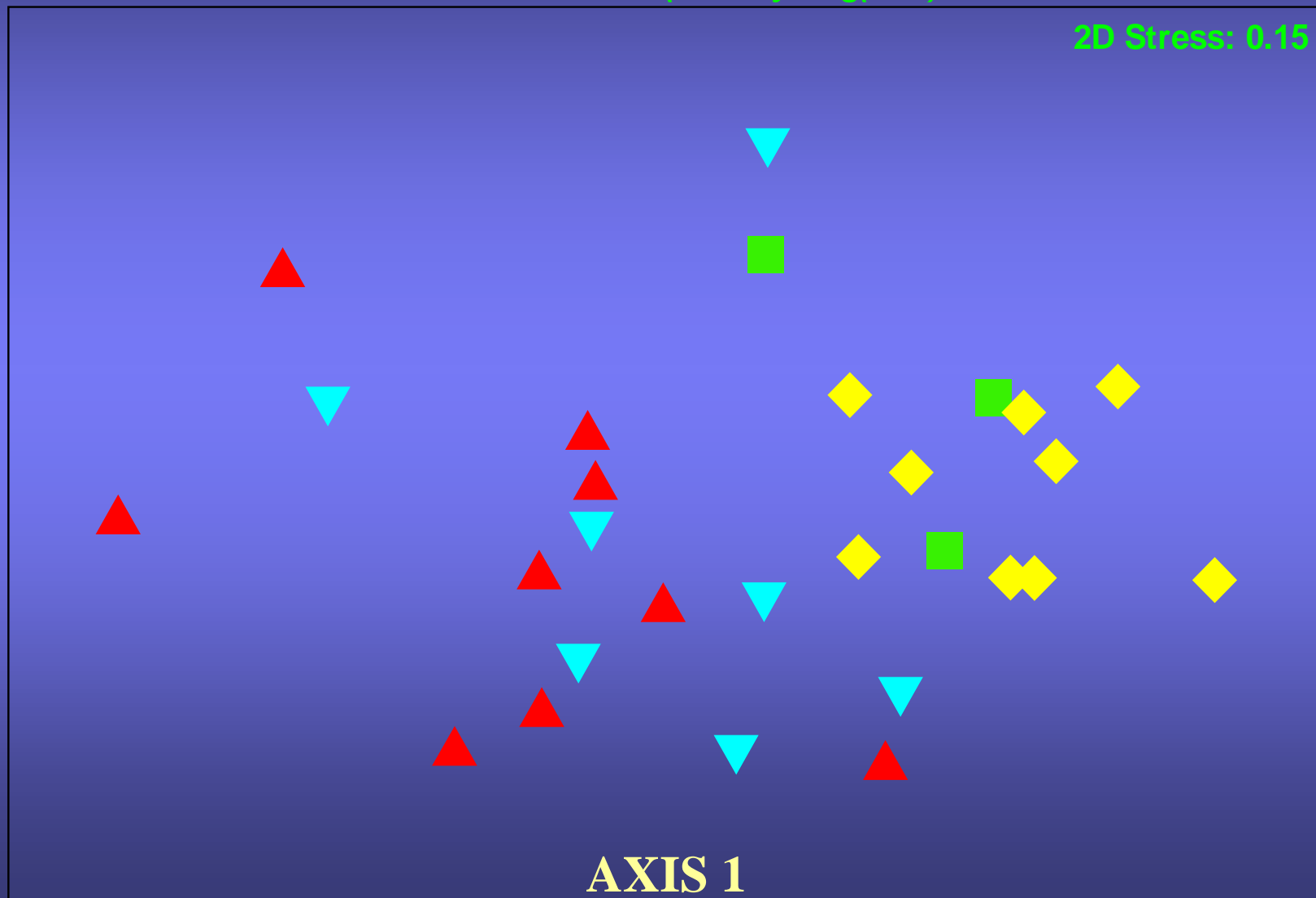
15 – 39

40 – 69

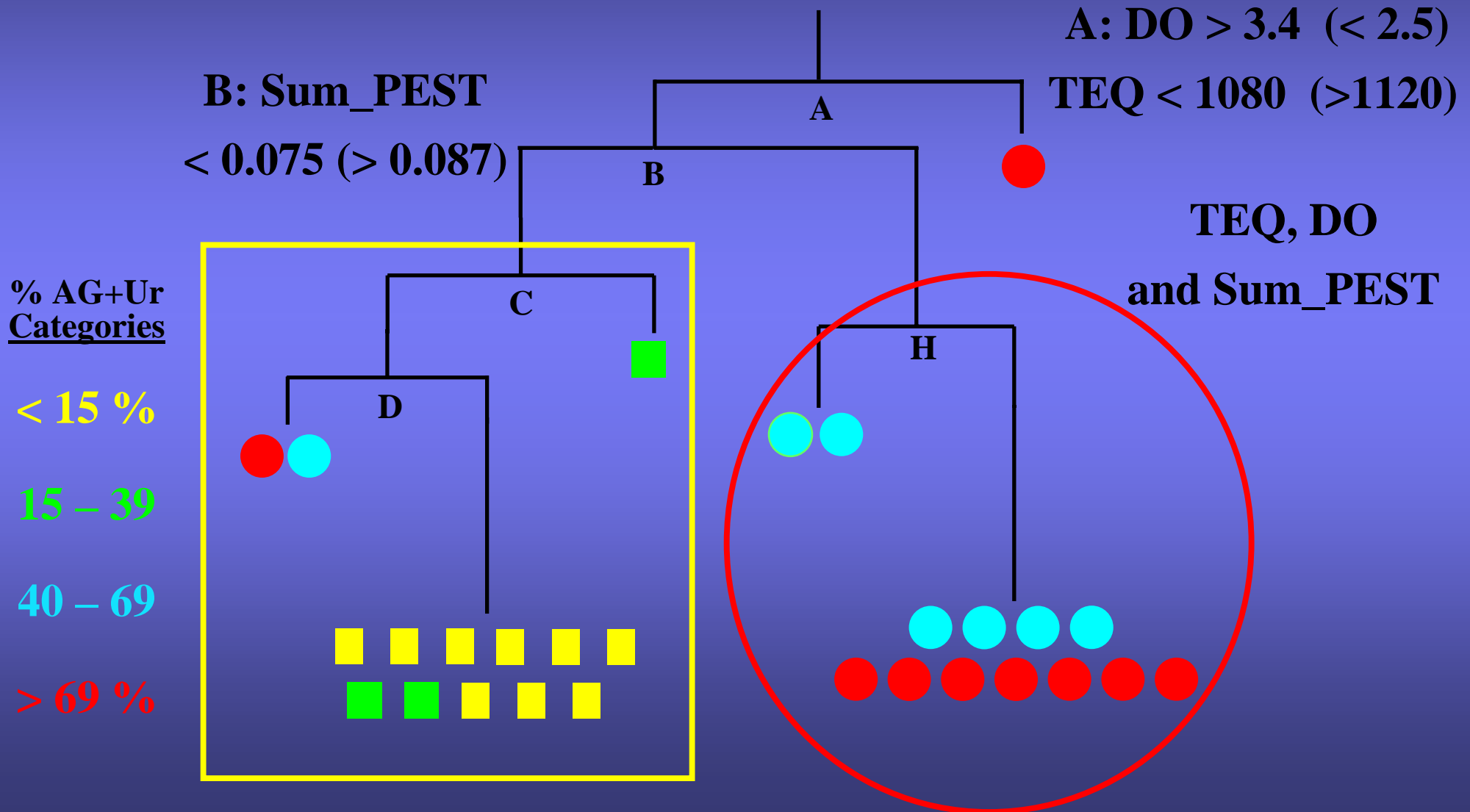
> 69 %

AXIS 2

AXIS 1



# Multivariate Regression Tree (MRT: Primer) Linking