Quantifying tolerance indicator values for common stream fish species of the United States

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Tolerance in Bioassessment

- Many fish species classified as
  - Tolerant
  - Moderately tolerant
  - Intolerant
- Classifications are opinion-based representing tolerance to general environmental disturbance
- "Tolerance and Trophic Guilds of Selected Fish Species" (Barbour et al. 1999)

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Quantifying Tolerance

Provides the opportunity to better utilize tolerance classifications and aid in understanding fish responses to potential stressors

1. Non-specific tolerance classifications based on expert opinion beg the question… ”TOLERANT TO WHAT”?

2. Much of the classification information may go unused. How can we use it more effectively?

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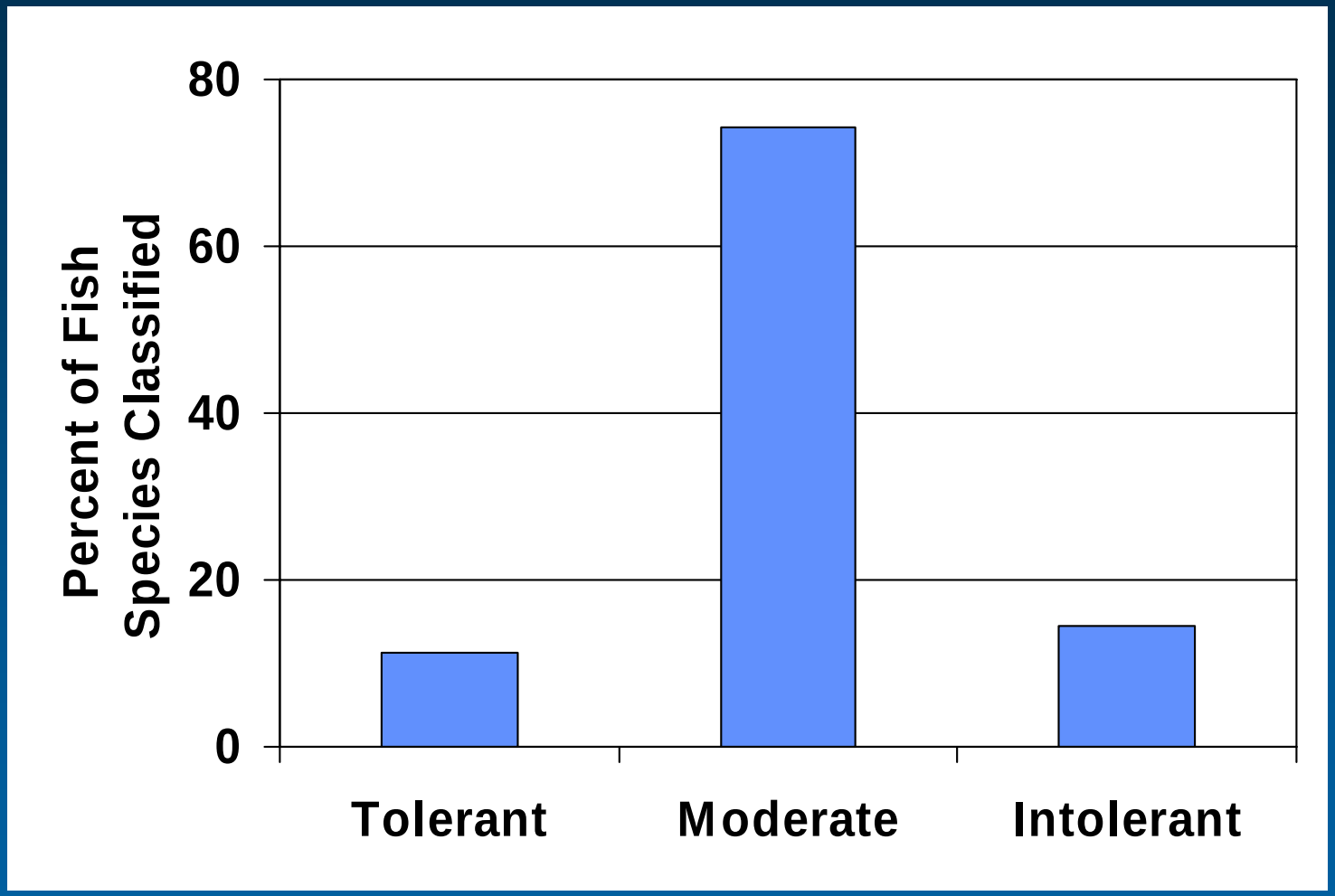
Most Species Are Classified as Moderate



