The Value of Bioassessment

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This set of slides does not include the photos used in the original presentation.

Value:

Monetary worth of something

Relative worth, utility, importance

BIOLOGICAL ASSESSMENT

an evaluation of the biological condition of a site using biological surveys or other direct biological measurements of resident biota

The biota provides:

- Benchmark: a standard by which others are measured;
- Guide: a device for steadying or directing the motion of something
- Goal: the end toward which effort is directed

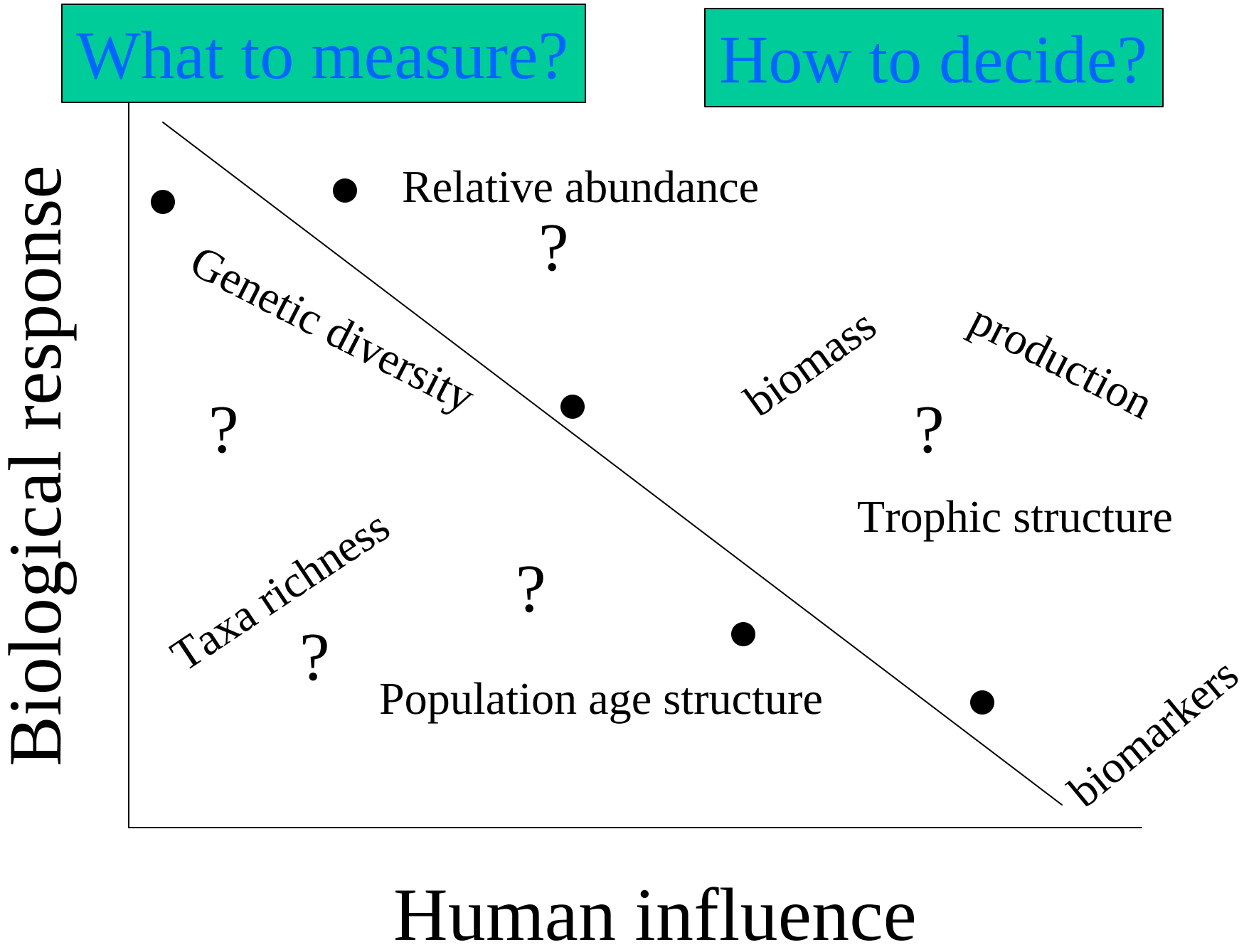
“no civilization can wage relentless war on life without destroying itself, and without losing the right to be called civilized.”

