

An aerial photograph of a river winding through a dense forest. The river is the central focus, with its banks covered in lush green trees. The overall scene is a natural, undisturbed watershed.

Planning and Measuring Watershed Management

Conceptual Models and Environmental Indicators

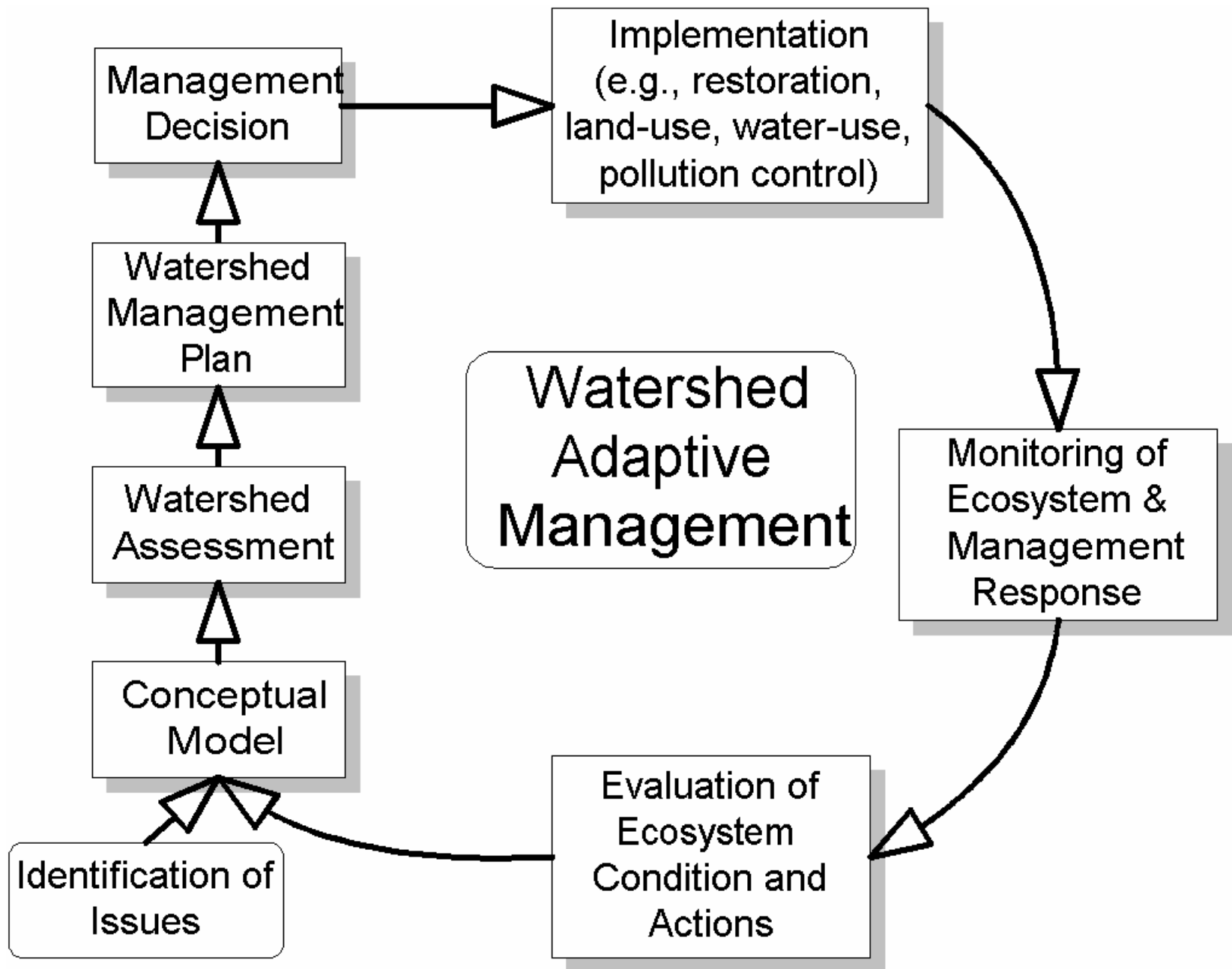
Fraser Shilling

Department of Environmental Science & Policy

University of California, Davis

Watershed Adaptive Management

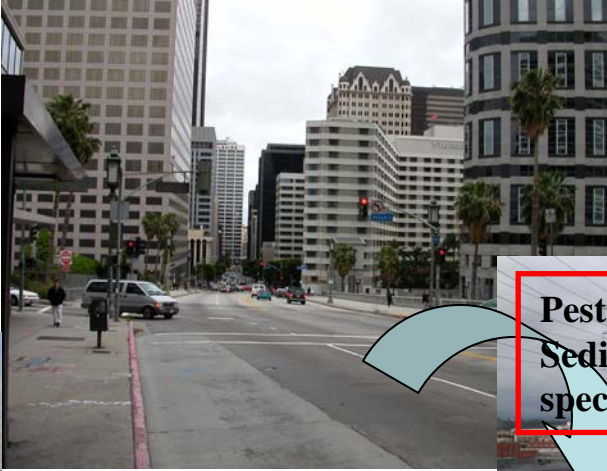
- Watershed management
 - Watershed assessment
 - What can we influence?
 - Conceptual modeling
 - Select and use environmental and management indicators



What is influencing watershed condition?



Pesticides, Metals, Nutrients, Sediment, Flows, Organic carbon, Invasive species



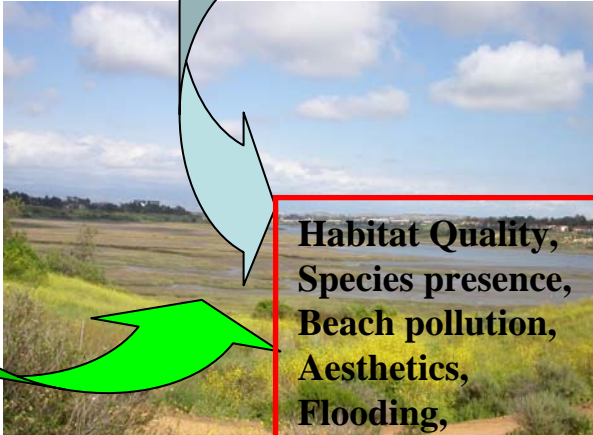
Pesticides, Metals, Nutrients, Sediment, Flows, Invasive species



