The Stressor Identification Process and CADDIS

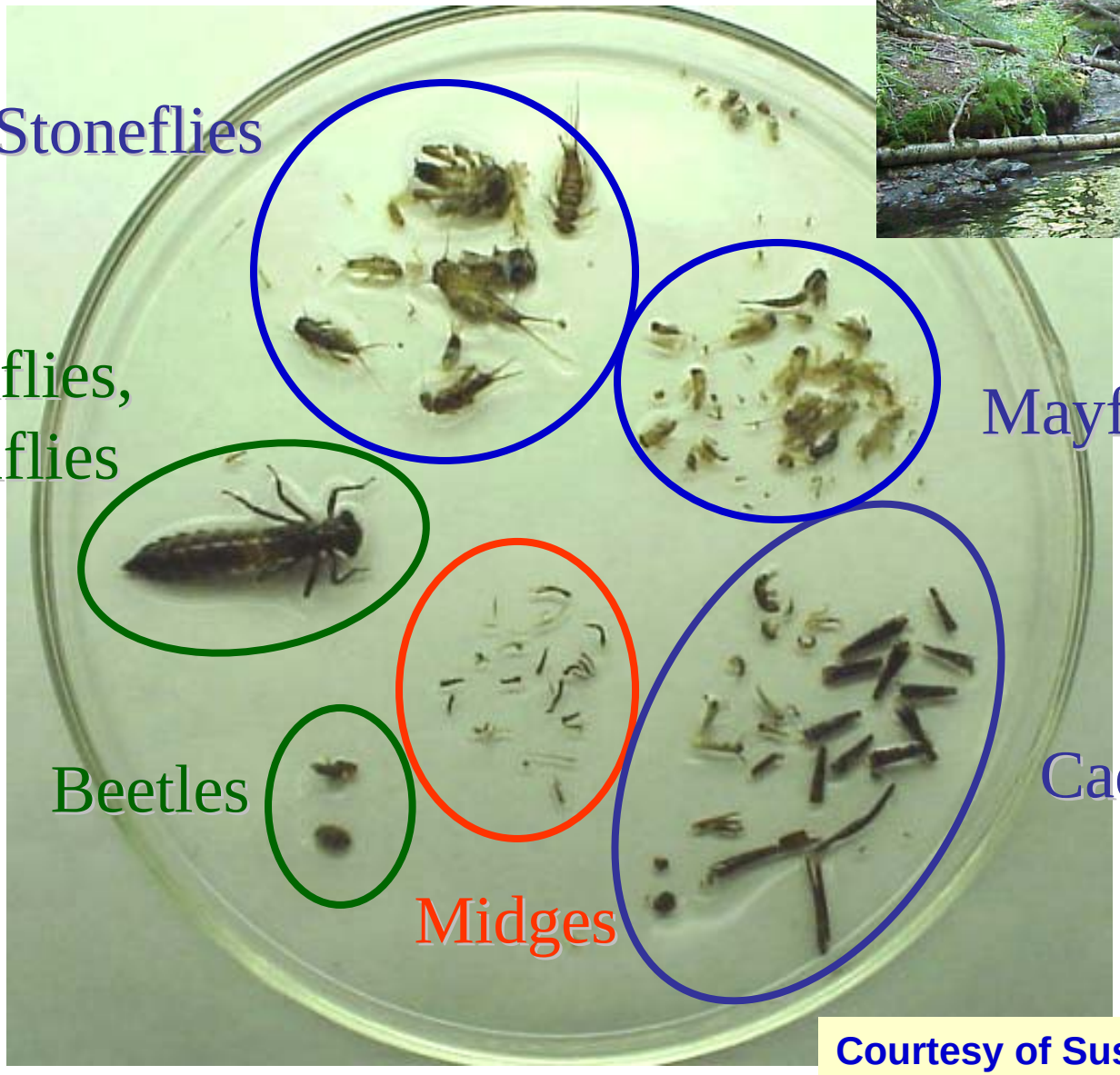
New Tools for Better Causal Assessment

Susan B. Norton
USEPA/ORD
National Center for Environmental Assessment
U.S. EPA's Causal Analysis Team

New Methods for Improving our Environment

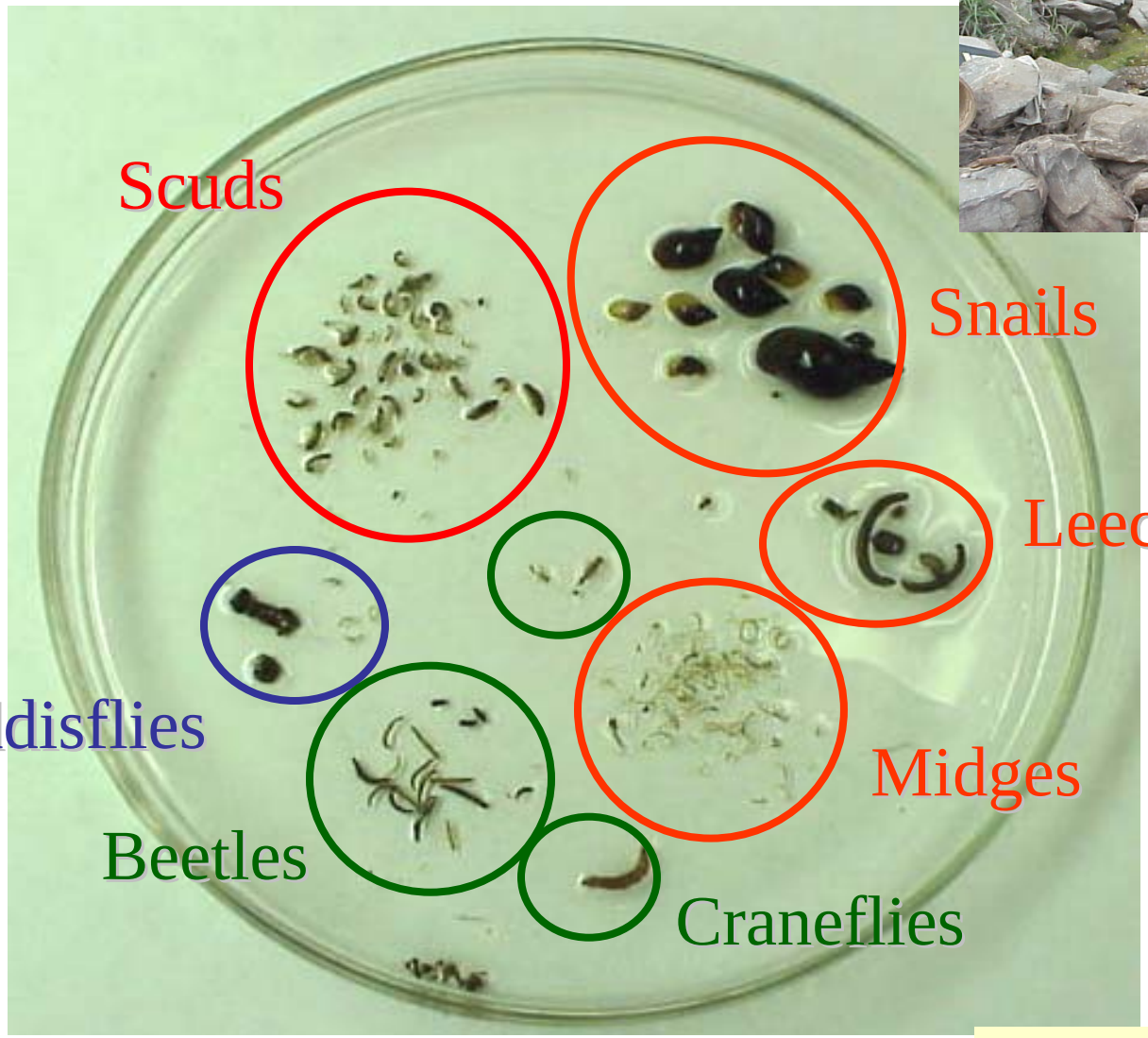
- *Biological assessment* is providing important insights into the condition of our aquatic systems
- *Causal analysis* methods help identify the right next steps for management action
  - guide efficient data collection
  - make effective remedial and restoration decisions

