

An overview of CADDIS and ongoing systematic reviews of nutrient-stressor response relationships

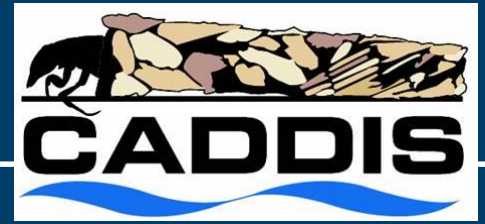
Kate Schofield, Micah Bennett, Sylvia Lee, Caroline Ridley, and Sue Norton



Office of Research and Development
National Center for Environmental Assessment

National Training Workshop for CWA 303(d) and TMDL Staff
May 30, 2019 – Shepherdstown, WV

What is CADDIS?



- Causal Analysis/Diagnosis Decision Information System
- Website that helps users conduct causal assessments of stream biological impairment
 - Strength of evidence based framework for stressor identification
 - Information on specific stressors, data analysis methods, etc.
 - Case studies
 - Tools for data analysis and literature evaluation



Causal Analysis/Diagnosis Decision Information System (CADDIS)

The Causal Analysis/Diagnosis Decision Information System, or CADDIS, is designed to help scientists and engineers in the Regions, States, and Tribes conduct causal assessments in aquatic systems. It is organized into five volumes.

Learn About CADDIS



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Volume 1: Stressor Identification



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Volume 2: Sources, Stressors and Responses



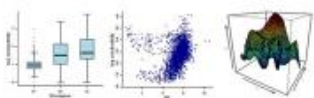
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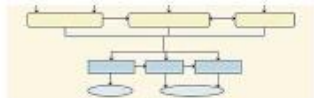
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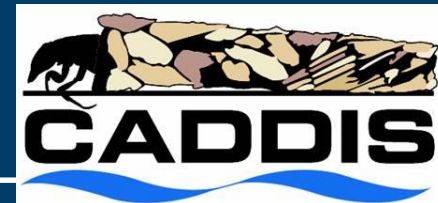


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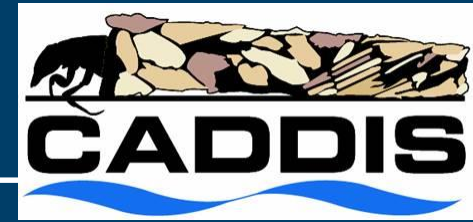


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Vol 1: Stressor Identification



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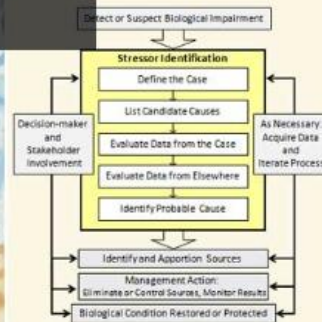
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Stressor Identification



Volume 1. Stressor Identification

The causal assessment process used in CADDIS is derived from the *Stressor Identification Guidance Document*. The method weighs all relevant evidence to identify the most likely cause or causes of undesirable biological effects.

- Step-by-Step Guide
- Causal Assessment Background

Basic Information

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- [Causal Concepts](#)
- [Frequent Questions](#)
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Step-by-Step Guidance

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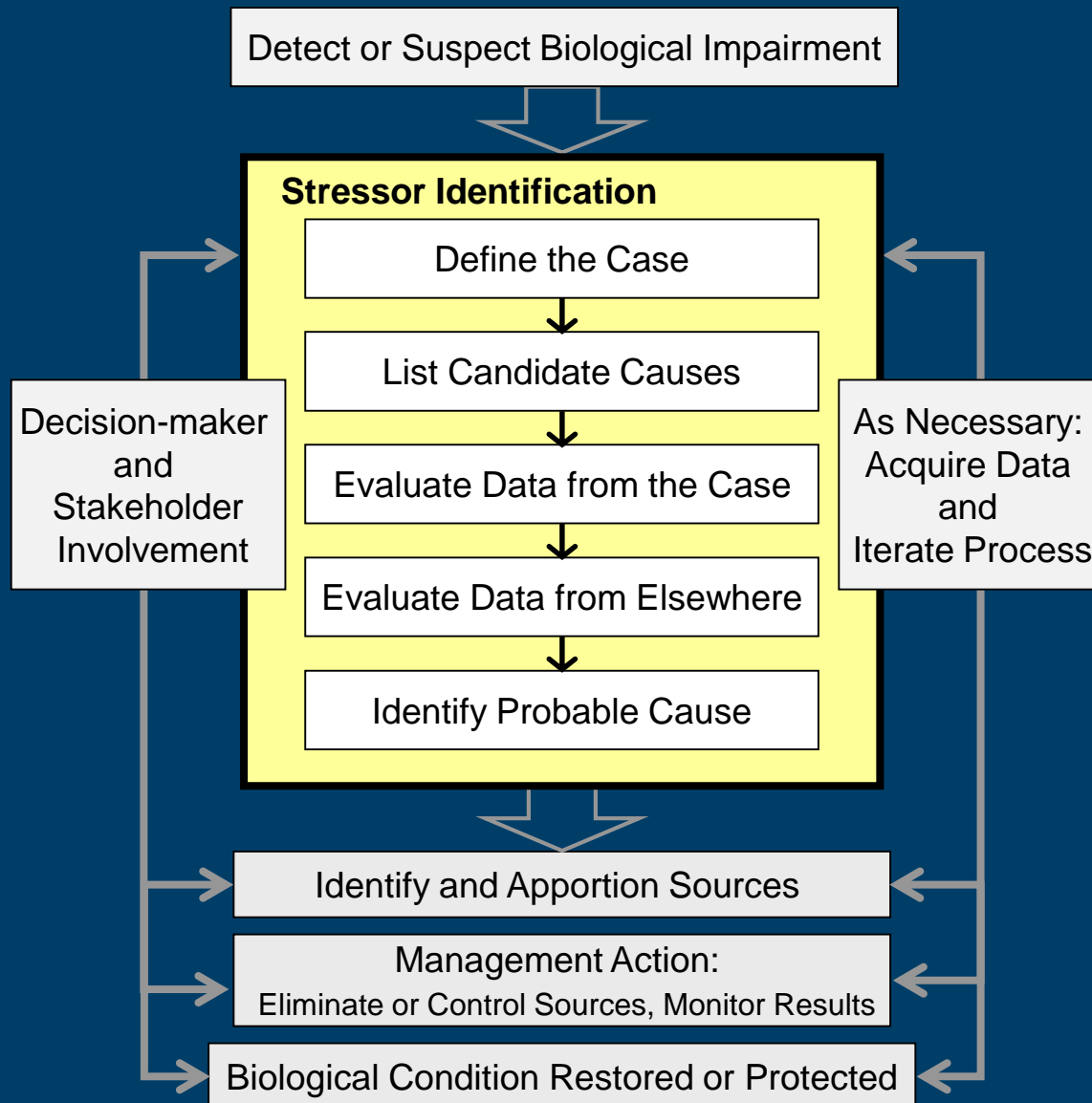
Tools and Tables