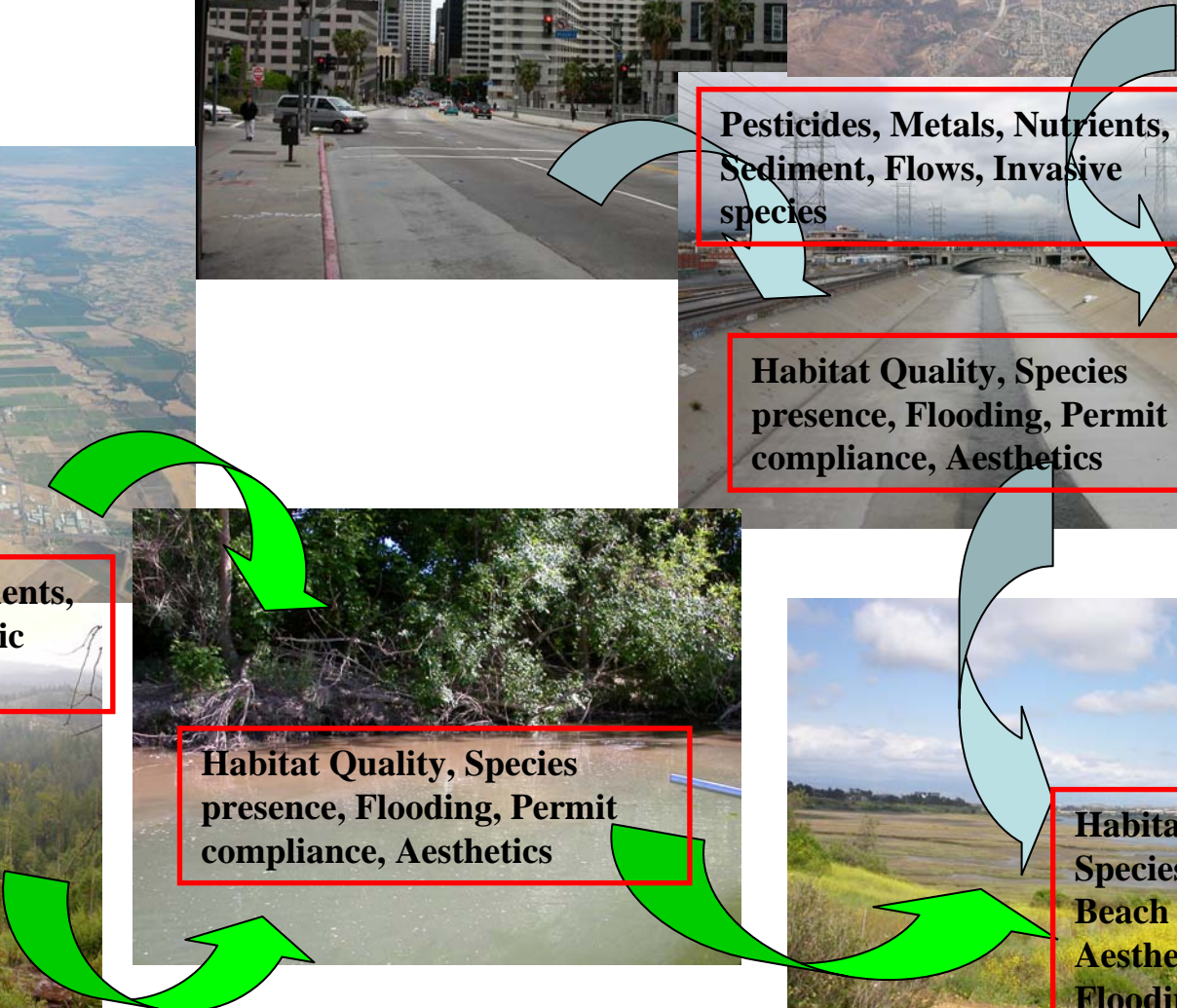
Habitat Quality, Species presence, Flooding, Permit compliance, Aesthetics



Habitat Quality, Species presence, Flooding, Permit compliance, Aesthetics



Habitat Quality, Species presence, Beach pollution, Aesthetics, Flooding,



Influences and Stresses

- There are myriad stresses and influences on watershed functioning:

Non-human	Human
Natural climatic cycles	Climate change
Geomorphic processes (erosion)	Geomorphological transformation
Fire ecology	Fire suppression/prevention
Vegetation succession	Wildland “cropping”
	Agriculture
	Transportation systems
	Land development (e.g., subdivision)
	Water diversions and returns
	Pollution (permitted or otherwise)

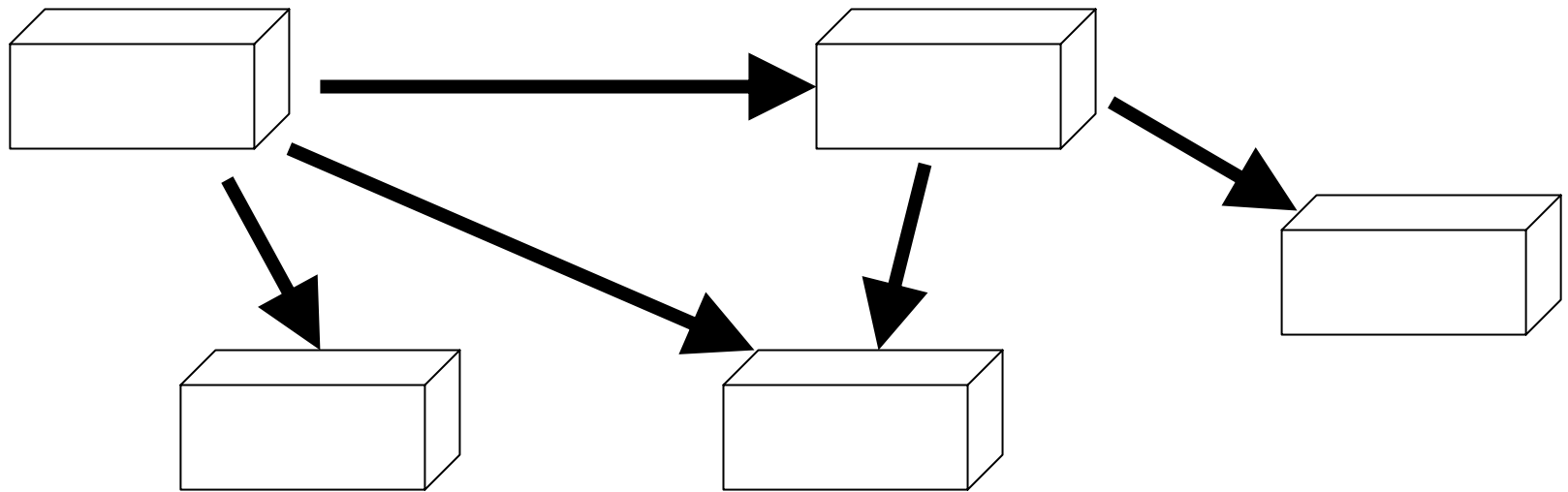
- And they interact with each other in the watershed

