Stressor Identification -- Moving from Responses to Probable Causes: EPA's Causal Analysis/Diagnosis Decision Information System - CADDIS

United States Environmental Protection Agency

Jeffrey Frithsen, Ph.D.

USEPA – ORD – NCEA

National Nutrient TMDL Conference
New Orleans, LA
February 15-17, 2011

Identify the Stressor

- August 1973
  Canadian Lake 226

- Nutrients? Which nutrient? N or P? Chemical spill?

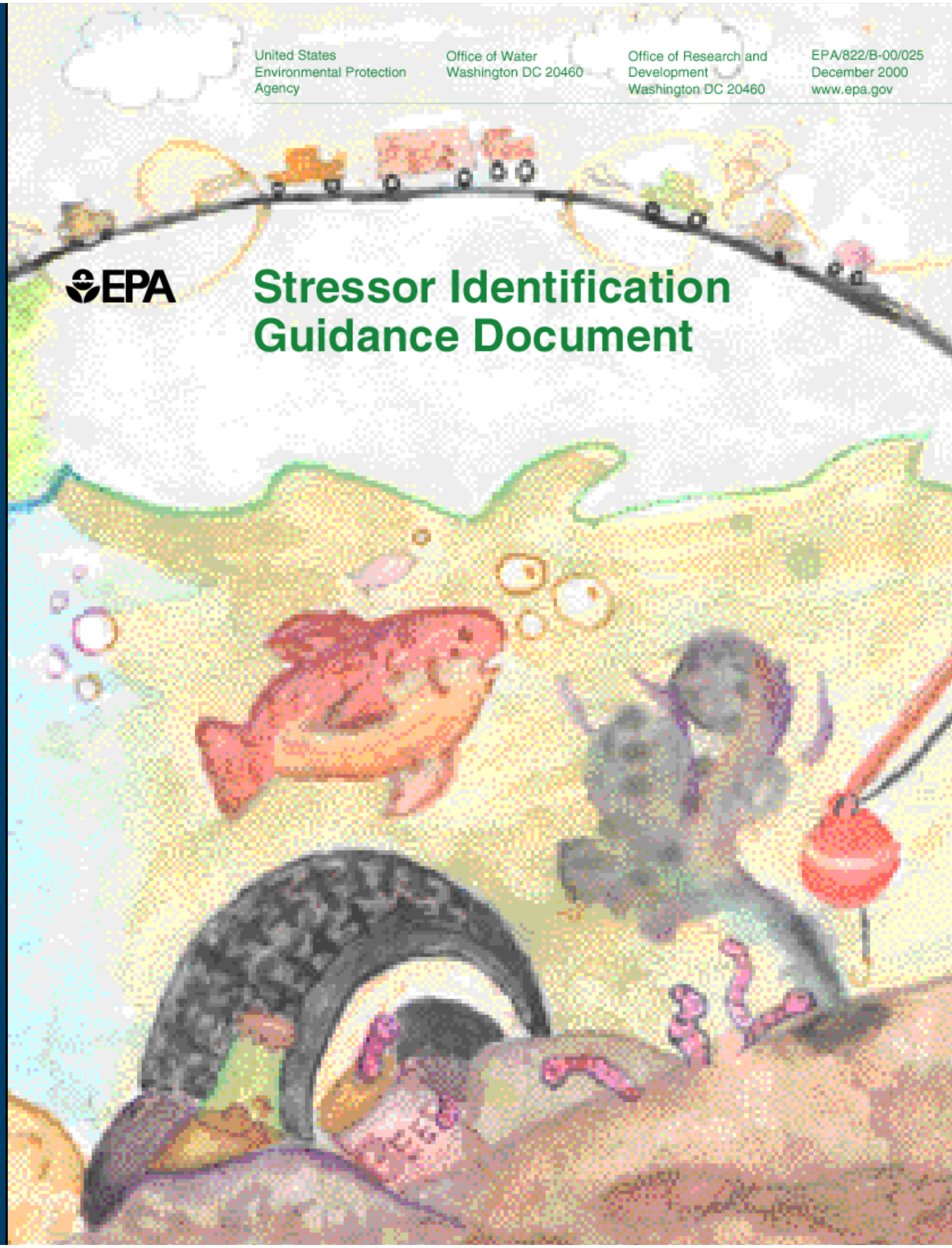
Schindler, D.W. 1974. Science 184: 897-899.

Identify the Stressor

- Greenwich Bay, RI.
  August 2003

- Nutrients?
  Hydrographic event?
  Chemical spill?
  Pathogens?

RIDEM 2003.


United States
Environmental Protection
Agency

Office of Water
Washington DC 20460

Office of Research and
Development
Washington DC 20460

EPA/822/B-00/025
December 2000
www.epa.gov

EPA

Stressor Identification Guidance Document

Why Stressor Identification?

- Many states and several tribes use biological assessments to identify whether streams and small rivers are impaired.
- In many cases, causes of impairment are unknown.

General Impairment Name	Causes of Impairment Reported	Percent of Reported
MERCURY	8555	13.45
PATHOGENS	8526	13.41
SEDIMENT	6689	10.52
METALS (OTHER THAN MERCURY)	6389	10.05
NUTRIENTS	5654	8.89
OXYGEN DEPLETION	4568	7.18
PH	3389	5.33
CAUSE UNKNOWN - BIOLOGICAL INTEGRITY	2866	4.51
TEMPERATURE	2854	4.49
HABITAT ALTERATION	2220	3.49
PCBS	2081	3.27
TURBIDITY	2050	3.22
CAUSE UNKNOWN	1356	2.13
PESTICIDES	1322	2.08
SALINITY/TDS/CHLORIDES	996	1.57
FLOW ALTERATION	591	.93
ALGAL GROWTH	510	.80
AMMONIA	415	.65
OTHER TOXIC ORGANICS	339	.53
TOTAL TOXICITY	292	.46
DIOXINS	290	.46
TOXIC INORGANICS	270	.42
FISH CONSUMPTION ADVISORY - PO	260	[illegible]

Why use a formal method?

- To convince stakeholders
- To increase confidence that remedial or restoration efforts can improve biological condition
- To identify causal relationships that are not immediately apparent
- To prevent biases and other lapses of logic

"Science is a way of trying not to fool yourself. The first principle is that you must not fool yourself – and you are the easiest person to fool." *[Feynman 1964]*

We all make mistakes about causality

- We overweight meaningful chance events

Every time I wash my car it rains

- We all have biases

Flow is always the real problem

- We all think we know how to do it

This looks like the last site I studied, where DO was the problem

- We form conclusions quickly, based on intuition & prior experiences…

  …and because we're smart, we can ably defend our opinions

The # 1 reason for mistaken conclusions is ***theory tenacity***!

Causation

- One of the most difficult and controversial concepts in philosophy
- Only one reliable method for establishing causation: **randomized**, **replicated**, **controlled** experiment
- Unfortunately, this approach is not usually available

What is CADDIS?

- **Online application 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.
  - Tools for data analysis & literature evaluation
  - Case studies

http://www.epa.gov/caddis

CADDIS: The Causal Analysis/Diagnosis Decision Information System

Contact Us Share

Quick Finder

CADLit
CADStat
Case Studies
Causal Assessment Background
Getting Started with Data Analysis
ICD Application
Step-by-step Guide

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

- **Volume 1: Stressor Identification** provides a step-by-step guide for identifying probable causes of impairment in a particular system, based on the U.S. EPA's Stressor Identification process. If you are interested in conducting a complete causal assessment, learning about different types of evidence, or reviewing a history of causal assessment theory, start with this volume.
- **Volume 2: Sources, Stressors & Responses** provides background information on many common sources, stressors, and biotic responses in stream ecosystems. If you are interested in viewing source- and stressor-specific summary information (e.g., for urbanization, physical habitat, nutrients, metals, pH and other stressors), start with this volume.
- **Volume 3: Examples & Applications** provides examples illustrating different steps of causal assessments. If you are interested in reading completed causal assessment case studies, seeing how Stressor Identification worksheets are completed, or examining example applications of data analysis techniques, start with this volume.
- **Volume 4: Data Analysis** provides guidance on the use of statistical analysis to support causal assessments. If you are interested in learning how to use data in your causal assessment, start with this volume.
- **Volume 5: Causal Databases** provides access to literature databases and associated tools for use in causal assessments. If you are interested in applying literature-based evidence to your causal assessment, start with this volume.

Basic Information
Recent Additions
Frequent Questions
Publications
Glossary
Related Links
Authors & Contributors
Site Map

Top Three Questions

1. What's new in the 2010 release of CADDIS?
2. How do I cite CADDIS?
3. Where can I view a site map for CADDIS?

CADDIS Navigation

CADDIS Home
Volume 1: Stressor Identification
Volume 2: Sources, Stressors & Responses
Volume 3: Examples & Applications
Volume 4: Data Analysis
Volume 5: Causal Databases

Recent Additions

1. New Causal Assessment Background section
2. New source & stressor modules
   - Urbanization
   - Ammonia
   - Herbicides
   - Insecticides
   - pH
   - Physical habitat
3. New causal assessment Case Studies
4. Revised Data Analysis section
5. Expanded Interactive Conceptual Diagram application

CADDIS Organization

Volume 1: Stressor Identification
[Step-by-Step Guide]

Volume 2: Sources, Stressors & Responses
[Candidate Causes]

Volume 3: Examples & Applications
[Examples, Databases]

Volume 4: Data Analysis
[Analyzing Data]

Volume 5: Causal Databases
[Databases]