Data from Barbour et al. (1999)

Fish species abundance and water-quality data collected from 1993-2004 as part of the USGS National Water-Quality Assessment Program provided the opportunity to quantify fish species tolerances to selected water-quality variables

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Objectives

- Calculate fish species tolerance indicator values (TIVs) to selected water-quality variables from a national-scale dataset
- Assess the ability of TIVs to discriminate among opinion-based tolerance classes
- Application example: Use TIVs to assess relations between fish assemblages and urbanization

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Study Area

- Data were collected from 773 stream sites
- Combined these sites are located downstream of basins that drain 43% of the total km of streams and rivers in the Nation

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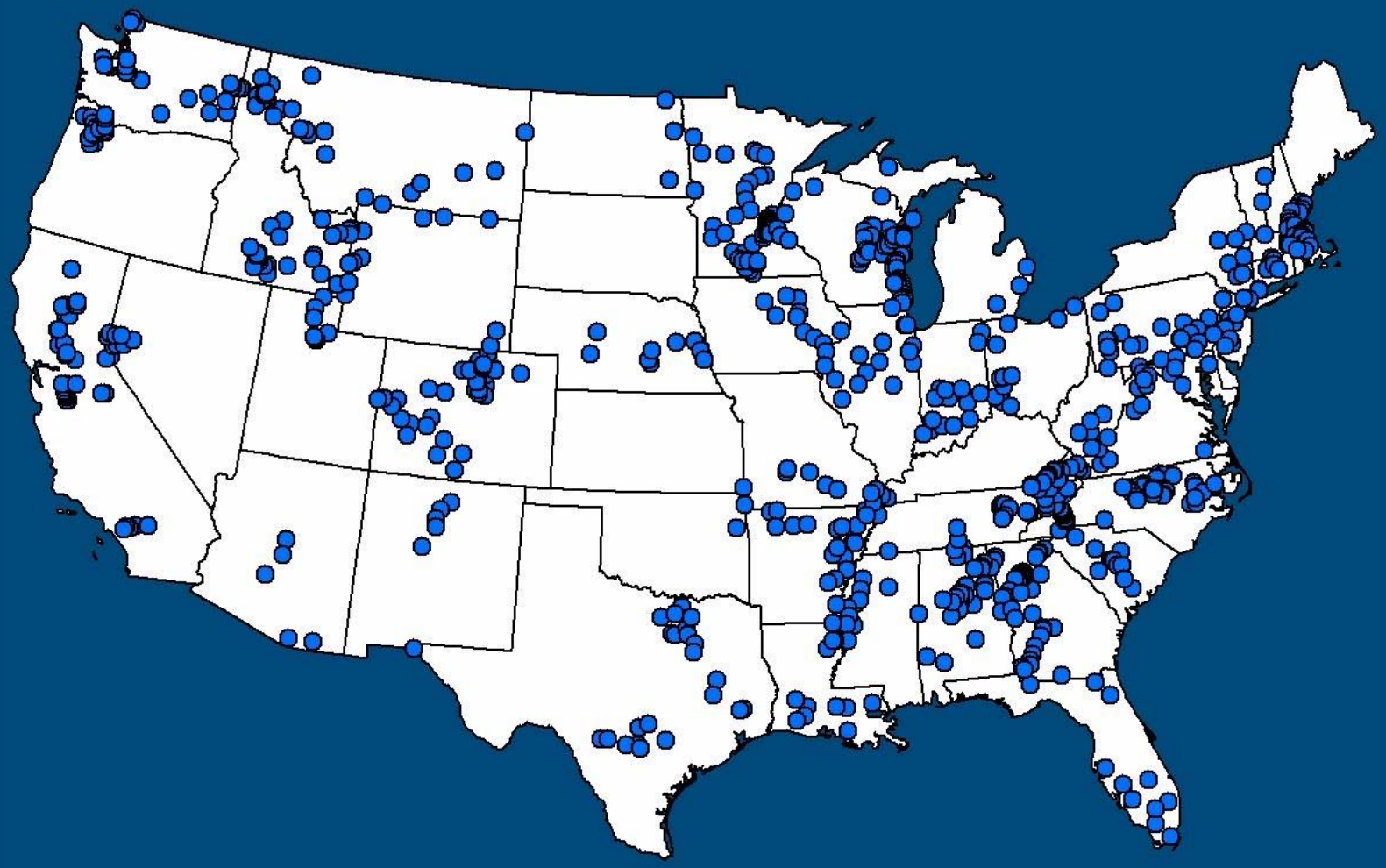
773 Fish and Water-Quality Sampling Sites