Undisturbed/Minimally Disturbed Stream



Courtesy of Susan Davies, ME DEP

A Stream Adjacent to a Shopping Mall

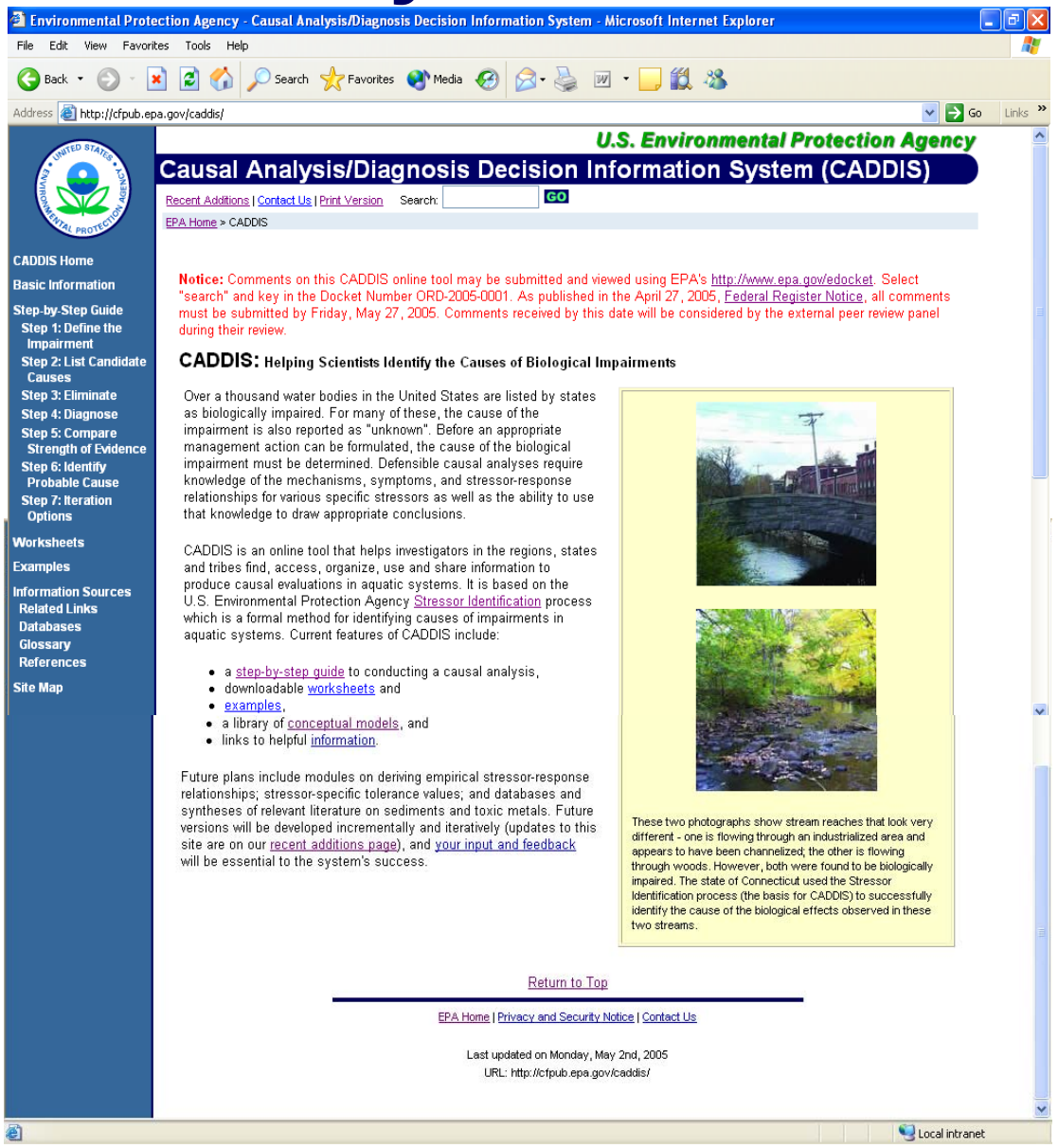


Courtesy of Susan Davies, ME DEP

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

Causal Analysis/Diagnosis Decision Information System

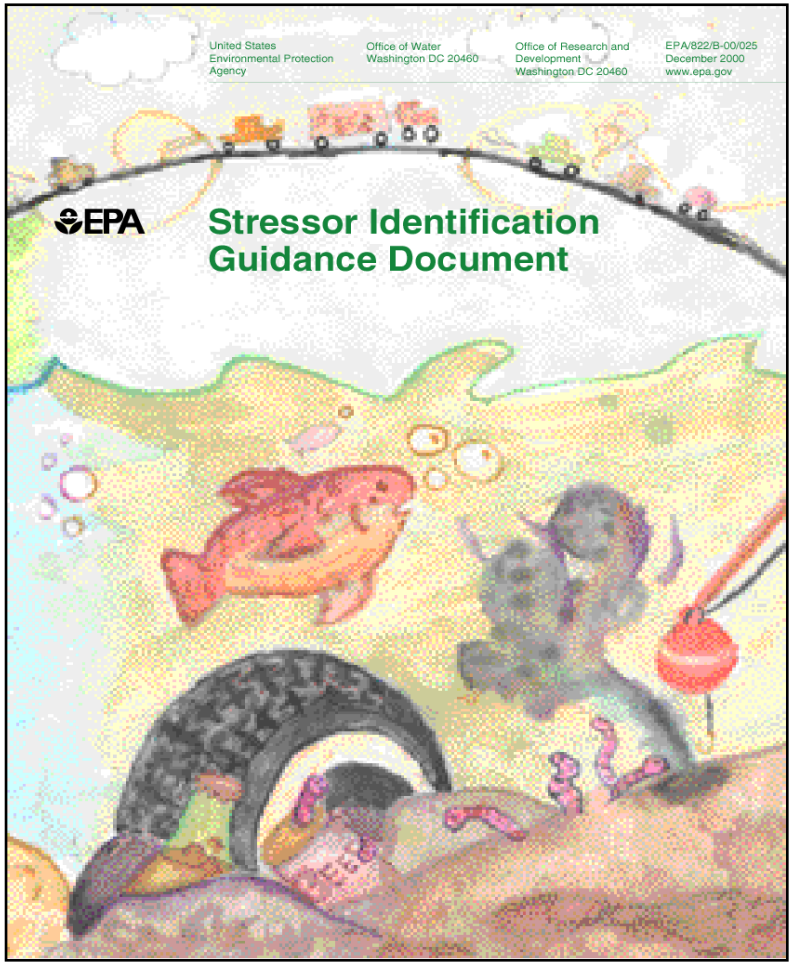
- CADDIS helps make causal analysis easier
- Used when a biological impairment is observed and the cause is unknown or uncertain
- Currently focused on streams



CADDIS is based on a formal method (U.S. EPA 2000)

Why Use a Formal Method?

- To increase confidence that costly remedial or restoration efforts are targeted at factors that can truly improve biological condition; and
- To identify causal relationships that are otherwise not immediately apparent.



Even smart people make mistakes about causation

First: We all think we know how to do it

- Hard-wired to jump to conclusions from sparse information

Even worse: Because we are smart, we can ably defend our opinions

- Theory tenacity: the number one reason for mistaken conclusions

"*The first principle of science is that you must not fool yourself – and you are the easiest person to fool* "

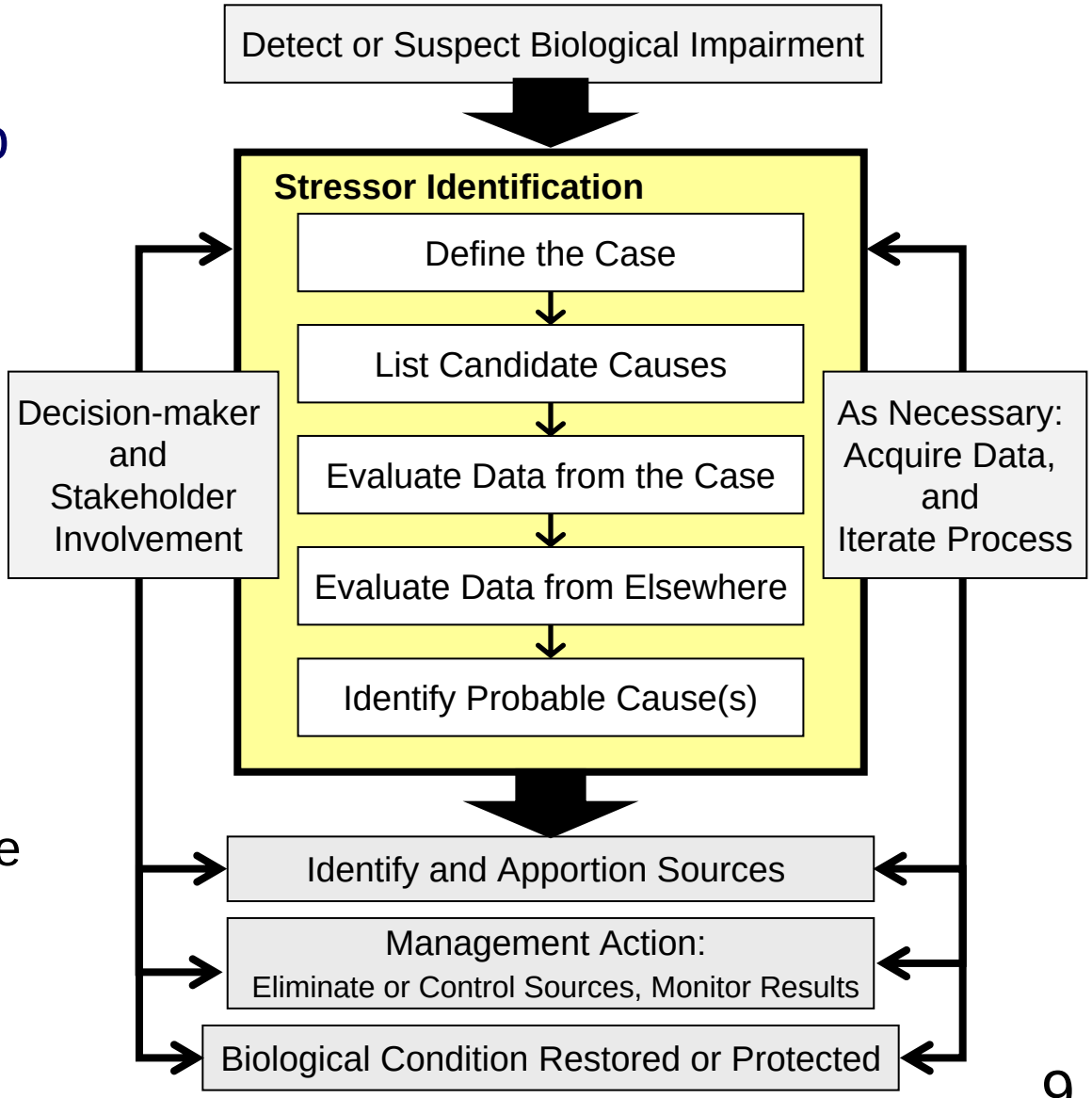
- Richard Feynman

CADDIS 1:

A rigorous approach to Stressor Identification

Method Features

- Site-specific causation
- Weight of evidence approach
- Compare alternative candidate causes
- Identifies the most probable cause among the alternatives



Environmental Protection Agency - Causal Analysis/Diagnosis Decision Information System - Microsoft Internet Explorer

http://www.epa.gov/caddis

Causal Analysis/Diagnosis Dec (CADDIS)

Protection Agency

stem

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Summary Tables of Types of Evidence
Summary Table of Scores
Examples
Information Sources
Related Links
Databases

CADDIS: Helping Scientists Identify the Causes of Bi

Over thousand water bodies in the United States are listed states as biologically impaired. For many of these, the caus impairment is also reported as "unknown". Before an approp management action can be formulated, the cause of the biol impairment must be determined. Defensible causal analyses require knowledge of the mechanisms, symptoms, and stres response relationships for various specific stressors as well ability to use that knowledge to draw appropriate conclusion

CADDIS is an online application that helps scientists and engineers in the Regions, States and Tribes find, access, organize, use and share information to conduct causal assessments in aquatic systems. It is based on the U.S. Environmental Protection Agency Stressor Identification pro which is a formal method for identifying causes of impairme aquatic systems and watersheds. Current features of this sit include:

- The Step-by-Step Guide to conducting a causal analysis,
- Example worksheets, a library of conceptual models, and
- Information sources including related links, glossary and acronyms, ar reference section.

Future plans include modules on deriving empirical stressor- response relationships, stressor-specific tolerance values, a databases and syntheses of relevant literature on sediments toxic metals. Future versions will be developed incrementally iteratively (updates to this site can be found on our recent a page), and your input and feedback will be essential to the

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be biologically impaired.
tressor Identification
uccessfully identify the
ved in these two streams.

Done

Local intranet

Step-by-Step Guide
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Summary Table of Scores
Summary Tables of Types of Evidence
Examples

Maine

Long Creek

- Urbanized system
- Flow alteration & dissolved oxygen are key stressors

Birch Stream, Capisic Brook, Barberry Creek, &Trout Brook

- Urban NPS Assessments

Urban Streams Nonpoint Source Assessments in Maine

Final Report

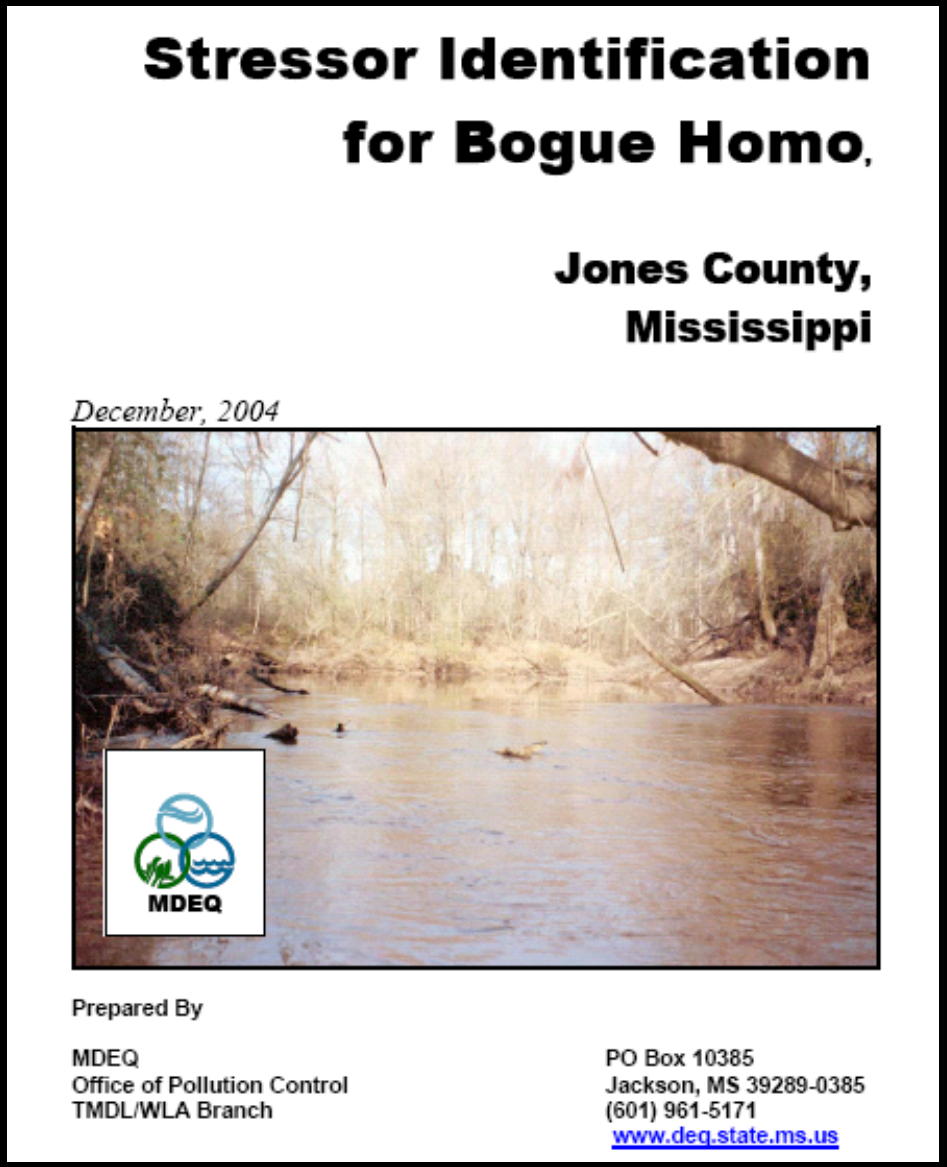
Birch Stream
Bangor

Trout Brook
Cape Elizabeth and South Portland

Barberry Creek
South Portland

Capisic Brook
Portland

Mississippi



Stressor Identification for Bogue Homo,

Jones County, Mississippi

December, 2004

MDEQ

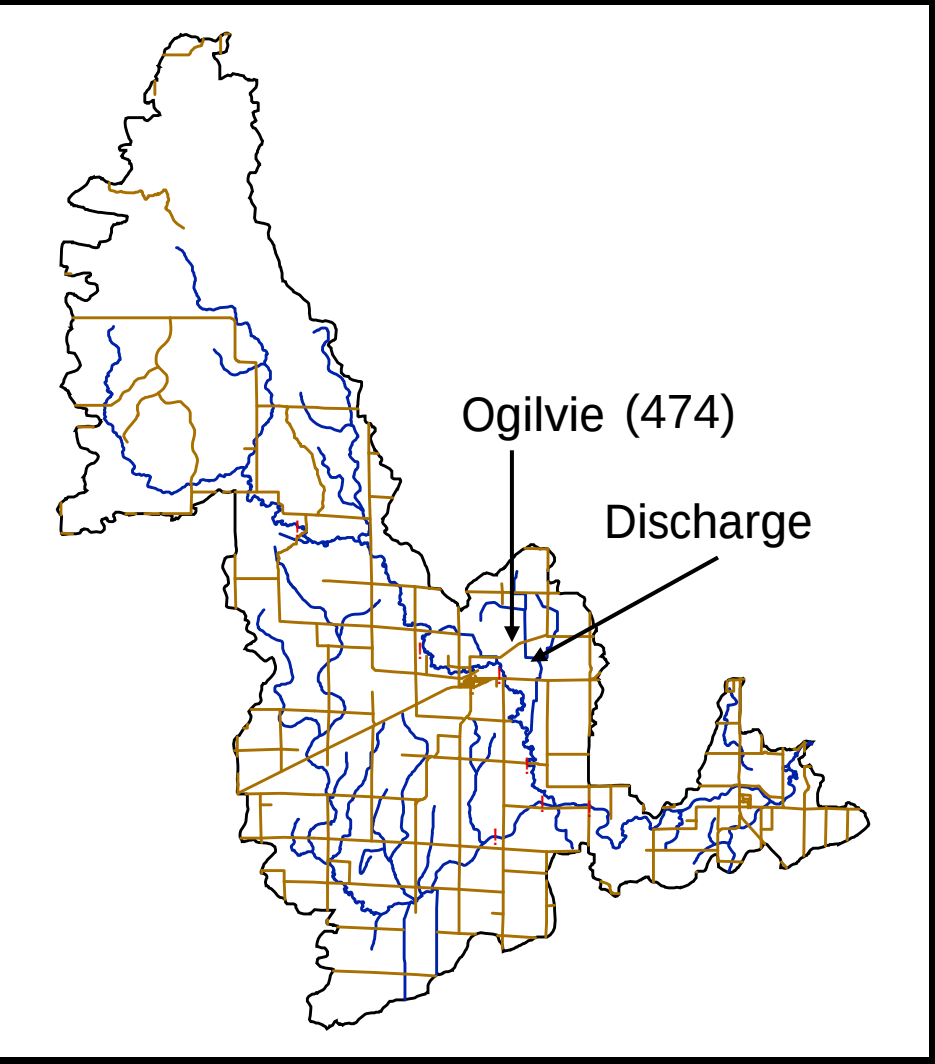
Prepared By

MDEQ
Office of Pollution Control
TMDL/WLA Branch

PO Box 10385
Jackson, MS 39289-0385
(601) 961-5171
www.deq.state.ms.us

Methods to speed up assessments—more than 757 court ordered TMDL within 10 yrs.