1

Español | 中文: 繁體版 | 中文: 简体版 | Tiếng Việt | 한국어

EPA United States Environmental Protection Agency

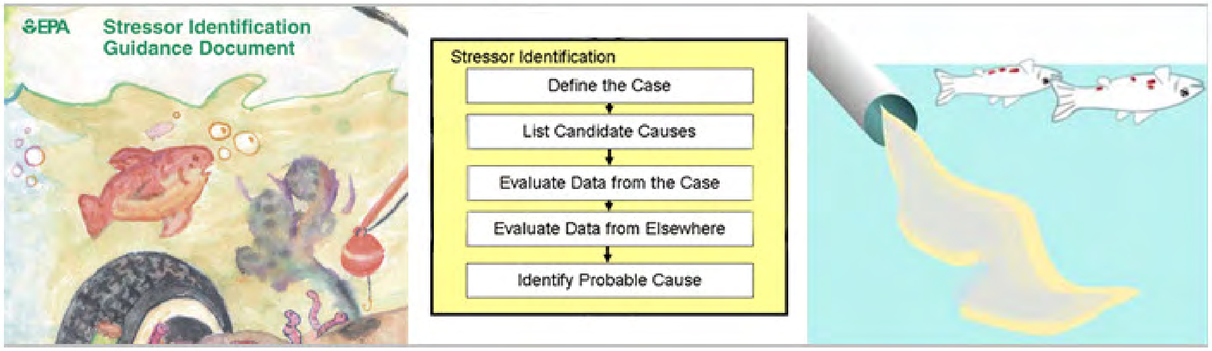
LEARN THE ISSUES | SCIENCE & TECHNOLOGY | LAWS & REGULATIONS | ABOUT EPA

ALL EPA THIS AREA Advanced Search

SEARCH

CADDIS Volume 1: Stressor Identification

Contact Us Share



Quick Finder

Analogous Stressors
Causal Pathway
Evidence of Exposure
Lab Test of Site Media
Manipulation of Exposure
Manipulation at Other Sites
Mechanistically Plausible Cause
Spatial/Temporal Co-occurrence
Stressor-Response from Simulation Models
Stressor-Response from Lab
Stressor-Response from Other Field Studies
Stressor-Response from the Case
Symptoms
Temporal Sequence
Verified Predictions

CADDIS provides a pragmatic guide for determining the causes of detrimental changes and undesirable biological conditions observed in aquatic systems.

In this volume, we present a five-step process for conducting a causal assessment at a particular site:

- Step 1: Define the Case
- Step 2: List Candidate Causes
- Step 3: Evaluate Data from the Case
- Step 4: Evaluate Data from Elsewhere
- Step 5: Identify Probable Causes

This causal assessment process is derived from the Stressor Identification Guidance Document, published jointly by the Office of Water and the Office of Research and Development of the U.S. EPA. The basic approach remains the same, but several changes have been made to make the process more accessible.

This volume also contains additional materials supporting the SI process. Users new to SI may want to read through the Step-by-Step Guide Introduction. More experienced users may wish to jump directly pages on specific types of evidence (listed in the Quick Finder). Users interested in the historial and philosophical underpinnings of causal assessment may wish to review the Causal Assessment Background section.

Introduction
Step 1: Define the Case
Step 2: Candidate Causes
Step 3: Data from the Case
Step 4: Data from Elsewhere
Step 5: Identify Probable Causes
Causal Assessment Background

Top Three Questions

1. What are the most frequently used types of evidence from the case?
2. What are the most frequently used types of evidence using information from elsewhere?
3. Where can I view a site map of this volume?

CADDIS Navigation

CADDIS Home

Volume 1: Stressor Identification

Volume 2: Sources, Stressors & Responses

Volume 3: Examples & Applications

Volume 4: Data Analysis

Volume 5: Causal Databases

CADDIS Five Step Process

Step 1: Define the case

Step 2: List candidate causes

Step 3: Evaluate data from the case

Step 4: Evaluate data from elsewhere

Step 5: Identify probable cause

2

Español | 中文: 繁體版 | 中文: 简体版 | Tiếng Việt | 한국어

EPA United States Environmental Protection Agency

LEARN THE ISSUES | SCIENCE & TECHNOLOGY | LAWS & REGULATIONS | ABOUT EPA

ALL EPA THIS AREA Advanced Search

SEARCH

CADDIS Volume 2: Sources, Stressors & Responses

Contact Us Share



Deciding which pathways to consider in a causal assessment—that is, listing candidate causes as described in Step 2 of the SI process—sets the framework for causal assessment. This section of CADDIS provides background information on commonly encountered sources, stressors, and responses for use in deciding which candidate causes to consider, as well as in developing cases for or against those candidate causes in the actual assessment.

Each stressor module is organized into five sections, or tabs:

- **Introduction** provides a summary overview of the stressor, including a checklist of evidence that suggests including a given stressor in your assessment (i.e., listing it as a candidate cause).
- **When to List** provides more detailed information on the sources, activities, site evidence, and biologial responses that suggest inclusion as a candidate cause.
- **Ways to Measure** details different methods for quantifying the stressor.
- **Conceptual Diagrams** illustrates hypothesized causal linkages among the stressor, its sources, and associated biotic responses.
- **References** lists the references cited throughout the module.

In addition, some stressor modules have a **Literature Reviews** tab, which presents an annotated bibliography of key references providing general background information, particularly regarding stressor-response relationships.

The source module for urbanization contains similar summary information on effects of urban development on stream ecosystems, but it is presented in a different format. The module is organized using a simple schematic of how urbanization affects streams. Users can click on any shape in the schematic to navigate through the module and focus on areas of interest; within each section (i.e., under each shape) the user can click on additional topic boxes for more detailed information.

Ammonia	Insecticides	pH	Temperature
Dissolved Oxygen	Ionic Strength	Physical Habitat	Unspecified Toxic Chemicals
Flow Alteration	Metals	Sediments	Urbanization
Herbicides	Nutrients		

Top Three Questions

1. What are sources, stressors & responses?
2. Is there additional literature-based information available for these sources, stressors & responses?
3. Can I view a site map of this volume?

CADDIS Navigation

CADDIS Home

Volume 1: Stressor Identification

Volume 2: Sources, Stressors & Responses

Volume 3: Examples & Applications

Volume 4: Data Analysis

Volume 5: Causal Databases

CADDIS Home

Stressor Identification

Sources, Stressors & Responses
SOURCES
Urbanization
STRESSORS
Ammonia
Dissolved Oxygen
Flow Alteration
Herbicides
Insecticides
Ionic Strength
Metals
Nutrients
pH
Physical Habitat
Sediments
Temperature
Unspecified Toxic Chemicals
RESPONSES

Examples & Applications

Data Analysis

Causal Databases

Nutrients

Introduction | When to List | Ways to Measure | Conceptual Diagrams | References

Figure 1. A cyanobacterium (*Nodularia spumigens*) bloom in the Gippsland Lakes, Victoria, Australia in January, 2002.
Courtesy of J.D. Kinnon, Wood's Hole Oceanographic Institute.

Nutrients are elements that are essential for plant growth, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), and silicon (Si). N, P, and K are considered primary nutrients, and N and P are the major limiting nutrients in most aquatic environments.

When considering candidate causes, N and P are evaluated to determine the trophic status (or relative nutrient condition) of freshwater systems. In lakes, streams, large rivers, and estuaries, trophic status may be expressed in terms of oligotrophy (low nutrients, minimally productive), mesotrophy (moderate nutrients, moderately productive), or eutrophy (high nutrients, highly productive).

Related Links

On this page

- Checklist of sources, site evidence and biological effects

Other sources/stressors/responses

- Ammonia
- Sediments
- Dissolved osygen

Databases

- ICD
- CADLit
- Stressor-response galleries

Examples

- Case studies

Authors: J.C. Kurtz, M.B. Griffith, M.A. Morrison, C.E. Hornig

In most cases, nutrients are not proximate stressors for aquatic communities. Although certain forms of N [i.e., unionized ammonia (NH_3), nitrite (NO_2^-) and, in some cases, nitrate (NO_3^-)] may be toxic, these effects are considered in the ammonia and unspecified toxic chemicals modules. Nutrients have indirect adverse effects on aquatic communities through their effects on primary production, the growth and accumulation of plant and algal biomass, and the species composition of algae (i.e., phytoplankton in lakes or periphyton in streams) and other plant assemblages (Figures 1 and 2); Dodds and Welch 2000).

Increasing primary production and changes in plant species composition can be proximate causes of effects on consumers (i.e., macroinvertebrates and fish) by:

- **Altering food resources**: the amount of food resources, their type (e.g., living plant and algal biomass versus detritus),or their palatability (e.g., changes in cell size in algae for filter-feeding animals);

Consider listing nutrients as a candidate cause when the following sources and activities, site evidence, and biological effects are present:

Sources and Activities	Site Evidence	Biological Effects
• Wastewater treatment plant effluents • Industrial effluents • Municipal landfills and waste disposal sites • Animal feed lots or confined animal feeding operations • Construction and development sites • Combined stormwater and sanitary sewers • Agricultural and irrigation runoff • Runoff from impervious surfaces associated with urban or other developed areas • Pasture and rangeland runoff • Septic systems • Atmospheric deposition • Landscaping runoff, such as from residential lawns, golf courses, and athletic fields	• Proliferation of filamentous algae or algal mats • Phytoplankton blooms (i.e., green water) • Abundant macrophytes	• Alteration of algal assemblages (i.e., phytoplankton or periphyton) • Alteration of invertebrate assemblages (i.e., zooplankton or benthic macroinvertebrates) • Fish kills

Consider these commonly associated candidate causes when listing nutrients as a candidate cause:

- Dissolved oxygen
- Temperature
- Suspended and bedded sediments
- pH
- Ammonia toxicity
- Pathogens
- Co-migrating contaminants