Methods

- Fish collected during summer low-flow periods using a standard sampling protocol

- Water-quality variables sampled during summer low-flow periods using standardized methods and collected within 14 days of fish sampling

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Methods

10 water-quality variables:

- ammonia (mg/L)
- chloride (mg/L)
- dissolved oxygen (mg/L)
- nitrate plus nitrite (mg/L)
- pH
- specific conductance (μS/cm at 25 ^{o}C)
- sulfate (mg/L)
- suspended sediment (mg/L)
- total phosphorus (mg/L)
- water temperature (^{o}C)

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Data Analysis

- TIVs calculated as predictors of water-quality (WQ) variables using fish abundance weighted averaging (WA)
- Included species collected from > 60 samples and >100 individuals total (all sites combined)

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Creating TIVs

- Transformed weighted averages to ordinal ranks (1-10)
- Ordinal rank of each species was assigned based on the percentiles of WAs across all species for each WQ variable
- A rank of 1 reflected the lowest 10% of WAs whereas a rank of 10 reflected the highest 10% of WAs (except for dissolved oxygen)

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Data Analysis

- Principal components analysis used to assess the ability of TIVs to discriminate among opinion-based tolerance classes

- Provides a means to look at patterns in the data and identify factors that help explain those patterns

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Results

- 1,734 fish assemblage samples
- 583,666 individuals
- 485 fish species

- TIVs were calculated for:
  - 105 fish species
  - 457,882 individuals

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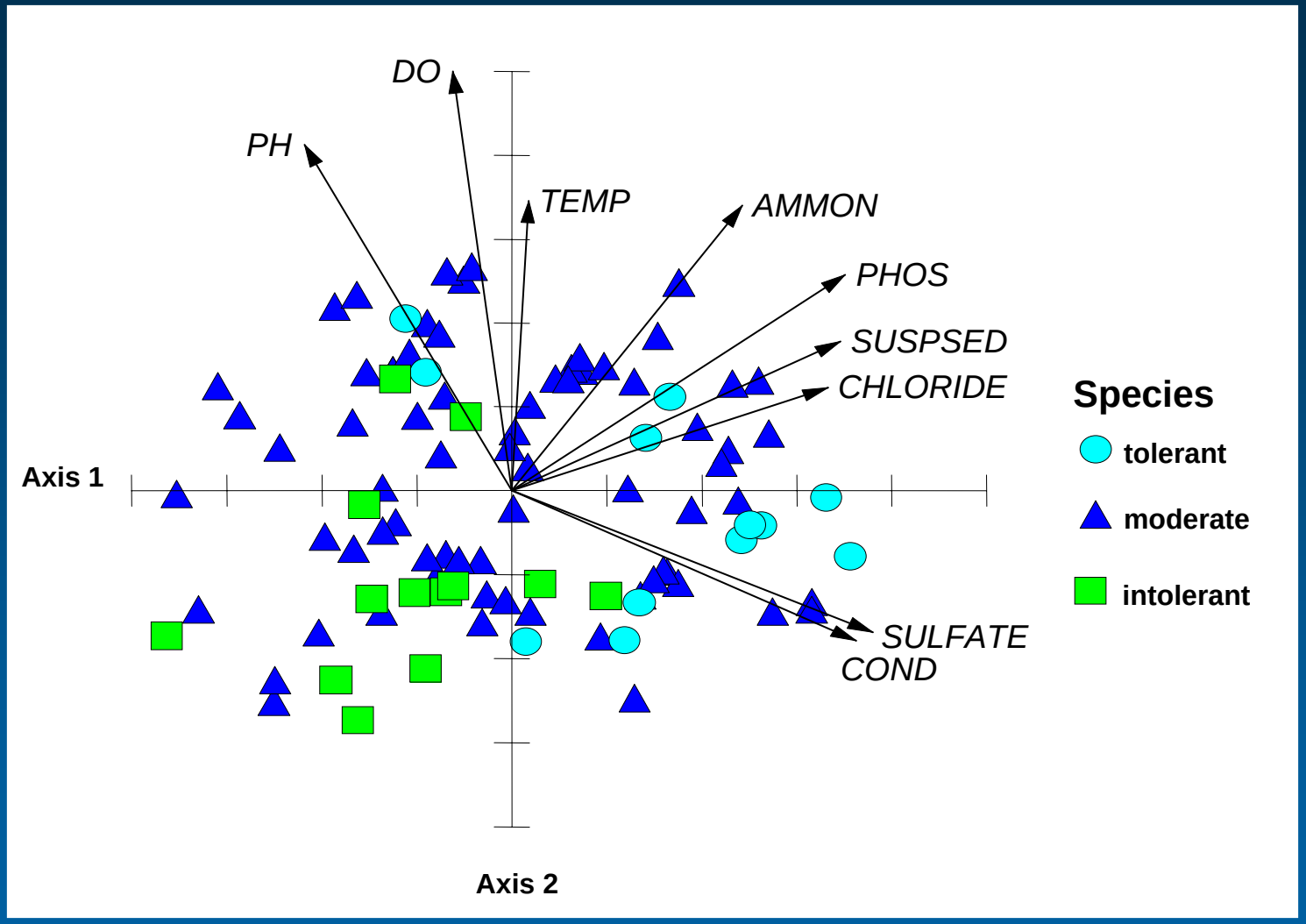
TIVs Discriminate Among Tolerance Classes