Inverts to Environmental Data (coded by %AG+Urban)





# Nonparametric Regression Tree Linking Inverts to Environmental Data (coded by %AG+Urban)

■ C: TEQ

■ H: TEQ

■ D & E: DO

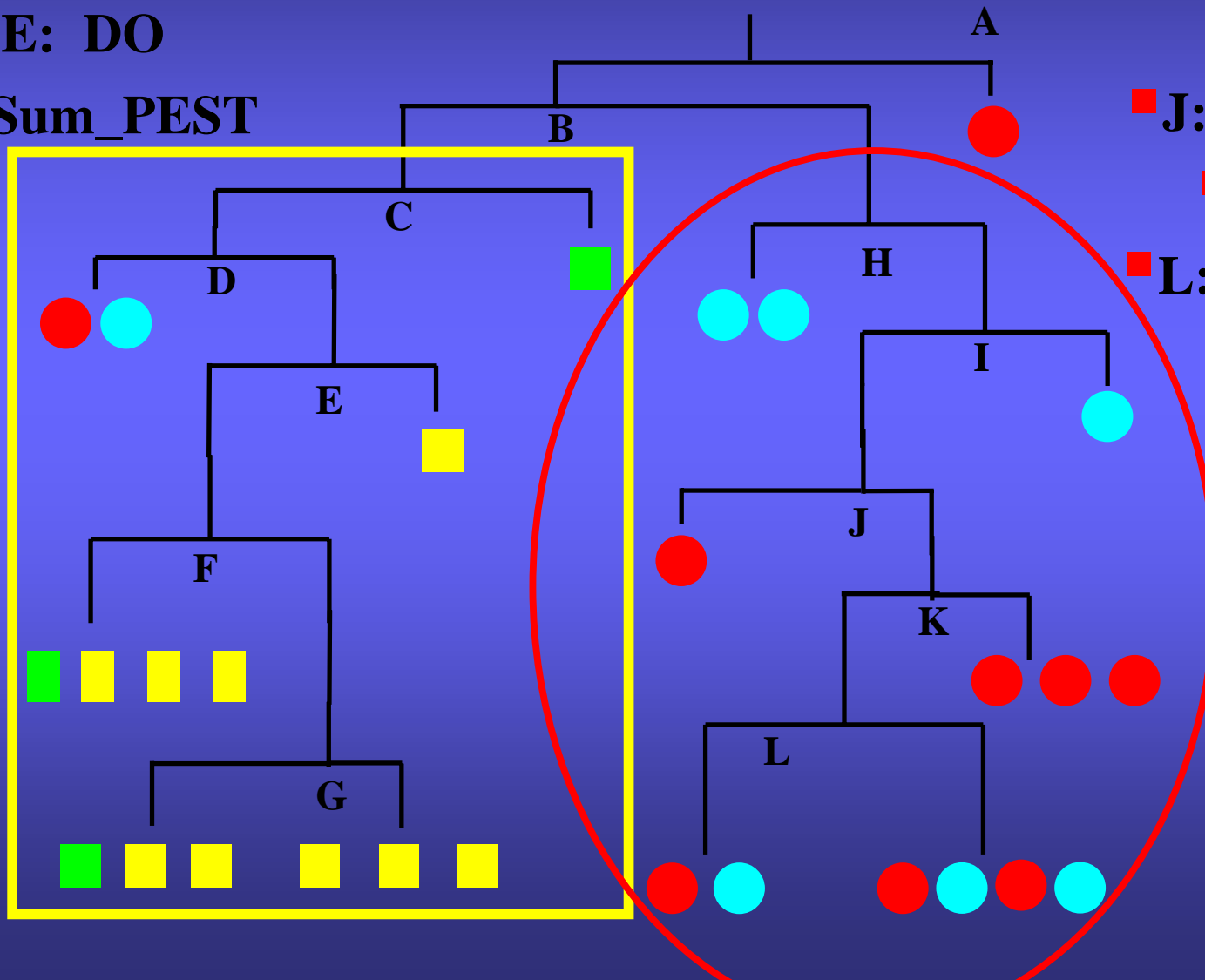
■ I: DO

■ F & G: Sum\_PEST

■ J: Sum\_PEST

■ K: TEQ

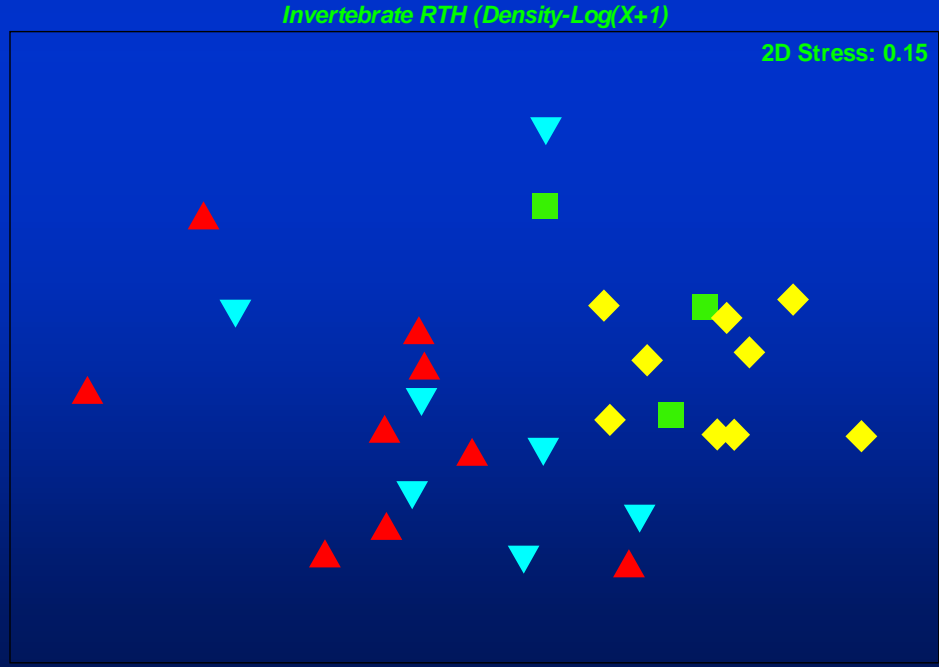
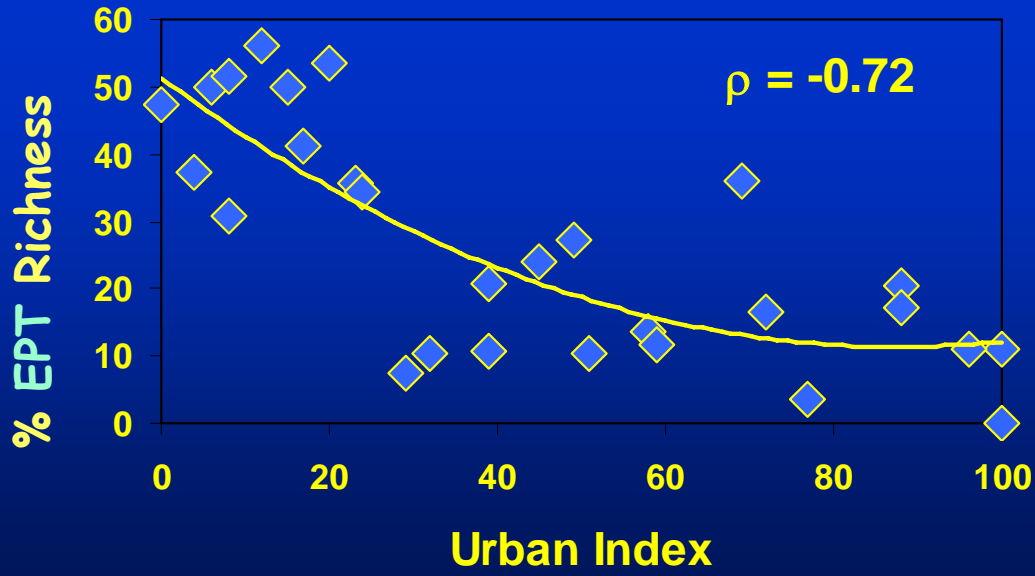
■ L: Sum\_PEST



# Preliminary CONCLUSIONS



◆◆ Invertebrates showed a threshold for some metrics (EPT Richness and % EPT Richness) at Urban Index values of ~25 or < 1-4 % Impervious