Conceptual modeling

reflecting interactions among processes

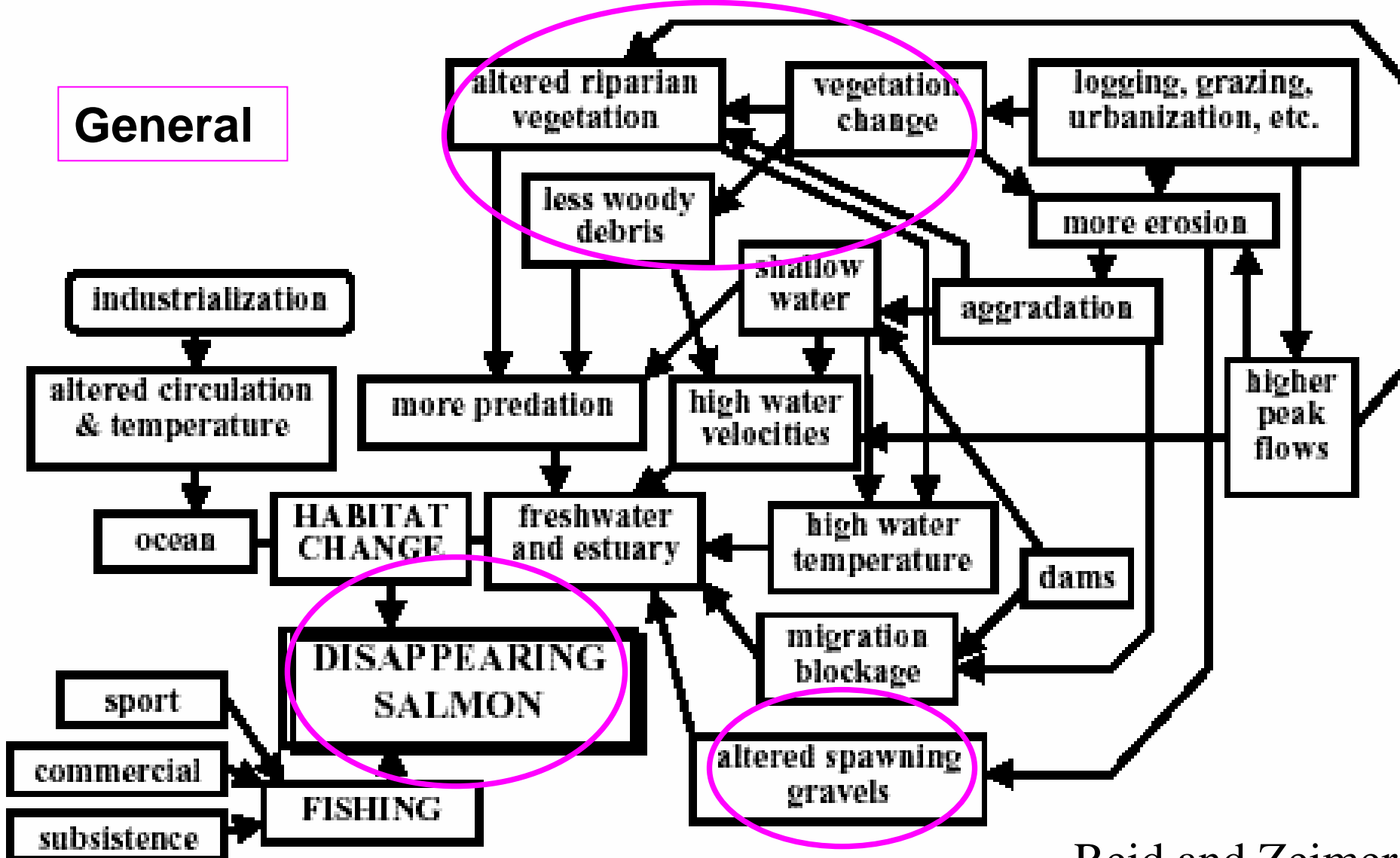
- What is it?
- How can I use it?
- Important step for successful adaptive management

Influence diagrams and conceptual models



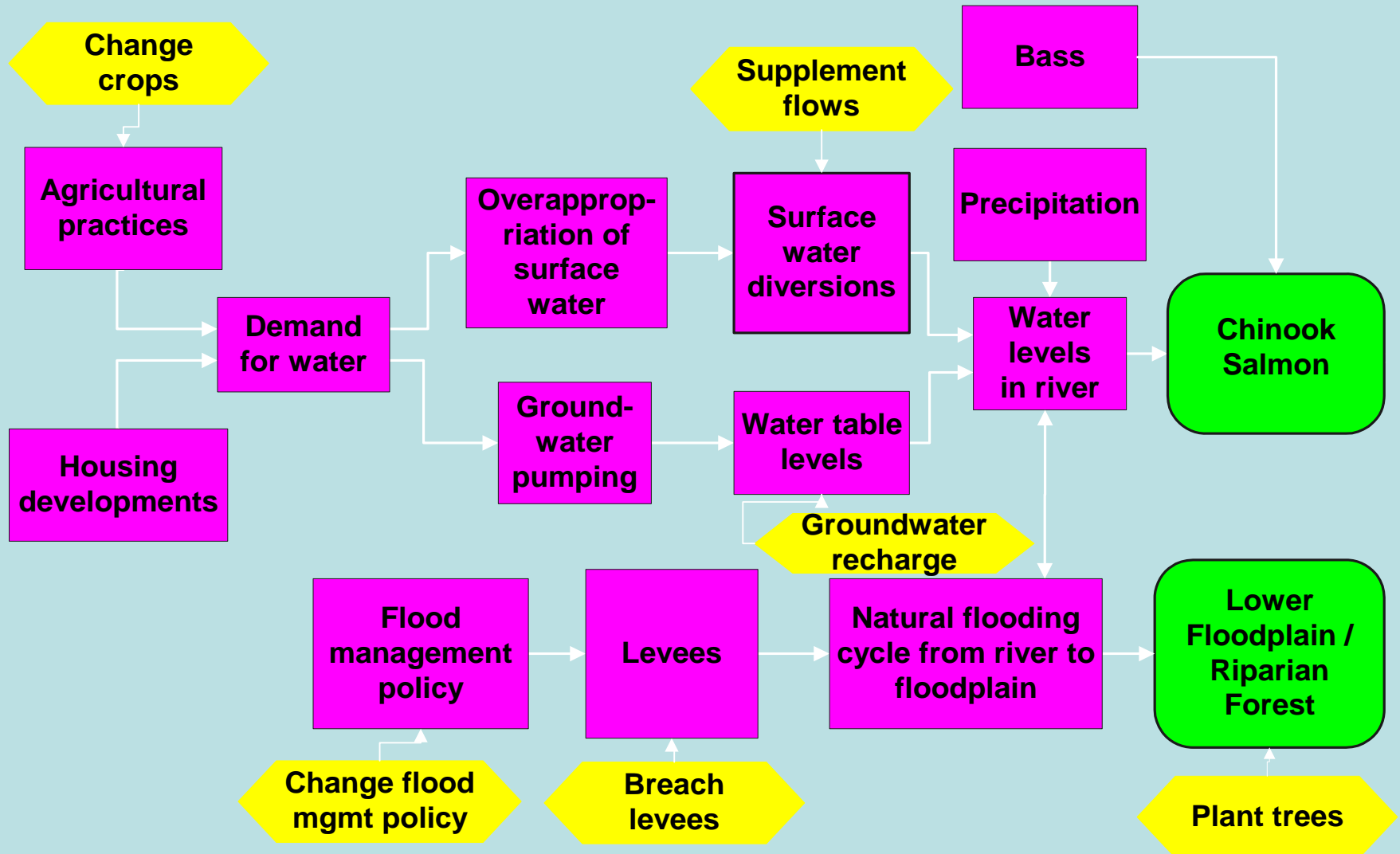
Boxes indicate concepts and arrows indicate influence or connection. The boxes can be attributes or processes, the arrows can be hypotheses, or based on knowledge of the system