Minnesota



Mechanical treatment plant
- **trickling filter/chlorine disinfection**
- **continuous discharge**
- **avg. annual design flow 200,000 gpd**
- **violates CBOD and TSS limits with some frequency**

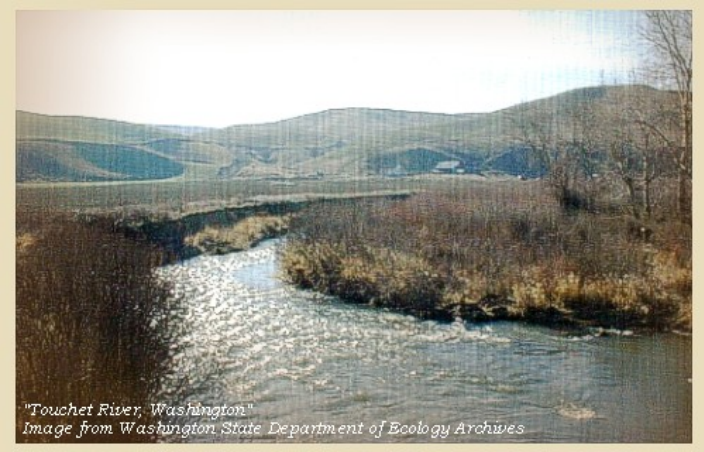
Groundhouse River

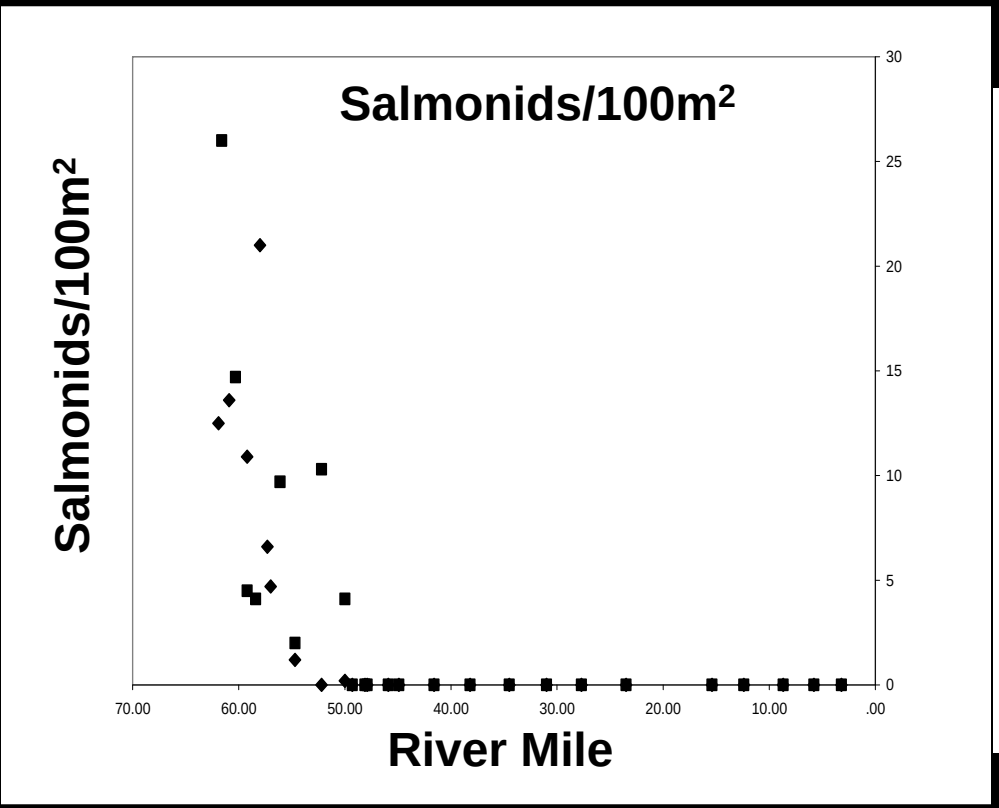
- Screening case study
- Identified data needs
- Used to secure grant money
- Data collected and being evaluated