- [Quantifying Uncertainty](#)
- [Types of Evidence Tables](#)
- [Scoring Tables](#)
 - [Scoring the Evidence](#)
- [Tips for Listing Candidate Causes](#)
- [Listing Multiple Stressors](#)

Related Information

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The SI Process



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Step 1. Define the Case

Overview

In-Depth Look

Results and Next Steps

The Stressor Identification process begins by **defining the subject** for analysis (i.e., the case, Figure 1-1). This is accomplished by determining the investigation's geographic scope and the effects to be analyzed. The case definition is foundational for causal analysis: it influences what information is assembled, which causes are considered and how conclusions are presented. For this reason, it is important to get input from managers and stakeholders at this early stage.

Causal analysis is triggered by the observation of a biological effect, including:

- Kills of fish, invertebrates, plants, domestic animals, or wildlife;
- Anomalies in any life form, such as tumors, lesions, parasites, or disease;
- Changes in community structure, such as loss of species or shifts in species abundance (e.g., increased algal blooms, loss of mussel species, increases in tolerant species);
- Response of indicators designed to monitor or detect biological condition, such as the Index of Biotic Integrity (IBI) or the Invertebrate Community Index (ICI);
- Changes in organism behavior;
- Changes in population structure, such as population age or size distribution;
- Changes in ecosystem function, such as nutrient cycles, respiration, or photosynthetic rates;
- Changes in the area or pattern of different ecosystems, such as shrinking wetlands or increased sandbar habitats.

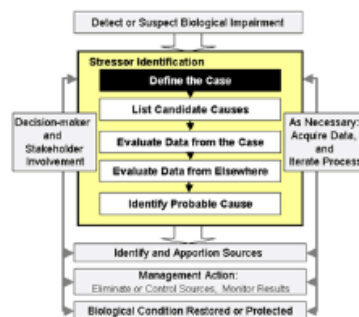


Figure 1-1. Illustration of where Step 1: Define the Case fits into the Stressor Identification process.

- Overview
- In-Depth Look
- Results and Next Steps



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About Causal Assessment

Getting Started

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Step 3. Evaluate Data from the Case

Spatial/Temporal Co-occurrence

Evidence of Exposure

Causal Pathway

Stressor-Response Relationships

Manipulation of Exposure

Laboratory Tests

Temporal Sequence

Verified Predictions

Symptoms

Step 4. Evaluate Data from Elsewhere

Step 5. Identify Probable Causes

Summary Tables of Types of Evidence

Summary Tables of Scores

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Spatial/Temporal Co-occurrence Concept

Spatial/Temporal Co-occurrence: The biological effect must be observed where and when the cause is observed, and must not be observed where and when the cause is absent.



Figure 3-1a. Spatial/Temporal Co-occurrence with Upstream/Downstream Comparisons, Supports.

[Click for more information](#)



Figure 3-1b. Spatial/Temporal Co-occurrence with Upstream/Downstream Comparisons, Refutes.

[Click for more information](#)

[Additional Illustrations of Spatial/Temporal Co-occurrence](#)

Examples

Consider increased suspended solid concentrations as a candidate cause of reduced aquatic invertebrate abundance. What findings support or weaken the case for increased suspended solids as the cause, based on spatial/temporal co-occurrence?

- Supporting evidence (spatial co-occurrence) - Suspended solid concentrations are higher at the impaired site(s) than at unimpaired reference sites.
- Supporting evidence (temporal co-occurrence) - Suspended solid concentrations are episodic, and

Helpful Links

- [Concept](#)
- [Examples](#)
- [How Do I Analyze the Data?](#)
- [What Evidence Would Support or Weaken the Case for a Candidate Cause?](#)
- [How Do I Score the Evidence?](#)
- [Helpful Tips](#)

Additional Resources

- [Types of Evidence that Use Data from the Case](#)
- [Types of Evidence that Use Data from the Elsewhere](#)
- [Summary Tables of Scores](#)
- Back to [Evaluate Data from the Case, In-Depth Look](#)



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Summary Tables of Scores

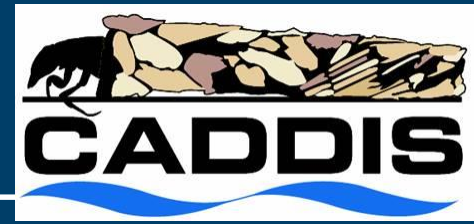
Types of Evidence that Use Data from the Case

Types of Evidence that Use Data from Elsewhere

Evaluating Multiple Types of Evidence

Type of Evidence	Finding	Interpretation	Score
Spatial/Temporal Co-occurrence	The effect occurs where or when the candidate cause occurs, OR the effect does not occur where or when the candidate cause does not occur.	This finding <i>somewhat supports</i> the case for the candidate cause, but is not strongly supportive because the association could be coincidental.	+
	It is uncertain whether the candidate cause and the effect co-occur.	This finding <i>neither supports nor weakens</i> the case for the candidate cause, because the evidence is ambiguous.	0
	The effect does not occur where or when the candidate cause occurs, OR the effect occurs where or when the candidate cause does not occur.	This finding <i>convincingly weakens</i> the case for the candidate cause, because causes must co-occur with their effects.	---
	The effect does not occur where and when the candidate cause occurs, OR the effect occurs where or when the candidate cause does not occur, and the evidence is indisputable.	This finding <i>refutes</i> the case for the candidate cause, because causes must co-occur with their effects.	R


Vol 2: Sources, Stressors & Responses




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CADDIS Volume 2

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Sources, Stressors and Responses

Volume 2. Sources, Stressors, Responses

This volume of CADDIS provides useful information on common sources, stressors and responses. This information helps you decide which candidate causes to include in your assessment and develop cases for or against those causes.