Rachel Carson, 1963

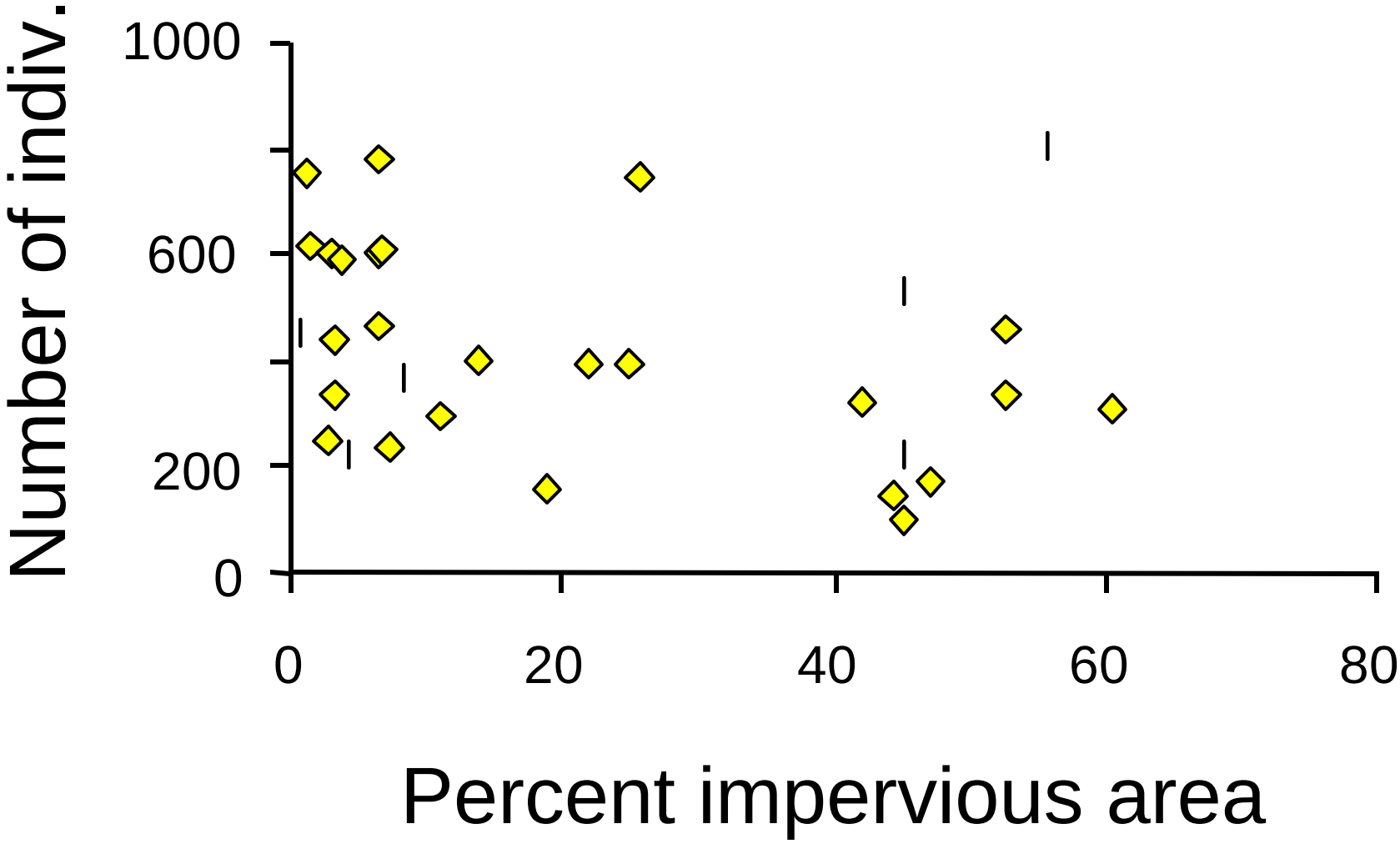
- GOAL: Clean Water Act compliance
  - protect public's interest in water resources
- KEY ACTIONS:
  - monitor the biota of water bodies
  - assess the biological consequences of human actions
  - employ biological criteria to determine if those consequences are acceptable
  - take appropriate actions