⇧Top of Page

CADDIS Home

Stressor Identification

Sources, Stressors & Responses

SOURCES

Urbanization

STRESSORS

Ammonia

Dissolved Oxygen

Flow Alteration

Herbicides

Insecticides

Ionic Strength

Metals

Nutrients

pH

Physical Habitat

Sediments

Temperature

Unspecified Toxic Chemicals

RESPONSES

Examples & Applications

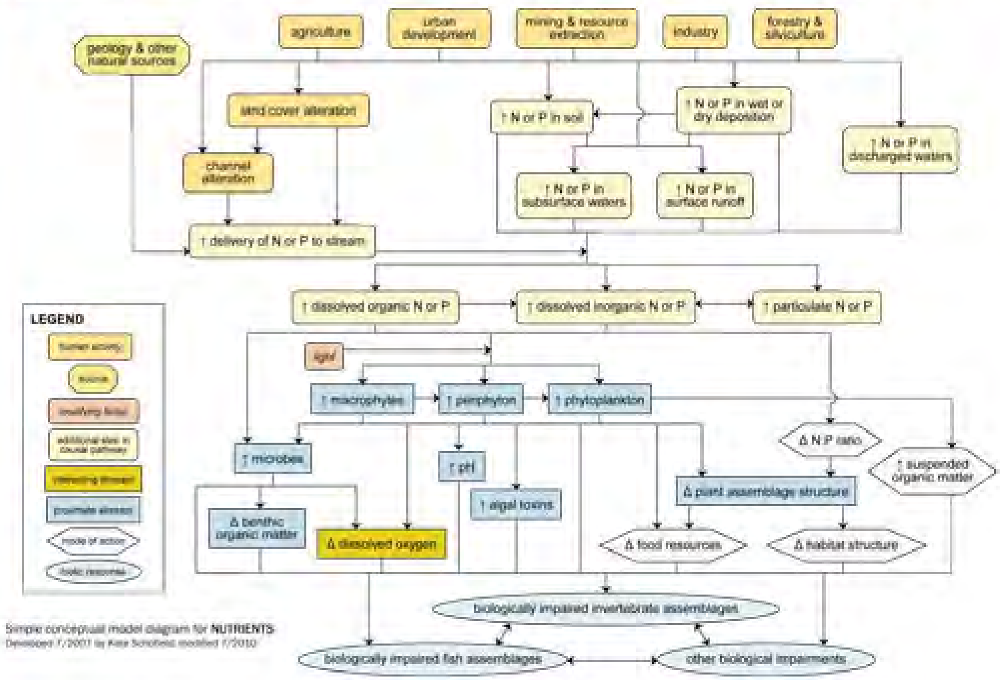
Data Analysis

Causal Databases

Nutrients

Introduction | When to List | Ways to Measure | Conceptual Diagrams | References

Nitrogen & Phosphorus: Simple Conceptual Diagram



Click diagram to view larger version

Diagram Options

- Detailed diagram for N
- Detailed diagram for P
- About conceptual diagrams

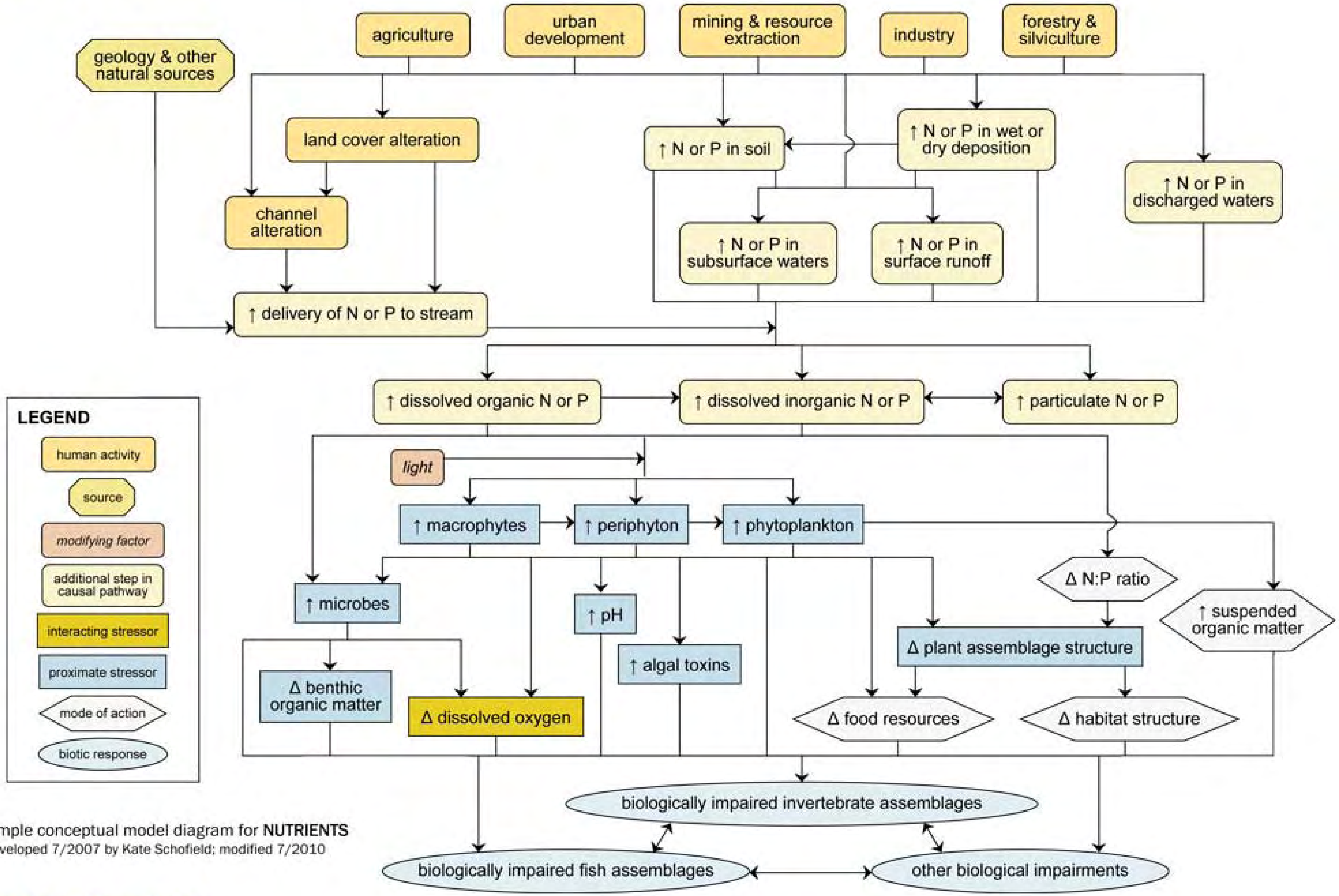
Downloads

- Diagram PDF for N & P [1 p, 76 K, About PDF]
- Diagram PPT for N & P
- Narrative PDF for N & P [2 pp, 19 K, About PDF]

Diagram narrative

Enrichment of aquatic systems due to excess nutrient concentrations is a common cause of biological impairment. Although aquatic plants and microbes require nitrogen (N) and phosphorus (P) for growth and reproduction, excess nutrient inputs may adversely affect biotic communities. Often these excess inputs of N and P are related to human activities and sources in the watershed, which influence in-stream nutrient concentrations via six dominant pathways: (1) by increasing the delivery of N or P from the watershed;

Print Page | Close Window



Simple conceptual model diagram for **NUTRIENTS**
Developed 7/2007 by Kate Schofield; modified 7/2010

Print Page | Close Window

Nutrients

Introduction | When to List | Ways to Measure | Conceptual Diagrams | References

CADDIS Home

Stressor Identification

Sources, Stressors & Responses

SOURCES

Urbanization

STRESSORS

Ammonia

Dissolved Oxygen

Flow Alteration

Herbicides

Insecticides

Ionic Strength

Metals

Nutrients

pH

Physical Habitat

Sediments

Temperature

Unspecified Toxic Chemicals

RESPONSES

Examples & Applications

Data Analysis

Causal Databases

References

APHA (American Public Health Association); AWWA (American Water Works Association); WEF (Water Environment Federation) (1998) Standard Methods for the Examination of Water and Wastewater (20th edition). American Public Health Association, Washington DC.

ASTM (1999) Annual Book of ASTM Standards. American Society for Testing and Materials, Philadelphia PA.

Barbour MT, Gerritsen J, Griffith GE, Frydenborg R, McCarron E, White JS, Bastian ML (1996) A framework for biological criteria for Florida streams using benthic macroinvertebrates. Journal of the North American Benthological Society 15:185-211.

Barbour MT, Gerritsen J, Snyder BD, Stribling JB (1999) Rapid bioassessment protocols for use in wadeable streams and rivers: periphyton, benthic macroinvertebrates, and fish (2nd edition). U.S. Environmental Protection Agency, Office of Water, Washington DC. EPA 841-B-99-002.

Carlson RE, Simpson J (1996) A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. 96 pp.

Clarke KR, Warwick RM (1994) Change in Marine Communities: An Approach to Statistical Analysis and Interpretation. Plymouth Marine Laboratory, National Research Council.

Deshon JE (1995) Development and application of the Invertebrate Community Index (ICI). Pp. 217-243 in: David WS, Simon TP (Eds). Biological Criteria and Assessment: Tools for Risk-Based Planning and Decision Making. Lewis Publishers, Boca Raton FL.

Dodds WK, Welch EB (2000) Establishing nutrient criteria in streams. Journal of the North American Benthological Society 19 (1):186-196.

Griffith MB, Hill BH, McCormick FH, Kaufmann PR, Herlihy AT, Selle AR (1995) Comparative application of indices of biotic integrity based on periphyton, macroinvertebrates, and fish to southern Rocky Mountain streams. Ecological Indicators 5:117-136.

Klemm DJ, Blocksom KA, Fulk FA, Herlihy AT, Hughes RM, Kaufmann PR, Peck DV, Stoddard JL, Thoeny WT, Griffith MB, Davis WS (2003) Development and evaluation of a macroinvertebrate biotic integrity index (MBII) for regionally assessing Mid-Atlantic Highlands streams. Environmental Management 31:656-669.

CADDIS Home

Stressor Identification

Sources, Stressors & Responses

SOURCES

Urbanization

STRESSORS

Ammonia

Dissolved Oxygen

Flow Alteration

Herbicides

Insecticides

Ionic Strength

Metals

Nutrients

pH

Physical Habitat

Sediments

Temperature

Unspecified Toxic Chemicals

RESPONSES

Examples & Applications

Data Analysis

Causal Databases

Ammonia

Introduction | When to List | Ways to Measure | Conceptual Diagrams | Literature Reviews | References

Figure 1. Landfill settling pond.
Courtesy of U.S. EPA Region 10: The Pacific Northwest, KPC Photo Gallery.

