Identifying Changes to Stream Condition caused by Urbanization

How understanding the responses can improve ecological risk characterization

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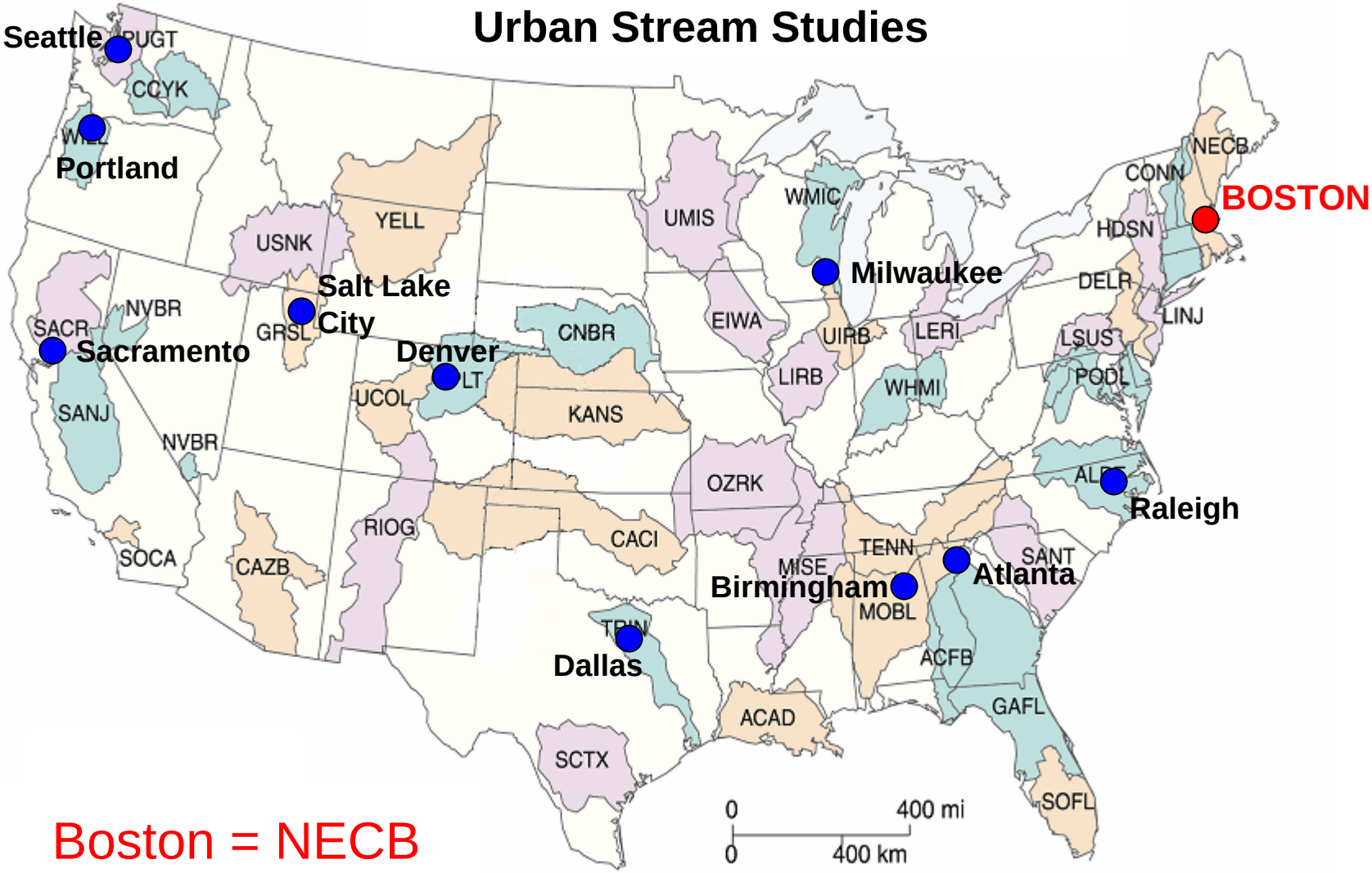
National Water-Quality Assessment (NAWQA) Program
Urban Stream Studies



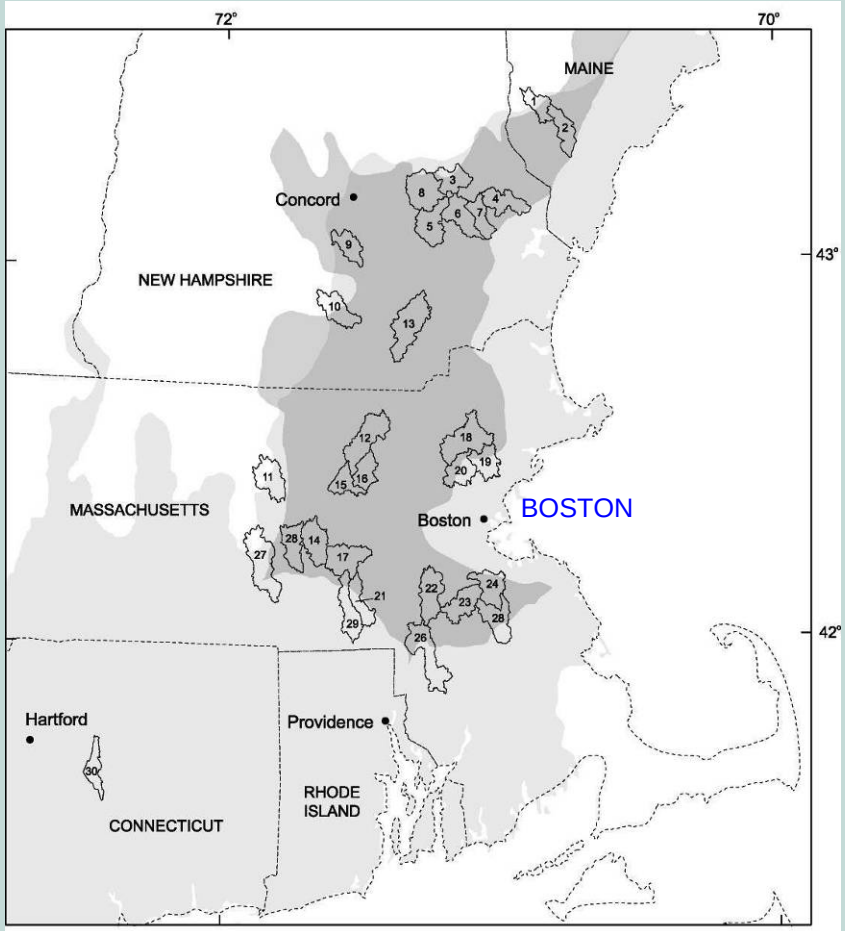
Boston = NECB

New England Coastal Basins

Setting up the Study Design

- **Define homogeneous environmental setting.**
  - ***minimize natural variability***
- **Determine watershed indicators of urbanization.**
  - ***related to human presence***
- **Select sites to represent urban intensity gradient.**
  - ***minimal to high levels of urbanization***
- **Establish consistent sampling reaches**
  - ***150 meters, riffles, riparian cover, stable channel***

New England Study Sites



Site Map for Urban Land-Use Gradient Study

Explanation

17 Urban Land-Use Gradient Basins
Site name and location given on table 2

Gulf of Maine Coastal Plain,
U.S. Forest Service Subsection 221Ai

Northeastern Coastal Zone,
U.S. Environmental Protection Agency Ecoregion 59

0 10 20 30 40 Miles

0 30 60 Kilometers

Develop an Index to measure Urban Intensity

Low Urban (0)

High Urban (100)

and which also corresponds to stream condition

Original (*a priori*) Index of Urban Intensity (UII) used 24 landuse and demographic variables to characterize an urbanizing landscape.