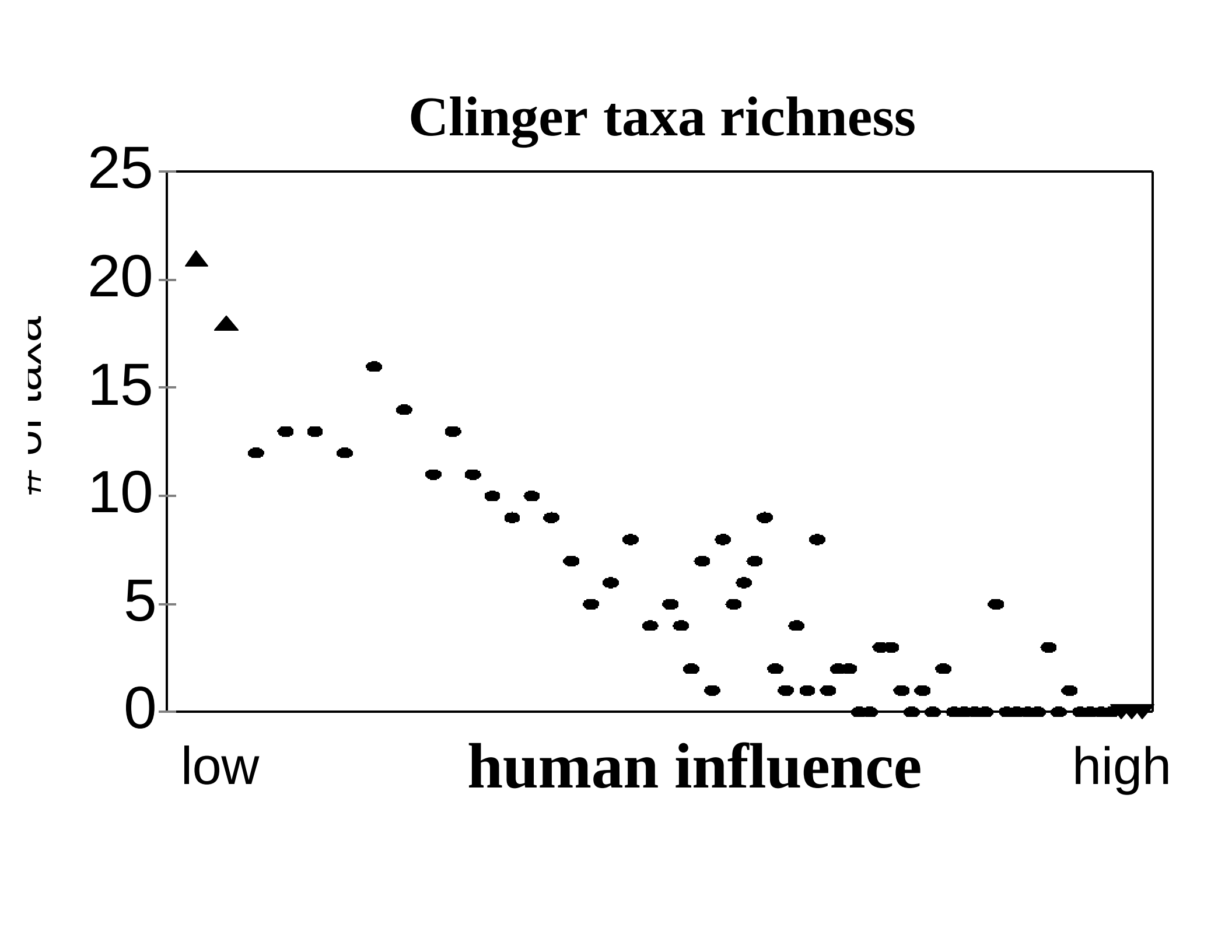
Steps to Multimetric Success

- Classify to define homogeneous sets
- Select appropriate attributes = metrics
- Develop sampling protocols
- Define analytical procedures
- Communicate results to citizens and policymakers