Ammonia (NH_3) is a common toxicant derived from wastes (Figure 1), fertilizers, and natural processes. Ammonia nitrogen includes both the ionized form (ammonium, NH_4^+) and the unionized form (ammonia, NH_3). An increase in pH favors formation of the more toxic unionized form (NH_3), while a decrease favors the ionized (NH_4^+) form. Temperature also affects the toxicity of ammonia to aquatic life. Ammonia is a common cause of fish kills, but the most common problems associated with ammonia relate to elevated concentrations affecting fish growth, gill condition, organ weights, and hematocrit (Milne et al. 2000). Exposure duration and frequency strongly influence the severity of effects (Milne et al. 2000).

Ammonia in sediments typically results from bacterial decomposition of natural and anthropogenic organic matter that accumulates in sediment. Sediment microbiota mineralize organic nitrogen or (less commonly) produce ammonia by dissimilatory nitrate reduction. Ammonia is especially prevalent in anoxic sediments because nitrification (the oxidation of ammonia to nitrite [NO_2^-] and nitrate [NO_3^-]) is inhibited. Ammonia generated in sediment may be toxic to benthic or surface water biota (Lapota et al. 2000).

Ammonia also exerts a biochemical oxygen demand on receiving waters (referred to as nitrogenous biological oxygen demand or NBOD) because dissolved oxygen is consumed as bacteria and other microbes oxidize ammonia into nitrite and nitrate. The resulting dissolved oxygen reductions can decrease species diversity and even cause fish kills. Additionally, ammonia can lead to heavy plant growth (eutrophication) due to its nutrient properties (see the Nutrients module). Conversely, algae and macrophytes take up ammonia, thereby reducing aqueous concentrations.

Related Links

On this page

- Checklist of sources, site evidence and biological effects

Other sources/stressors/responses

- pH
- Temperature
- Nutrients

Databases

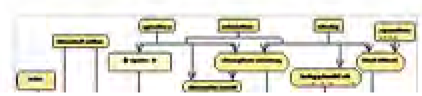
- ICD
- CADLit

Examples

- Case studies

Authors: G.W. Suter II, S.M. Cormier, K. Schofield, M. Bowersox, H. Latimer

Checklist of sources, site evidence and biological effects



CADDIS Home

Stressor Identification

Sources, Stressors & Responses
- SOURCES
  - Urbanization
- STRESSORS
  - Ammonia
  - Dissolved Oxygen
  - Flow Alteration
  - Herbicides
  - Insecticides
  - Ionic Strength
  - Metals
  - Nutrients
  - pH
  - Physical Habitat
  - Sediments
  - Temperature
  - Unspecified Toxic Chemicals
- RESPONSES

Examples & Applications

Data Analysis

Causal Databases

Dissolved Oxygen

Introduction | When to List | Ways to Measure | Conceptual Diagrams | References

Figure 1. This natural stream in a forest setting has water flowing over boulders, causing turbulence and aeration.

Courtesy of Eric Vance, U.S. EPA.

Dissolved oxygen (DO) refers to the concentration of oxygen gas incorporated in water. Oxygen enters water by direct absorption from the atmosphere, which is enhanced by turbulence (Figure 1). Water also absorbs oxygen released by aquatic plants during photosynthesis. Sufficient DO is essential to growth and reproduction of aerobic aquatic life (e.g., see Murphy 2006, Giller and Malmqvist 1998, Allan 1995).

Advice for deciding whether to include depleted or (less commonly) excessive DO as a candidate cause is provided in this module.

Related Links

On this page
- Checklist of sources, site evidence and biological effects

Other sources/stressors/responses
- Temperature
- Nutrients
- Flow alteration

Databases
- ICD
- CADLit

Examples
- Case studies

Authors: S.K.M. Marcy, G.W. Suter II, S.M. Cormier

Checklist of sources, site evidence and biological effects

This module addresses low or excessive DO as a proximate stressor, that should be listed as a candidate cause when potential human sources and activities, site observations, or observed effects support portions of the source-to-impairment pathways in the conceptual diagram for DO (Figure 2). A checklist is provided below to help you identify key data and information useful for determining whether to include DO among your candidate causes; for more information on specific sources and activities, site evidence, and biological effects listed in the checklist, click on checklist headings or go to the When to List tab of this module.

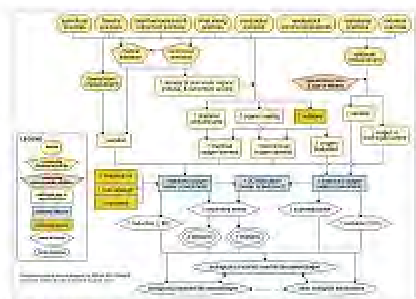


Figure 2. A simple conceptual diagram illustrating causal

CADDIS Home

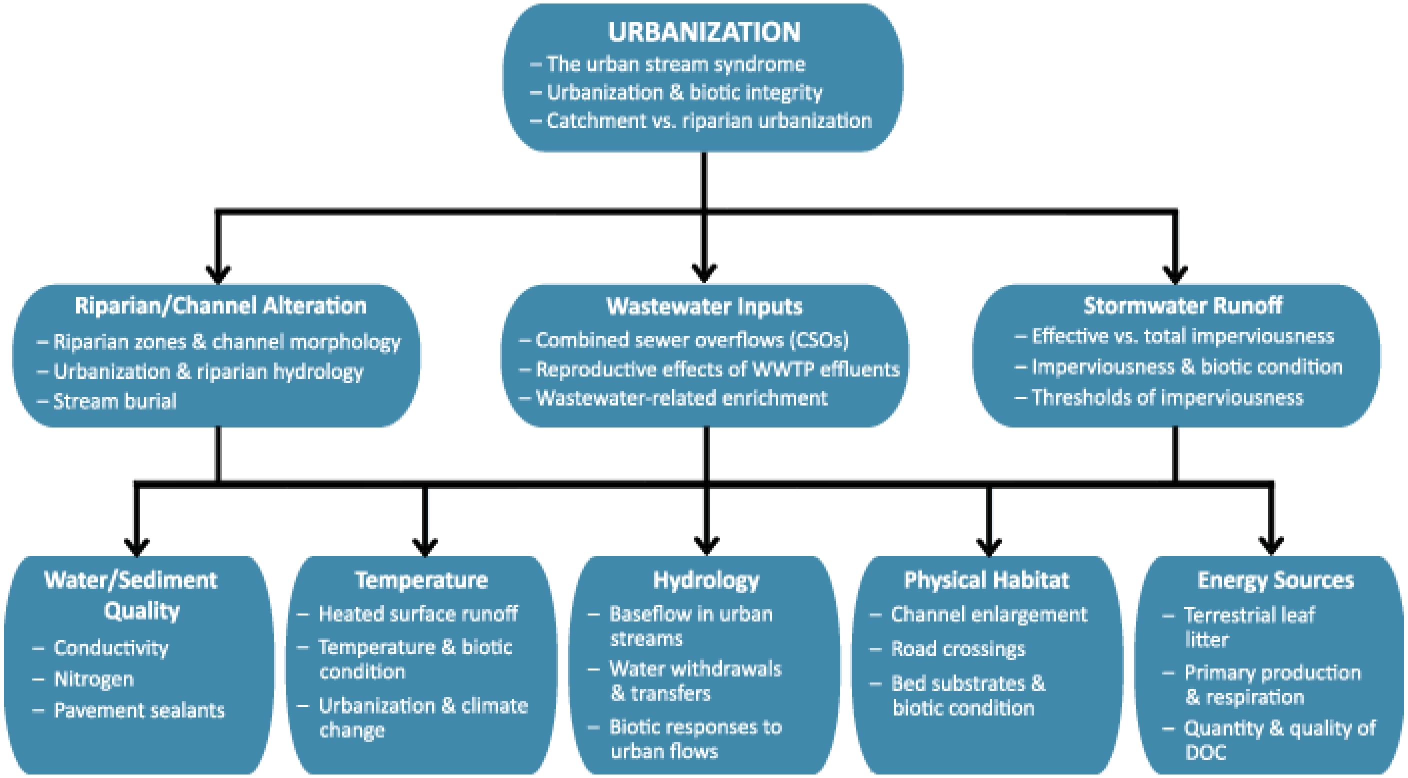
Stressor Identification

Sources, Stressors & Responses
SOURCES
Urbanization
STRESSORS
Ammonia
Dissolved Oxygen
Flow Alteration
Herbicides
Insecticides
Ionic Strength
Metals
Nutrients
pH
Physical Habitat
Sediments
Temperature
Unspecified Toxic Chemicals
RESPONSES

Examples & Applications

Data Analysis

Causal Databases



Click on any heading to see more detailed information about that pathway.
Click on subheadings to read more about highlighted topics under each heading.

Urbanization is an increasingly pervasive land cover transformation that significantly alters the physical, chemical and biological environment within surface waters.

The diagram above provides a simple schematic illustrating pathways through which urbanization may affect stream ecosystems. **Riparian/channel alteration**, **wastewater inputs** and **stormwater runoff** associated with urbanization can lead to changes in five general stressor categories: **water/sediment quality**, water **temperature**, **hydrology**, **physical habitat** within the channel, and basic **energy sources** for the stream food web.

This module is organized along these pathways. You can learn more about urban stream sources and stressors by clicking on these headings in the diagram above. You can click on subheadings within each shape to learn about specific topics in greater detail. To return to this organizational diagram from any point in the module, simply click on the Urbanization link in navigation bar (at left) or

3

Español | 中文: 繁體版 | 中文: 简体版 | Tiếng Việt | 한국어

EPA United States Environmental Protection Agency

LEARN THE ISSUES | SCIENCE & TECHNOLOGY | LAWS & REGULATIONS | ABOUT EPA

ALL EPA THIS AREA Advanced Search SEARCH

CADDIS Volume 3: Examples & Applications

Contact Us Share

Quick Finder

- Assemble Data from Case
- Assemble Data from Elsewhere
- Causal Pathway
- Consistency of Evidence
- Define the Case
- Evidence of Exposure or Mechanism
- Explanation of Evidence
- Identify Probable Cause
- List Candidate Causes
- Mechanistically Plausible Cause
- Spatial Co-occurrence with Regional Reference Sites
- Stressor-Response from Field
- Stressor-Response from Lab
- Summary of Scores from Case
- Summary of Scores from Elsewhere
- Verified Prediction with PECBO
- Verified Prediction with Traits

This volume provides examples that illustrate different aspects of a causal analysis.