- **Infrastructure (Dams, Roadways, TRI sites)**
- **Land cover (Forest, Developed land)**
- **Census statistics (Population, Socioeconomic factors)**

Perhaps an Index of Urban Intensity (UII) could be derived that is as effective, but uses fewer than 24 variables

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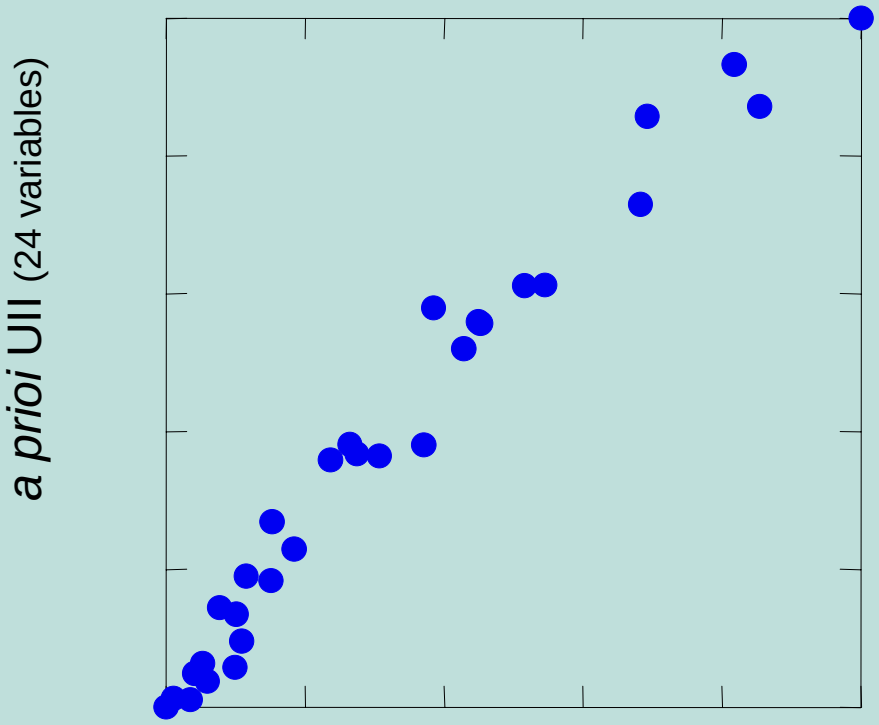
<u>Revised UII</u>

- Road Density
  - *Expansion of Infrastructure*
- Percentage of Buffer in Forest
  - *Encroachment along riparian zone*
- Percentage of Developed land
  - *Change from natural landscape*
- Population Density
  - *Human presence on landscape*

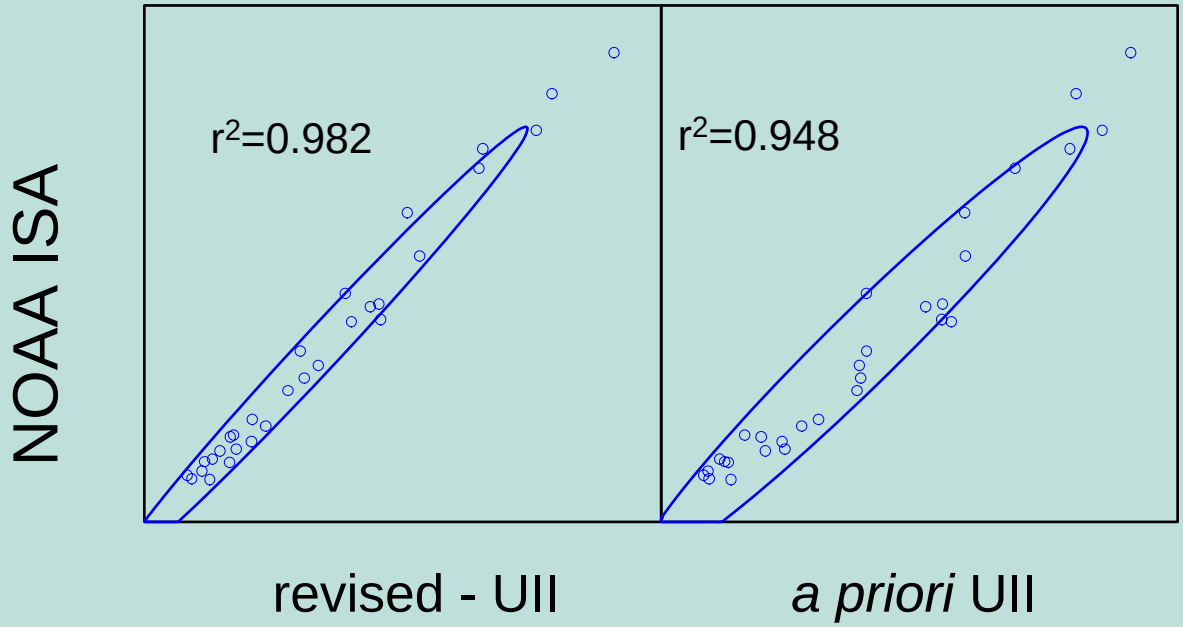
Comparing the Urban Intensity Indices (UII)



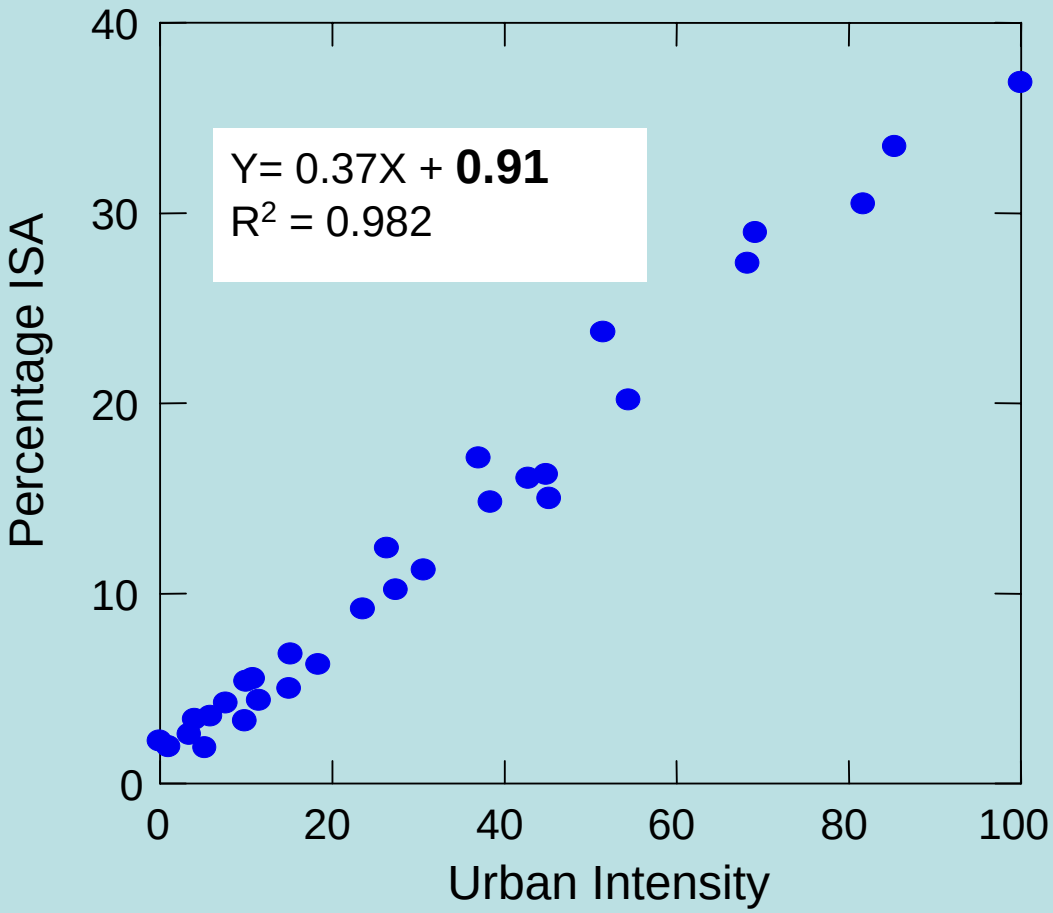
Comparing responses of Indicator Variables between versions of the UII