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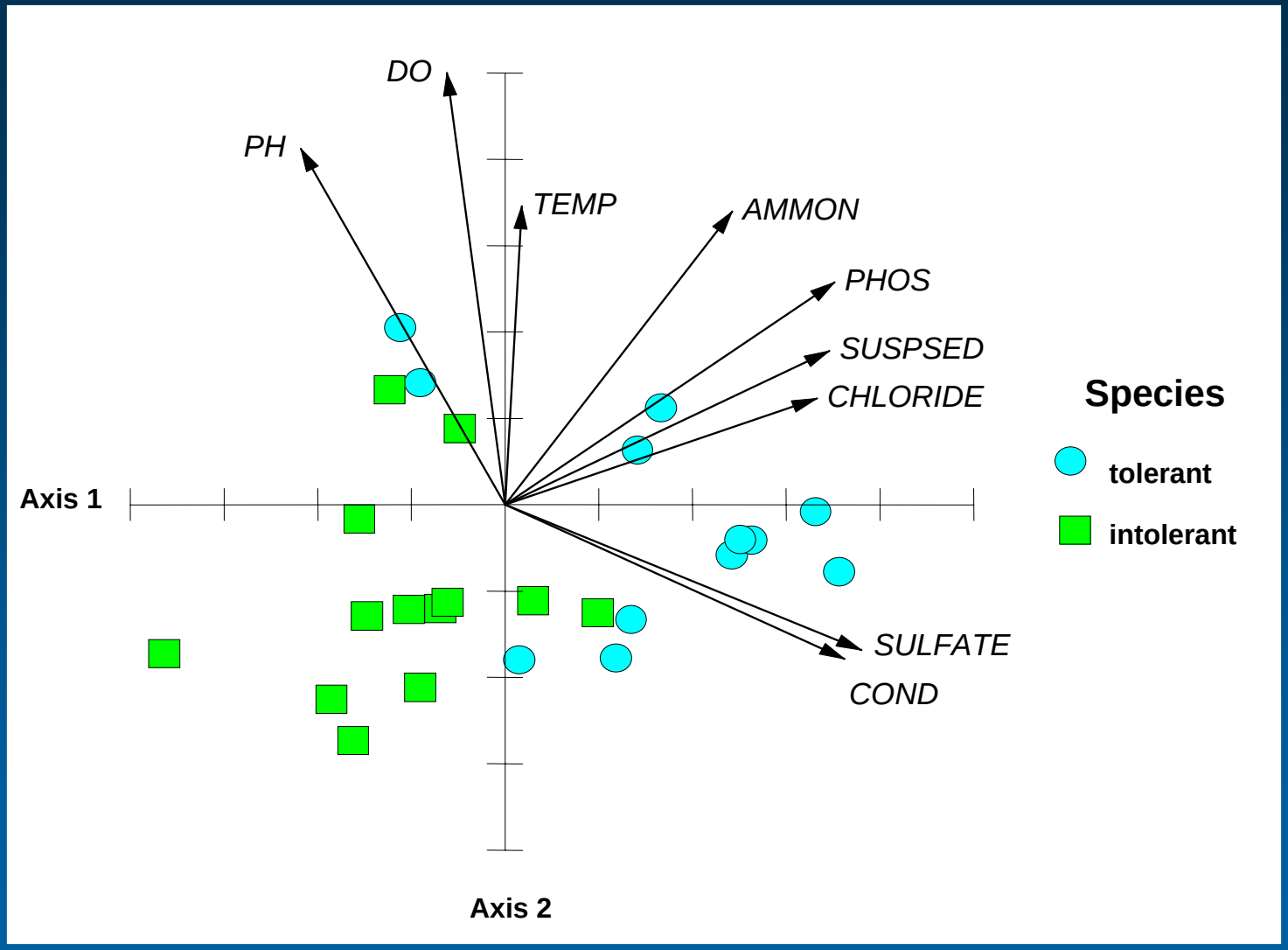