Basic Information

- [Learn About Sources](#)
 - [Urbanization](#)
- [Learn About Stressors](#)
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Stressors (A-M)

- [Ammonia](#)
- [Dissolved Oxygen](#)
- [Flow Alteration](#)
- [Herbicides](#)
- [Insecticides](#)
- [Ionic Strength](#)
- [Metals](#)

Stressors (N-Z)

- [Nutrients](#)
- [pH](#)
- [Physical Habitat](#)
- [Sediments](#)
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- [Unspecified Toxics](#)

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[Contact Us](#) to ask a question, provide feedback, or report a problem.

- Ammonia
- Dissolved oxygen
- Flow alteration
- Herbicides
- Insecticides
- Ionic Strength
- Metals
- Nutrients
- pH
- Physical Habitat
- Sediments
- Temperature
- Unspecified Toxics
- **Urbanization**

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Temperature

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- [Checklist of Sources, Site Evidence and Biological Effects](#)
 - [Consider Listing Temperature as a Candidate Cause](#)
 - [Consider Contributing, Modifying and Related Factors as Candidate Causes](#)



Figure 1. Major heat flux processes in streams. Click diagram to view a larger version.

Adapted from Moore et al. (2005) and Johnson and Jones (2000)

Temperature is the concentration of thermal energy in a substance such as water. The phrase "thermal regime" is used when emphasizing the temporal and spatial distribution of temperature.

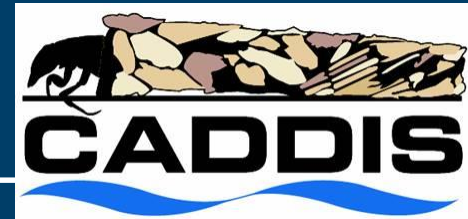
Temperatures in streams and rivers are influenced by many atmospheric and hydrologic processes affecting the movement of heat (see Figure 1). In turn, temperature plays a fundamental role in shaping the structure and function of aquatic systems (see Table 1). It is frequently used as a basis for classifying streams (e.g., coldwater, warmwater).

This module provides advice for deciding whether to include temperature in your list of candidate causes. You may go directly to a specific section of interest by clicking on the tabs above.

Table 1. Example Attributes of Aquatic Ecosystems Affected by Temperature

Category	Example Attributes
Physical	Water density, thermal stratification, solubility of oxygen and other chemicals

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Examples and Applications



Volume 3. Examples and Applications

The examples in this section show how the CADDIS framework has been applied to both aquatic and terrestrial effects. They illustrate applications representing a variety of locations, stressors, and affected species or communities.

Analytical Examples

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 - [Spatial Co-occurrence](#)
 - [Verified Prediction \(PECBO\)](#)
 - [Stressor-Response from the Field](#)
 - [Stressor-Response from the Lab](#)
 - [Verified Prediction \(Traits\)](#)

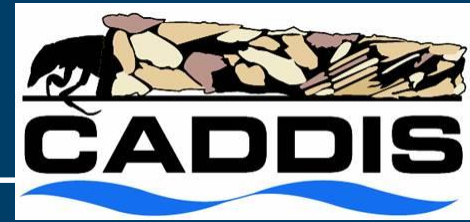
Case Studies and Examples

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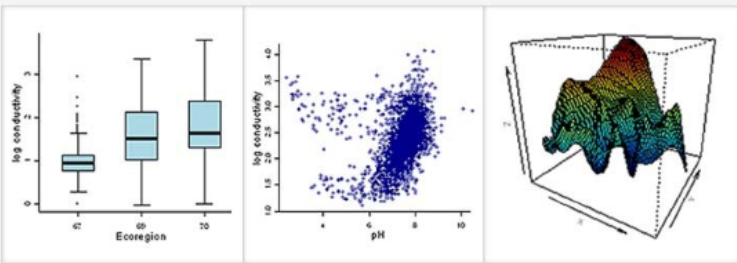
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Data Analysis



Volume 4. Data Analysis

This volume of CADDIS provides useful information on different analytical techniques that can be applied to causal analysis.

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- [Selecting an Analysis Approach](#)
- [Getting Started with Data Analysis](#)
- [Basic Principles and Issues](#)
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- [Download Software](#)



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- [CADStat](#)
- [Classification and Regression Trees](#)
- [Conditional Probability](#)
- [Confidence Intervals](#)
- [Confounding](#)
- [Controlling for Natural Variability](#)

Data Analysis Topics (C-R)

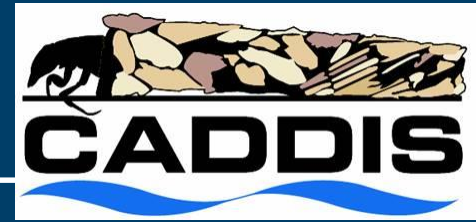
- [Correlation Analysis](#)
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- [Propensity Scores](#)
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- [Scatterplots](#)
- [Spatial Analysis and GIS](#)
- [Species Sensitivity Distributions \(SSDs\)](#)
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- CADStat
- SSD Generator
- R Command Line Tutorial

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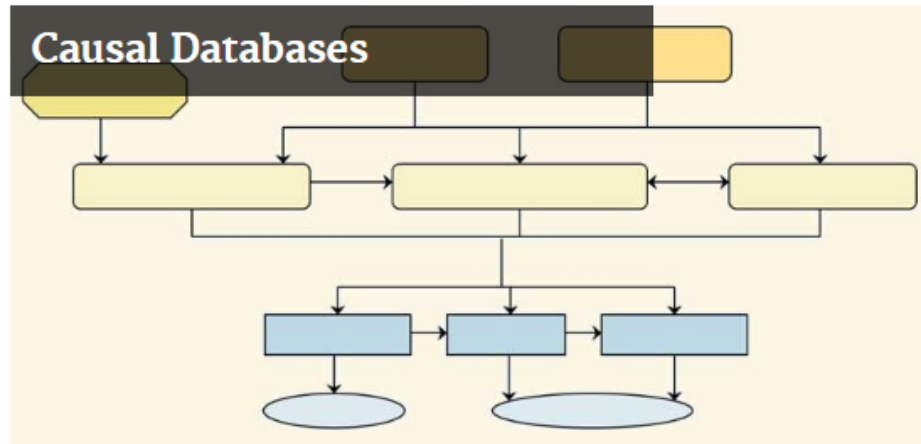
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Causal Databases



Volume 5. Causal Databases

Causal assessments rely on evidence from the literature to support or refute causal relationships. This volume provides tools for creating conceptual model diagrams and finding relevant literature-based information to help evaluate different causal pathways.