Indicator Variable Category	Metrics Compared	*a priori* UII average correlation	Revised-UII average correlation
• Water Chemistry	11	0.829	0.830
• Invertebrates	24	0.837	0.845
• Benthic Algae	12	0.756	0.743
• Fish	6	0.804	0.785
• Habitat	7	0.788	0.773
Overall Average	**60**	**0.810**	**0.807**

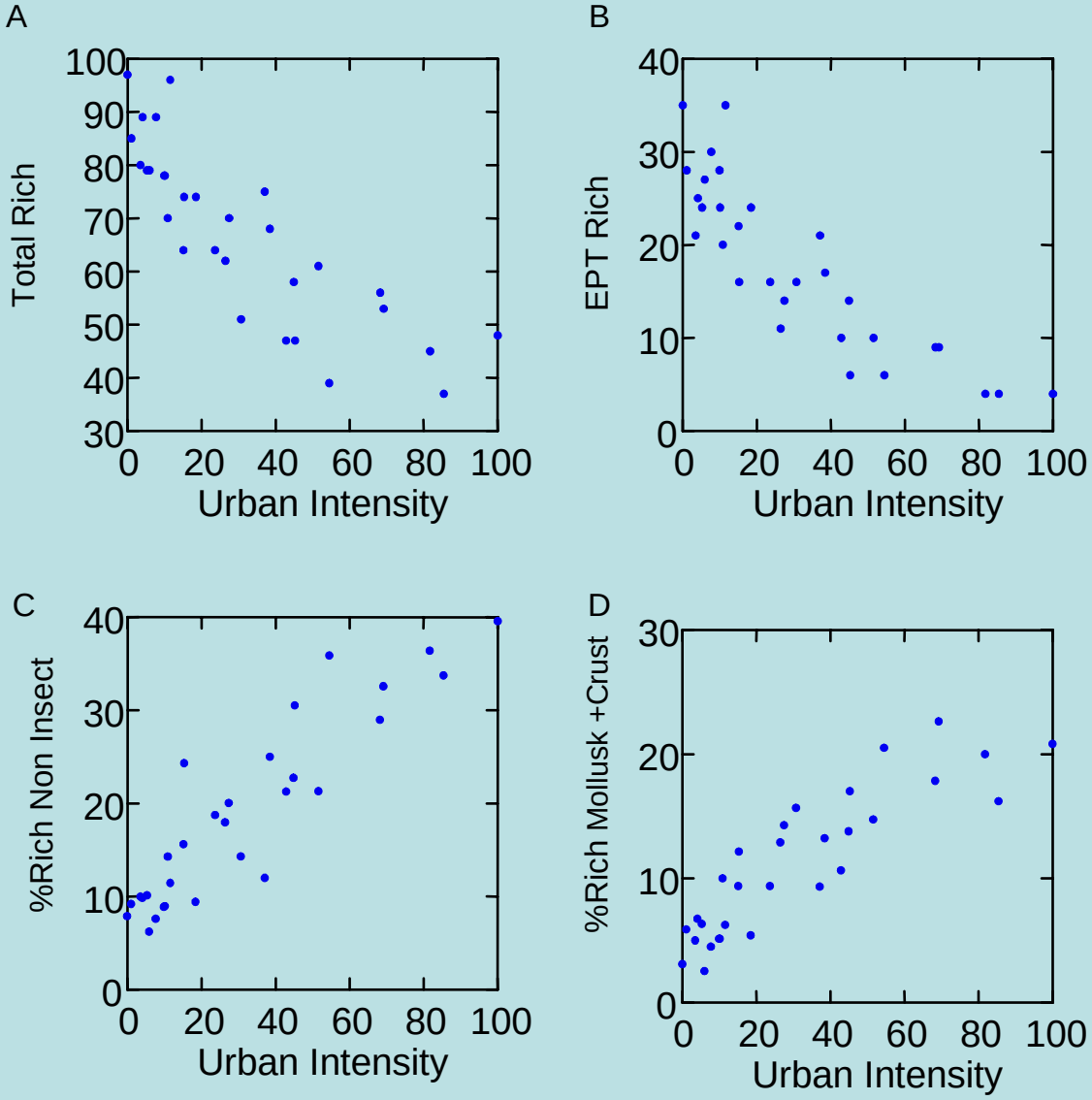
Impervious Surface Area (ISA) compared to Revised and the *a priori* UII



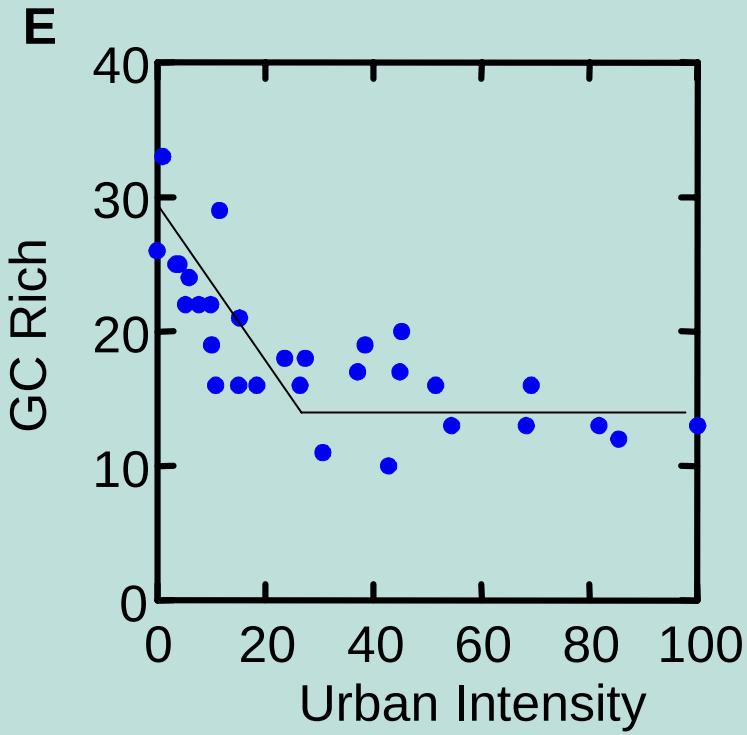
Impervious Surface Area compared to Urban Intensity (revised UII)

