The Use of Biological Indicators for the Evaluation of Multiple Stressors and the Identification of Impairments in Streams

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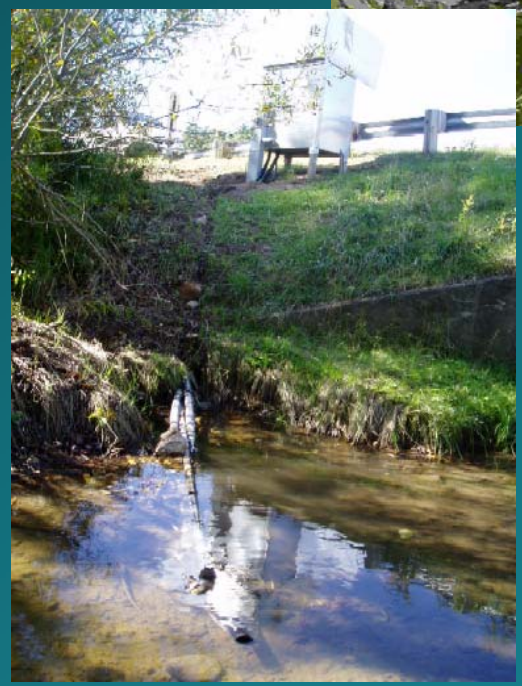
Data Collected & Analyzed

- Fish Abundance and Species Composition
- Aquatic Macroinvertebrate Communities
- Stream Hydrology
- Water Quality and Nutrients
- Habitat Quality

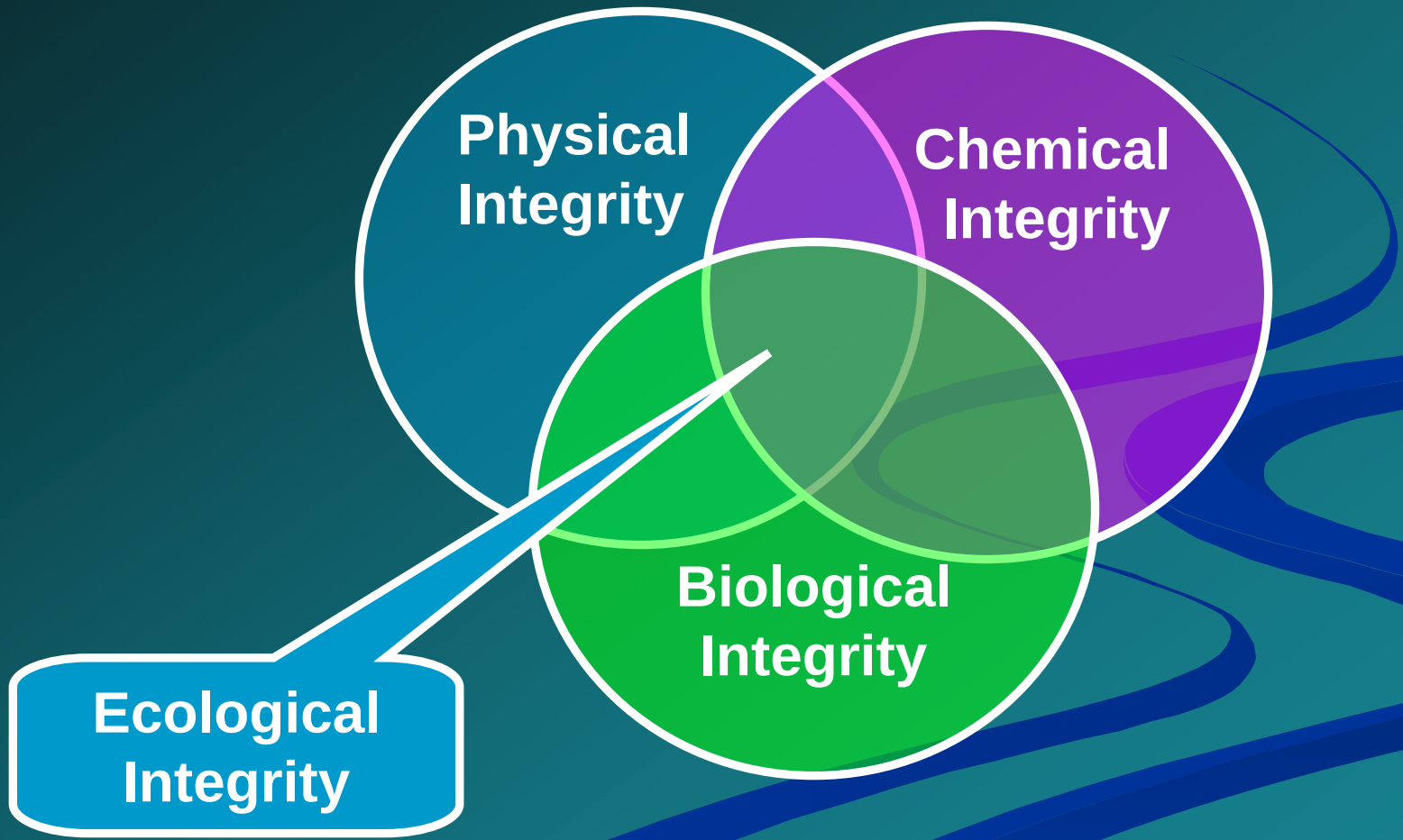


US Federal Clean Waters Act (CWA)

- ***"Congressional declaration of goals and policy"*** to achieve the ***"Restoration and maintenance of chemical, physical and biological integrity of Nation's waters…"***

THE LOWER FOX RIVER watershed monitoring program

The 3 Dimensions of Ecological Integrity (*CWA*)



THE LOWER FOX RIVER watershed monitoring program

Water Quality Standard

- Consists of three basic elements:
  - Designated uses of the water body
    - e.g., recreation, water supply, aquatic life, agriculture
    - "Fishable and Swimable"
  - Water quality criteria to protect designated uses
    - numeric pollutant concentrations and narrative requirements
  - An antidegradation policy to maintain and protect existing uses