Interactive Conceptual Diagrams (ICDs)

- [Learn about ICDs](#)
- [User Guide](#)
- [Quick Start Instructions](#)
- [Open the Application](#)

Literature Database

- [CADLink - CADDIS Literature Database](#)
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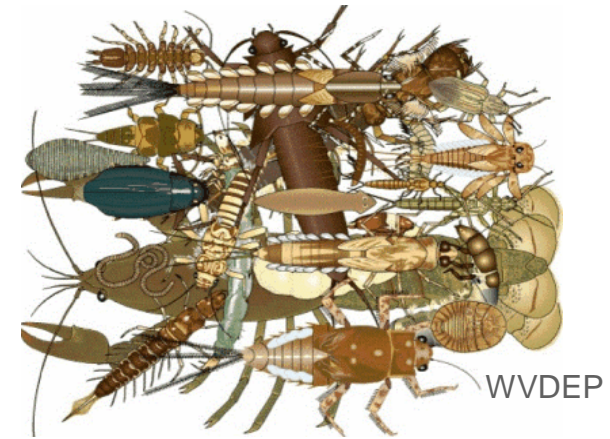
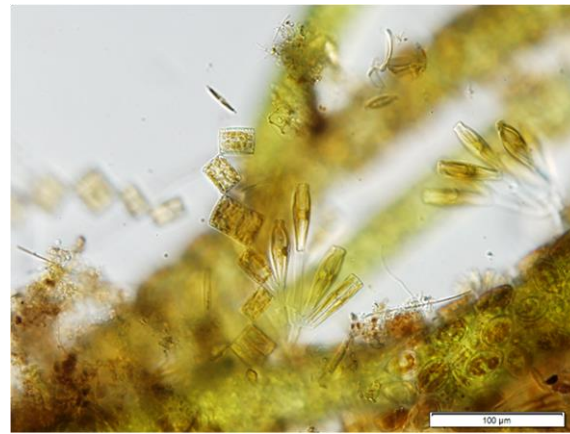
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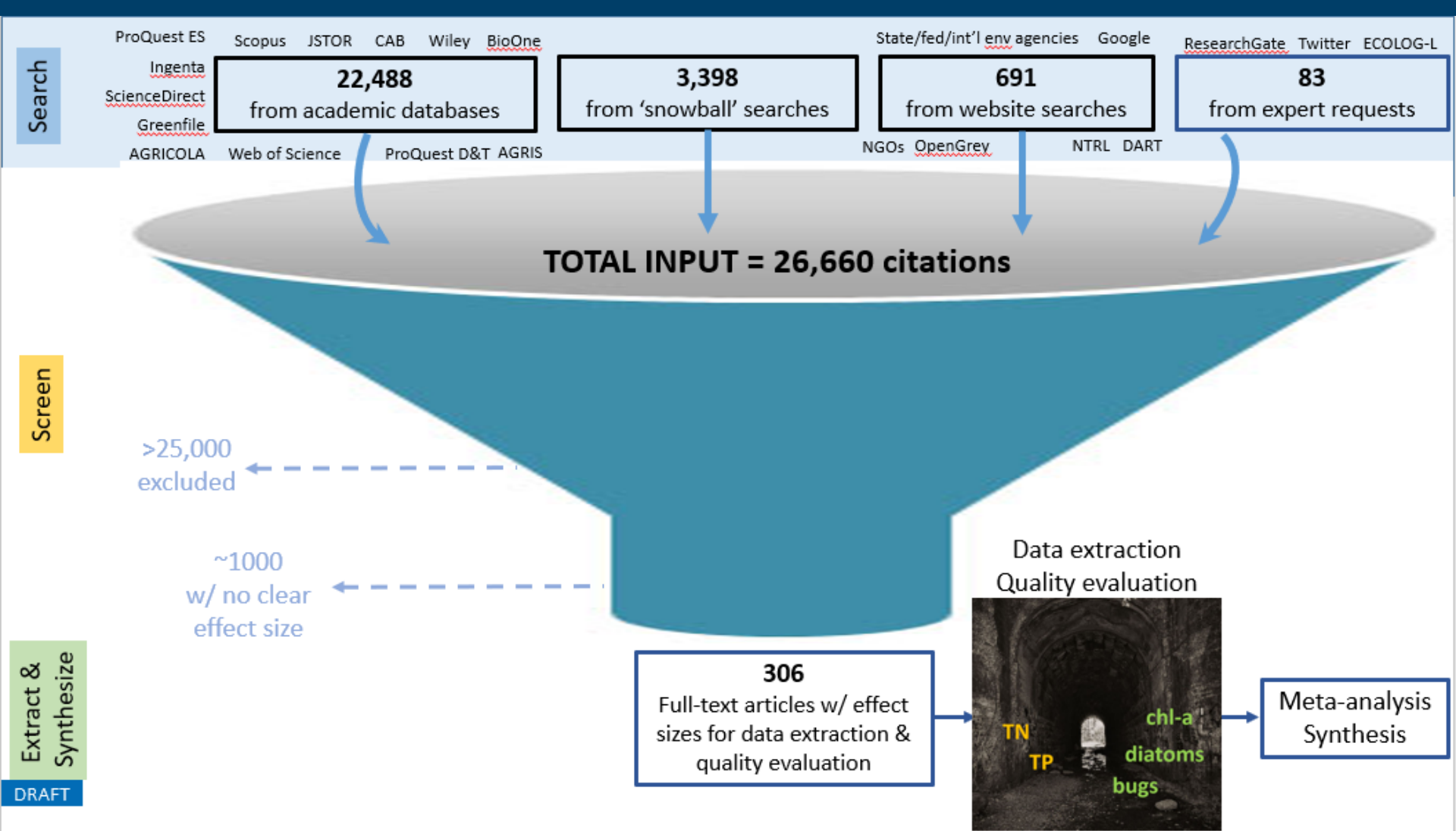
- CADLink
- ICD (*)

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Systematic review of nutrient stressor-response relationships

- What are the responses of **chlorophyll-*a***, **diatoms**, and **macroinvertebrates** to **total nitrogen (TN)** and **total phosphorus (TP)** concentrations in lotic ecosystems?
- How are these relationships affected by other factors?