Ecosystem Attribute Conceptual Model



Evaluate Actions

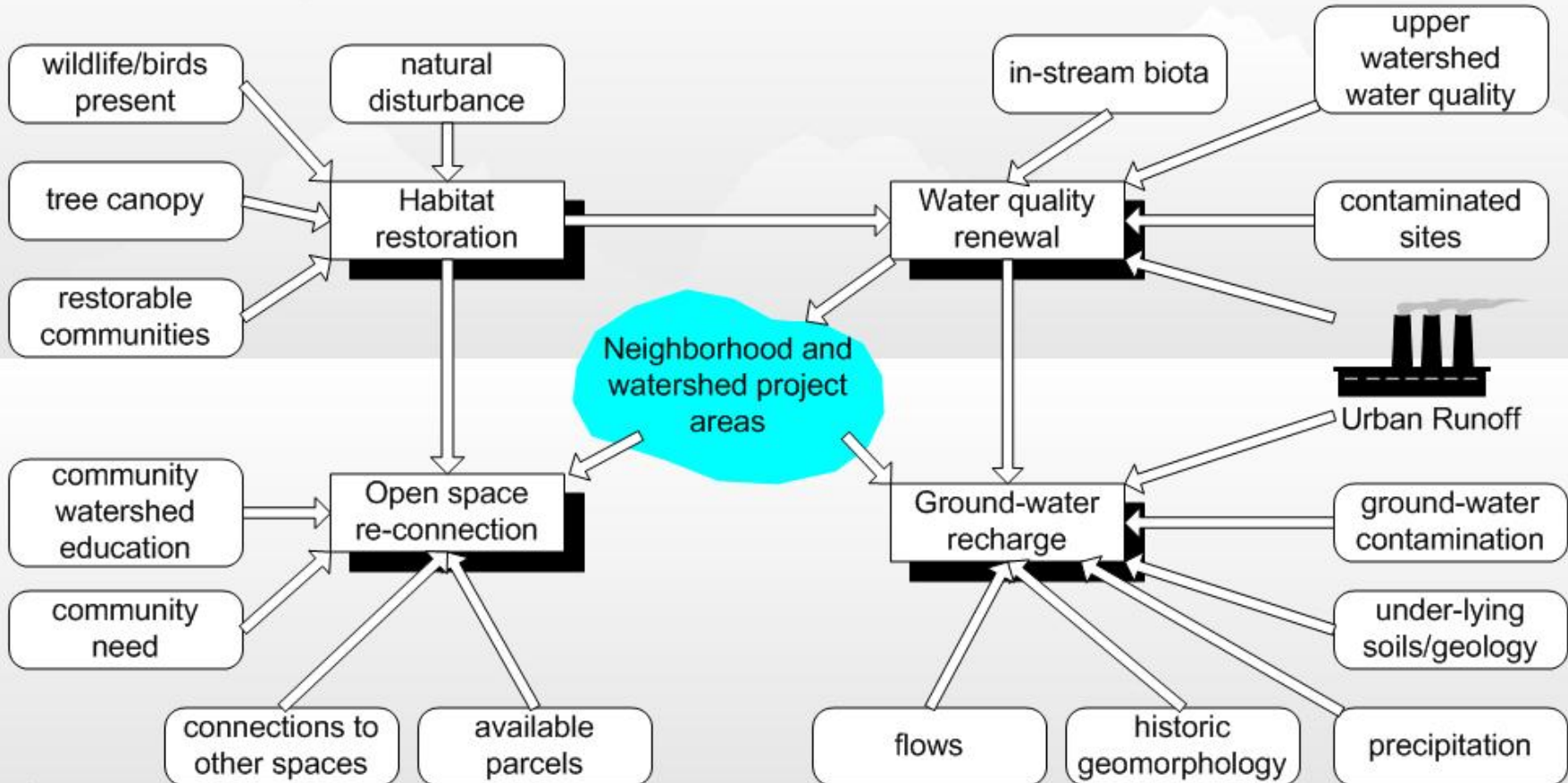
TNC, 2006



Whole Watershed Conceptual Model

Urban Watersheds

Recharge, Reconnect, Restore, Renew



Selecting Indicators

- “An environmental indicator is a discreet measure of one aspect of environmental quality that can be used alone or in combination with other indicators to deliver a message or tell a story related to the overall environmental health of an ecosystem.”