Impaired Waters in the Lower Fox River Basin

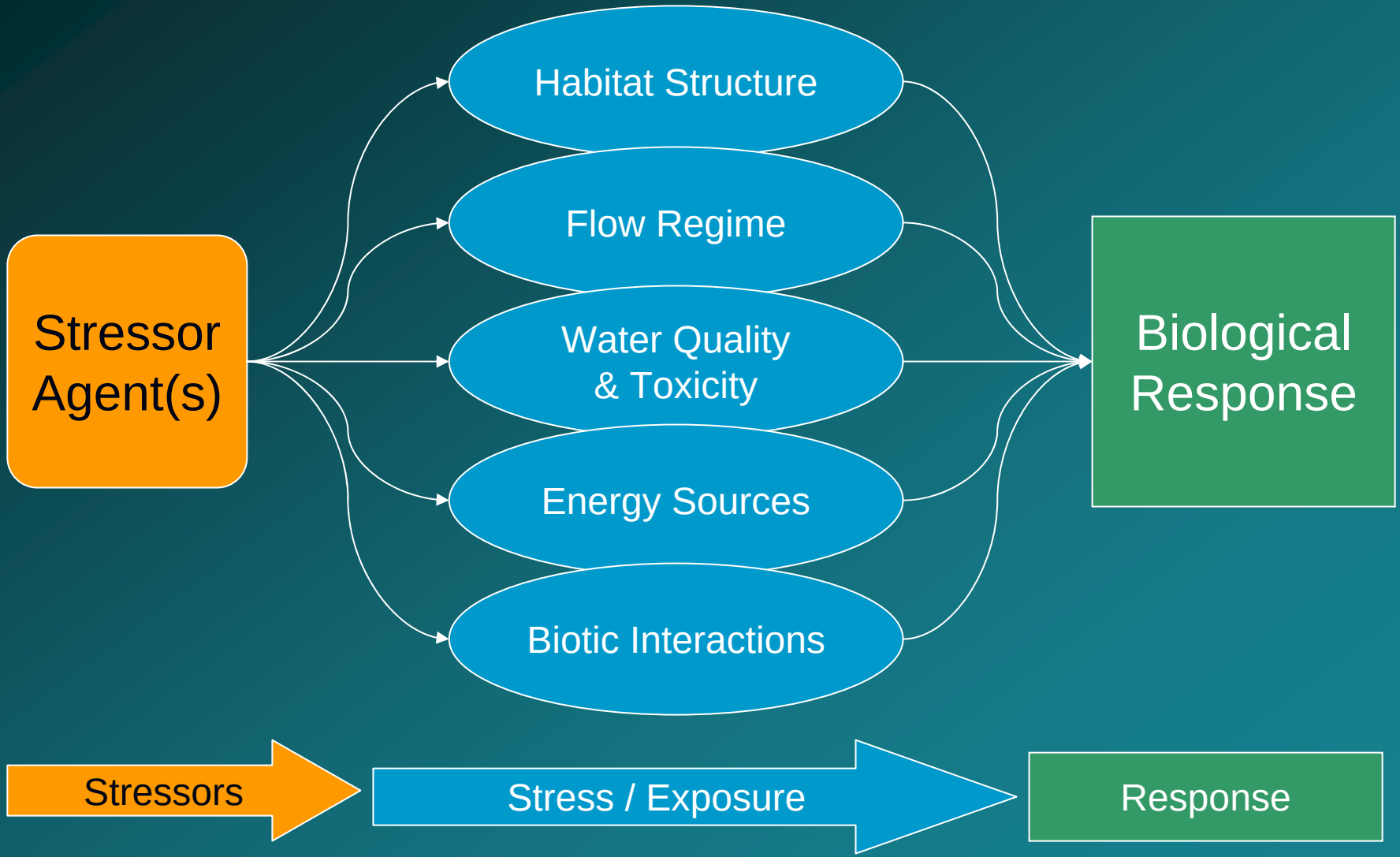
Data from:
Wisconsin DNR
March 2006

Increased Use of of *Biological Integrity* in establishing Use Classifications and Criteria for meeting Water Quality Standards

- "The Ability of an Aquatic Community to support and maintain a structural and functional performance comparable to the natural habits of a region."
  - *As modified from Karr and Dudley (1981)*

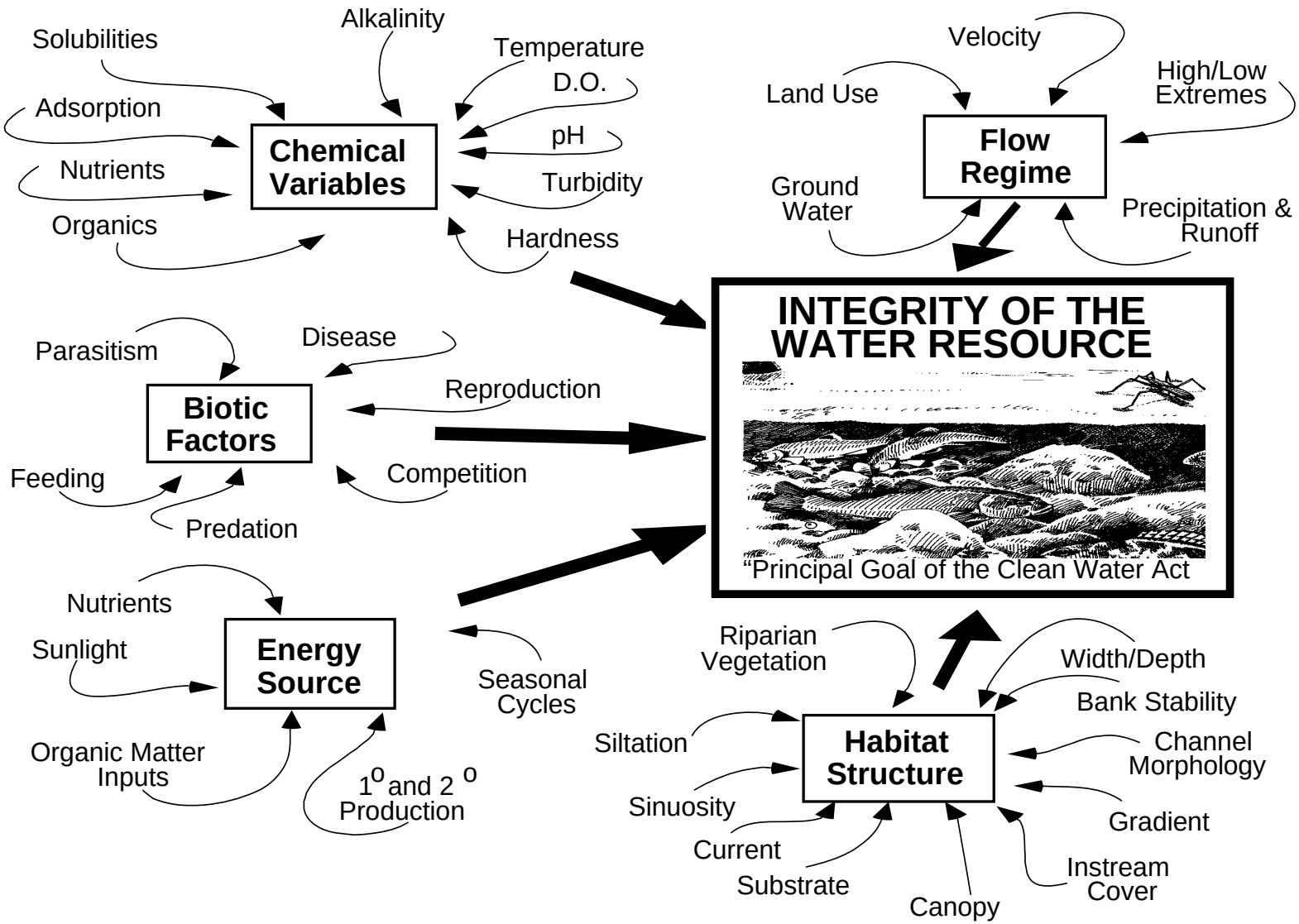
Cause and Effect:

Linking stressors to the resultant biological response

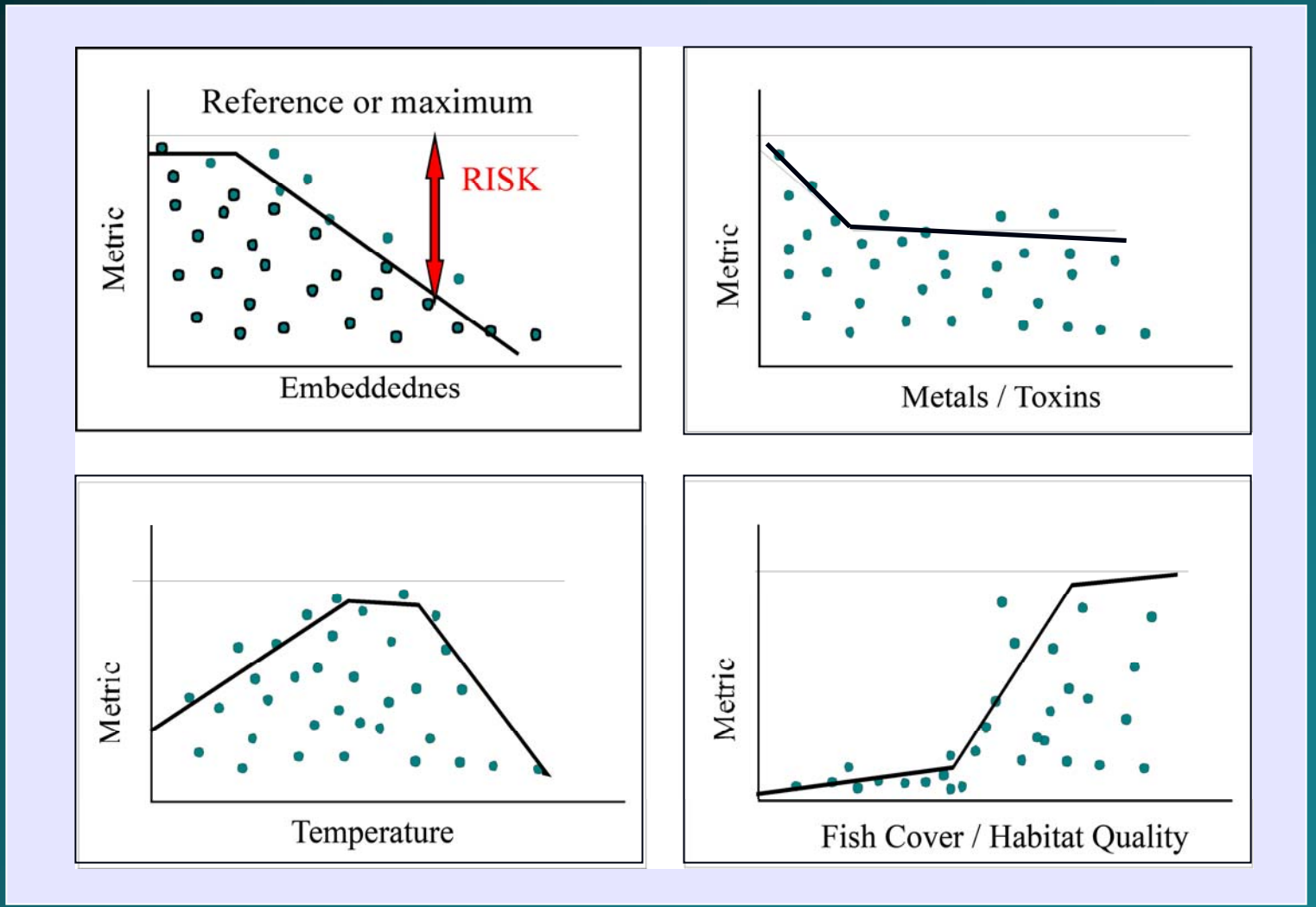


- (Yoder and Rankin, 1998)(Karr and Yoder, 2004)

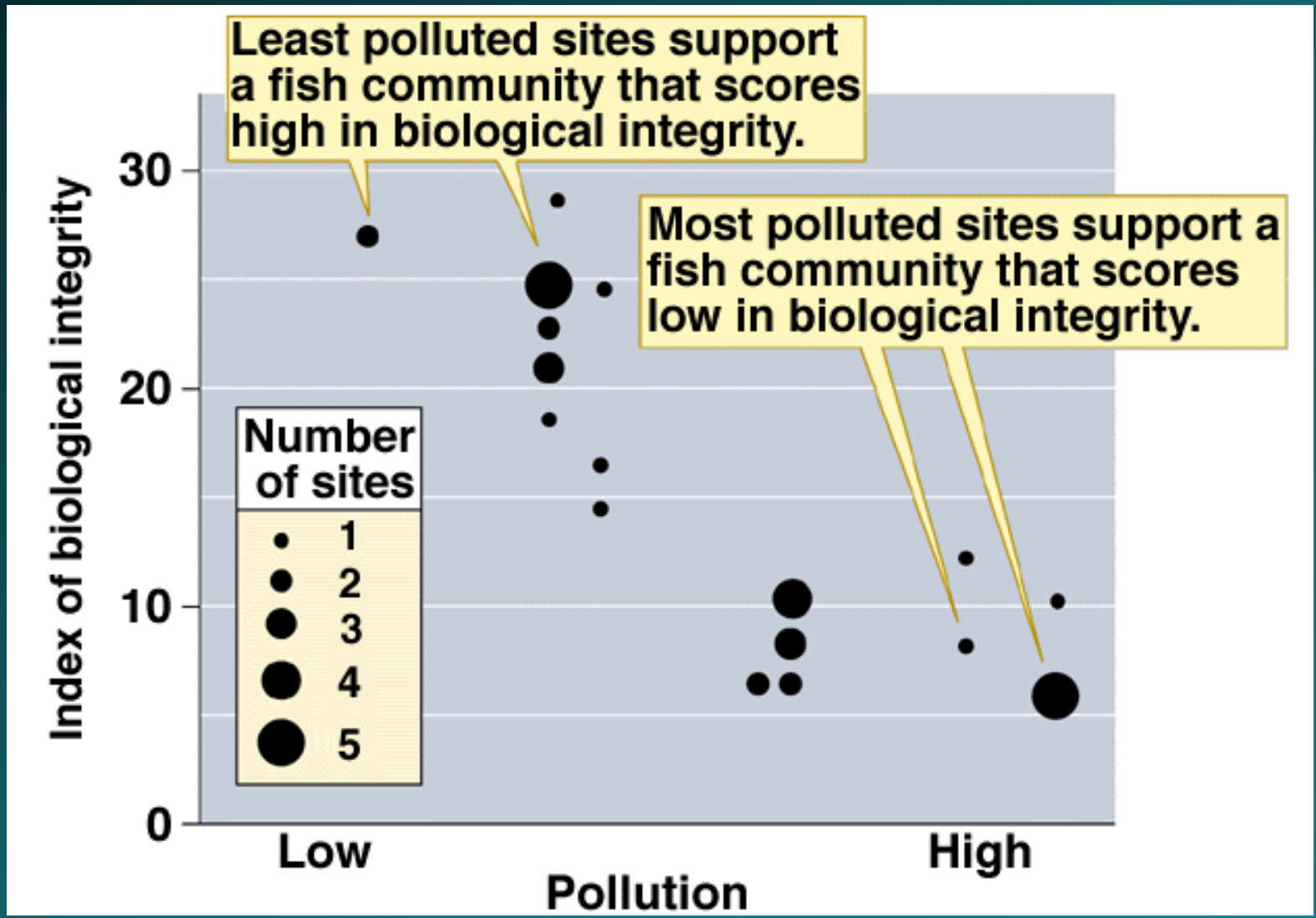
The Five Major Factors Which Determine the Integrity of Aquatic Resources