What to measure?
How to decide?
Biological response
Relative abundance
?
Genetic diversity
biomass
production
?
?
Trophic structure
Taxa richness
?
?
Population age structure
biomarkers
Human influence

Puget Sound Streams - 1994



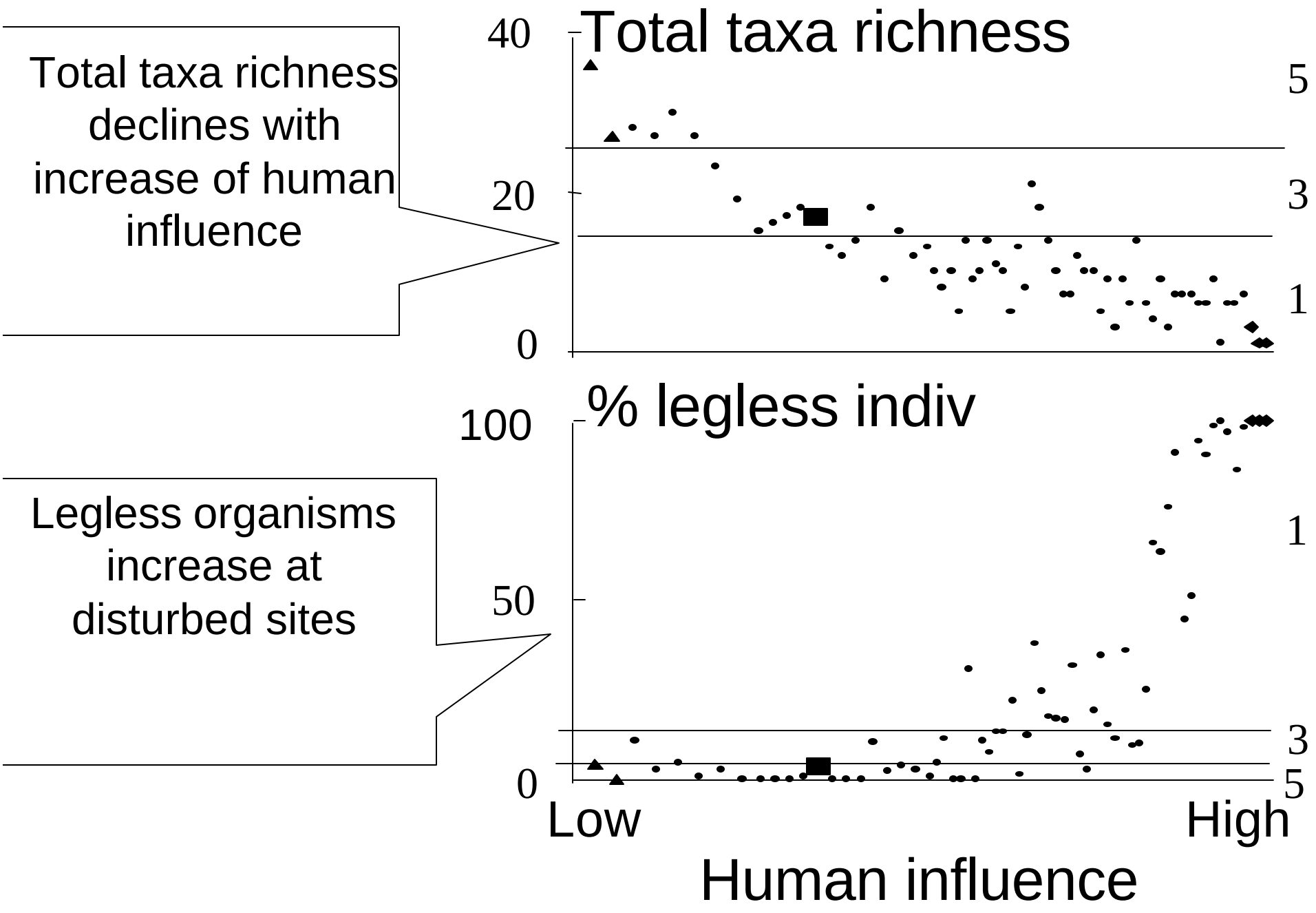

Clinger taxa richness
25
20
15
10
5
0
# of taxa
low
human influence
high

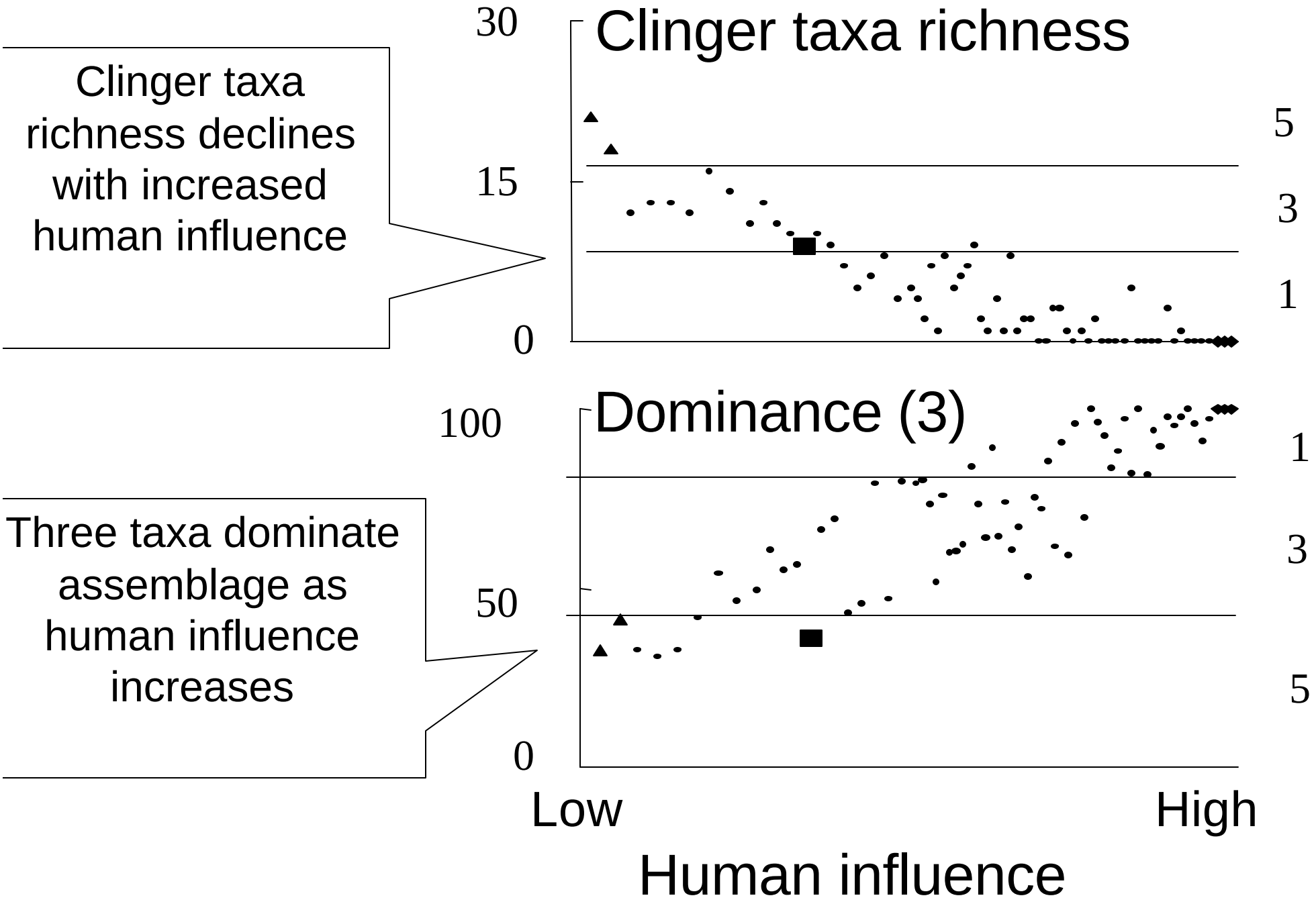
Biological Assessment Process

1. Collect samples of invertebrates, fish, or other organisms

2. Sort, identify, and count by taxonomic and ecological characteristics

3. Score metrics based on divergence from expectation at undisturbed sites


Total taxa richness declines with increase of human influence
Total taxa richness
40
20
0
5
3
1
% legless indiv
100
50
0
1
3
5
Low
High
Human influence