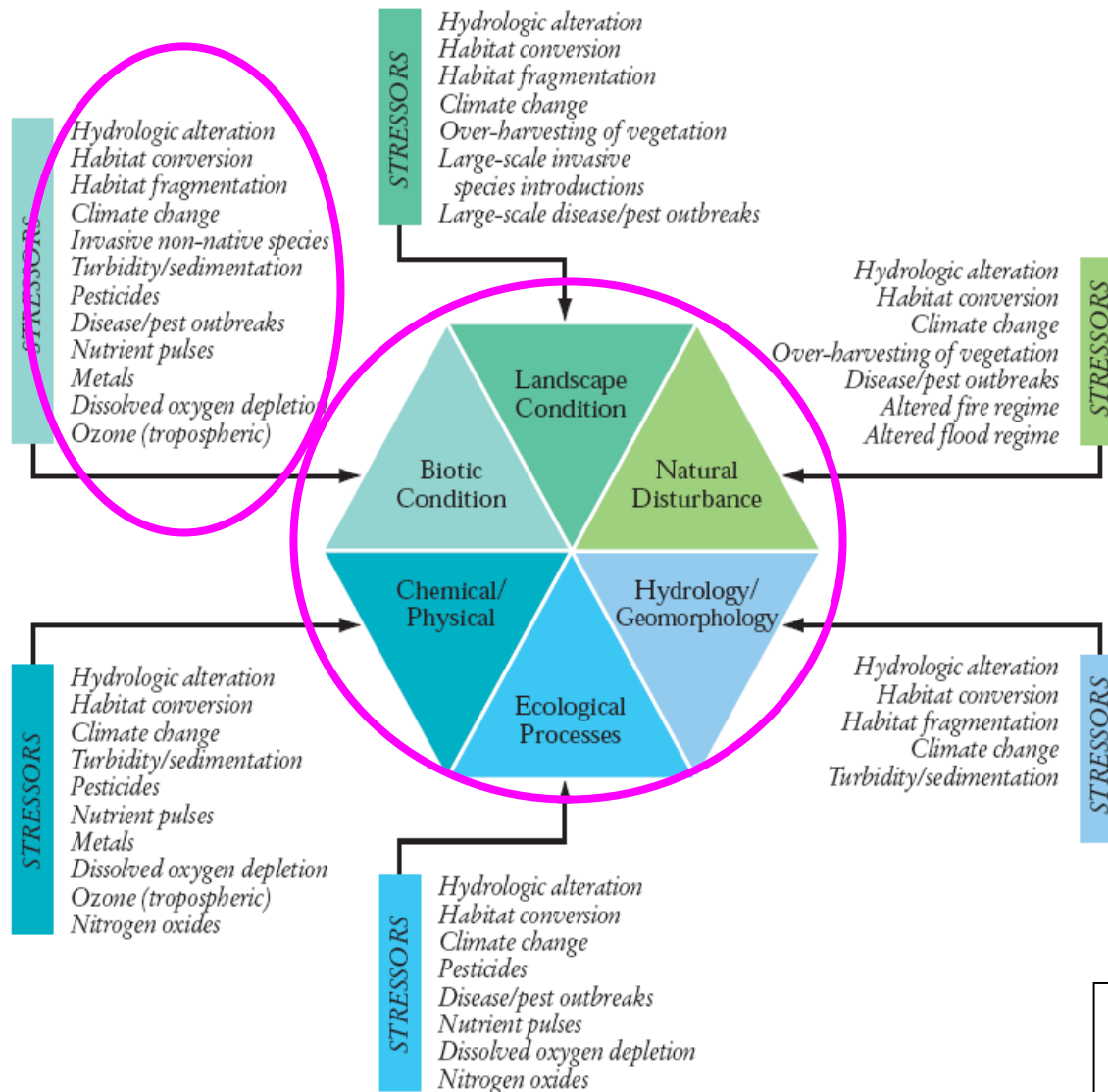
(Chesapeake Bay Program, 2002)

Selecting Indicators

- What are you trying to measure with indicators?
- Are you concerned more about natural processes, or the impact of human actions on natural processes?
- What time scale are you interested in?
- Are there existing indicators that others have used in the same watershed that you could replicate or continue?
- Who are the other parties that may be interested in these indicators and who could assist with investigating them now or in the future?
- Do you have the financial or community resources to investigate indicators?

(Draft guidance in Volume II of the California Watershed Assessment Manual)

Selecting Indicators

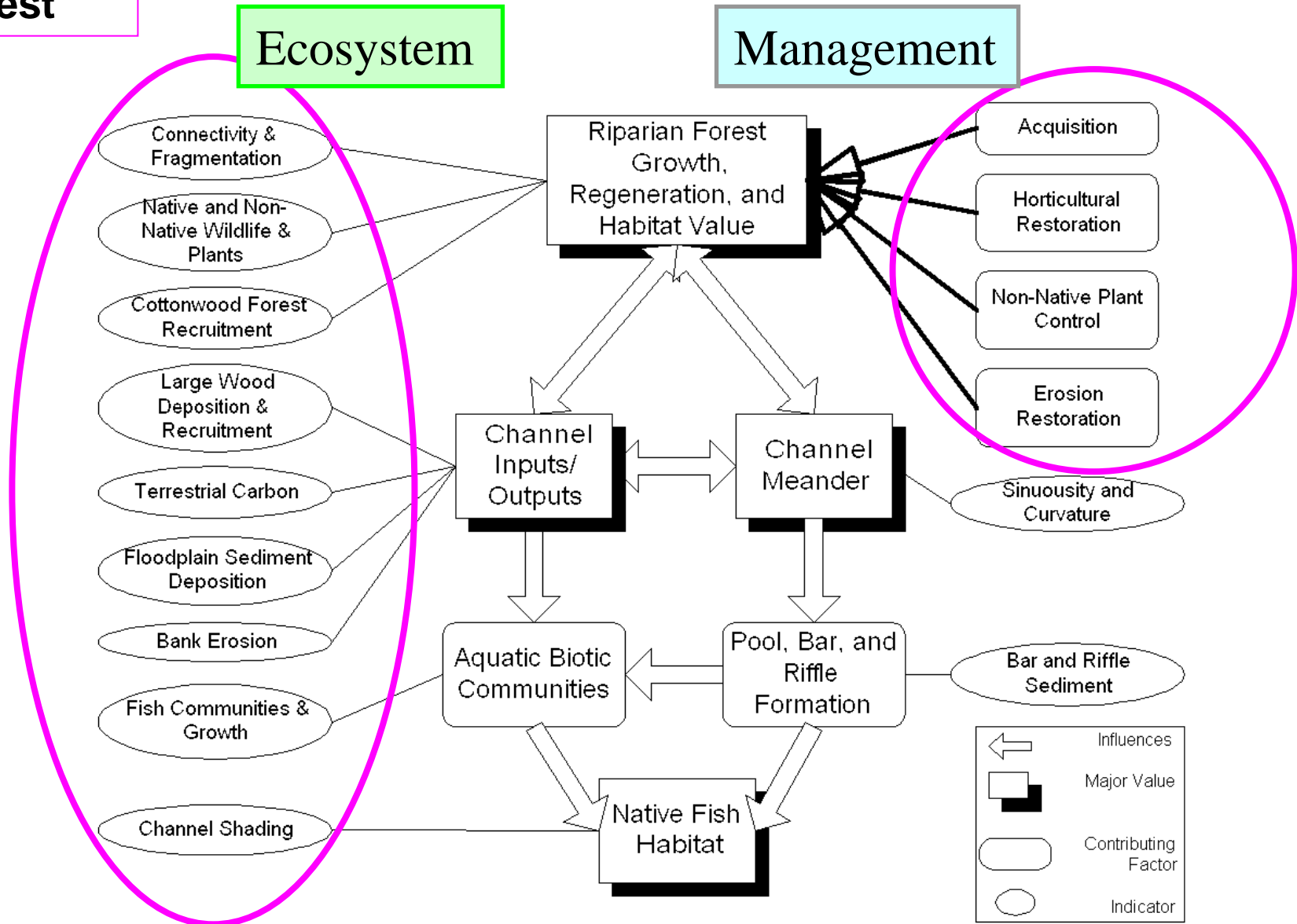


Indicator selection framework from the USEPA Science Advisory Board (Young and Sanzone, 2002)