Multiple Stressors and Nonlinear Functional Response Relationships



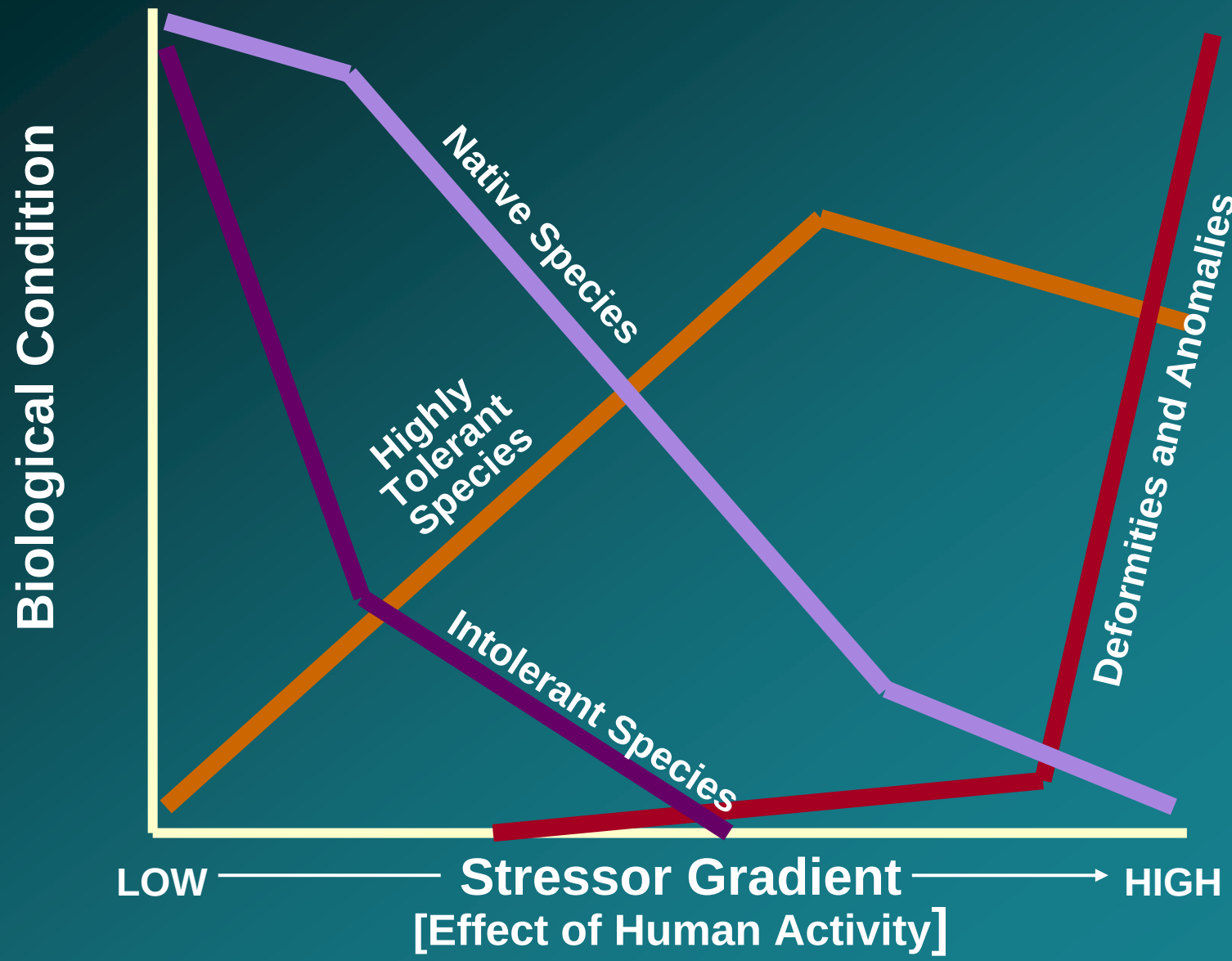
Concept of an Index of Biotic Integrity



From Molles (2006), McGraw-Hill Inc.

Some Fishes of the Fox River and It's Tributaries

Multimetric Components of Biological Integrity



Metrics used for Wisconsin Fish IBI
for Warmwater, Wadeable Streams

Species richness and composition

1. Total number of native species
2. Number of darter species
3. Number of sucker species
4. Number of sunfish species
5. Number of intolerant species
6. Percent (by number of individuals) that are tolerant species

Trophic and reproductive function

1. Percent that are omnivores
2. Percent that are insectivores
3. Percent that are top carnivores
4. Percent that are simple lithophilous spawners

Fish abundance and condition (correction factors)