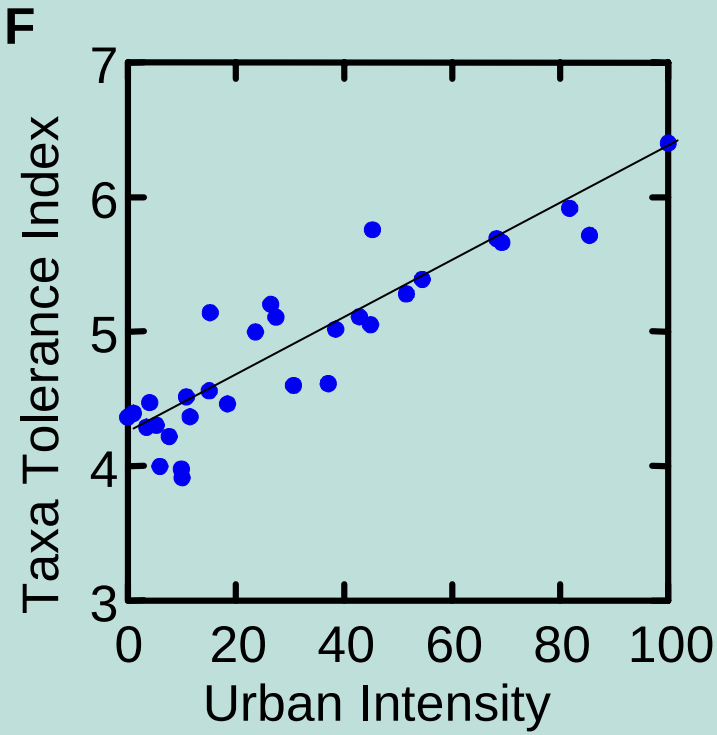


Invertebrate responses to urbanization
(Urban Intensity scaled 0 to 100)



Response of Functional Group and Taxa Tolerance

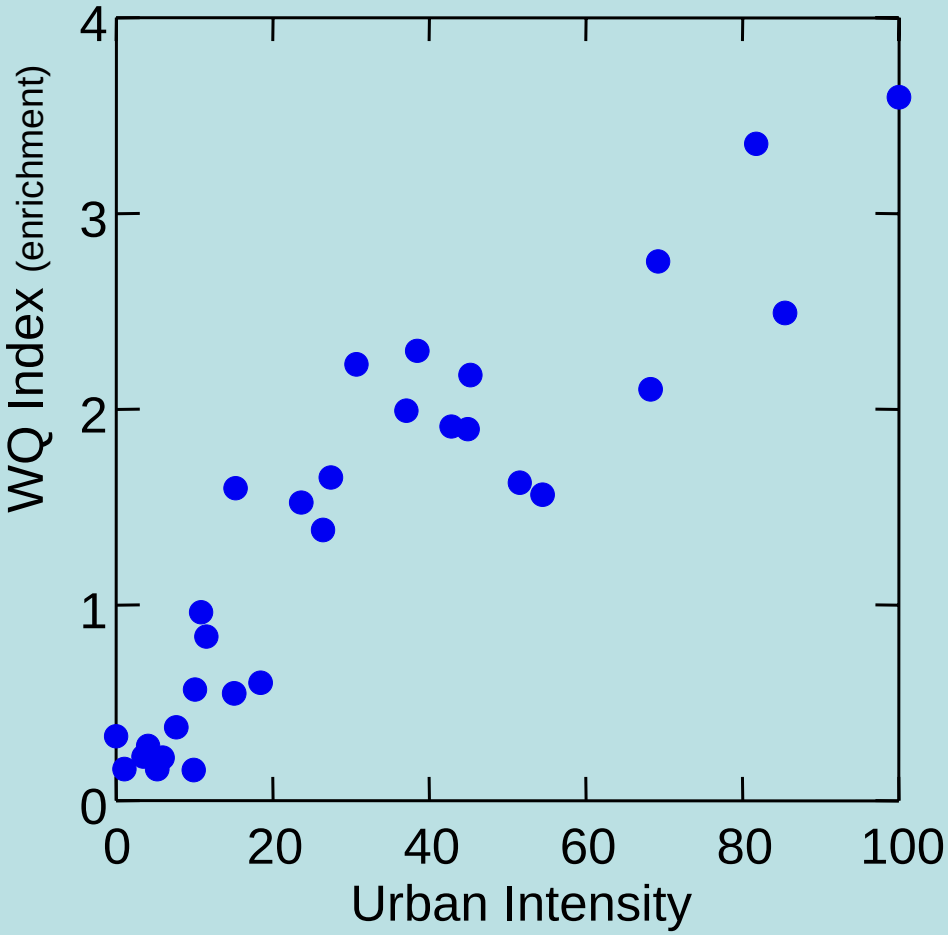




Threshold Response

Linear Response

Response of Water Quality to Urbanization



Parameters in WQ index:

- **TKN**
- **pH**
- **Conductance**
- **Alkalinity**

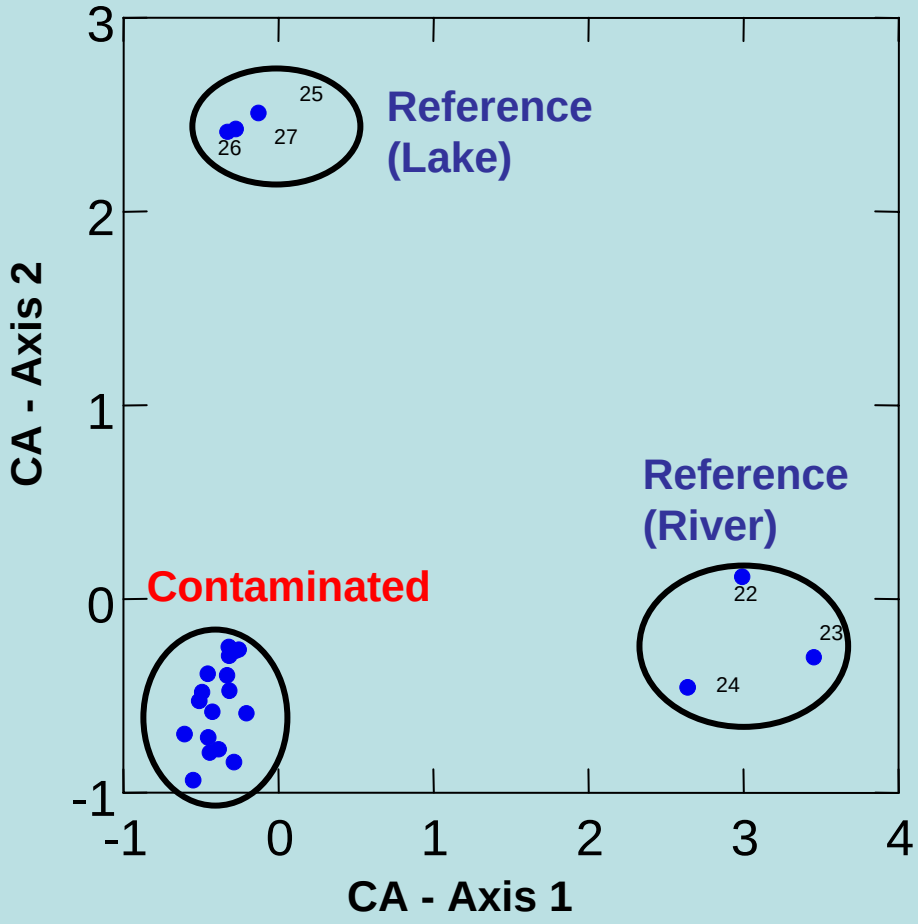
Improving Ecological Risk Assessments

The value of knowing the urban intensity of a site where contamination occurs.

(Is it urban intensity or the Superfund-site that is affecting stream condition?)