(Draft guidance in Volume II of the California Watershed Assessment Manual)

**Example:
Riparian
Forest**

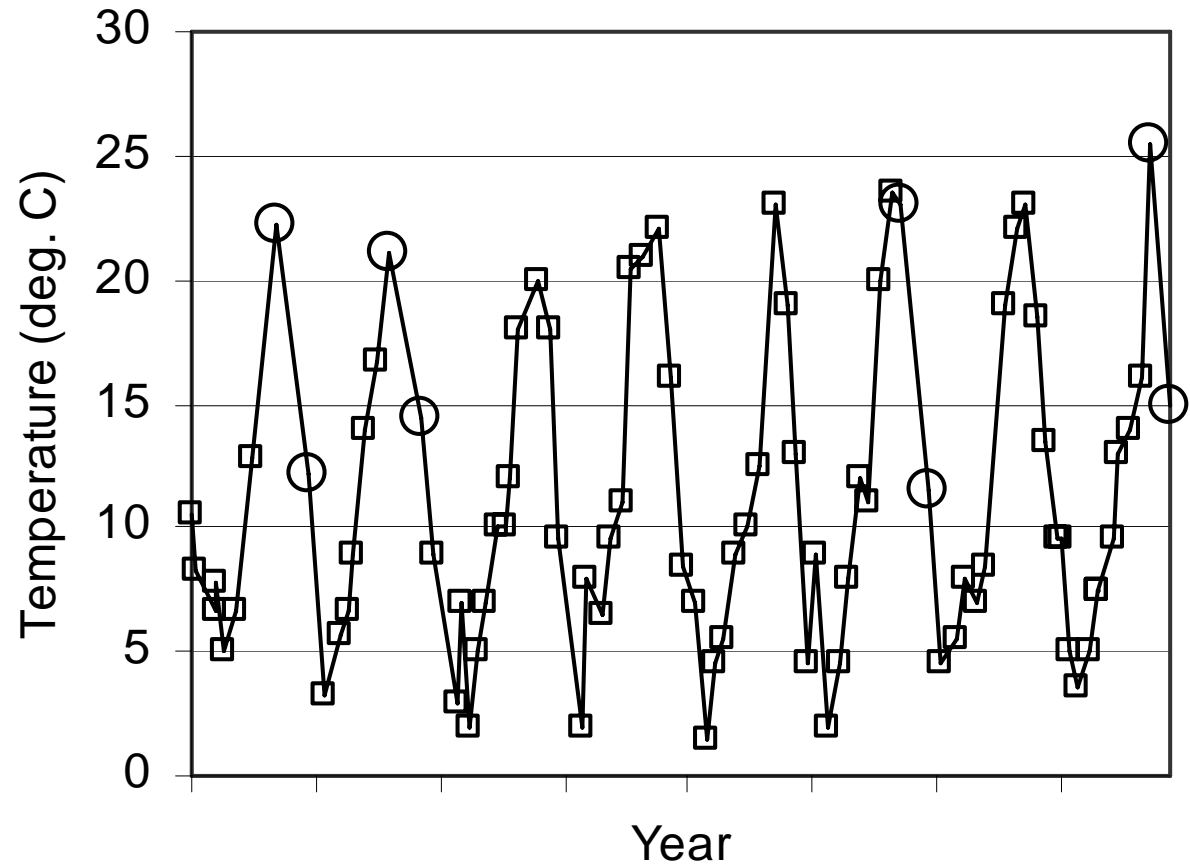
Selecting Indicators



Selecting Indicators – Types

What will they look like?

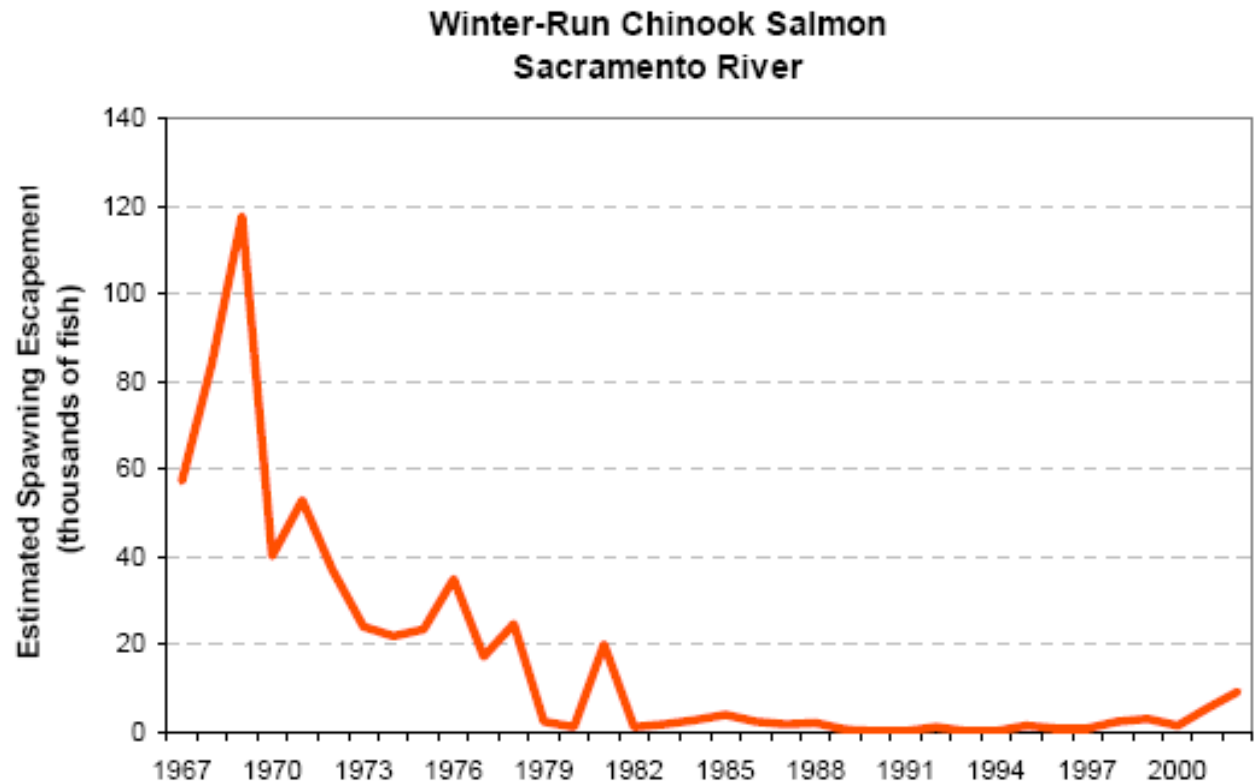
Example –
surface water
temperature
measured several
times a year



Selecting Indicators – Types

What will they look like?