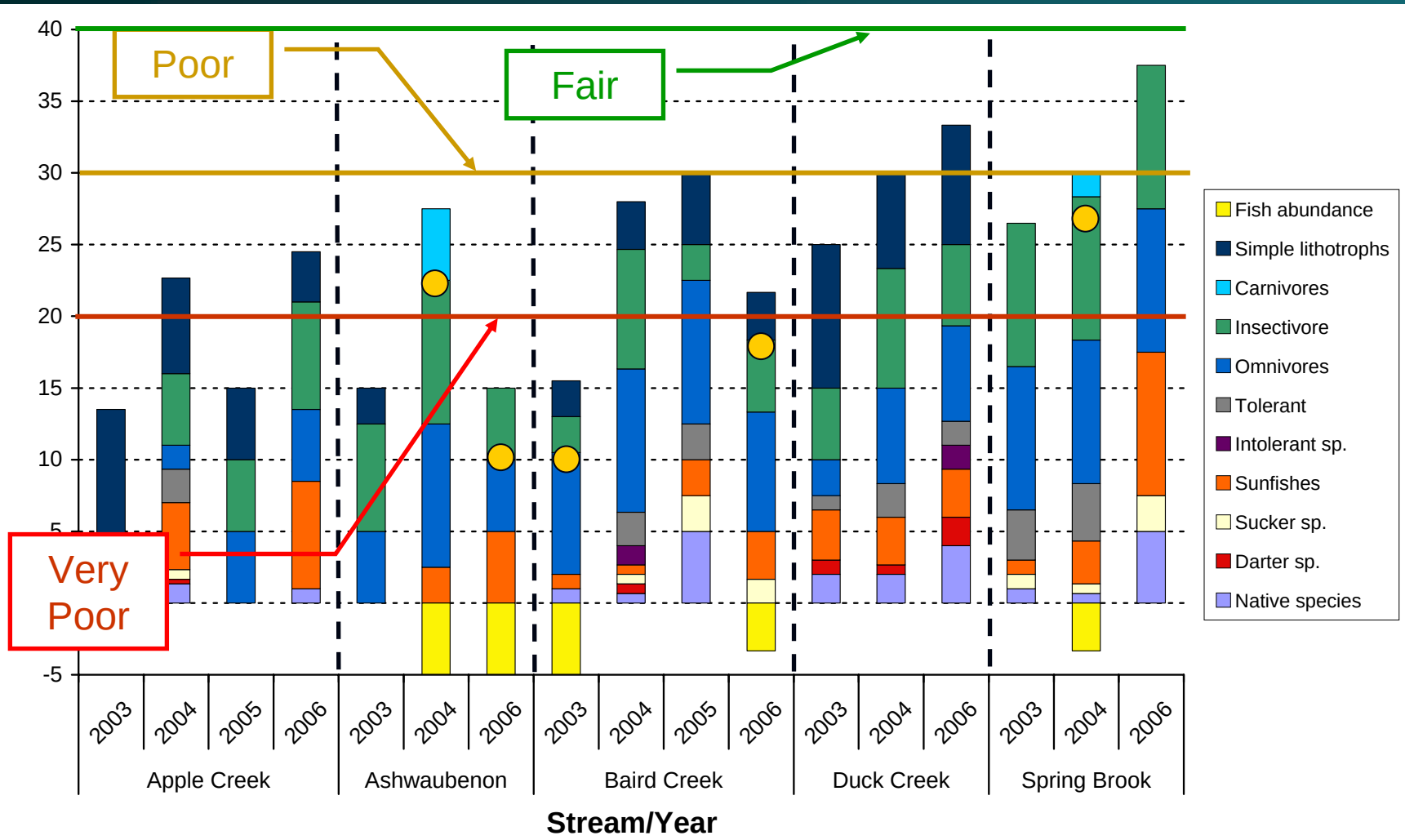
1. Number of individuals (excluding tolerant species) per 300 m sample
2. Percent with deformities, eroded fins, lesions, or tumors (delt)

Scoring Criteria for Wisconsin Version of the Fish IBI

Metric or correction factor	Scoring Criteria				
	10	**7**	**5**	**2**	**0**
Total number of native* species	>25	20-25	15-20	10-15	<10
Number of darter species*	>5	4-5	3.0-3.9	2.0-2.9	<2
Number of sucker species*	>6.0	4.7-6.0	3.0-4.6	2.3-2.9	<2.3
Number of sunfish species*	>4.0	3.3-4.0	2.0-3.2	1.7-1.9	<1.7
Number of intolerant species*	>6.5	5.3-6.4	4.0-5.2	2.7-3.9	<2.7
Percent (by total individuals) that are tolerant	0-19	20	21-49	50	51-100
Percent that are omnivores	0-19	20	21-39	40	41-100
Percent that are insectivores	100-61	60	59-31	30	29-0
Percent that are top carnivores	100-15	14	18-8	7	6-0
Percent that are simple lithophilous spawners	100-51	50	49-21	20	19-0
Number of individuals (excluding tolerant species) per 300 m sampled	If < 50 fish, subtract 10 from overall IBI score				
Percent with deformities, eroded fins, lesions, or tumors (DELT)	If ³ 4%, subtract 10 from overall IBI score				

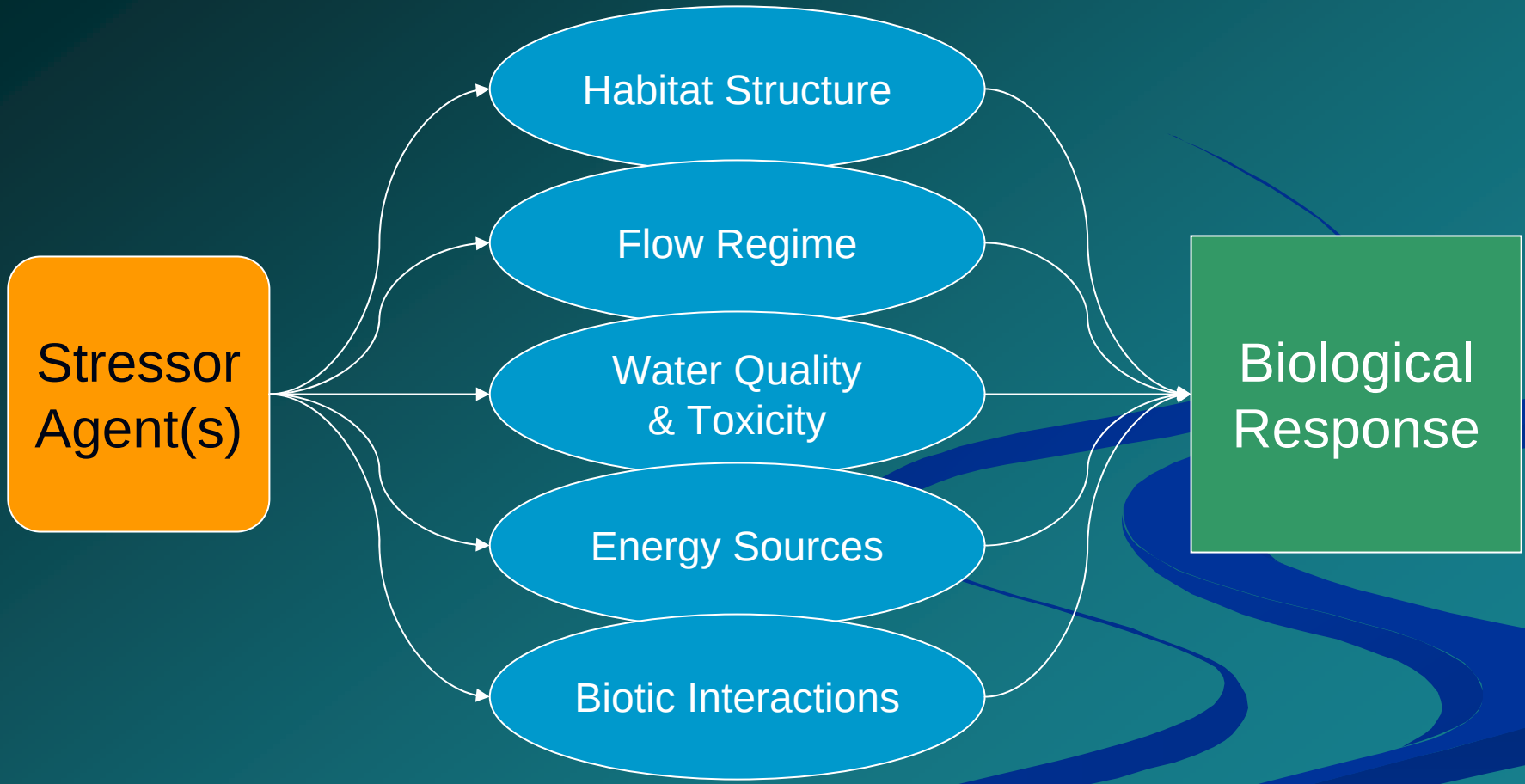
*values vary by region of state, values in table represent Central/Southern Wisconsin, Source: Lyons, 1992