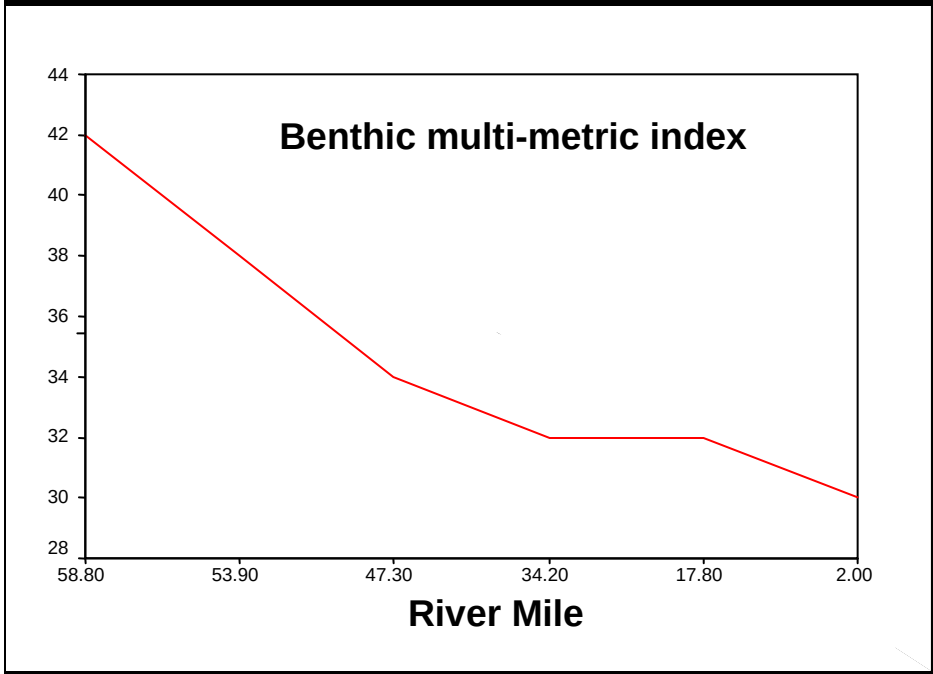
Washington

Touchet River

Temperature & sediment are key stressors







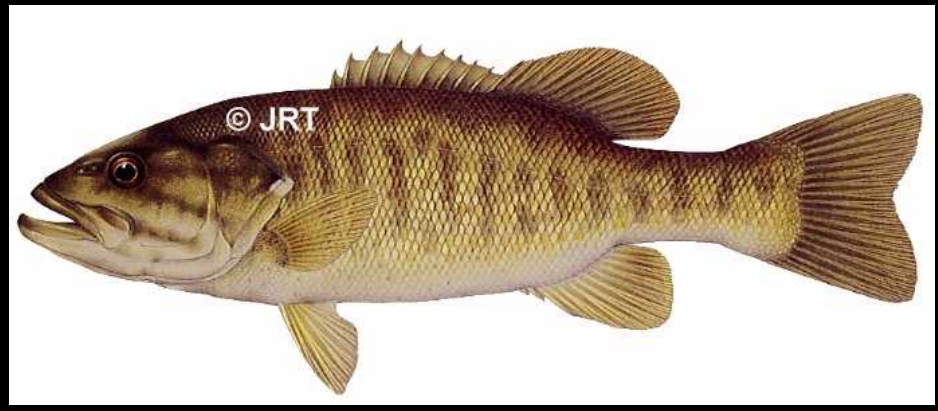
Potomac River Basin

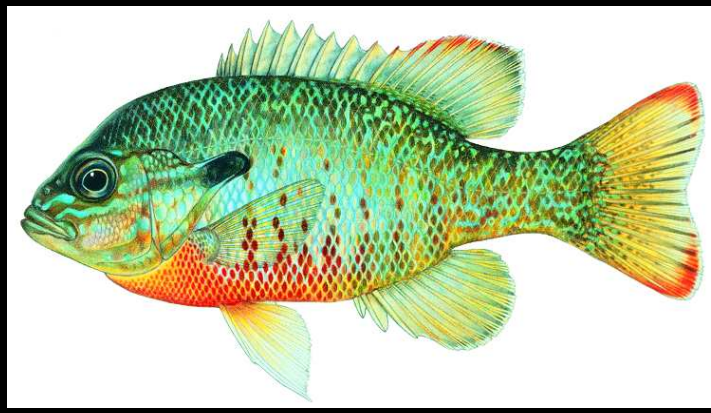
- Fish Kills in Spring 2006

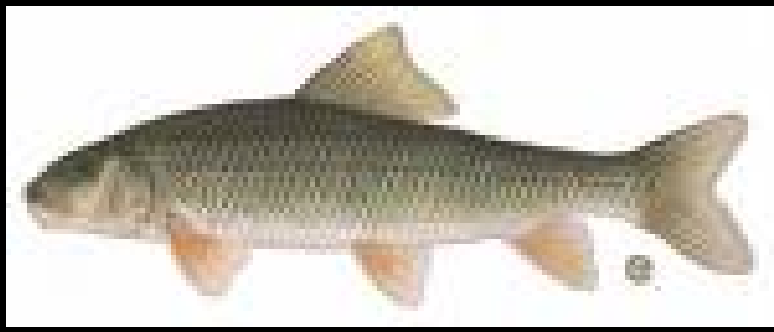
Shenandoah River

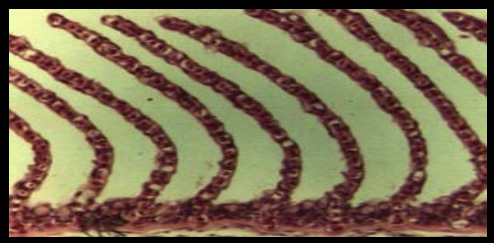
North Fork

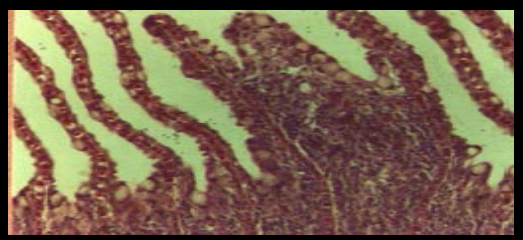
South Branch Potomac







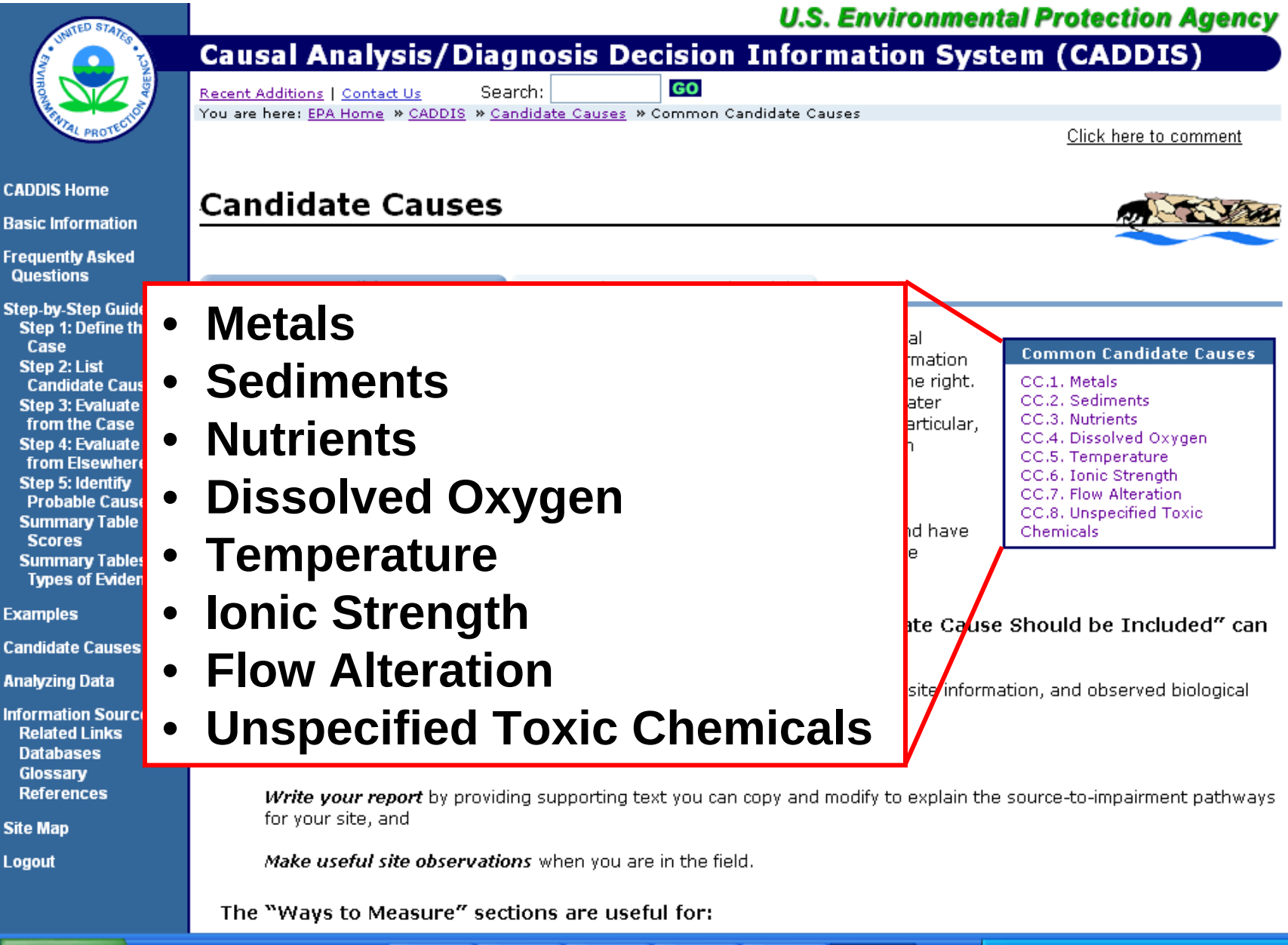




Case Studies Like These Guided CADDIS 2007 Development

- Common sets of stressors of interest
  - CADDIS provides basic information on eight commonly encountered candidate causes
- States have great data sets
  - CADDIS provides
    - better tools for analyzing regional data
    - advice for interpreting site-specific results in a regional context
- Good stressor-response information can be hard to find
  - CADDIS provides stressor-response information from the literature and regional analyses

CADDIS Candidate Cause Pages



- **Metals**
- **Sediments**
- **Nutrients**
- **Dissolved Oxygen**
- **Temperature**
- **Ionic Strength**
- **Flow Alteration**
- **Unspecified Toxic Chemicals**

CADDIS Candidate Cause Pages

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Candidate Causes

Common Candidate Causes | Interactive Conceptual Models

CC.4. Dissolved Oxygen

- When to include
  - Checklist
  - Sources
  - Site evidence
  - Biological effects
  - When to exclude
- Ways to measure

CC.4. Dissolved Oxygen
1. When to Include
Checklist
Sources
Site Evidence
Biological Effects
When to Exclude
2. Ways to Measure
[+] Authors

Common Candidate Causes
[+] Click to Expand/Collapse
Candidate Causes Home

conceptual model for DO (Figure CC.4-1). The most common problems associated with DO relate to depletion.

CC.4.1.1. Checklist of S

A checklist is provided below
determining whether to inclu
is linked to more detailed de
evidence to eliminate or enh
aware of other situations wh
please send us your insights using the comment section.

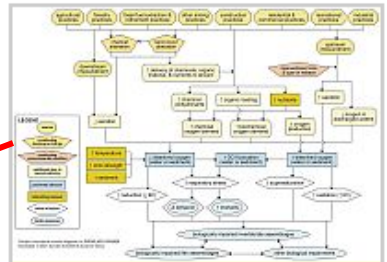

Figure CC.4-1. This simplified generic conceptual model traces causal pathways from sources to impairments for DO. Click on the diagram to go to a larger dissolved oxygen figure, accompanying narrative, and

Click to view Conceptual Model for Dissolved Oxygen

Linked to Conceptual Model Library

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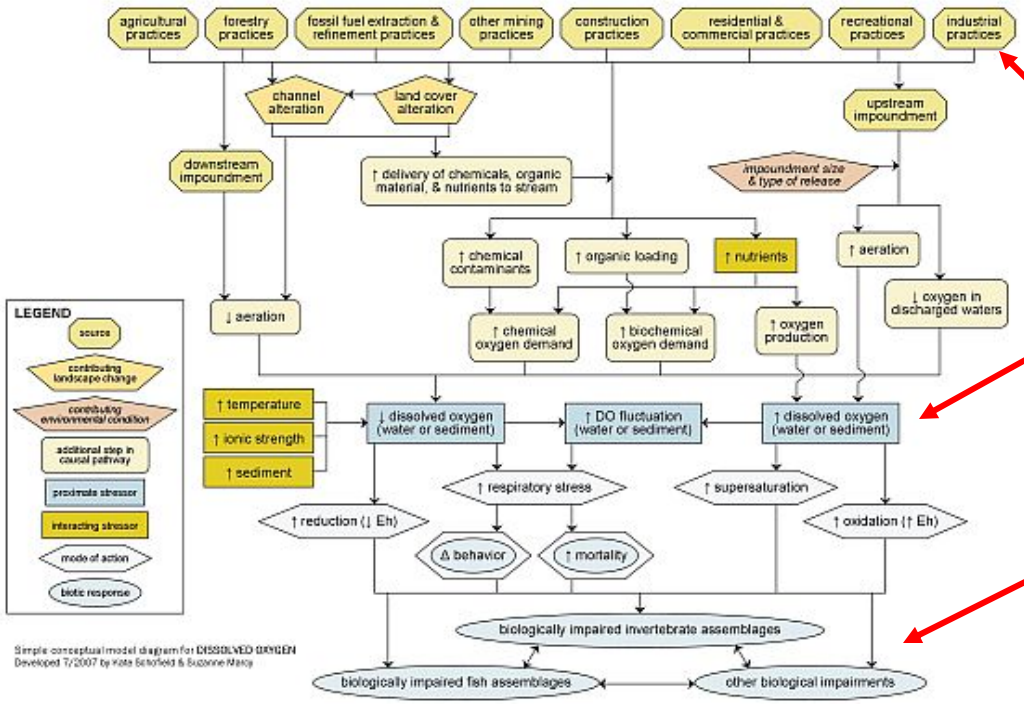
Dissolved Oxygen Simple Generic Conceptual Model