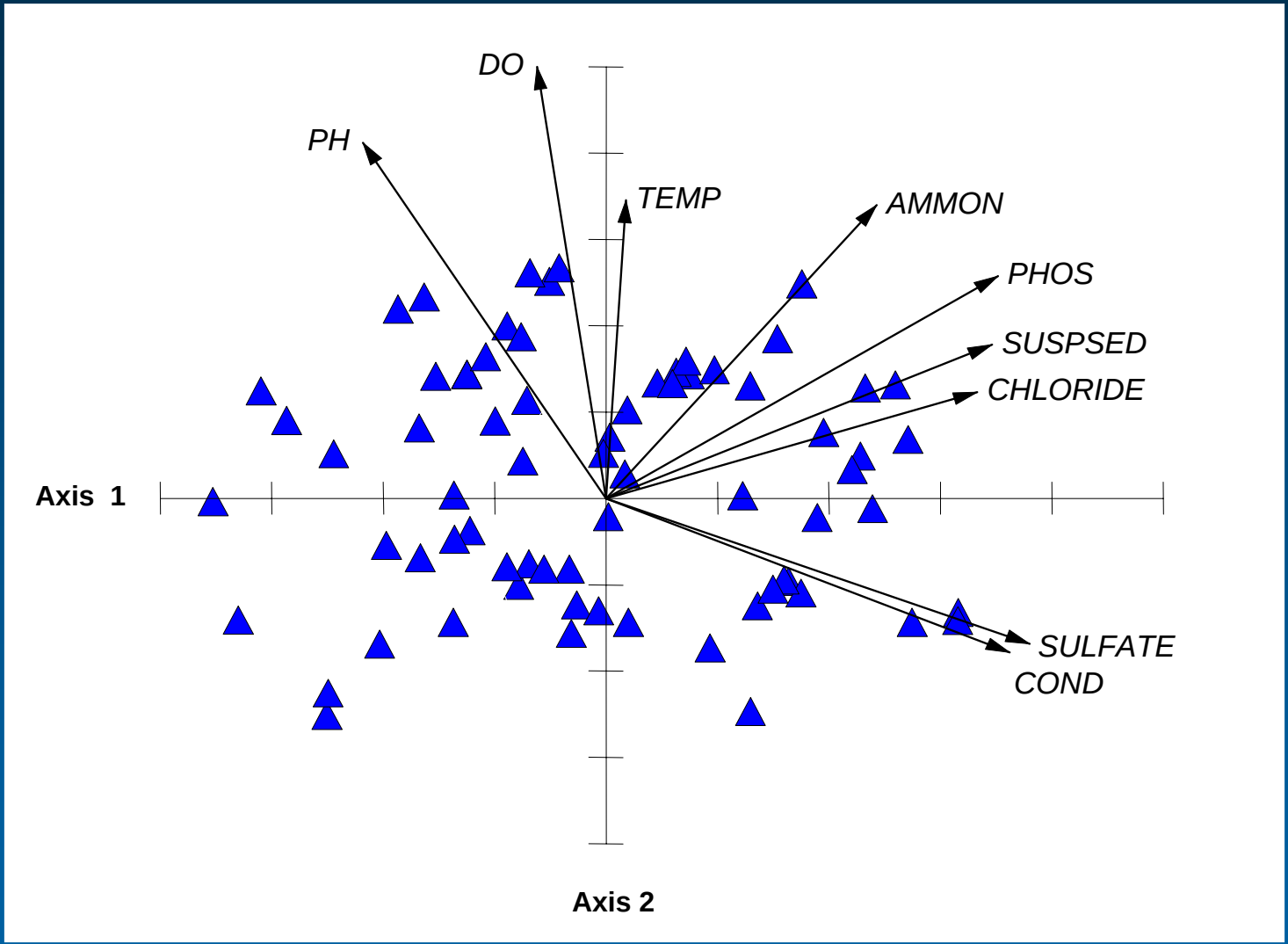