Legless organisms increase at disturbed sites


Clinger taxa richness declines with increased human influence
Three taxa dominate assemblage as human influence increases
Clinger taxa richness
30
15
0
5
3
1
Dominance (3)
100
50
0
1
3
5
Low
High
Human influence

Biological Assessment Process

4. Add metric scores to produce IBI

   IBI = S(tot) + S(legl) + S (cling) + S (dom)

   = 3 + 5 + 3 + 5 IBI = 16

5. Interpret IBI and other information to
   a. define condition (health) of waterbody
   b. identify likely causes of degradation
   c. evaluate management success

Key Terms

Attribute - measurable component of biological system

Metric - attribute with empirical change in value along gradient of human influence

Index - integrative expression of site condition across multiple metrics

Benefits of Biological Assessment

- Focus on correct endpoint
- Defines resource condition (numerical and verbal description)
- Useful in diagnosing causes of degradation
- Integrates across human influences
- Complements physical, chemical, and land-use data
- Statistically and biologically rigorous
  - low variability
  - improves decision making
  - time/money saved
  - multiple scales
- Evaluate management and restoration decisions
- Easily communicated to citizens and policy makers

Legacy:

something received from the past

Two Dimension of Loss

- Wetland Area
- Wetland Quality

They are connected

Protecting Wetland Health

- The legacy of narrow perspectives
  - wetlands as wastelands

    (deposit dredge spoil, drain and fill)
  - wetlands in the service of human society