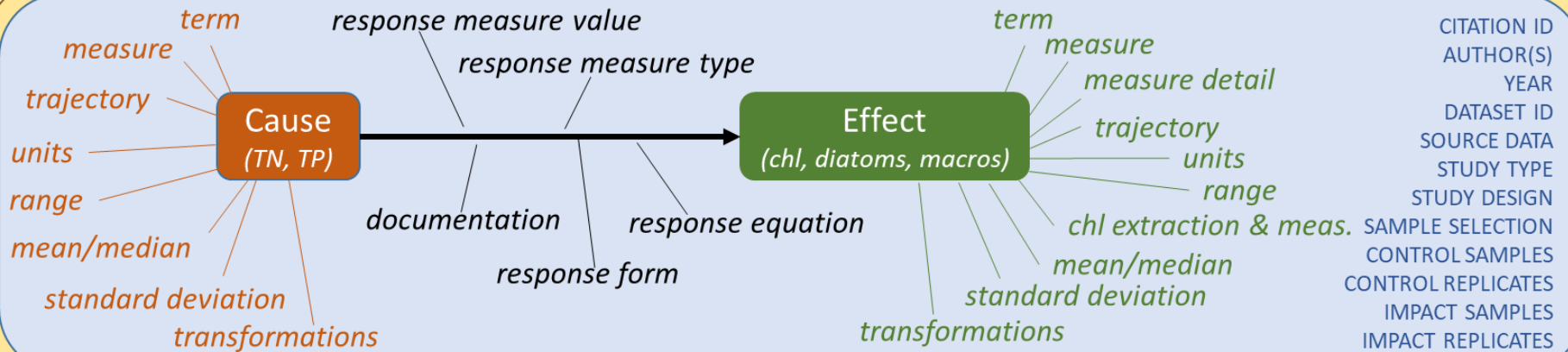


Cause
(TN, TP)



Effect
(chl, diatoms, macros)

Study Design



In-stream factors

pH	light
sediment load	canopy cover
suspended sediment	conductivity
temperature	elevation
alkalinity	habitat
discharge	dominant substrata
flow permanence	channel width
velocity	dissolved organic C
dissolved oxygen	water depth
turbidity	dissolved nutrient conc.