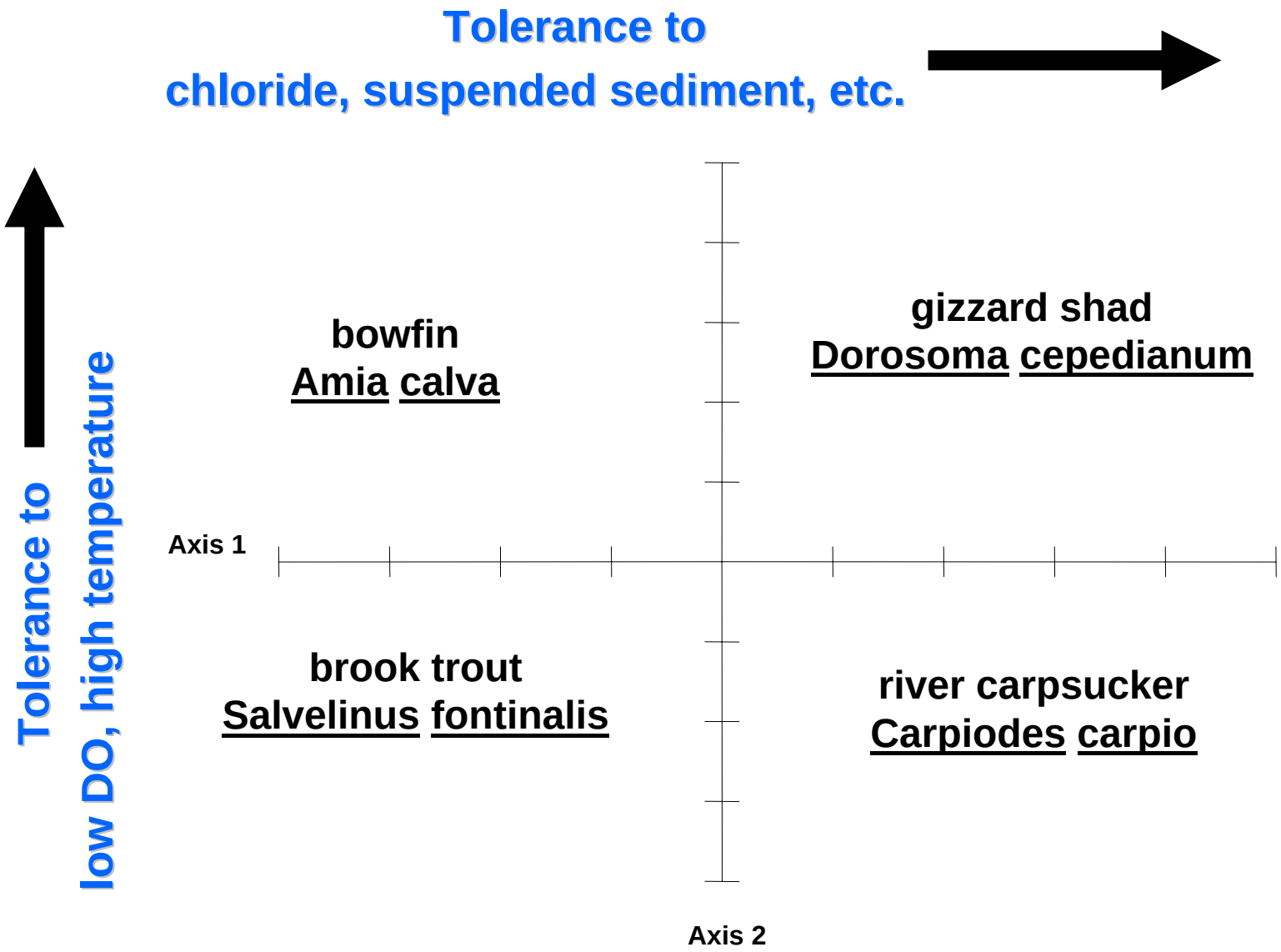
TIVs Distinguish Between Tolerant and Intolerant