Contributions to Fish IBI



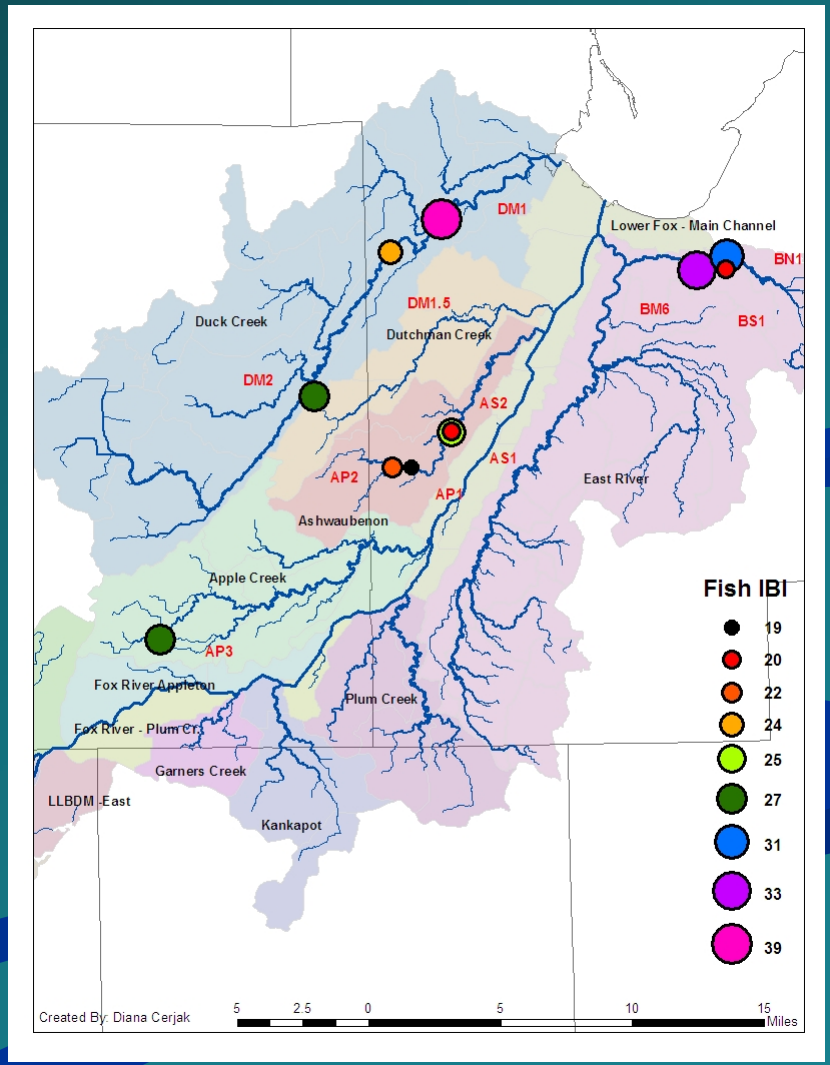
Cause and Effect:

Linking stressors to the resultant biological response



- (Yoder and Rankin, 1998)(Karr and Yoder, 2004)

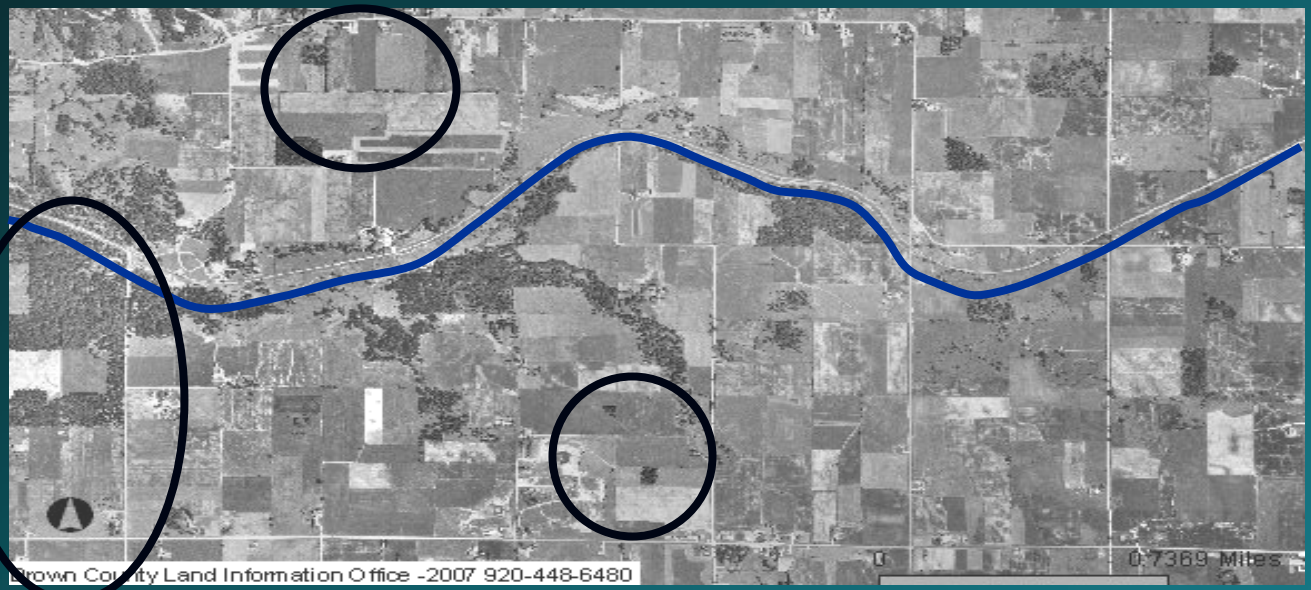
Exploring Human-Environmental Impacts using Geo-Spatial Analysis



Impacts of Changing Landscapes:

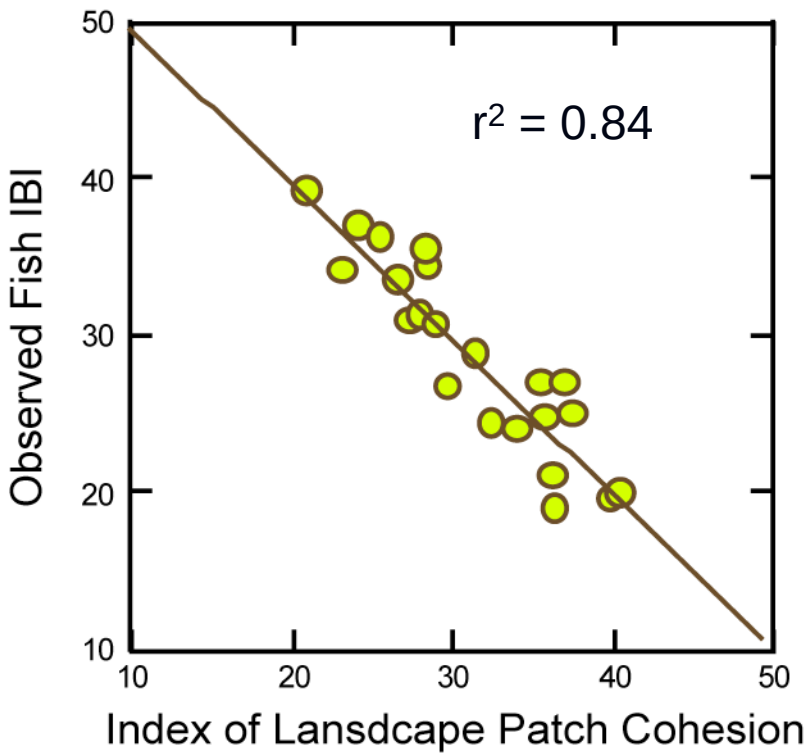
Baird Creek Satellite Images:

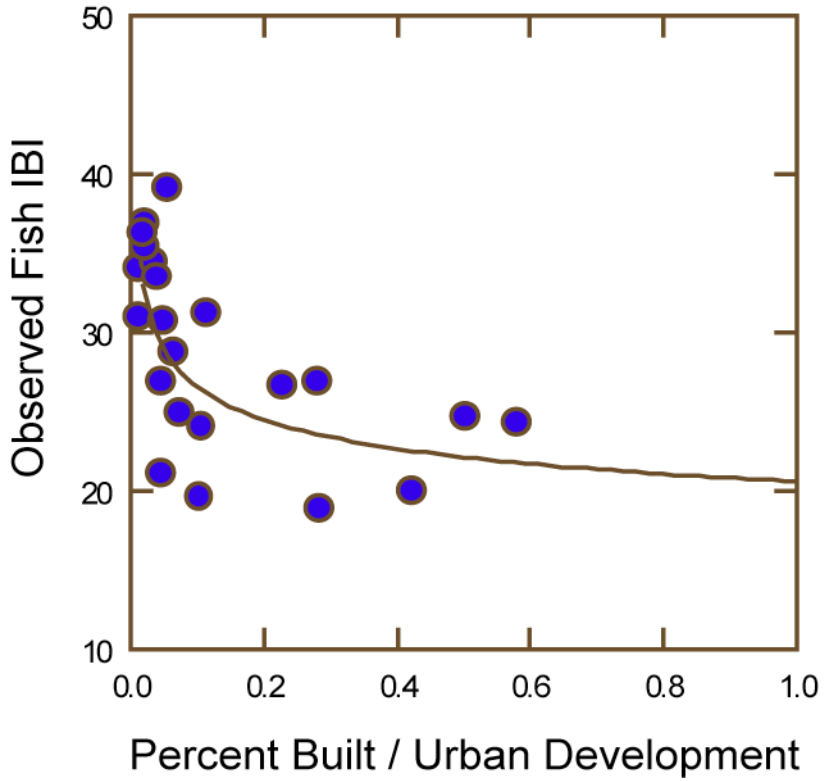
1960



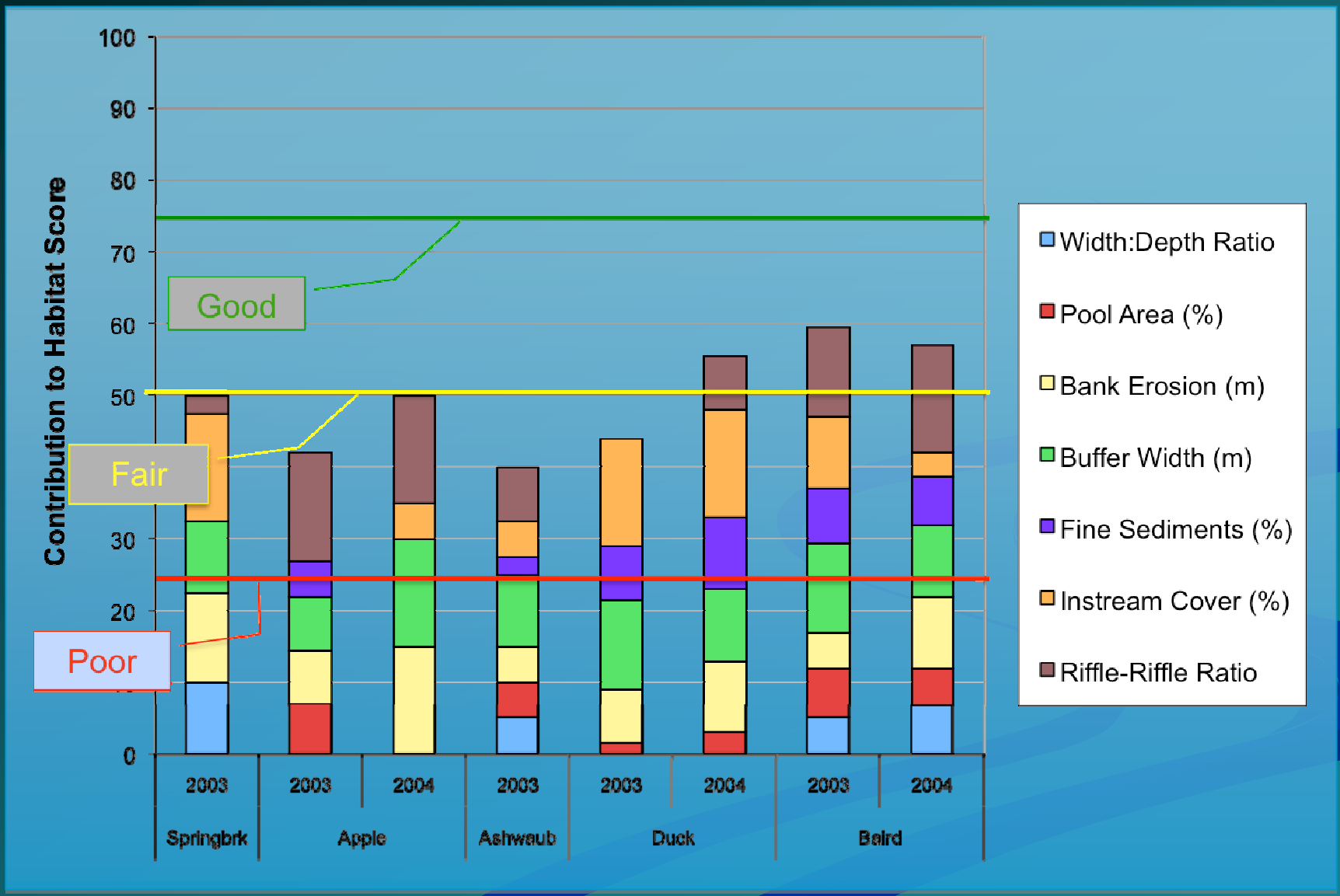
2005

Landscape vs Land Cover Predictors of IBI



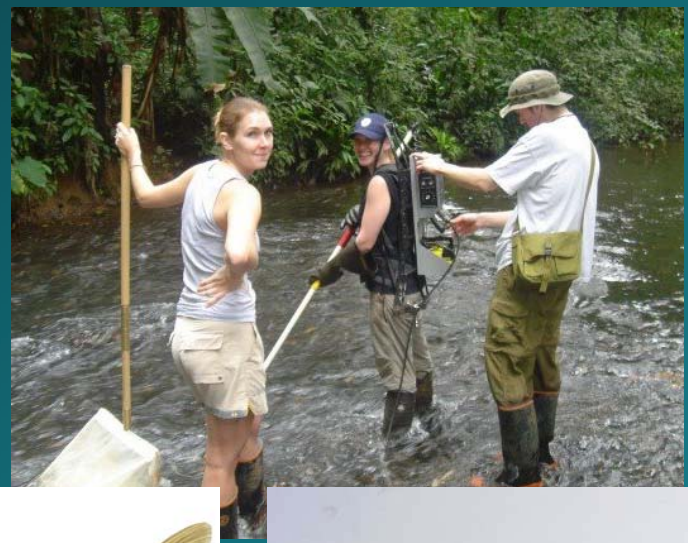


Fox River Tributary Habitat Ratings



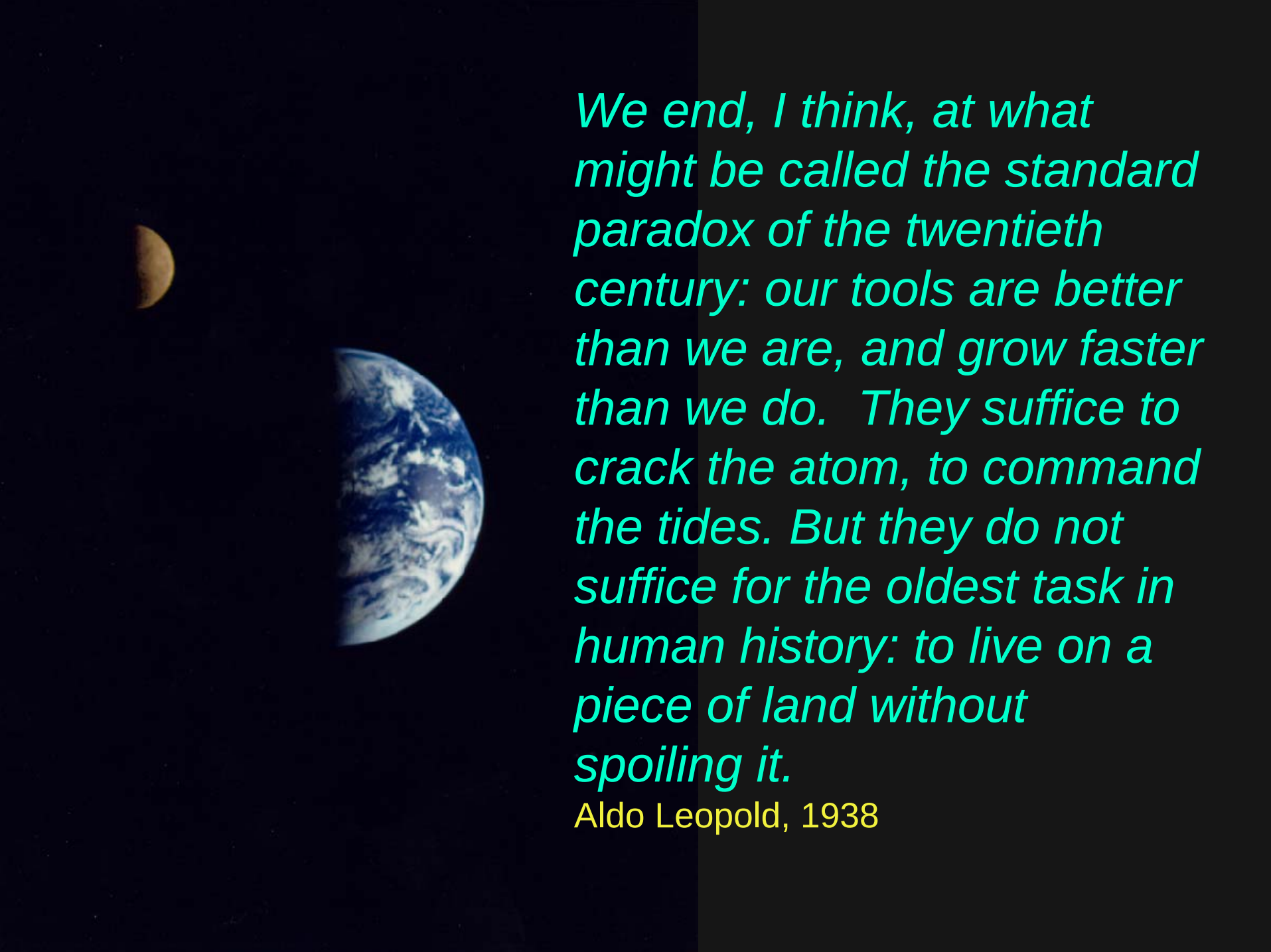
Potential Stressors Affecting Biological Integrity of Fish and Invertebrates

- Bank Erosion
- Substrate Composition
- Riparian Vegetation
- Canopy Cover
- Depth and Flow
- Water Quality



Impairments Identified from Biological Monitoring

- *Abundance of Fish and Invertebrates*
  - Flow Regime
    - Flashy peak flows
    - Low base flows
- *Species Composition*
  - Habitat
    - Siltation and bank erosion
- *Abundance of Tolerant Species*
  - Dissolved Oxygen
    - Eutrophication and Nutrient loading



We end, I think, at what might be called the standard paradox of the twentieth century: our tools are better than we are, and grow faster than we do. They suffice to crack the atom, to command the tides. But they do not suffice for the oldest task in human history: to live on a piece of land without spoiling it.

Aldo Leopold, 1938

Selway-Bitterroot Wilderness