Regional/landscape factors

climate

dominant land use

latitude/longitude

stream order

watershed area

ecoregion

precipitation

elevation

slope/gradient

Other context

state/province

country

sample year

sample month

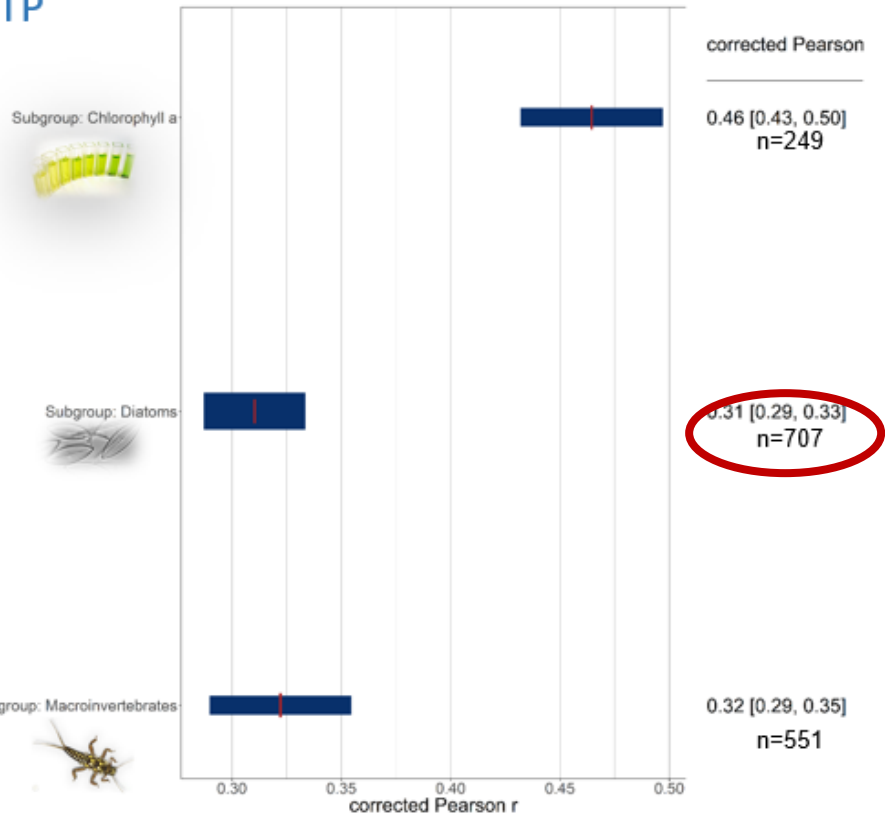
temporal extent

spatial extent

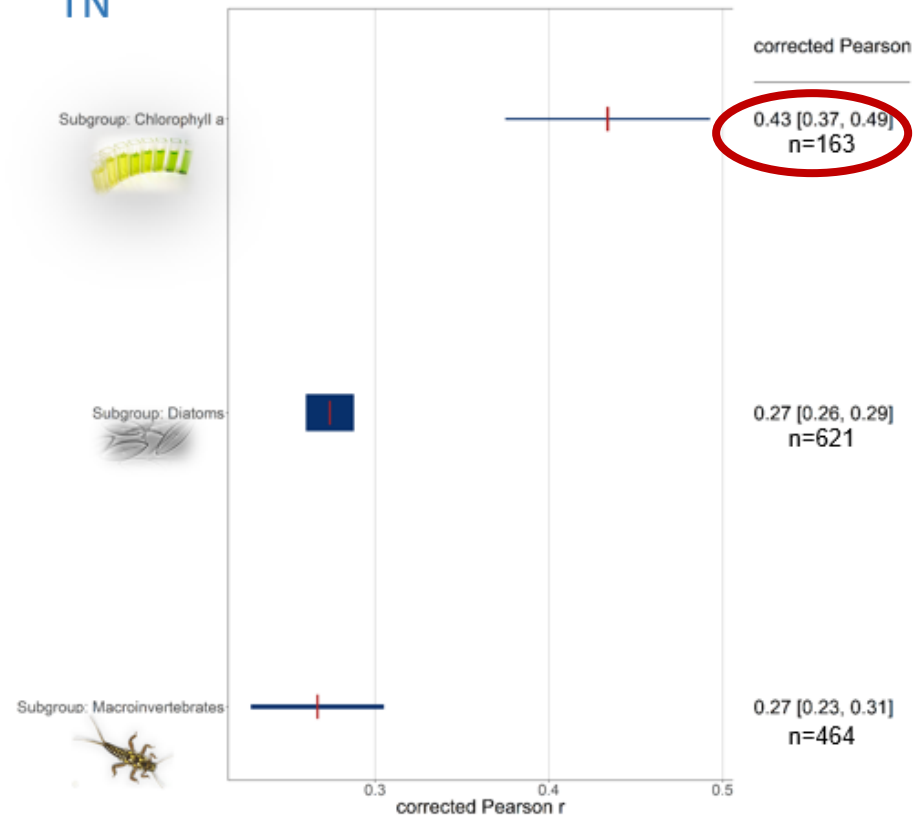
Modifying/confounding factors

How do biota respond to stressors?