- The **Analytical Examples** section provides examples illustrating the use of different data analyses to inform particular types of evidence. If you are interested in seeing how data analysis techniques can be applied in causal assessment, start with this section.
- The **Worksheets** section provides examples from the Little Scioto River in Ohio, one of the first Stressor Identification-based causal analyses conducted. These examples are presented as "worksheets" that one might complete as one conducts a causal analysis, so this section is a good place to start if you are planning on conducting a complete causal assessment.
- The **Case Studies** section provides brief summaries of completed causal assessments, as well as links to full case study reports. If you are interested in seeing how others have conducted causal assessments, start with this section.
- The **State & Other Regulatory Examples** section describes how different states have incorporated causal analysis and stressor identification (SI) in their water quality programs. If you are interested in seeing who is using the SI process and how they are using it, start with this section.
- The **Galleries** section provides examples of relationships that have been observed between common stressors and biological responses. If you are interested in viewing or downloading example stressor-response figures, start with this section.

Analytical Examples | Worksheets: Little Scioto | Case Studies | State Examples | Galleries

Top Three Questions

1. Where are examples of completed case studies?
2. How do I determine if a stressor co-occurs with the effect?
3. Where can I get a site map for this volume?

CADDIS Navigation

CADDIS Home
Volume 1: Stressor Identification
Volume 2: Sources, Stressors & Responses
Volume 3: Examples & Applications
Volume 4: Data Analysis
Volume 5: Causal Databases

You are here: EPA Home » CADDIS » Examples & Applications » Case Studies

CADDIS Home

Stressor Identification

Sources, Stressors & Responses

Examples & Applications
- Analytical Examples
- Worksheets: Little Scioto
- Case Studies
- State Examples
- Galleries

Data Analysis

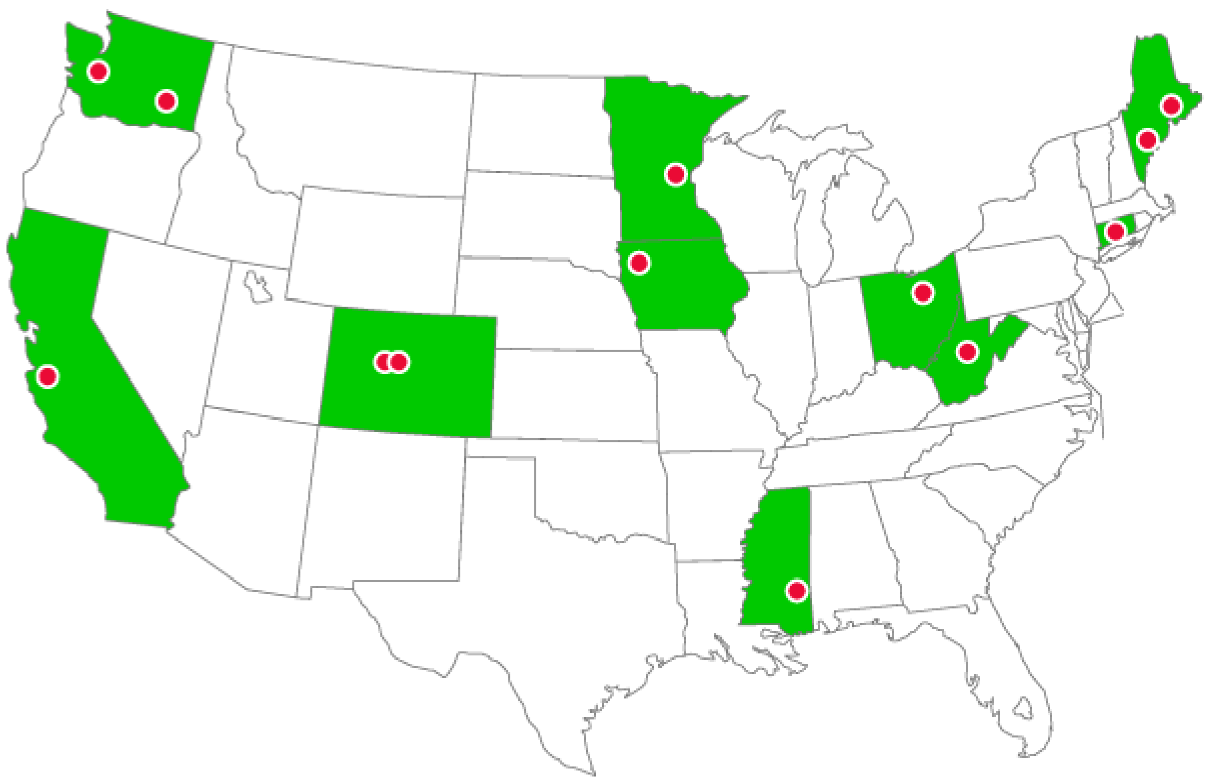
Causal Databases

Case Studies

These reports provide examples of how some assessors have developed and interpreted evidence to determine causes of biological impairments, and in some cases improved the quality of an ecosystem. They provide different examples of how to organize an assessment report, analyze data, and present results. Most of the cases assess rivers and streams, but a few assess terrestrial ecosystems.

The process for identifying causes of biological impairments continues to improve. As a result you will note differences among the case studies. In some examples, comments have been inserted by the U.S. EPA editor or the authors. These comments are not meant to indicate that these causal analyses are in error, but to assist other SI users by suggesting alternative approaches that may be applied to their cases.

Click on a location to view details about its case study.



4

Español | 中文: 繁體版 | 中文: 简体版 | Tiếng Việt | 한국어

EPA United States Environmental Protection Agency

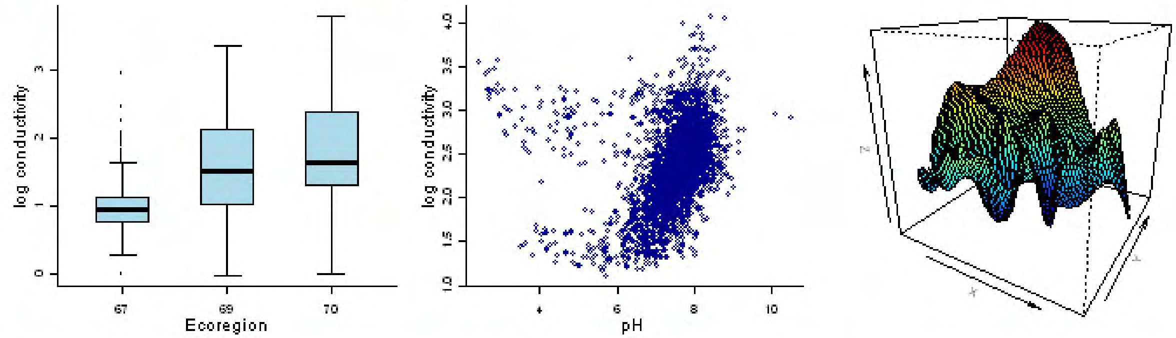
LEARN THE ISSUES | SCIENCE & TECHNOLOGY | LAWS & REGULATIONS | ABOUT EPA

ALL EPA THIS AREA Advanced Search

SEARCH

CADDIS Volume 4: Data Analysis

Contact Us Share



Quick Finder

- Autocorrelation
- Classification and Regression Trees
- Conditional Probability
- Confidence Intervals
- Confounding
- Controlling for Natural Variability
- Correlation Analysis
- Interpreting Statistics
- Multivariate Data Exploration
- PECBO
- Propensity Scores
- Quantile Regression
- Regression Analysis
- Scatterplots
- Spatial Analysis and GIS
- SSDs
- Tests of Significant Difference
- Traits

This volume of CADDIS was developed as a reference for users seeking information on different analytical techniques that can be applied to causal analysis.

Data analysis is a key phase of a causal assessment. In many cases, statistical analyses can be used to inform different types of evidence and strengthen confidence in the results of causal assessments.

The materials in this volume have been organized into topic areas (listed at right) which may be read individually or in sequence. Most materials were written for users with a basic background in statistics. Some topic areas also include advanced materials on an optional "Details" page.

- **Selecting an Analysis Approach**: initial guidance for selecting appropriate analyses that can inform different phases of a causal analysis.
- **Getting Started**: things to think about before you start analyzing data.
- **Basic Principles & Issues**: basic concepts to keep in mind while analyzing observational data.
- **Exploratory Data Analysis**: techniques for becoming familiar with your data.
- **Basic Analyses**: "building block" statistical methods.
- **Advanced Analyses**: statistical methods requiring knowledge of one or more basic techniques.
- **Download Software**: implementations of some basic and advanced techniques.

Selecting an Analysis Approach | Getting Started | Basic Principles & Issues | Exploratory Data Analysis | Basic Analyses | Advanced Analyses | Download Software

Top Three Questions

1. Where can I download CADDIS software?
2. How can I analyze my data?
3. Can I view a site map of this volume?

CADDIS Navigation

CADDIS Home

Volume 1: Stressor Identification

Volume 2: Sources, Stressors & Responses

Volume 3: Examples & Applications

Volume 4: Data Analysis

Volume 5: Causal Databases

Basic Principles & Issues

Confounding

Interpreting Statistics

Author: D. Farrar

The effect of a stressor on a measure of biological condition (i.e., the stressor-response relationship) may be misunderstood if other environmental variables or stressors that may affect the biological measure are ignored. In many cases, a simple relationship observed between a measure of biological condition and a single stressor may reflect the effects of additional stressors. For example, increased urban land use encompasses many different stressors (e.g., increased flow flashiness, increased concentrations of different pollutants, and degraded physical habitat), all of which can influence the aquatic biological community.