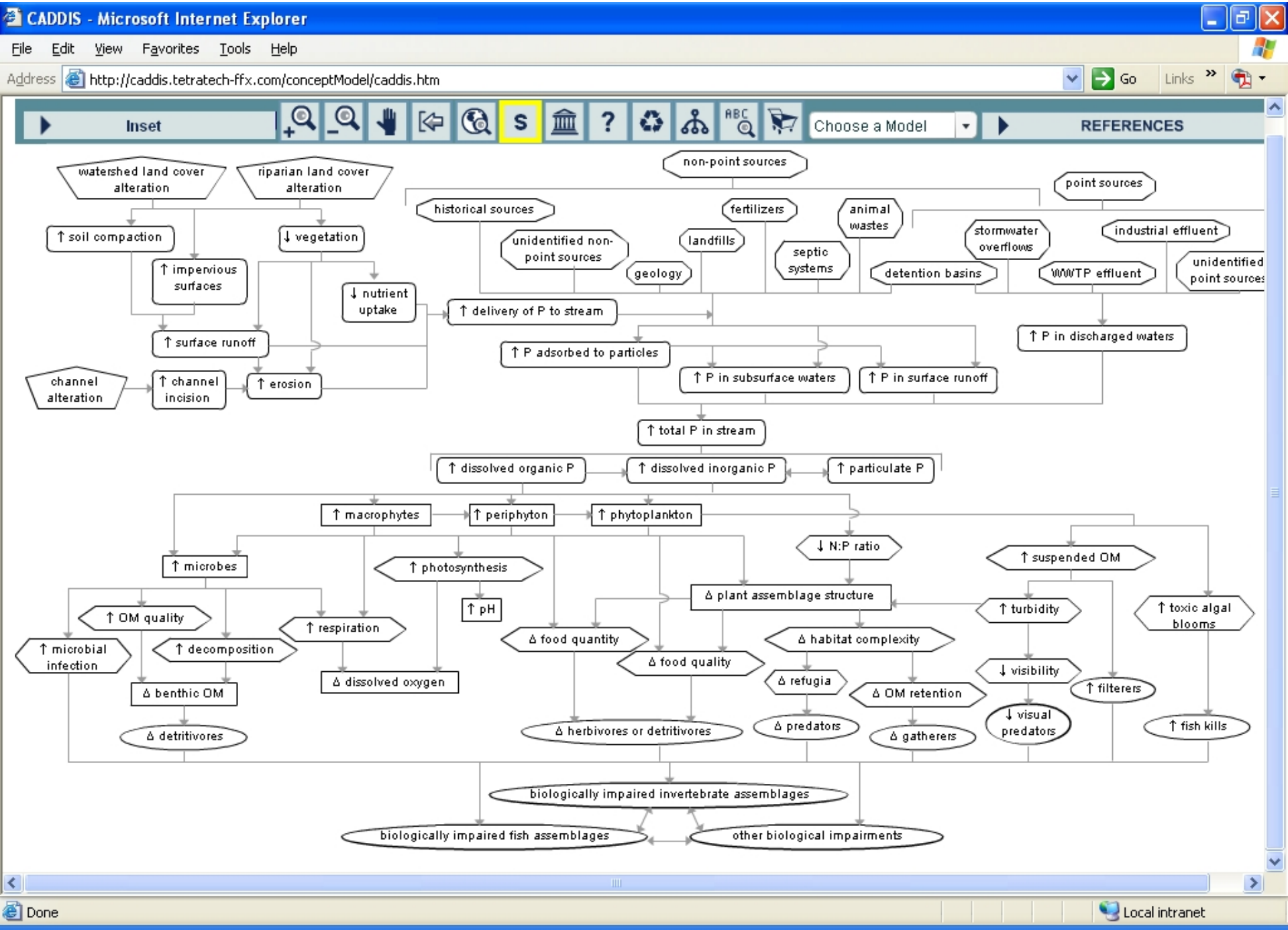
Each Model Diagram Describes how

- *human activities* may lead to
- *instream stressors* that may
- *impair biological communities*

Diagram Narrative

S.K.M. Marcy; 7-27-2007

Aerobic aquatic life requires oxygen for survival, and most are dependent upon oxygen dissolved in the water column. Dissolved oxygen (DO) concentrations are normally sufficient to maintain healthy biotic assemblages in unpolluted, free-flowing streams, but low or extremely high DO levels can impair or kill fishes and invertebrates. In addition, large fluctuations in DO levels over relatively short periods of time (e.g., daily) can stress aquatic organisms.


CADDIS - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://caddis.tetratech-ffx.com/conceptModel/caddis.htm
Go
Links
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REFERENCES
watershed land cover alteration
riparian land cover alteration
non-point sources
point sources
historical sources
fertilizers
animal wastes
unidentified non-point sources
landfills
septic systems
stormwater overflows
industrial effluent
geology
detention basins
WWTP effluent
unidentified point sources
↑ soil compaction
↓ vegetation
↑ impervious surfaces
↓ nutrient uptake
↑ delivery of P to stream
↑ surface runoff
↑ P adsorbed to particles
↑ P in discharged waters
channel alteration
↑ channel incision
↑ erosion
↑ P in subsurface waters
↑ P in surface runoff
↑ total P in stream
↑ dissolved organic P
↑ dissolved inorganic P
↑ particulate P
↑ macrophytes
↑ periphyton
↑ phytoplankton
↓ N:P ratio
↑ suspended OM
↑ microbes
↑ photosynthesis
↑ pH
Δ plant assemblage structure
↑ turbidity
↑ toxic algal blooms
↑ OM quality
↑ respiration
↑ microbial infection
↑ decomposition
Δ food quantity
Δ habitat complexity
Δ food quality
↓ visibility
↑ filterers
Δ benthic OM
Δ dissolved oxygen
Δ refugia
Δ OM retention
↓ visual predators
↑ fish kills
Δ detritivores
Δ herbivores or detritivores
Δ predators
Δ gatherers
biologically impaired invertebrate assemblages
biologically impaired fish assemblages
other biological impairments
Done
Local intranet

CADDIS - Microsoft Internet Explorer

File Edit View Favorites Tools Help

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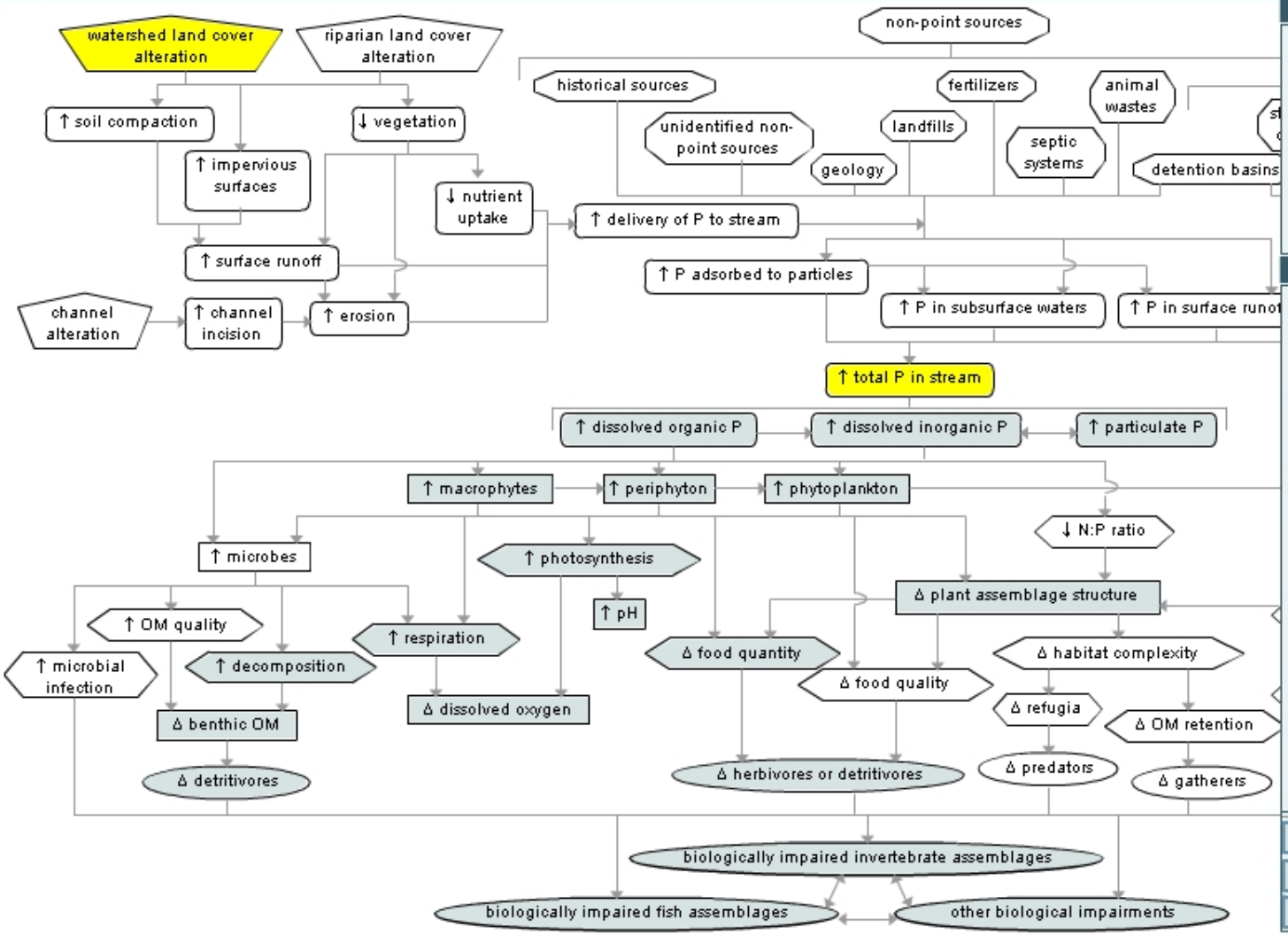