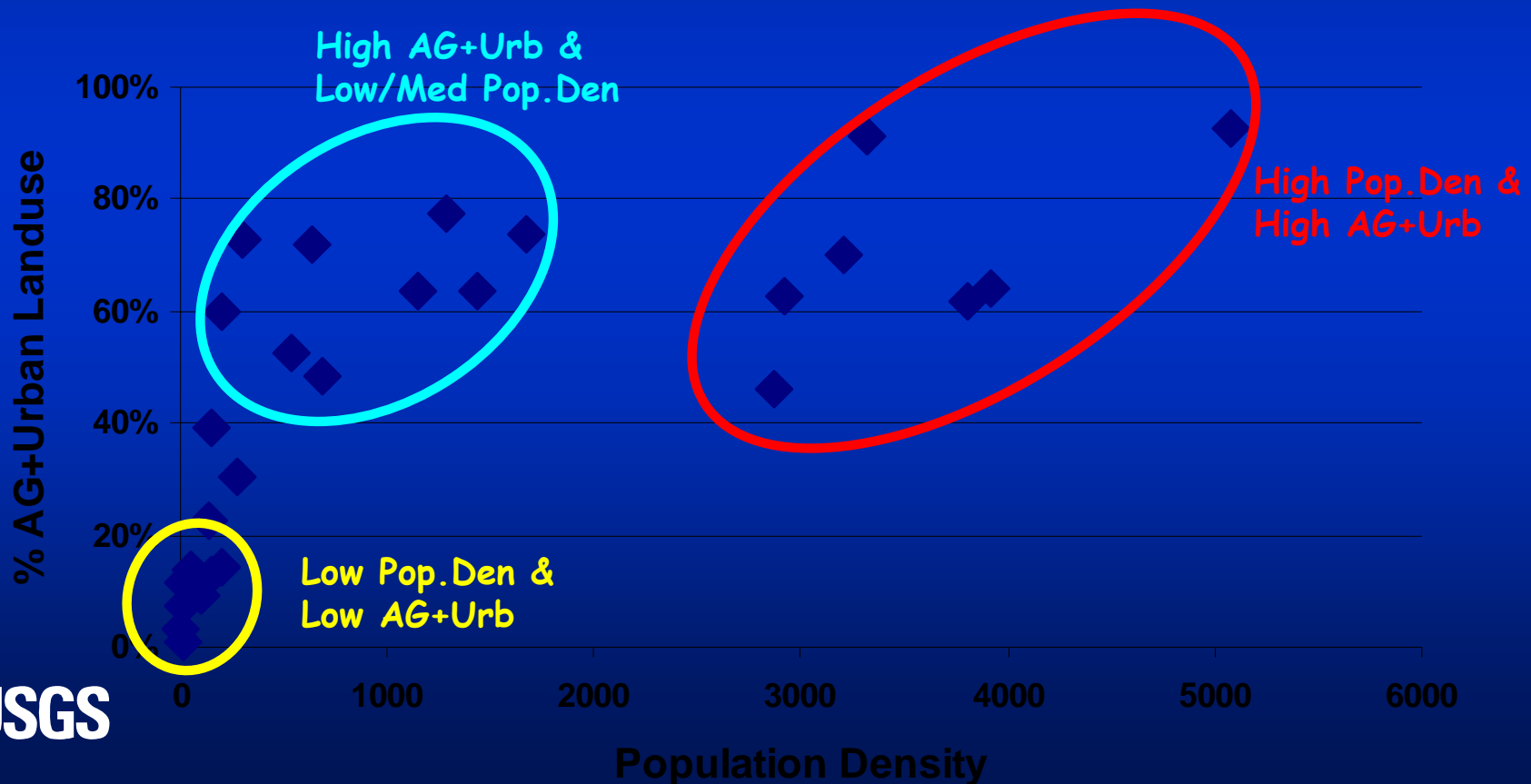
## Preliminary CONCLUSIONS



✳ Biotic assemblages were strongly related to differences in WQ among sites (e.g., TEQ, Pesticides, DO, and Water Temp.) likely due to Urban and AG land use disturbances - either singularly or in combination.

# Preliminary CONCLUSIONS

- ❖ Little difference found in fish and inverts between High AG+Urban (% disturbance) and High Population Density sites



# Preliminary CONCLUSIONS

- ❖ 1) WQ and Contaminants: strongest variables related to the macroinvertebrate similarity matrix along the Urban Index
- 2) then habitat variables, water temperature, and finally hydrologic metrics

## SUMMARY of BEST Variables Related to Inverts

Top TWO Variables:

TEQ (SPMD)