Eastland Woolen Mill Site

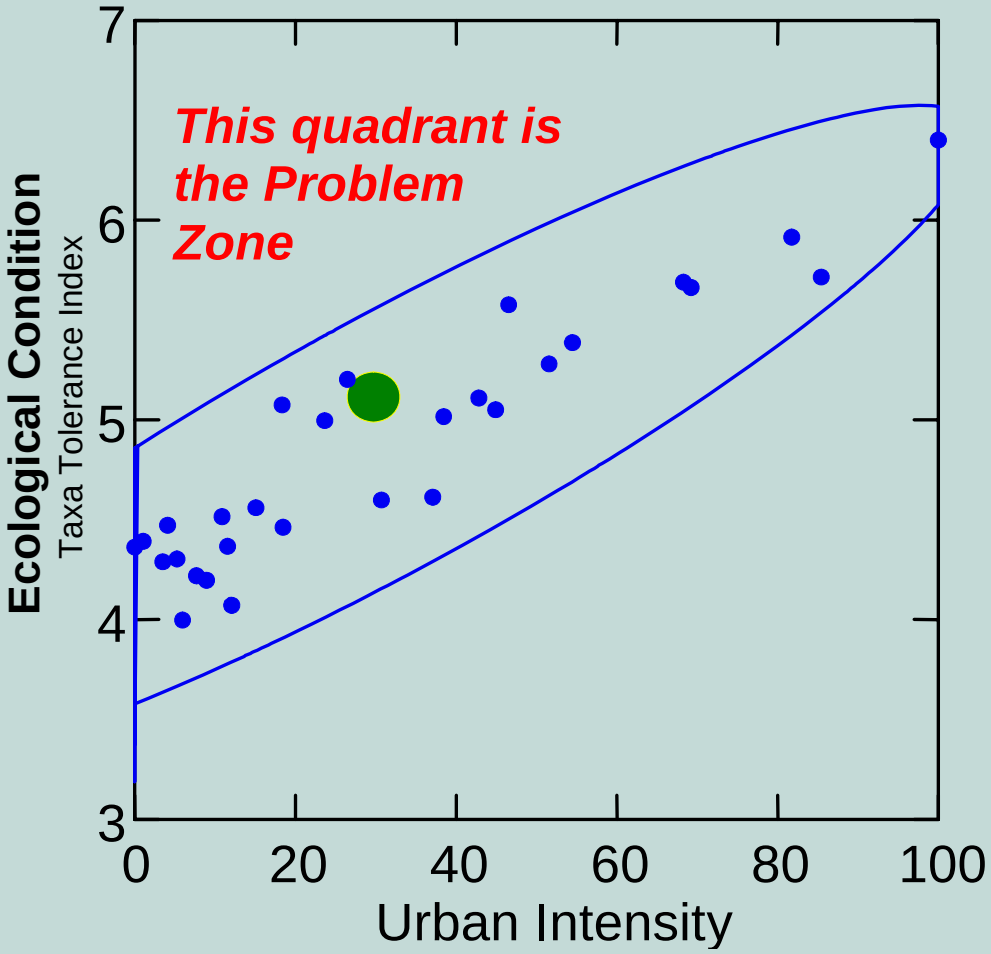
A Superfund Site in Corinna, ME.



Correspondence Analysis, interpretation of the biplot :

The two sets of reference sites are distinct from the group that has the contaminated sites.

Urban Intensity used to define the expected condition



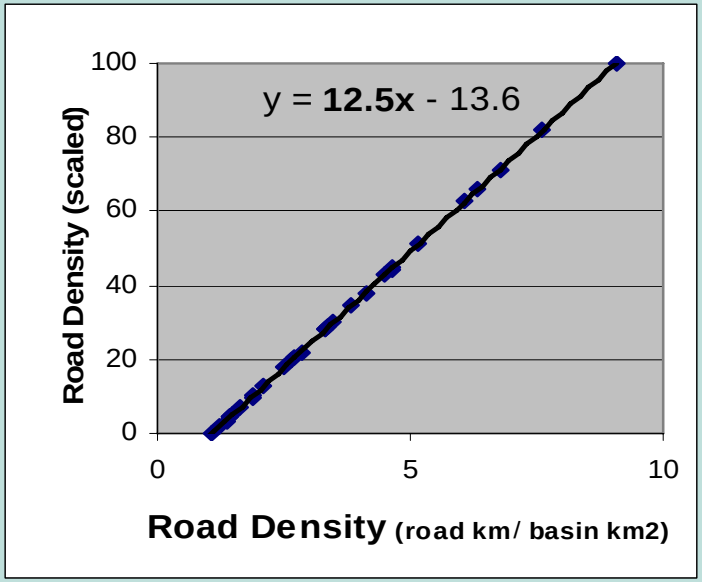
Large dot represents the Nyanza Superfund site. The Ecological Condition metric indicates that the cleanup was successful.

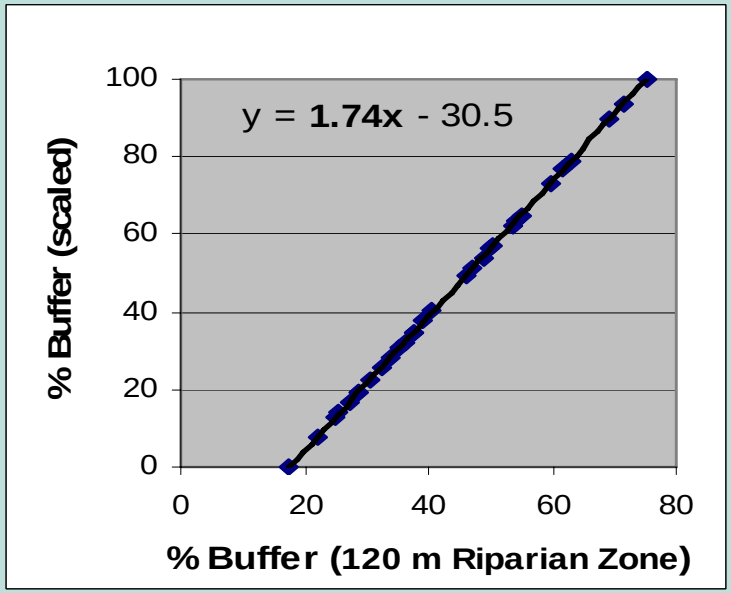
Developing Applications of the Urban intensity Index