Selected Shapes

watershed land cover alteration

↑ total P in stream

Supporting Literature

watershed land cover alteration resulting in ↑ total P in stream

- Bennett, EM; et al. (2001)
- Brett, MT; et al. (2005)
- Winter, JG & Duthie, HC. (2000)
- Leland, HV & Porter, SD. (2000)
- Naymik, J; et al. (2005)
- Sonneman, JA; et al. (2001)
- Viney, NR; et al. (2000)

Save Selected

Select All & Save

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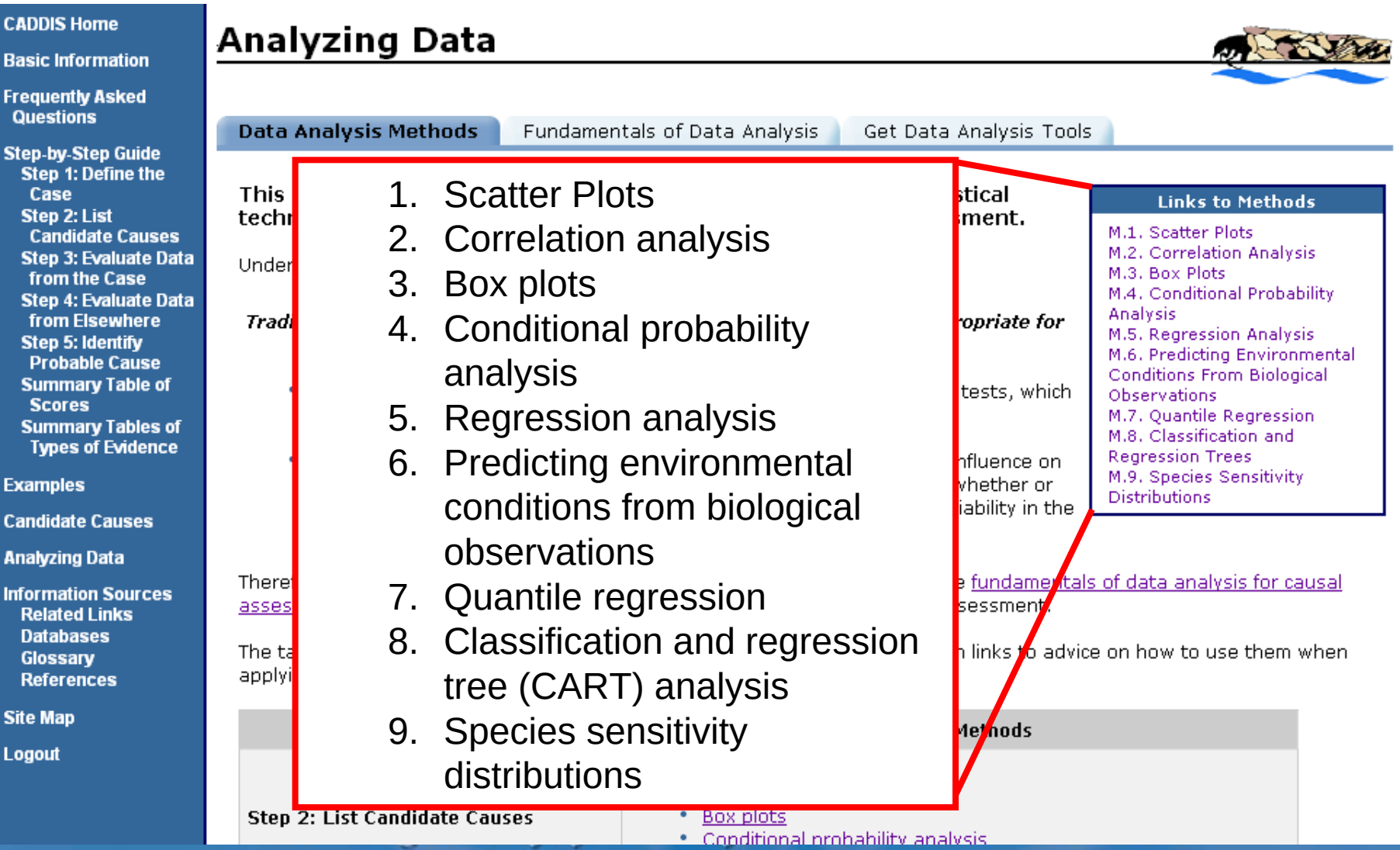
CADDIS Analytical Methods Pages

How methods are used to support causal analysis



Example Methods Page: Scatter Plots

Analyzing Data

M.1. Scatter Plots

M.1.

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1. What are they?
2. How do I use them in Stressor Identification
3. Can I use them with my data?
4. Helpful tips

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M.1. Scatter Plots
1. What are scatter plots?
2. How do I use scatter plots in Stressor Identification?
3. Can I use scatter plots with my data?
4. Helpful tips

[+] Authors

Links to Methods
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The Methods Home