Analyses to estimate stressor-response relationships often must take measures to avoid attributing biological effects to a single stressor when observed effects are as readily attributable to simultaneous exposure to multiple, associated stressors. This issue is particularly important when estimating stressor-response relationships from large, regional data sets, in which multiple, associated stressors are common.

Identifying concomitant variables

We use the term *concomitant variables* for variables that might confound estimates of the effect of a stressor variable on a measure of biological condition. Conceptual diagrams showing linkages between sources, stressors, and biological responses can help one identify a set of concomitant variables. In particular, one should look for variables that provide alternate pathways linking the stressor of interest and the biological effect, and include variables that block these pathways (see Confounding: Details for more information).

One approach for controlling for confounding variables

For a basic data analysis tool that can address confounding to some degree, we emphasize scatterplots in combination with stratification. Stratification breaks the dataset into subsets (i.e., strata) that are relatively homogeneous with respect to one or more concomitant variables. If there is adequate variation within strata for the stressor of interest, one can evaluate the stressor-response relationship with concomitant variables approximately fixed, minimizing their influence on the

Table 1. Percent substrate sand/fines (SED) in different strata. Column labeled as *r* shows the correlation coefficient between total nitrogen and SED within each stratum

CADDIS Volume 4: Data Analysis

Contact Us Share

- CADDIS Home
- Stressor Identification
- Sources, Stressors & Responses
- Examples & Applications
- Data Analysis
  - Selecting an Analysis Approach
  - Getting Started
  - Basic Principles & Issues
  - Exploratory Data Analysis
  - Basic Analyses
  - Advanced Analyses
  - Download Software
- Causal Databases

You are here: EPA Home » CADDIS » Data Analysis » Download Software: Overview

Download Software

Overview | CADStat | SSD Generator | R Command Line Tutorial

This section provides access to tools that you can download and use to analyze your data. Three tools currently are available:

- **Tool 1: CADStat**. CADStat is a menu-driven package of several data visualization and statistical methods, based on JGR (a Java Graphical User Interface to R).
- **Tool 2: Species Sensitivity Distribution (SSD) Generator**. The SSD Generator is a Microsoft Excel template that allows you to calculate and plot the proportion of species affected at different levels of exposure in laboratory toxicity tests.
- **Tool 3: R Command Line Tutorial**. On this page, you can download R scripts (i.e., programs) and sample data to walk through a primer on R, a free statistical software package. Background material and R scripts for predicting environmental conditions from biological observations also are available in a separate section.

The tools you select depend on the methods you need and your comfort level with programming. If you are **inexperienced with programming**, we recommend you begin by using the tools that do not require programming expertise. CADStat for, example, will allow you to conduct several types of statistical analyses using a menu-driven interface, and the Species Sensitivity Distribution (SSD) Generator provides detailed instructions and macros that may be used to generate an SSD. If you are **familiar with the R statistical package**, you may wish to use our more complex tools which require some knowledge of command-line statistical programming and provide more analytical flexibility.

5

Español | 中文: 繁體版 | 中文: 简体版 | Tiếng Việt | 한국어

EPA United States Environmental Protection Agency

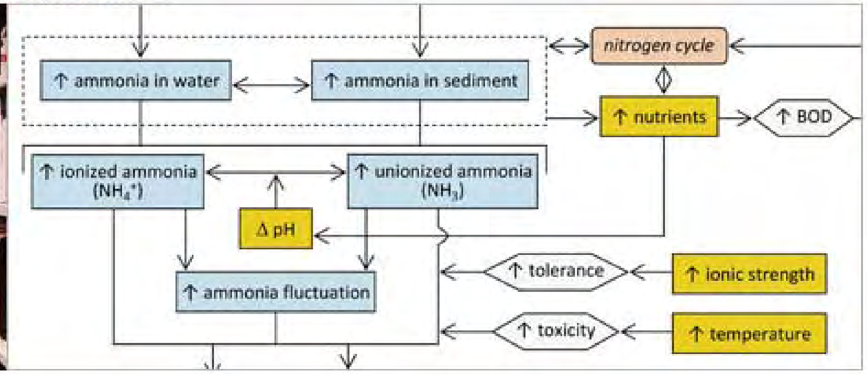
ALL EPA THIS AREA Advanced Search

SEARCH

LEARN THE ISSUES | SCIENCE & TECHNOLOGY | LAWS & REGULATIONS | ABOUT EPA

CADDIS Volume 5: Causal Databases

Contact Us Share



Quick Finder

CADLit Advanced Search
CADLit Keyword Search
CADLit User Guide
ICD Application
ICD Quick Start Instructions
ICD User Guide
Viewing ICDs
Editing ICDs

This section of CADDIS provides two tools (at right) to help users access and apply literature-based evidence in their causal assessments. These tools are designed for users interested in finding and compiling scientific literature (peer-reviewed and other) to support or weaken the cases for particular causal pathways.

A key part of causal assessment is taking what has been learned about causal pathways in other systems and using that knowledge to inform the current assessment. In the Stressor Identification process, this application of previous research typically occurs in Step 2: List Candidate Causes and Step 4: Evaluate Data from Elsewhere.

- The **Interactive Conceptual Diagram (ICD) application** uses conceptual diagrams as an organizing framework to provide supporting literature for linkages among different sources, stressors, and responses. Users can view literature linked to existing diagrams by clicking on diagram shapes, as well as create and populate their own diagrams with supporting literature.
- The **CADDIS Literature Resource (CADLit)** contains information on stressor-response associations reported in the peer-reviewed scientific literature. Currently, the stressors considered in CADLit include metals, sediment, and nutrients, although literature dealing with other stressors currently is being added.