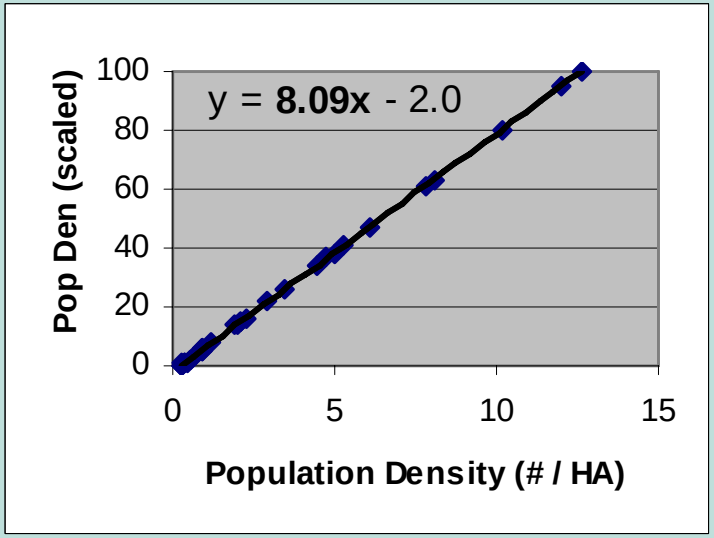
Addressing the details

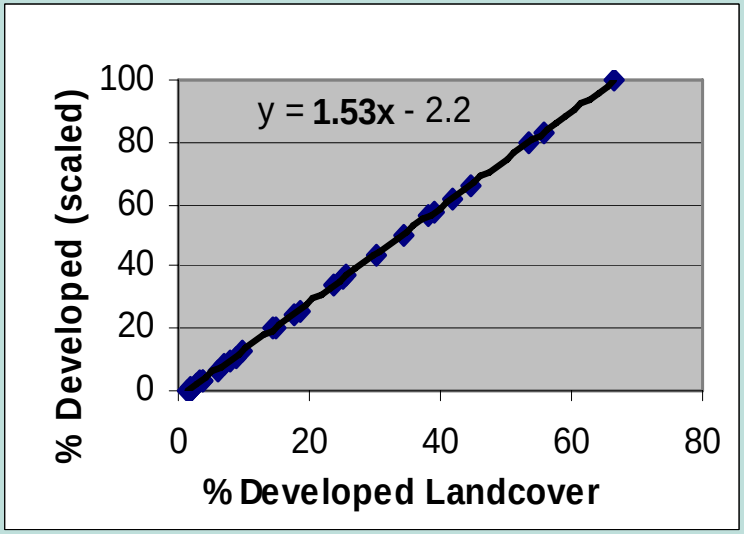
- Variables used in an urban index can be somewhat esoteric: *Socioeconomic factors*
- The Urban Intensity Index is standardized over the range of study sites, scaled 0 -100.
- Results from a single study of 30 sites may be tentative. Other data could be used to corroborate the Urban Intensity Index and the ecological responses.

Find regression coefficients to express the UII as equation









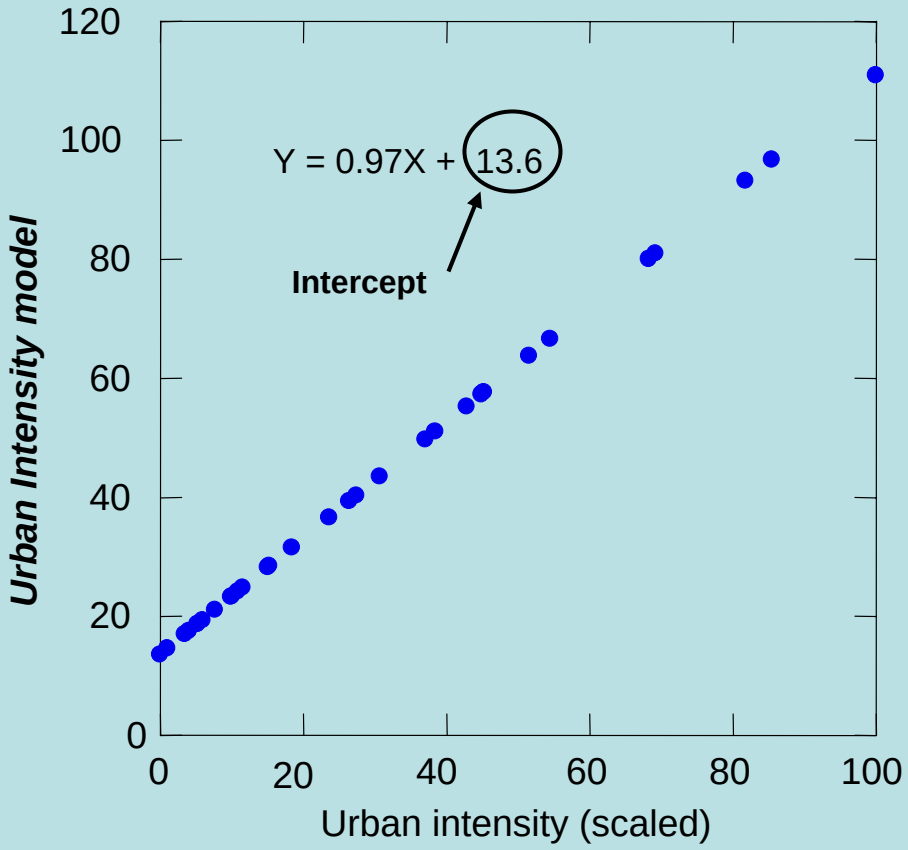
Set up the equation to include the Landuse Variables

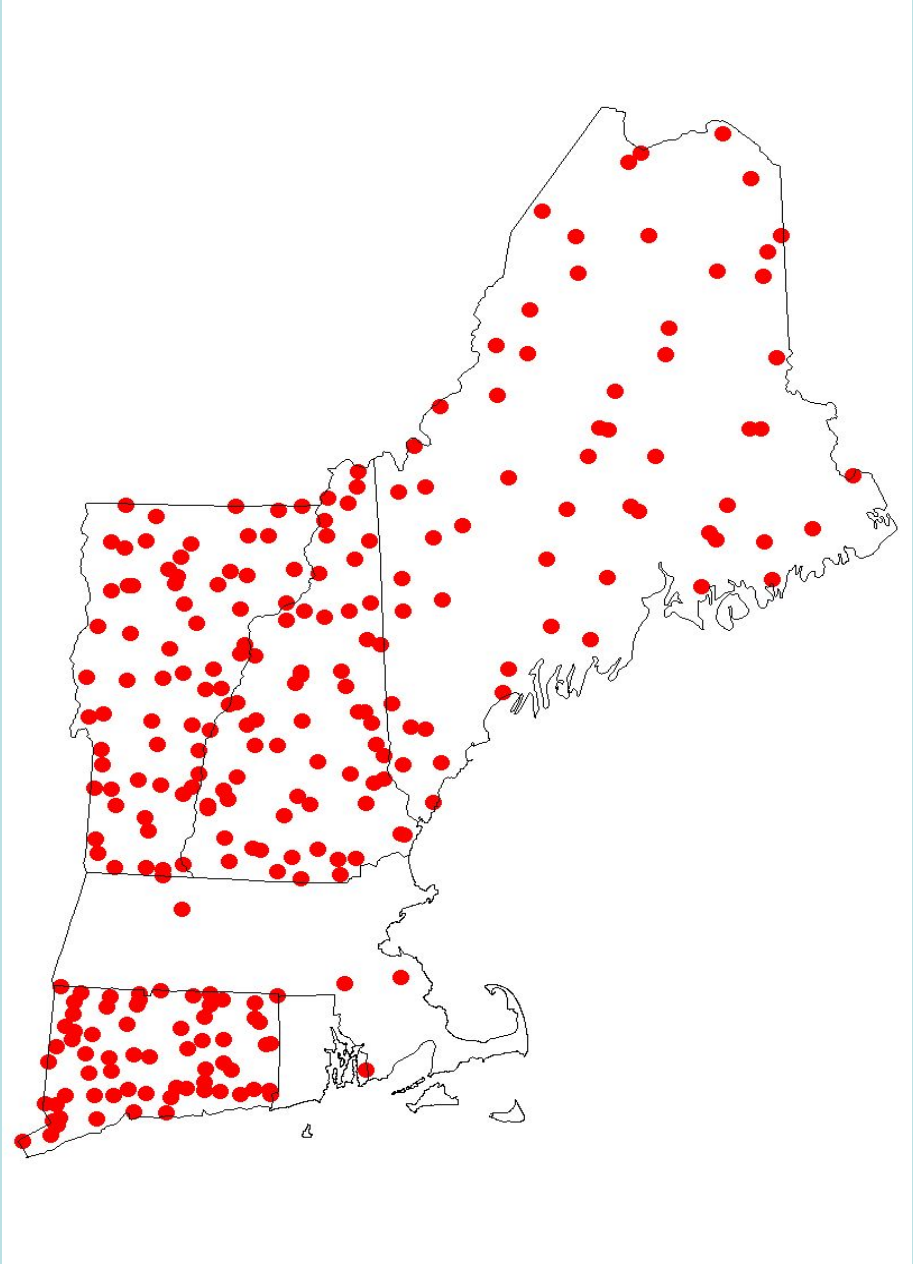
Urban Intensity =

(ROAD*12.5)+(BUFF%*1.74)+(DEV%*1.53)+(POP *8.09))*0.25)