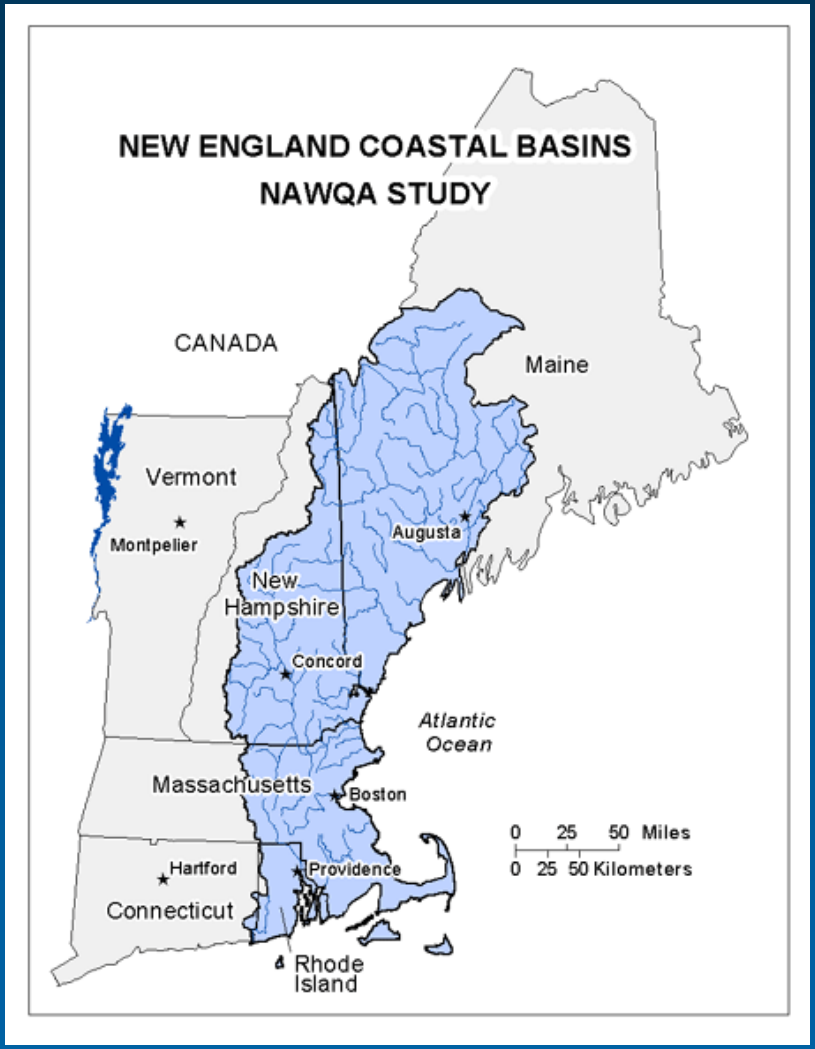


TIVs Can Be Used To Categorize Moderate




Tolerance to
chloride, suspended sediment, etc.
Tolerance to
low DO, high temperature
bowfin
Amia calva
gizzard shad
Dorosoma cepedianum
Axis 1
brook trout
Salvelinus fontinalis
river carpsucker
Carpiodes carpio
Axis 2

Application example:
Using TIVs to assess relations between fish assemblages and urbanization



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Application example: Data Analysis

- Species TIVs were averaged for each of 30 sites to determine a mean TIV representing a fish assemblage for each WQ variable

- Correlation analysis conducted to assess relations between mean TIVs and road density within a basin

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Use of TIVs in Stressor Diagnosis

Correlations with Road Density

STRESSOR	P	rho
Ions and pH (Chloride and ammonia) and pH	0.001	0.71
DO and Temperature	0.001	0.62
Conductivity and sulfate	0.001	-0.63
Suspended sediment	0.087	0.32
Nutrients (Phosphorus and nitrate/nitrite)	0.521	0.12

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Conclusions

1. Tolerant to what? – Tolerance variables identified
2. Can use classifications of moderate more effectively -
   - Fish species are tolerant to some stressors while less tolerant to others
3. TIVs have potential in stressor diagnosis

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Cautions

- Opinion-based classifications include habitat
- Chemical stressors may co-vary
- Wide range of environmental conditions sampled and the ordinal ranking approach robust to geographic variation

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http://water.usgs.gov/nawqa/ecology