TP

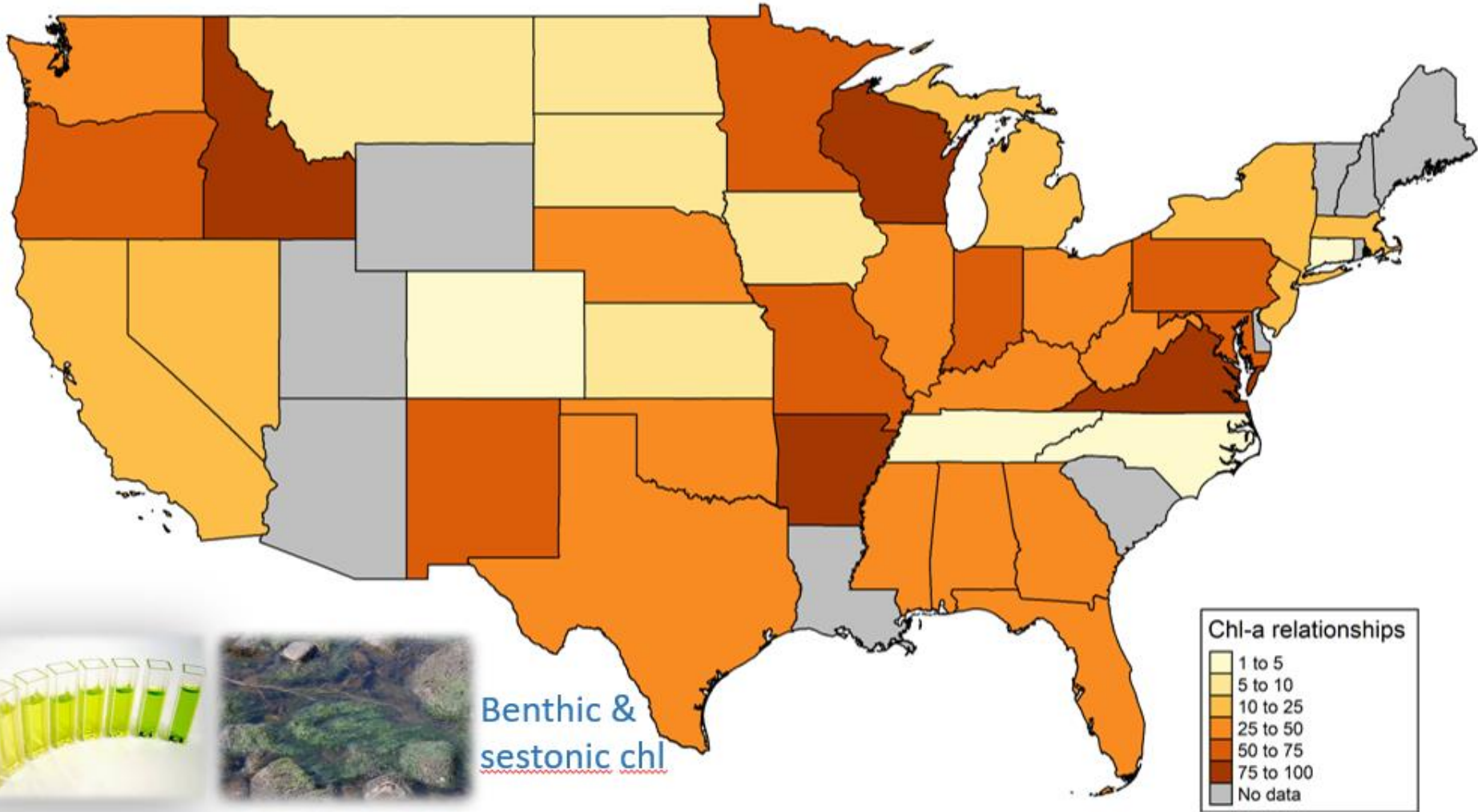


TN

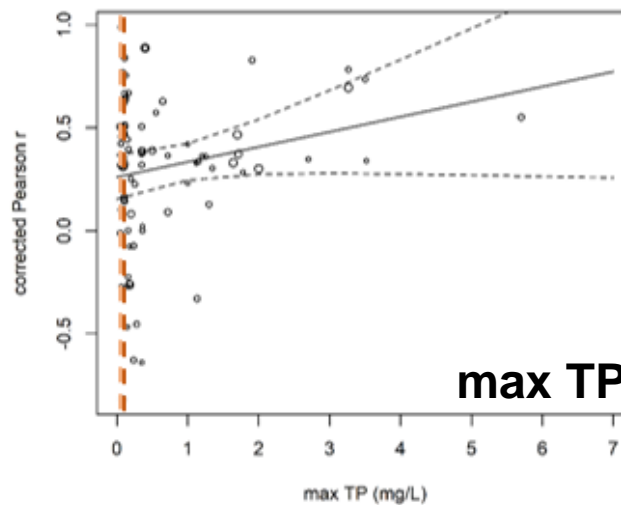
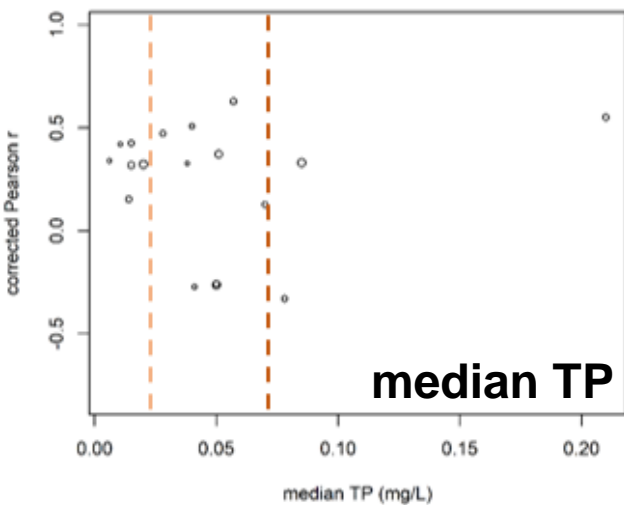
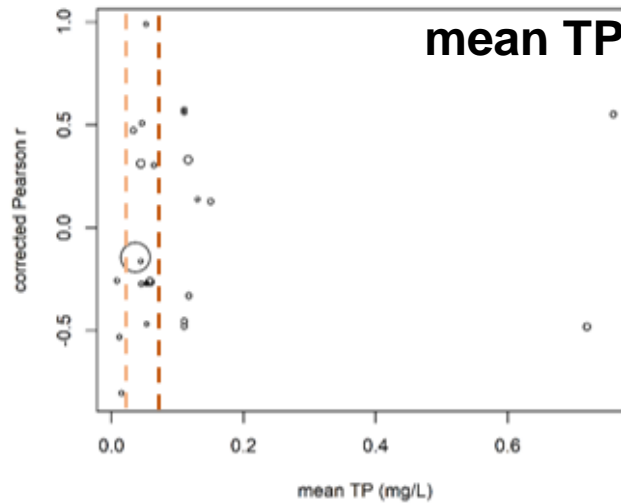
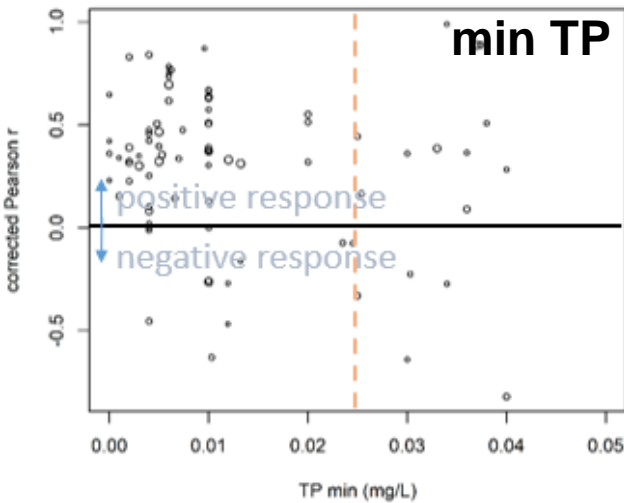


(absolute value of Pearson r)

How do nutrient stressor-response relationships vary geographically?



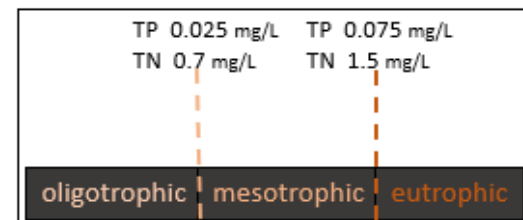
How does response strength change across a stressor gradient?