ICDs CADLit

Top Three Questions

1. How do I access the ICD application?
2. How do I access CADLit?
3. Can I view a site map of this volume?

CADDIS Navigation

CADDIS Home

Volume 1: Stressor Identification

Volume 2: Sources, Stressors & Responses

Volume 3: Examples & Applications

Volume 4: Data Analysis

Volume 5: Causal Databases

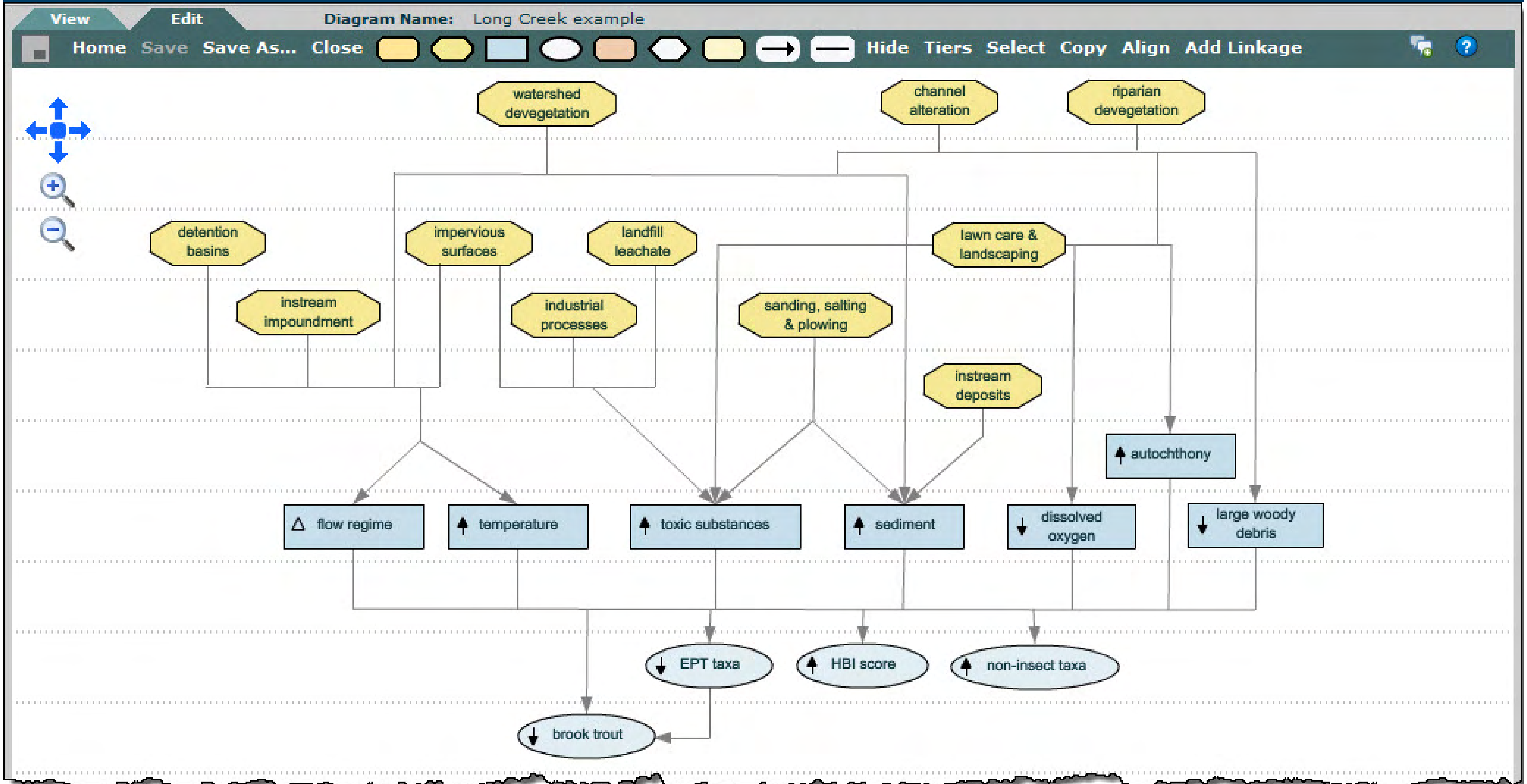
The ICD application

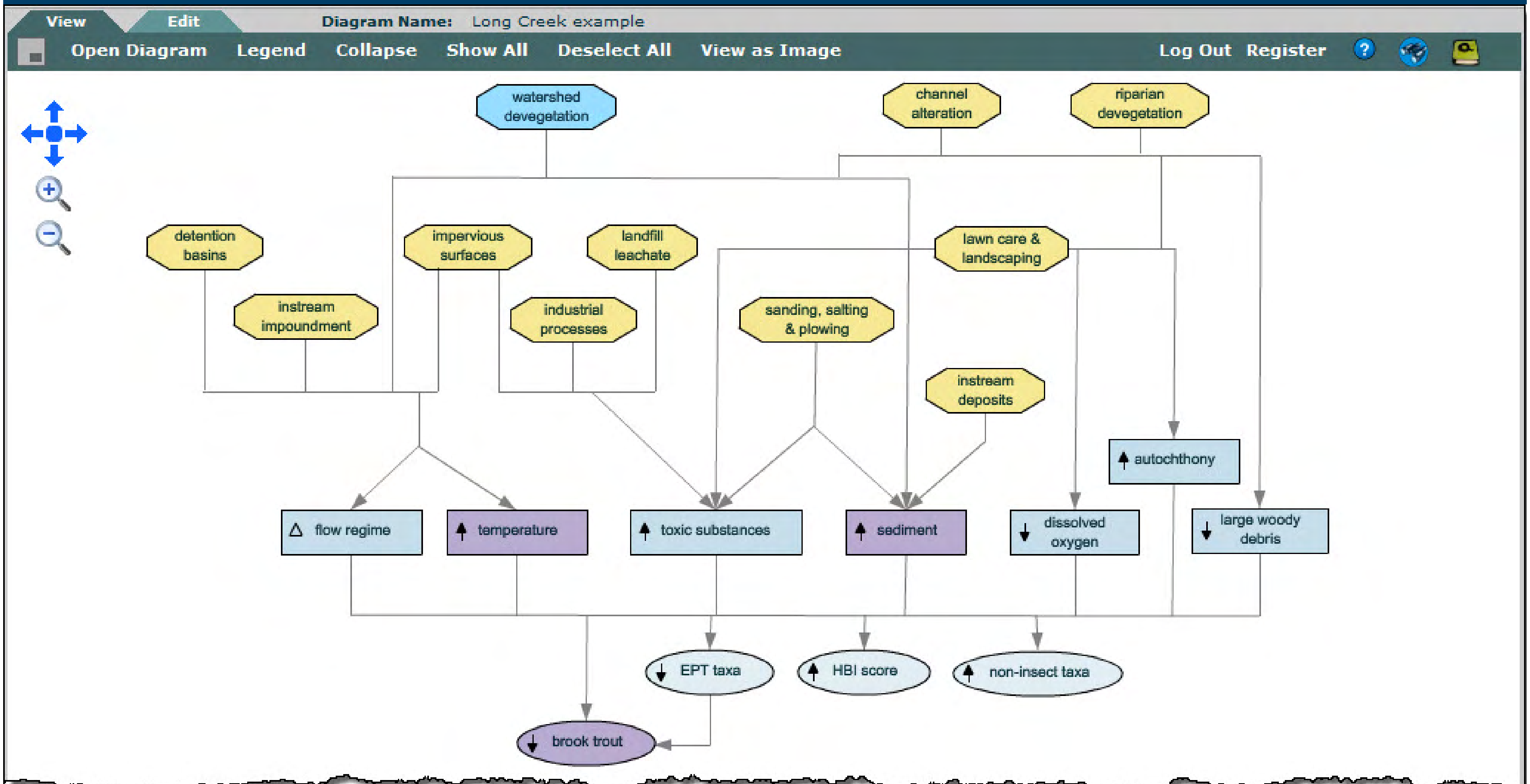
- Visual tool for organizing & accessing cause-effect information

- > 400 papers
  - Metals
  - Temperature
  - Sediment
  - Urbanization
  - Nitrogen & phosphorus

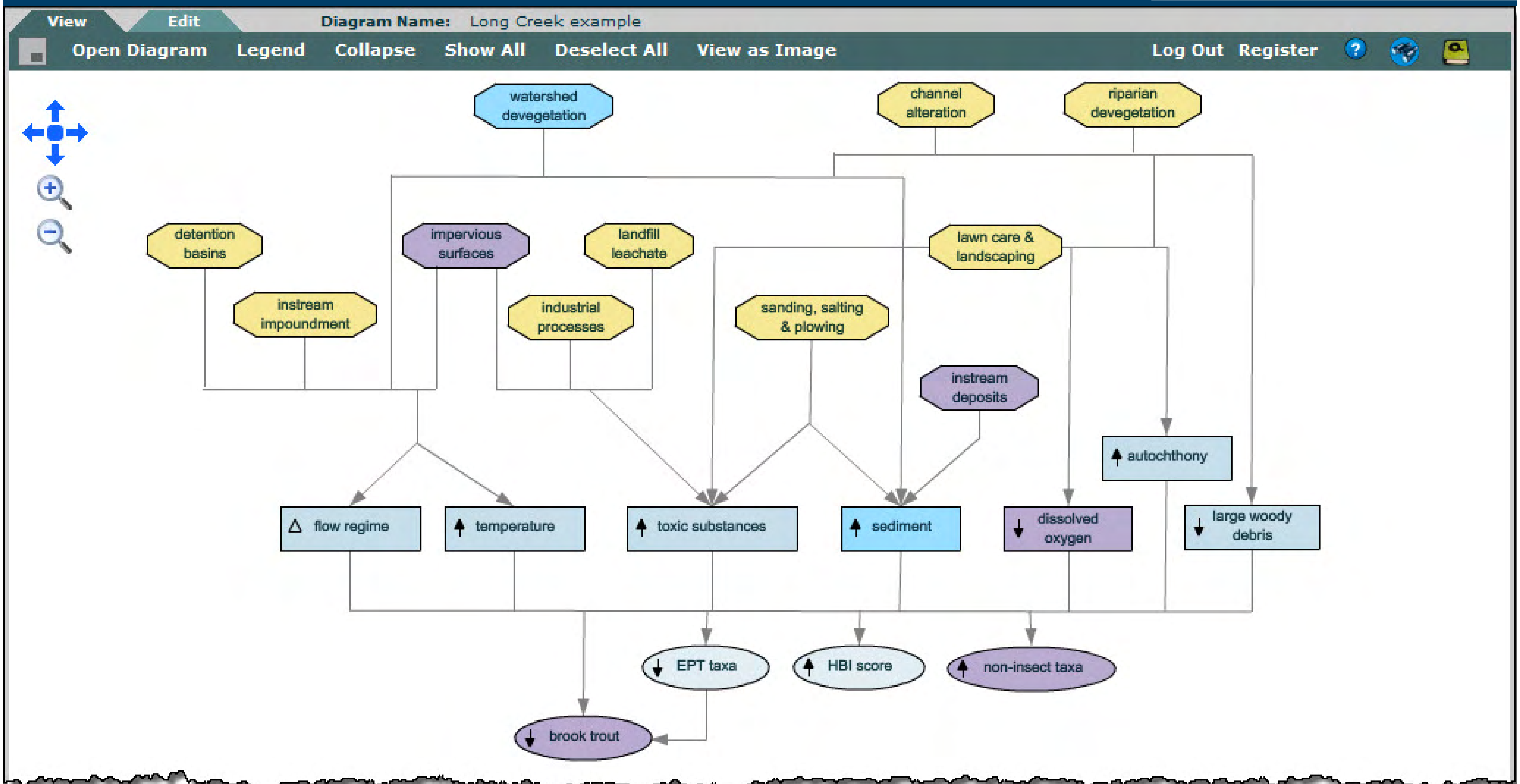
- 2 modes
  - **View** mode: access supporting literature for selected linkages (shape pair combinations)
  - **Edit** mode: create & modify diagrams, link supporting literature to diagrams