Example – adult salmon escapement from Sacramento River over 3 decades

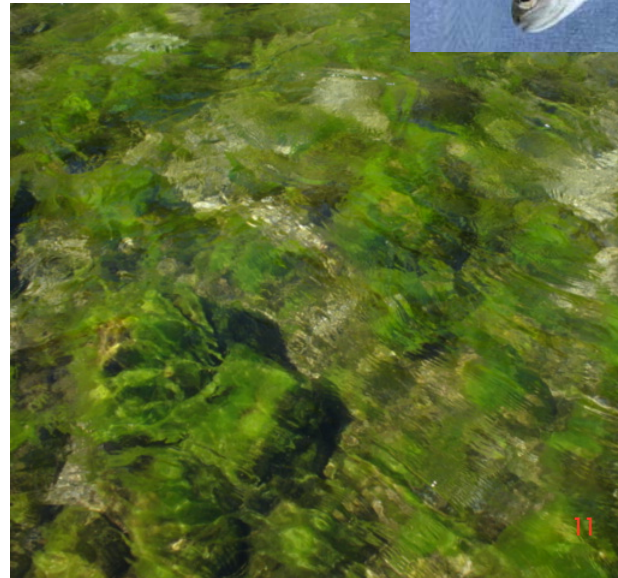


Selecting Indicators – Types

What will they look like?

Example – biota:

- 1) attached algae and other plants (periphyton)
- 2) native fish
- 3) amphibians



Watershed Indicators

Characteristics of Indicator Systems

- A **complete indicator system** will include consideration of the uses of the indicators, the process of analyzing the indicators, and the ecological basis of the indicators. The complete system usually has many of the following characteristics:
- It is **representative** of the ecosystem attributes that are within the scope of the management or study area;
- It includes **specific measures** or indicators already used for evaluating the ecosystem or program;
- It can be used to **evaluate** the ecological performance of management actions and other investments;
- It is **reportable** in a format that can be used and understood by a wide variety of stakeholders and implementing agencies;
- It takes into account the spatial and temporal **scales** relevant to condition assessment and/or management decision-making;
- It is **cost-effective**, yet representative of natural, social, and economic systems;
- It uses a mathematical system that is consistent with the nature of the responses of particular indicators (e.g., non-linear) to environmental gradients (e.g., temperature fluctuations);
- It is **robust** across different types of data and information;
- It describes how **error and uncertainty** can be propagated and understood to inform future management and monitoring.

(California Watershed Assessment Manual, Volume II DRAFT; Shilling et al.)

Example: Sustainability Indicator Systems

- Effects of economic activity on the environment (e.g., resource use, pollutant discharges, waste).
- Environmental services to the economy (e.g., natural resources, sink functions, contributions to economic efficiency and employment).
- Environmental services to society (e.g., access to resources and amenities, contributions to health, living and working conditions).
- Effects of social variables on the environment (e.g., demographic changes, consumption patterns, environmental education and information, institutional and legal frameworks).
- Effects of social variables on the economy (e.g., labour force, population and household structure, education and training; consumption levels, institutional and legal frameworks).
- Effects of economic activity on society (e.g., income levels, equity, employment).

(Organisation for Economic Co-operation and Development, OECD, 2005)

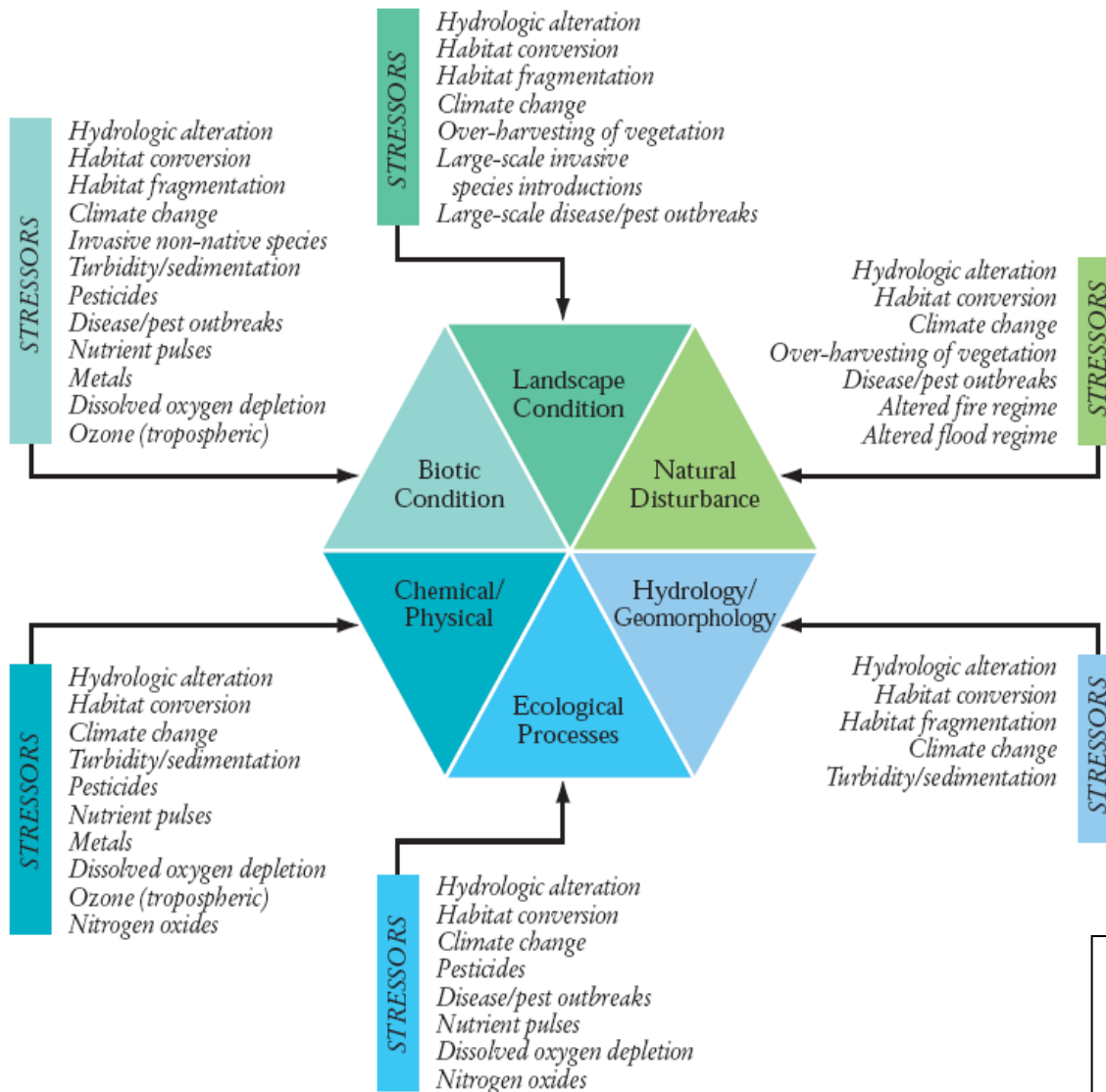
Example: Sustainability Indicator Systems