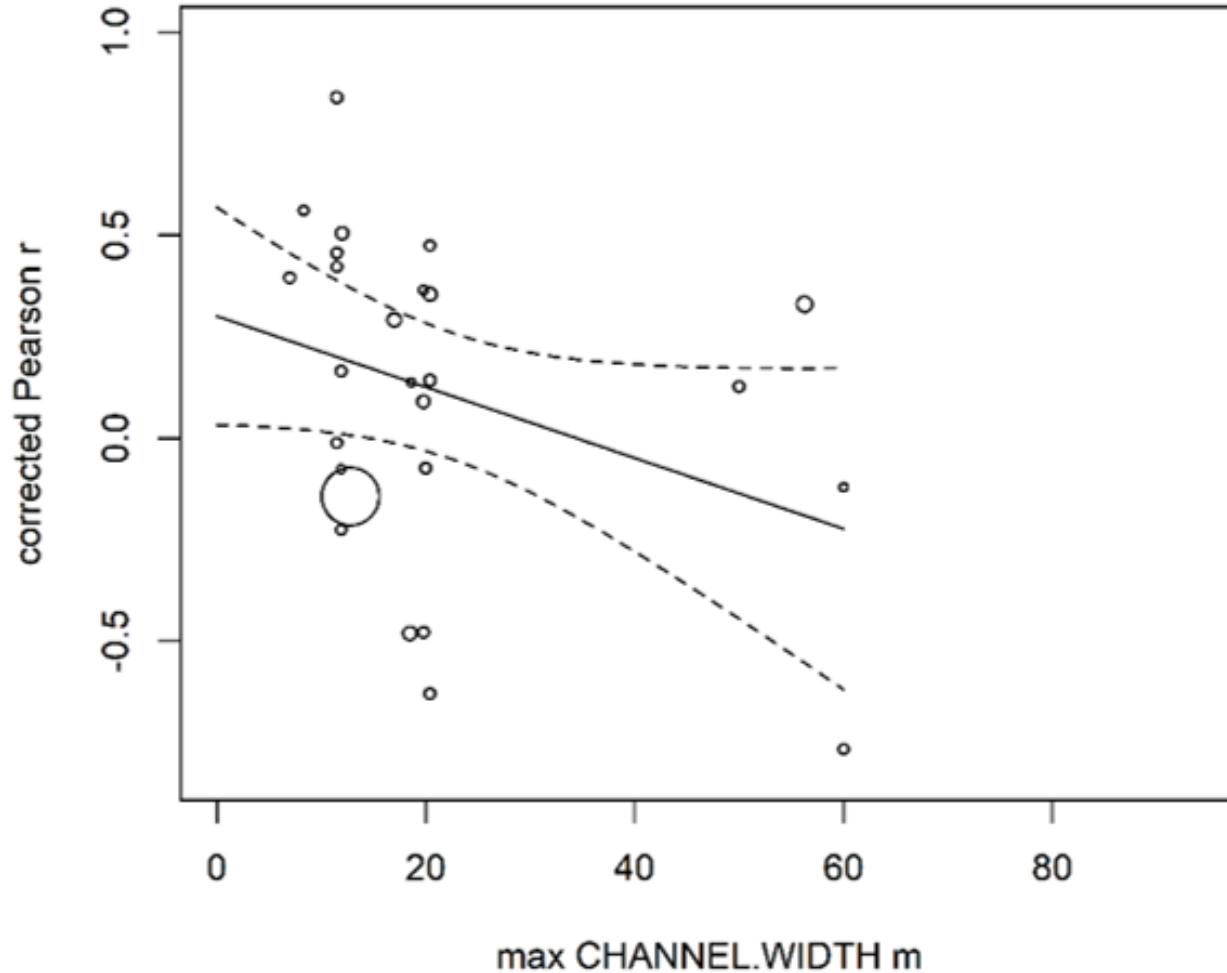
Benthic chl & TP



Stream Trophic Classification - Dodds et al. 1998



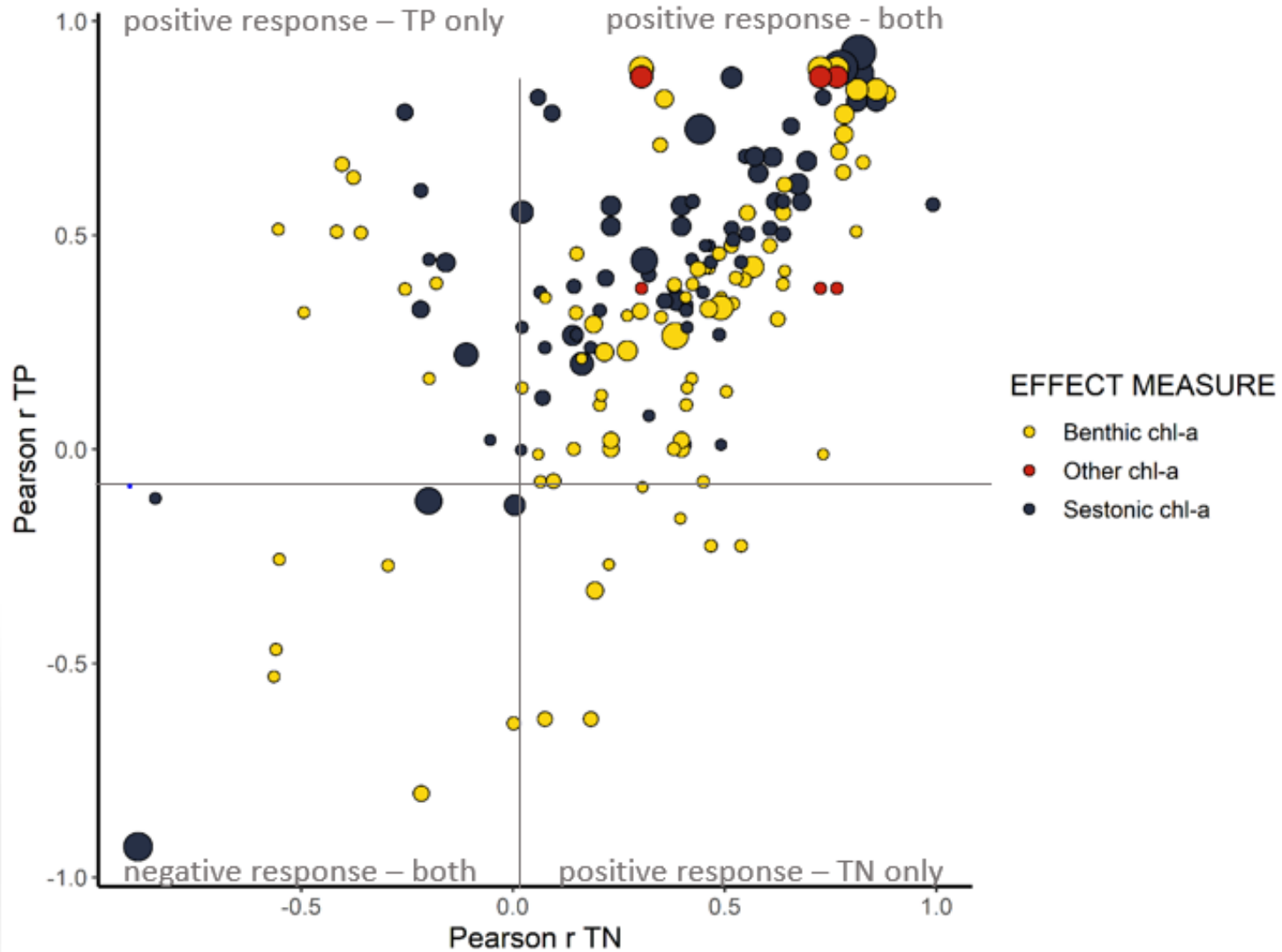
How do other factors affect stressor-response relationships?



Benthic chl & TP



Do biota respond similarly to TN and TP?



Next steps – and questions

- Conduct similar analyses for diatom and macroinvertebrate endpoints
- Make extracted raw data available to states/regions
- Questions
 - What are the most useful formats for making info available?
 - What are the most important relationships, contextual variables, etc.?