    (functions and values)
  - wetlands as living systems

    (protecting biological integrity)
- Selecting indicators for crucial endpoints

Biological Integrity

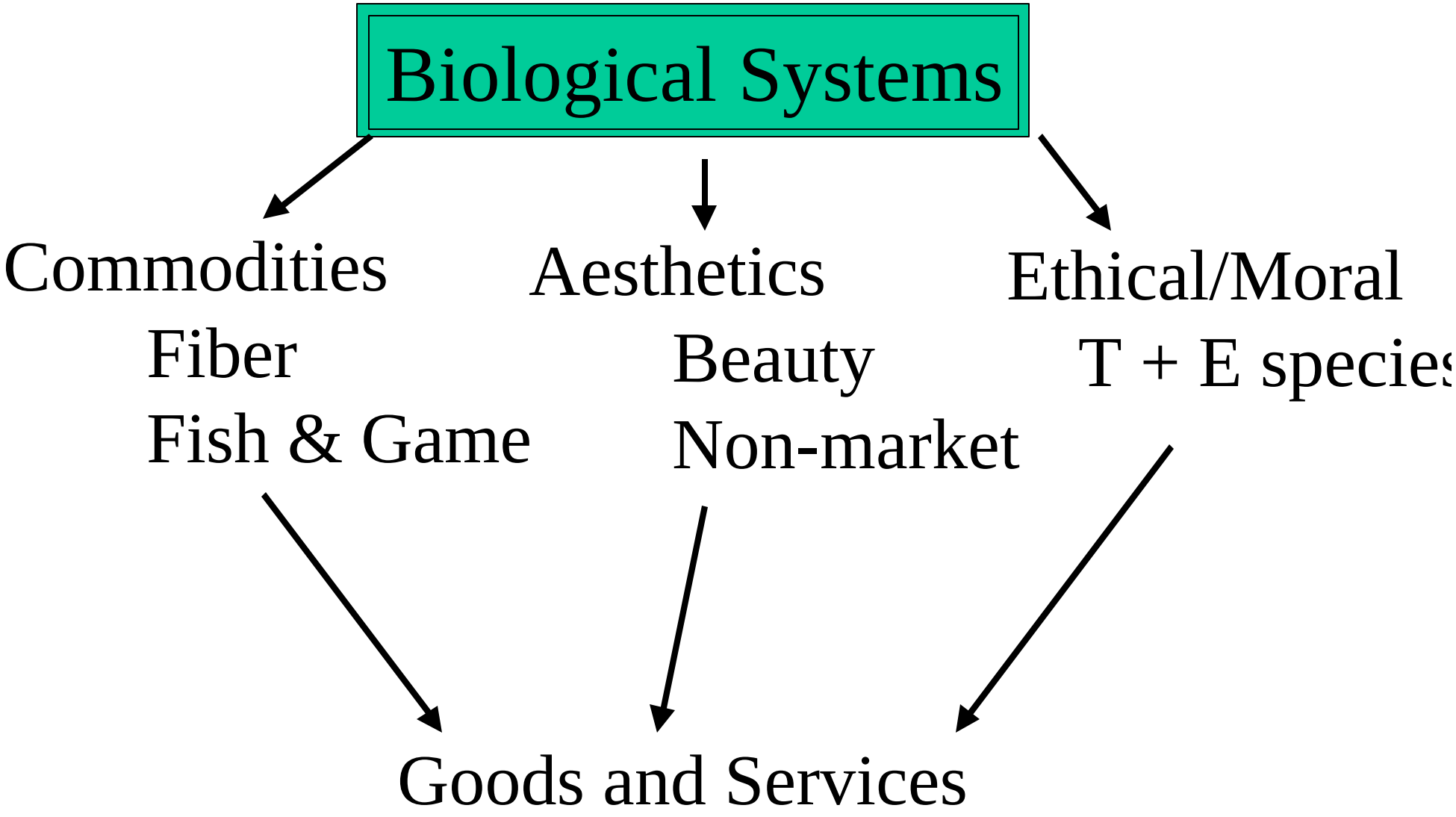
- parts and processes of nature's legacy ("wild nature")
- capacity to regenerate, reproduce, sustain, adapt, develop, and evolve
- temporally and spatially dynamic
- valuable and valued

“Ecosystem integrity is primarily a biological concern.”

Reynoldson et al., 1995 p. 215

The Economy

- Gross national product (GNP)
- Index of leading economic indicators
- Dow-Jones index
- Consumer price index


Biological Systems
Commodities
Fiber
Fish & Game
Aesthetics
Beauty
Non-market
Ethical/Moral
T + E species
Goods and Services

Monetary Valuation: Economic Value

- 17 ecosystem services for 16 biomes (Costanza et al
  - US$ 33,000 billion ($33 trillion)
  - 2 X global GNP

- Vital services provided by biota (soil formation, pollination, etc. Pimentel et al. 1997)
  - US$ 319billion (USA); US$ 2928 billion (global)
  - 5 % and 11% of gross domestic products

Ecological Footprints

- Appropriation with much broader focus
- Define amount ‘used’ (consumed, produced)
- Converted: land and water area required to produce or absorb
- Rees 1996, Wackenagel et al. 1999, Folke et al., 1997