- **Minnesota**

- Social spaces, neighborhood economic indicators (affordable housing), background conditions (air quality), deep sustainability (renewable resources)

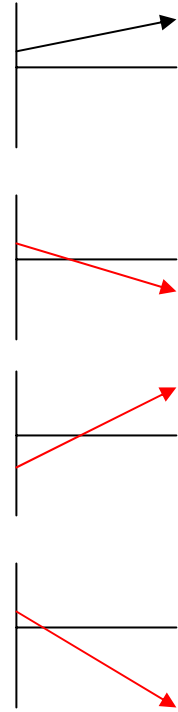
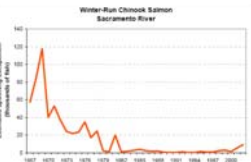
(<http://www.moea.state.mn.us/sc/neighborhoodguidebook.cfm>)

Integrate Indicators → Condition



Indicator selection framework from the USEPA Science Advisory Board (Young and Sanzone, 2002)

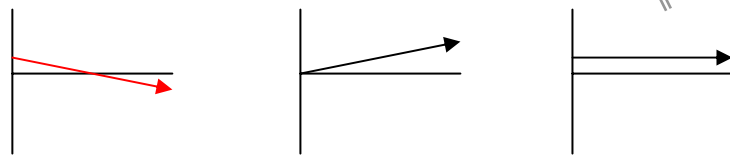
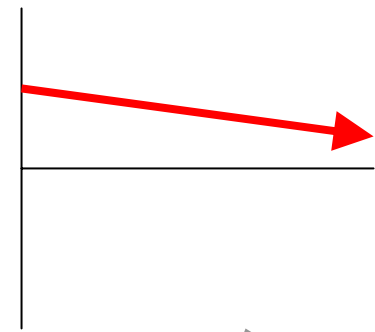
Condition/Performance Index



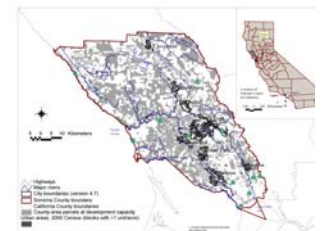
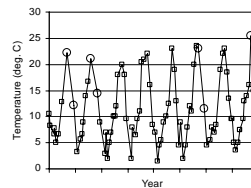
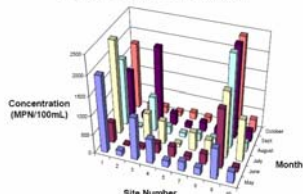
Biotic condition

Water/habitat quality

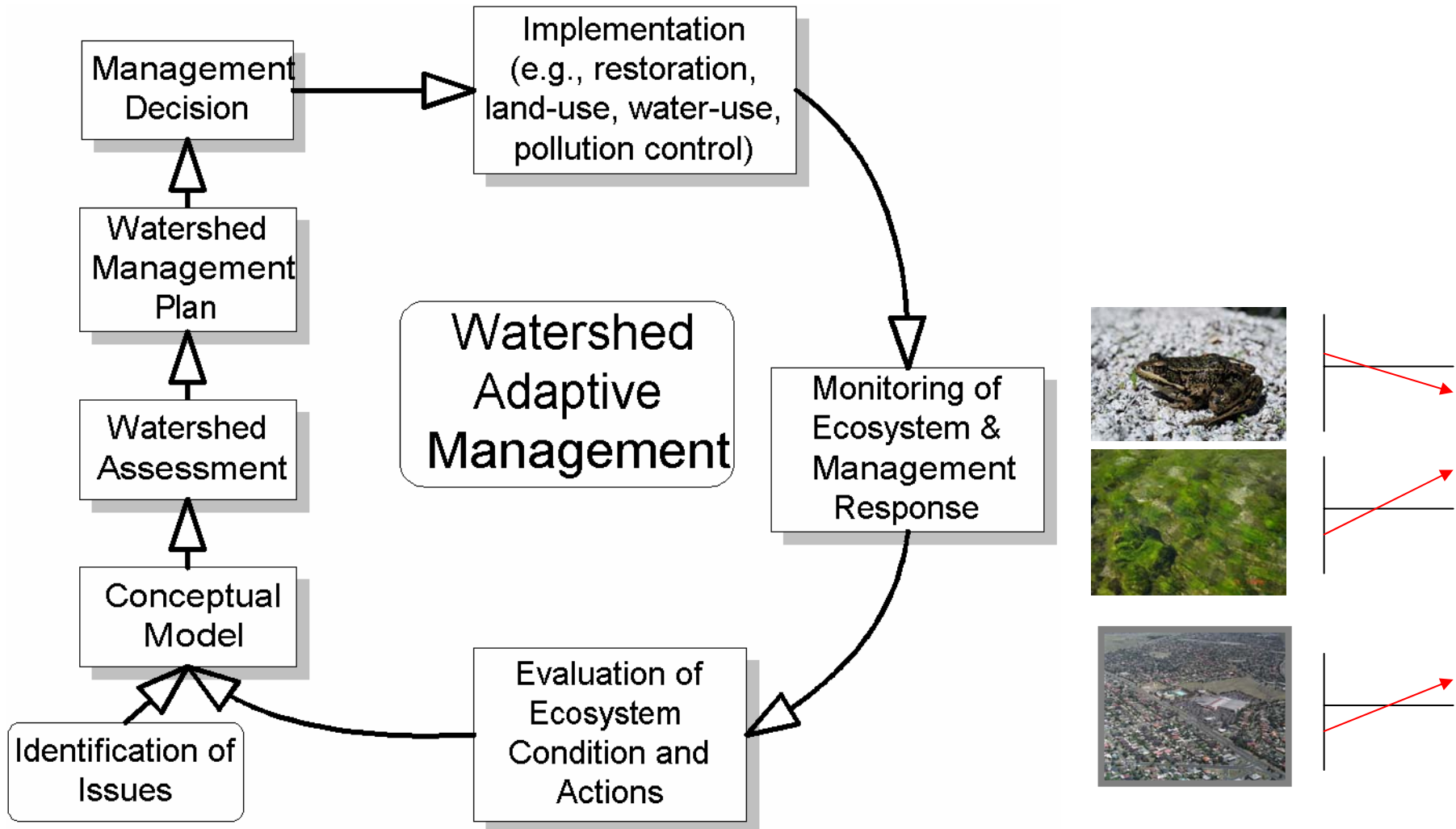
Watershed development



Summer 2000 E.coli Concentrations



Measure Condition/Performance, Inform Future Actions



Discussion?

Fraser Shilling

fmshilling@ucdavis.edu

530-752-7859