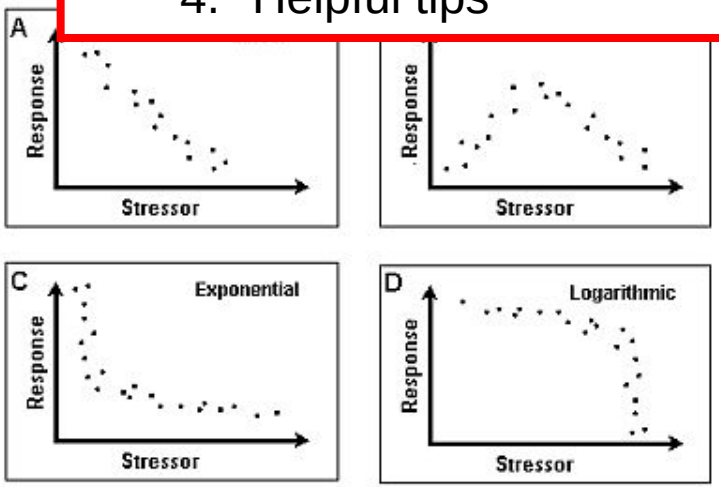


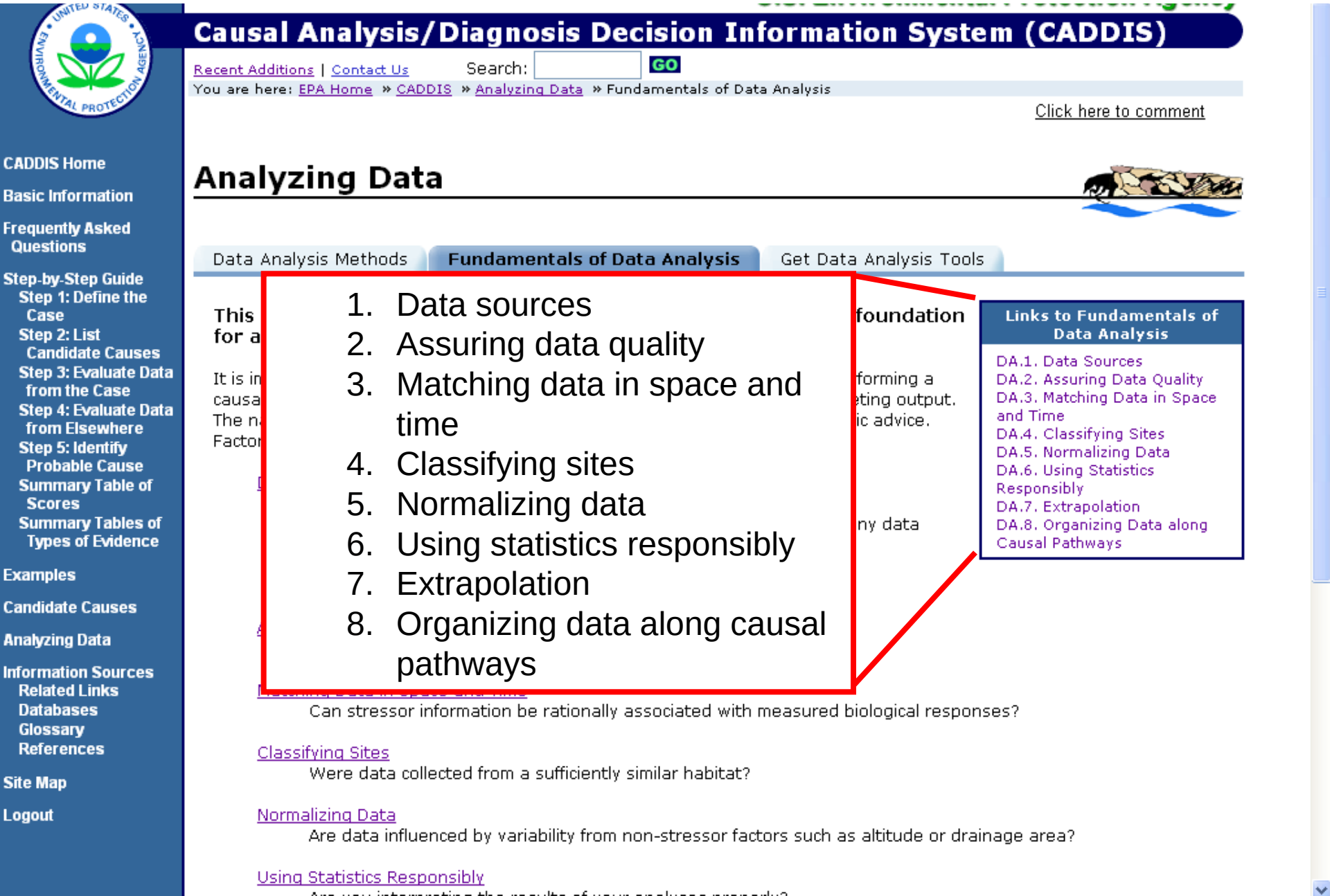
Figure M.1-1. Scatter plots illustrating different patterns suggesting the underlying form of the stressor-response relationship: A-linear, B-quadratic, C-exponential, and D-logarithmic.

h
relationships to model – A scatter of points that suggests the attribute responds to changes in the independent variable would be explored further using correlation or regression methods, while a scatter of points without any apparent relationship is unlikely to provide insights into relationships, even using multivariate analyses.

Select a model - The distribution of points in a scatter plot may suggest whether the relationship is, for example, (A) linear, (B) a higher-order polynomial (quadratic shown), (C) exponential, or (D) logarithmic (Figure M.1-1). The distribution of points also may reveal apparent thresholds or discontinuities in the relationship.

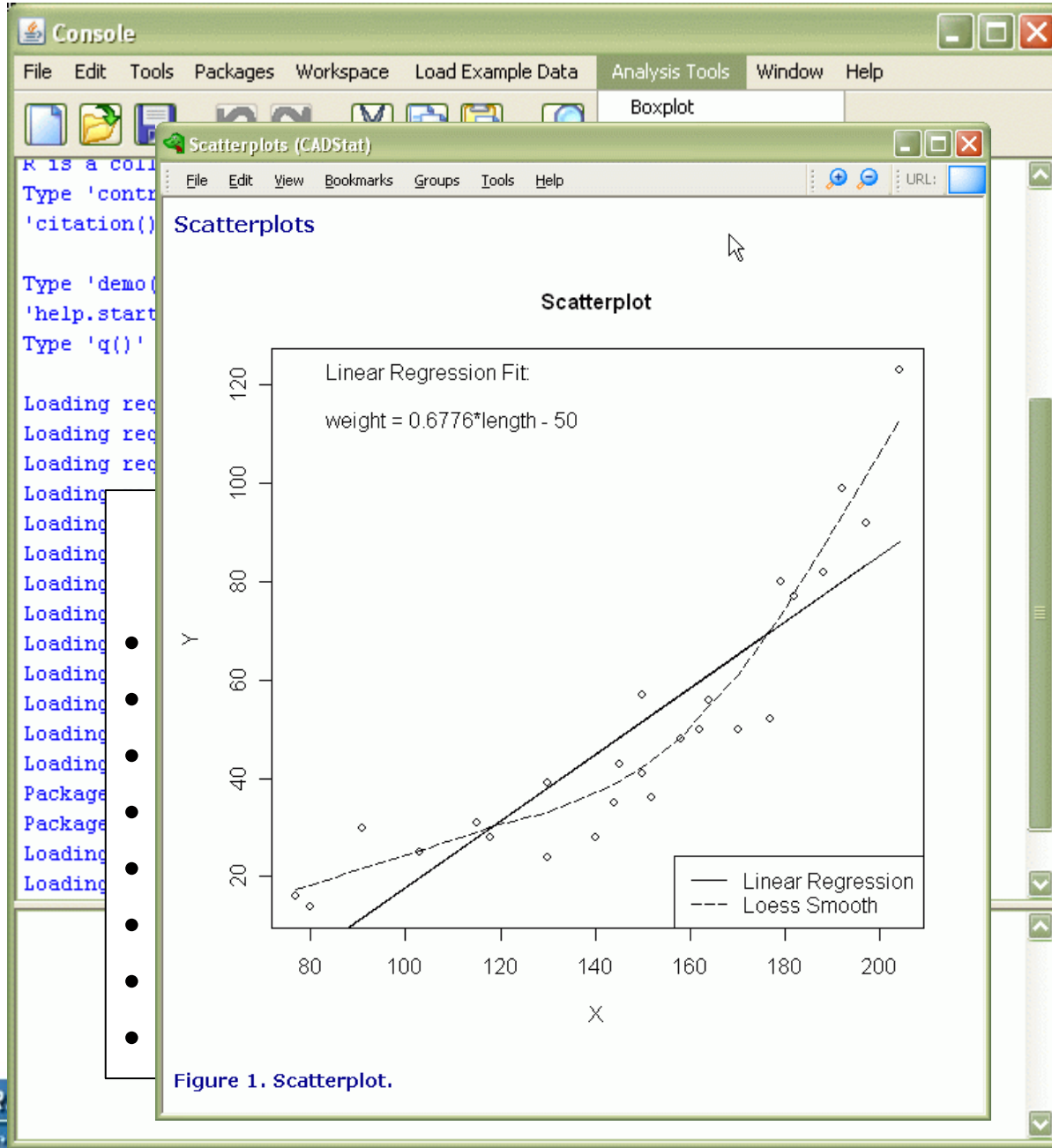
Top of Page

Fundamentals of Data Analysis



CADDIS Analytical Tools

- CADStat: Graphical User Interface for R



CADDIS Stressor-Response Databases

D.2. Metals Chronic Concentration-Response Gallery

Links to Databases

[+] Databases

D.3. Metals Species Sensitivity Distribution Gallery

Links to Databases

[+] Databases

D.4. Field Stressor-Response Association Gallery

Links to Databases

[+] Databases

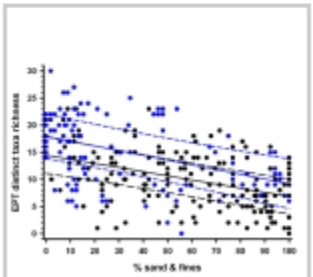
Back to Databases

Examples of stressor-response relationships computed from field data are provided here. They illustrate stressor-response relationships that have been observed in several datasets, using some of the methods described in the Analyzing data section. We recommend that you review the description of the methods and the Fundamentals of data analysis section prior to viewing or using the graphs.

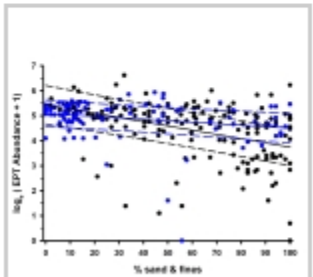
These graphs and models show you what to expect from these analyses and show the types of relationships that are found between some common stressors and biological responses. However, it is unlikely that the stressor-response relationships shown here will be exactly applicable to your particular situation. Please review the metadata provided with each graph carefully. Examine whether the sampling and analysis methods are comparable. Evaluate whether the response and explanatory variables are relevant to your aquatic system and causal analysis. Additional stressor-response relationships will be added in future updates to this page. Please contact us with comments and suggestions.

Click on a thumbnail for a larger image and metadata.

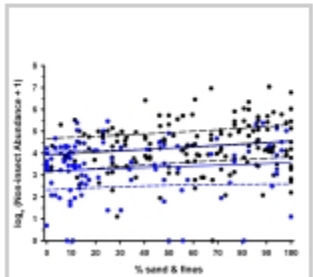
Linear regression



EPT Taxa Richness vs. Percent Sands and Fines for Minnesota Streams



EPT Relative Abundance vs. Percent Sands and Fines for Minnesota Streams



EPT Relative Abundance vs. Percent Sands and Fines for Minnesota Streams

The Future

- Add content
  - Physical habitat alteration
  - Multivariate statistical methods
  - Spatial analysis tools (landscape analysis)

- Involve community in development
  - Explore collaborative platform

CADDIS 2007

A rigorous process for
ecological causal assessment
-- and --
the technical content to help you do it.

www.epa.gov/caddis