- ROAD = road density [road length (km) / watershed area (km2)]
- BUFF% = percentage stream buffer not in forest landcover [MRLC level 1]
- DEV% = percentage watershed in developed landcover [MRLC level 1]
- POP = population density, people per hectare [U.S. census data]

Urban Intensity Index modeled vs. scaled



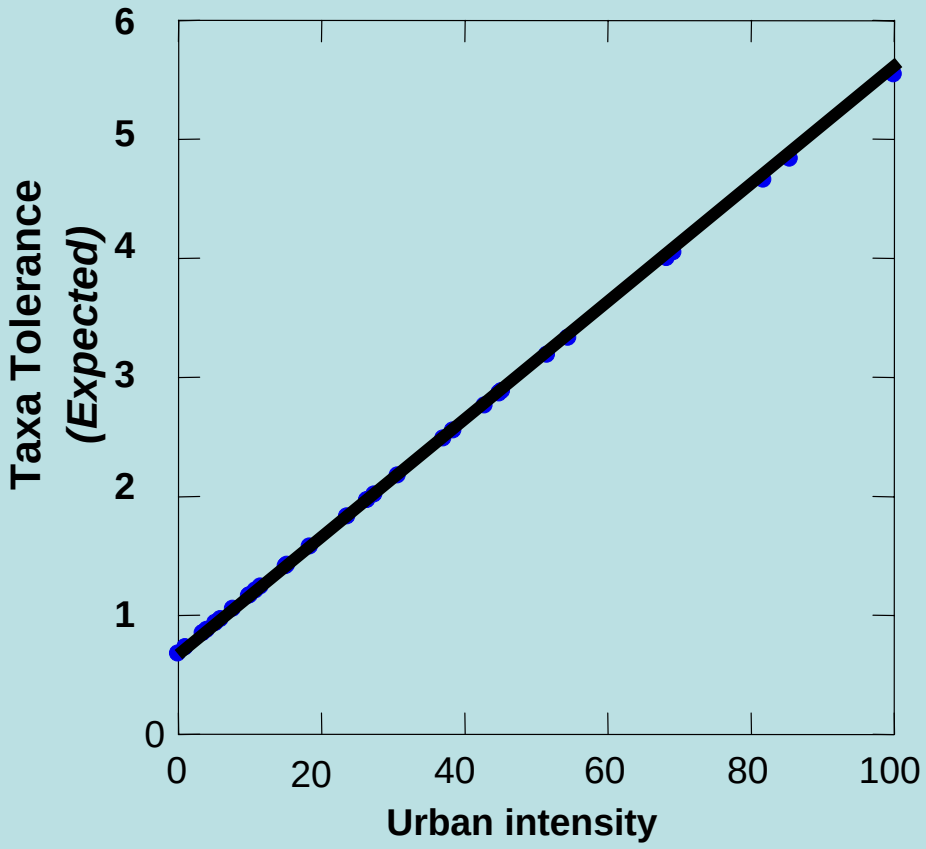


EPA Region 1 New England Wadeable Streams Project

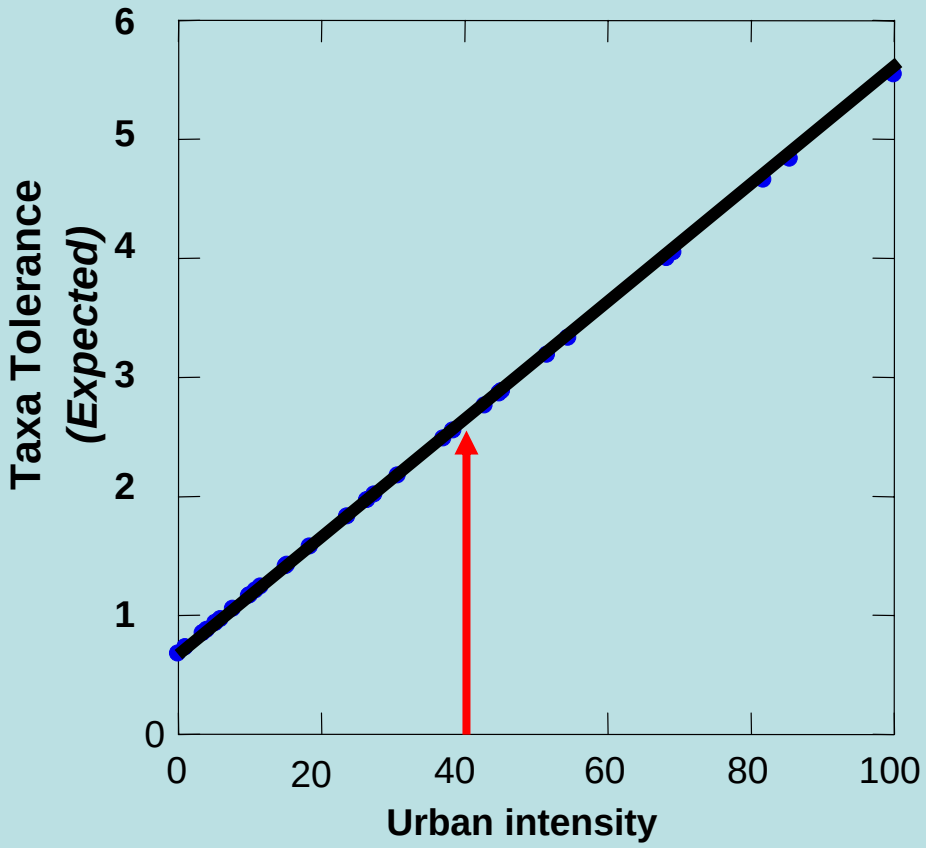
Regressions between response variables and the urban intensity index

Response Variable	Regression Coefficient (r^2)
EPT Richness (-)	0.743
% Richness non-Insects (+)	0.837
Taxa Tolerance Index (+)	0.824
WQ Index (+)	0.834