0.577

PRIMER

Sum of Total Pesticides

ANOSIM R

*then add in these three VARS*

Embeddedness

add .48

Percent Riffle

add .48

Summer DO

add .30

*minor improvement with*

Seven Day Ave. Temperature

add .18

Percent Urban+AG

add .13

Urban Index

add .13





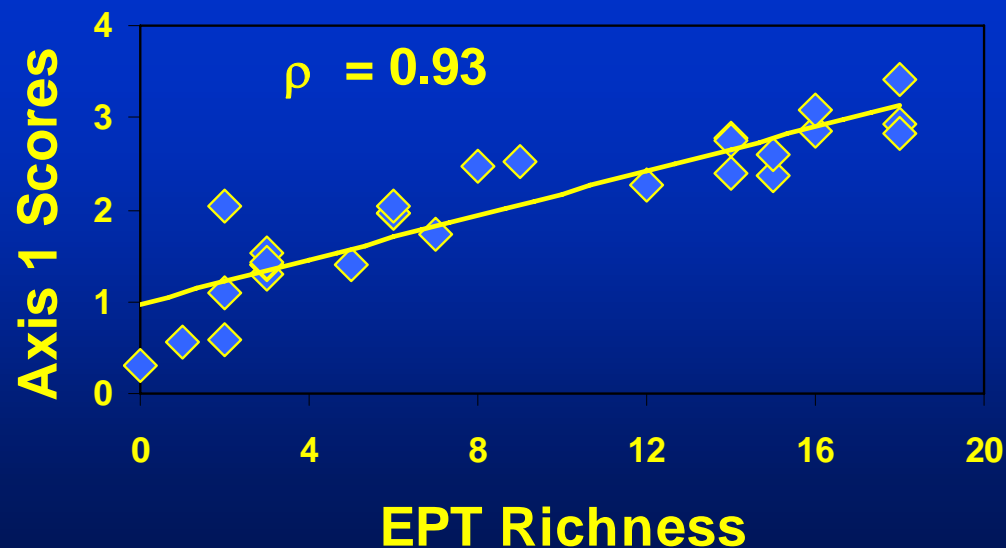
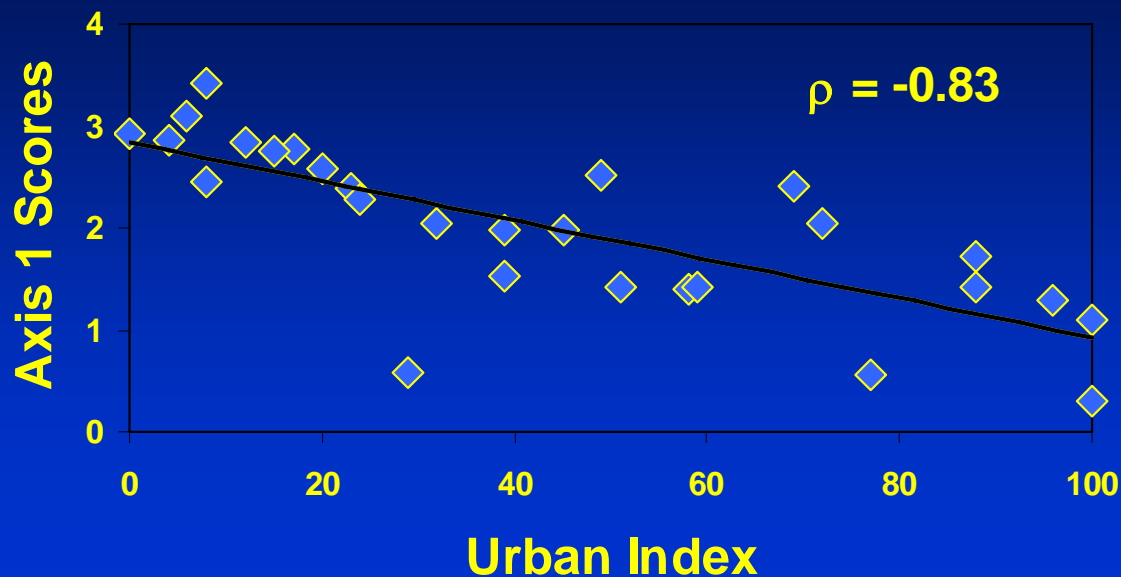
## NEW PROJECT

Develop Watershed Disturbance Predictive Models  
for WA, OR and CA

Collaborating with EPA Corvallis and States  
Focus on Macroinvertebrate Metrics

Lead Authors: Ian Waite, Larry Brown  
Jason May, Chris Konrad, Jim Orlando, Kim Jones,  
Tom Cuffney, Jonathan Kennen and Ann Brasher

# What variables are related to the Ordination Axis 1?



## Population Density

**% Impervious 0.98**

**% Urban 0.98**

**Road Den. 0.95**

**Urban Index 0.98**

**Mean Watershed Elev. -0.88**

**Watershed Slope -0.81**

**3 Flow Stats 0.73**

**DOC 0.70, SO4 0.71**

**TN 0.81, TP 0.73**

**Pest. Tox. Index\_Summer 0.70**

**Sum\_Insecticide 0.70**



**TEQ 0.79**

*Environmental Variables  
usually surrogates for many  
processes*



# Hypothetical response to increasing urban intensity....**threshold** or **linear** or none?