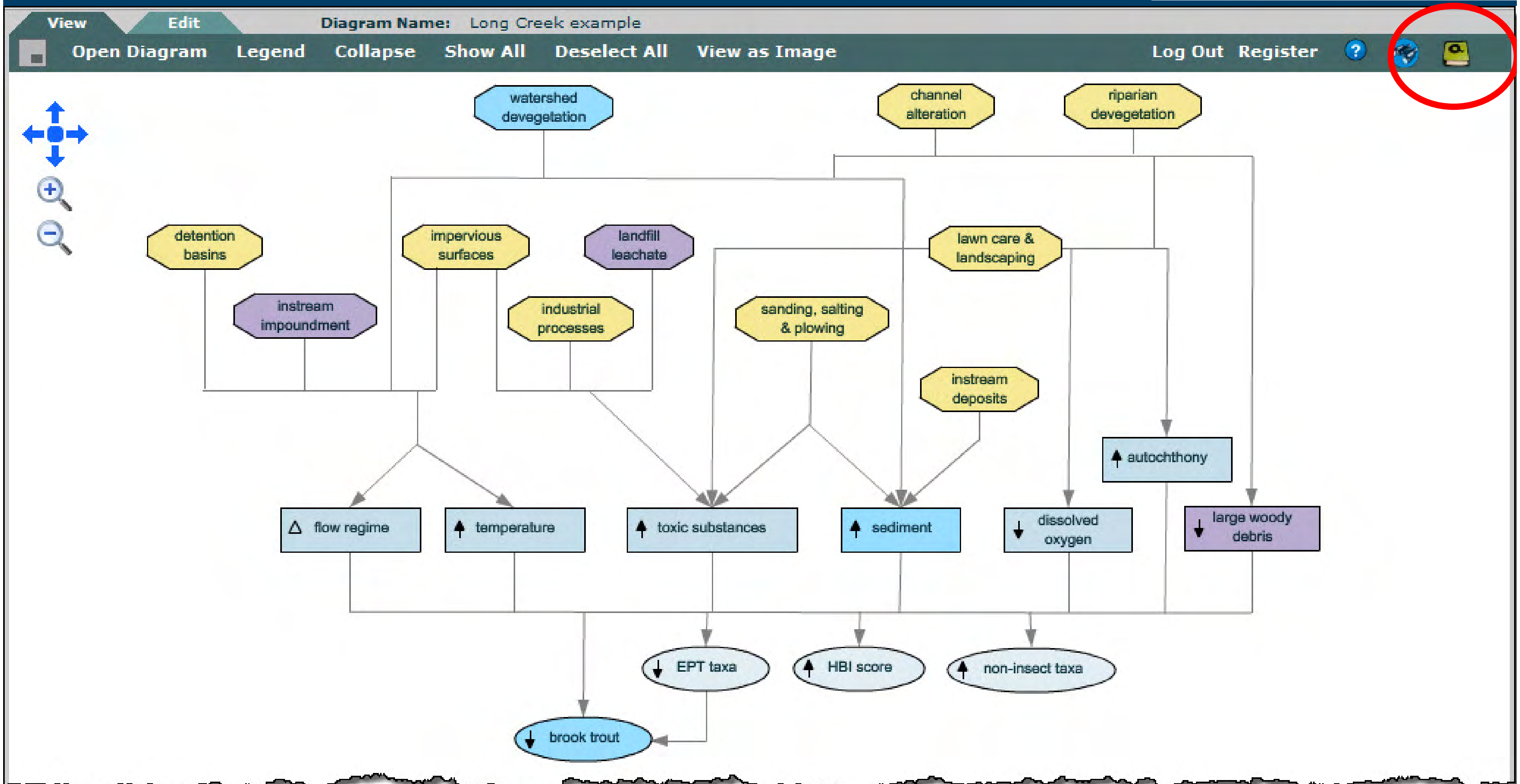
An ICD example…

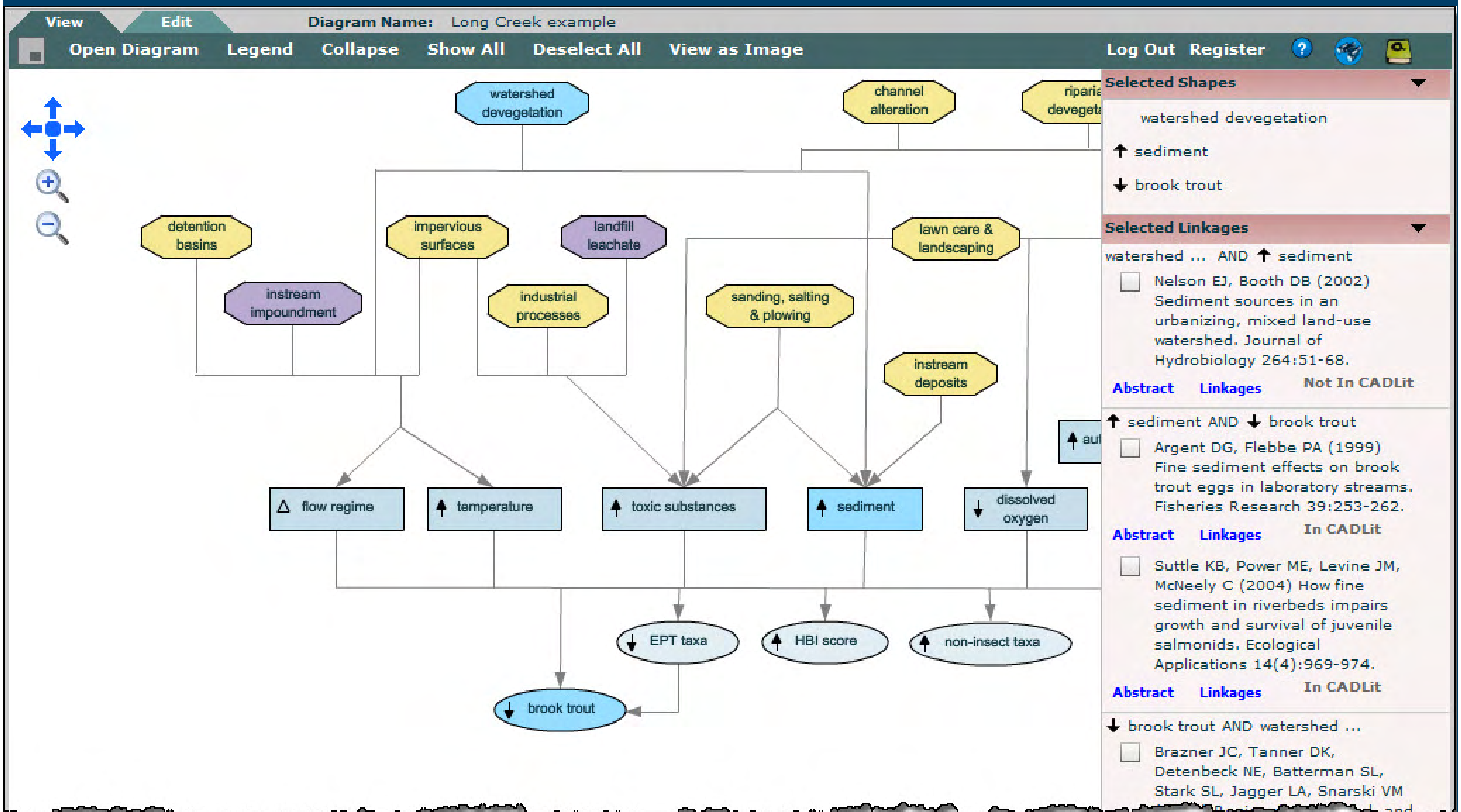




View
Edit
Diagram Name: Long Creek example
Open Diagram
Legend
Collapse
Show All
Deselect All
View as Image
Log Out
Register
watershed devegetation
channel alteration
riparian devegetation
detention basins
impervious surfaces
landfill leachate
lawn care & landscaping
instream impoundment
industrial processes
sanding, salting & plowing
instream deposits
autochthony
flow regime
temperature
toxic substances
sediment
dissolved oxygen
large woody debris
EPT taxa
HBI score
non-insect taxa
brook trout


View
Edit
Diagram Name: Long Creek example
Open Diagram
Legend
Collapse
Show All
Deselect All
View as Image
Log Out
Register
watershed devegetation
channel alteration
riparian devegetation
detention basins
impervious surfaces
landfill leachate
lawn care & landscaping
instream impoundment
industrial processes
sanding, salting & plowing
instream deposits
autochthony
flow regime
temperature
toxic substances
sediment
dissolved oxygen
large woody debris
EPT taxa
HBI score
non-insect taxa
brook trout


View
Edit
Diagram Name: Long Creek example
Open Diagram
Legend
Collapse
Show All
Deselect All
View as Image
Log Out
Register
watershed devegetation
channel alteration
riparian devegetation
detention basins
impervious surfaces
landfill leachate
lawn care & landscaping
instream impoundment
industrial processes
sanding, salting & plowing
instream deposits
autochthony
flow regime
temperature
toxic substances
sediment
dissolved oxygen
large woody debris
EPT taxa
HBI score
non-insect taxa
brook trout


View
Edit
Diagram Name: Long Creek example
Open Diagram
Legend
Collapse
Show All
Deselect All
View as Image
Log Out
Register
watershed devegetation
channel alteration
detention basins
impervious surfaces
landfill leachate
lawn care & landscaping
instream impoundment
industrial processes
sanding, salting & plowing
instream deposits
flow regime
temperature
toxic substances
sediment
dissolved oxygen
EPT taxa
HBI score
non-insect taxa
brook trout
Selected Shapes
watershed devegetation
sediment
brook trout
Selected Linkages
watershed ... AND sediment
Nelson EJ, Booth DB (2002) Sediment sources in an urbanizing, mixed land-use watershed. Journal of Hydrobiology 264:51-68.
Abstract
Linkages
Not In CADLit
sediment AND brook trout
Argent DG, Flebbe PA (1999) Fine sediment effects on brook trout eggs in laboratory streams. Fisheries Research 39:253-262.
Abstract
Linkages
In CADLit
Suttle KB, Power ME, Levine JM, McNeely C (2004) How fine sediment in riverbeds impairs growth and survival of juvenile salmonids. Ecological Applications 14(4):969-974.
Abstract
Linkages
In CADLit
brook trout AND watershed ...
Brazner JC, Tanner DK, Detenbeck NE, Batterman SL, Stark SL, Jagger LA, Snarski VM

CADDIS Volume 5: Causal Databases

Contact Us Share

- CADDIS Home
- Stressor Identification
- Sources, Stressors & Responses
- Examples & Applications
- Data Analysis
- Causal Databases
  - ICDs
  - CADLit

You are here: EPA Home » CADDIS » Causal Databases » CADLit

Introduction | Keyword Search | Advanced Search | Administrator Tools

CADLit contains stressor-response information for multiple stressor exposures reported in the peer-reviewed scientific literature.

As part of a causal analysis, CADLit can help you:

- Identify candidate or potential causes of impairment by providing information that may support or negate causal pathways in conceptual model diagrams.
- Support or negate the contribution of a specific stressor to an impairment by providing qualitative and quantitative data from other studies of similar stressor scenarios.

At this time, CADLit contains information for metals, sediment, and nutrients identified through literature searches up to 2009. We continue to expand the scope of the CADLit to include more stressors and types of information, so please contact with suggestions for additions (including submission of new papers by the authors).

Some additional characteristics of the CADLit database:

- Many of the reviewed papers are from studies in the United States and Canada, but a significant number of papers are from other parts of the world.
- The surveyed literature generally will be peer-reviewed papers in the English language from journal abstracted in bibliographical databases, such as Biological Abstracts, Biosis, Current Contents, Science Direct or Google Scholar.
- If more than one set of data were analyzed independently in a study, separate listings, called datasets, occur in the data base for each set of data.

To begin searching the CADLit database, select either the Keyword Search or Advanced Search tab above. For more information on searching and querying CADLit, see the CADLit User's Guide.

Top of page

CADDIS: A Team Effort

- Thanks to the many ecologists, hydrologists, engineers, and statisticians who have contributed to CADDIS.
- Additional thanks to our state partners for case study contributions.
- Suggestions for future enhancements welcome.

www.epa.gov/caddis