Expected stream condition based on Urban Intensity of watershed



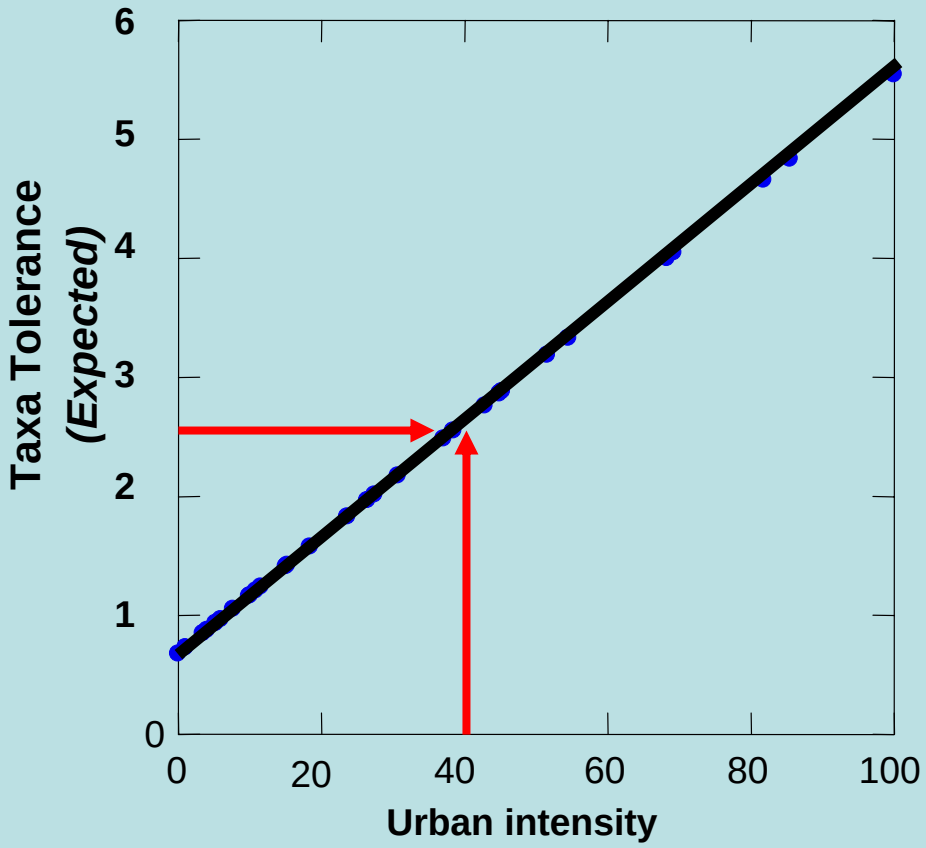
Expected stream condition based on Urban Intensity of watershed



Acme Chemical Site

- **Urban Intensity = 40**

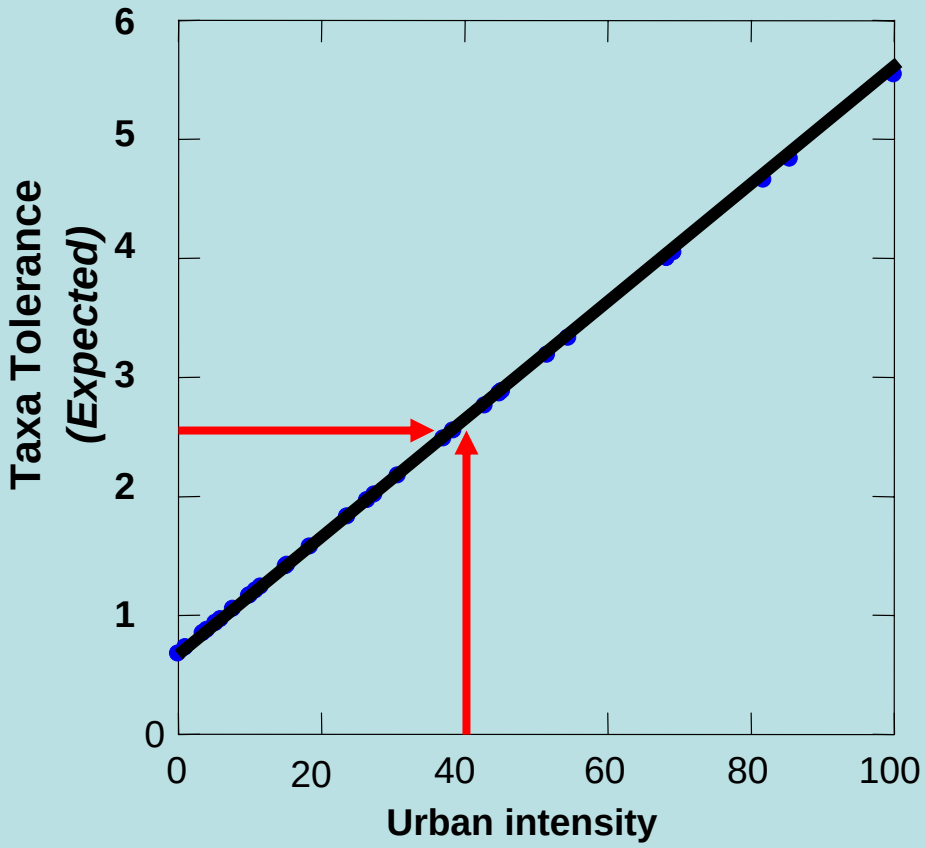
Expected stream condition based on Urban Intensity of watershed



Acme Chemical Site

- **Urban Intensity = 40**
- **Stream Condition = 2.5**

Expected stream condition based on Urban Intensity of watershed



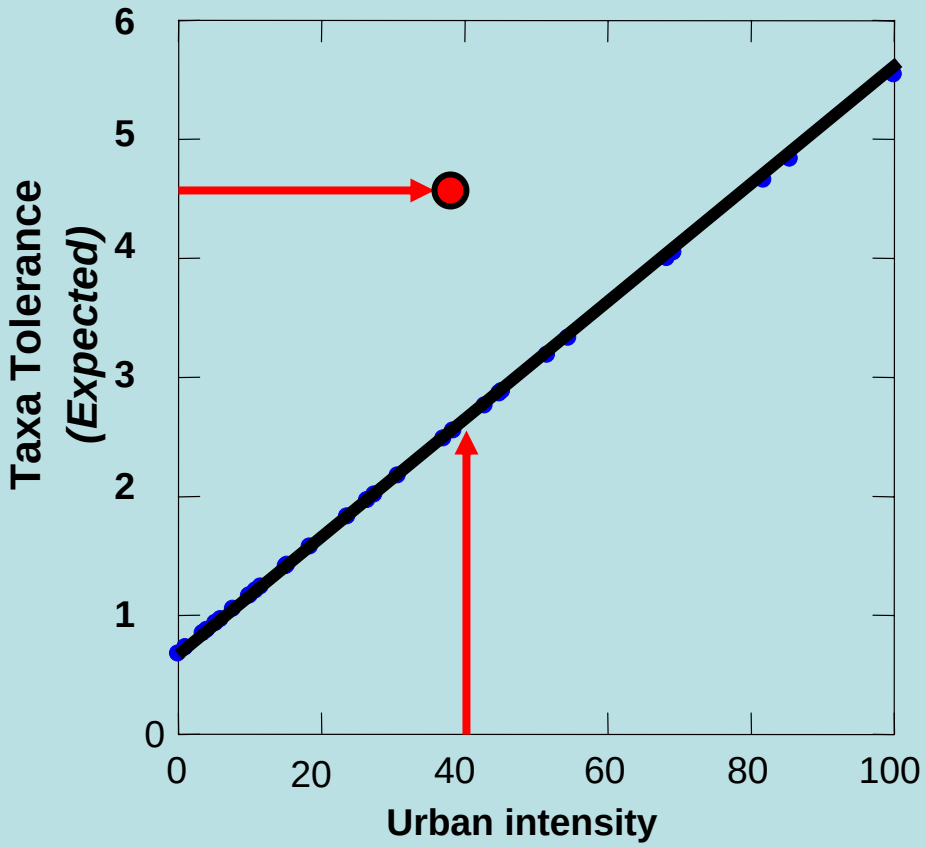
Acme Chemical Site

- **Urban Intensity = 40**
- **Stream Condition = 2.5**

CONCLUSION

No unacceptable ecological risk

Expected stream condition based on Urban Intensity of watershed



Acme Chemical Site

- **Urban Intensity = 40**
- **Stream Condition = 4.5**

CONCLUSION

Stream condition may be affected by site contamination.

Concluding Points

- Study currently being funded by EPA Region I (New England) to use this approach, which is expected to improve Ecological Risk Characterizations.
- Even a general awareness of the urban intensity of a basin is useful in making an interpretation of stream condition at a site.