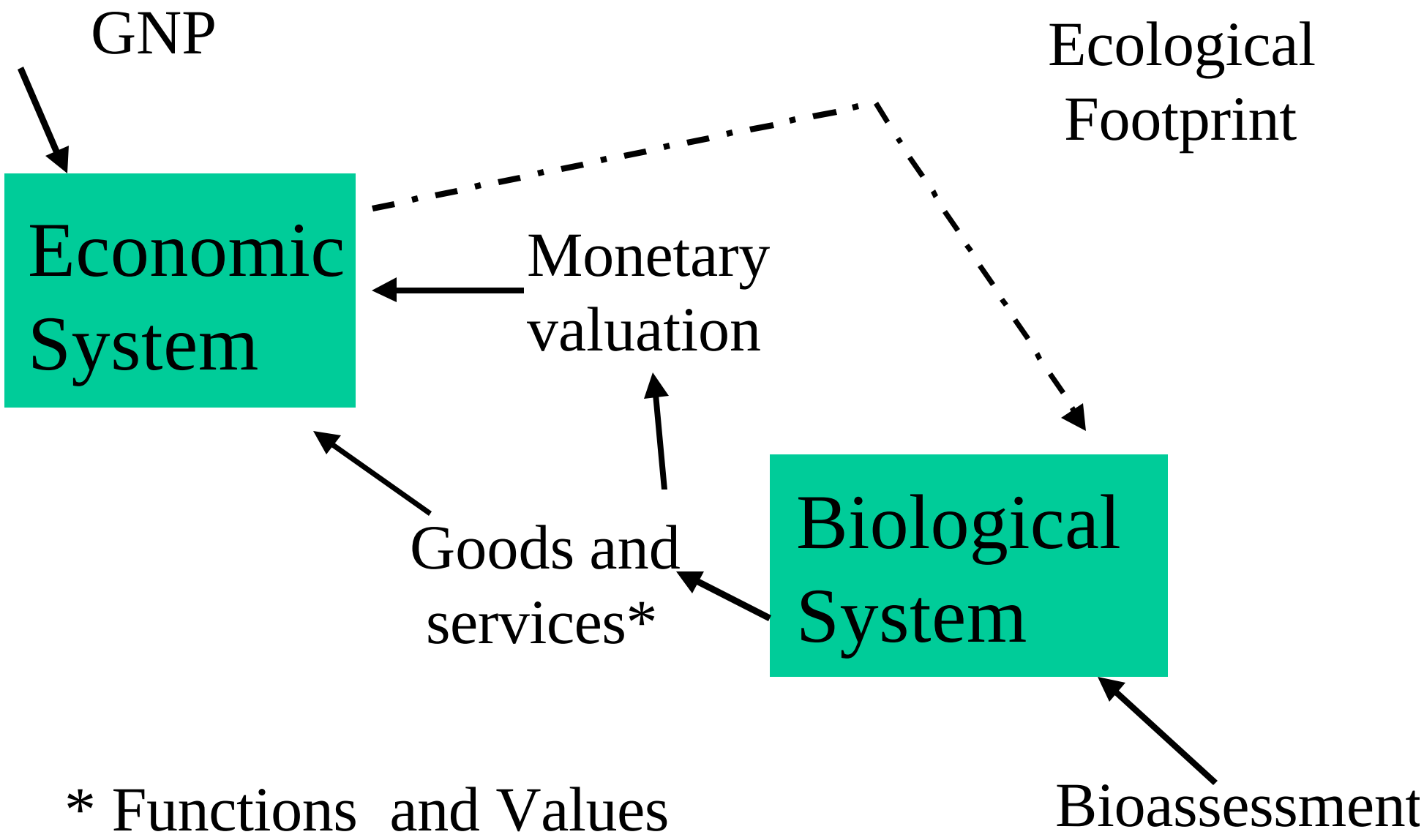
Ecological Footprints

- 29 Baltic Europe cities: ‘occupy’ forest, wetlands, marine and agricultural areas 565 to 1130 X areas of the cities themselves (Folke et al. 1997)
- 744 world cities appropriate forest area that exceeds full CO_2 capacity of global forests by 10%
- National ecological footprints (ha/capita)
  - 0.5 for Bangla Desh; 10.3 for USA
  - 52 nations: 2.8; 2.0 available
  - 34 of 52 nation’s operating with ecological deficits
- These are underestimates

Invisible hand assumed

Invisible foot ignored

Measuring What and Why?



Water Dichotomies

Water quantity	Water quality
Groundwater	Surface water
Point source	Non-point source
Fish-bearing	Non-fish-bearing

Although these dichotomies persist in water law and policy, they violate both science and common sense.

Measuring Environmental Progress: "The Continuum"

- Agency actions ("bean counting')
- Regulated community responses

Administrative actions

- Stressor (e.g., effluent) reductions
- Exposure tracking

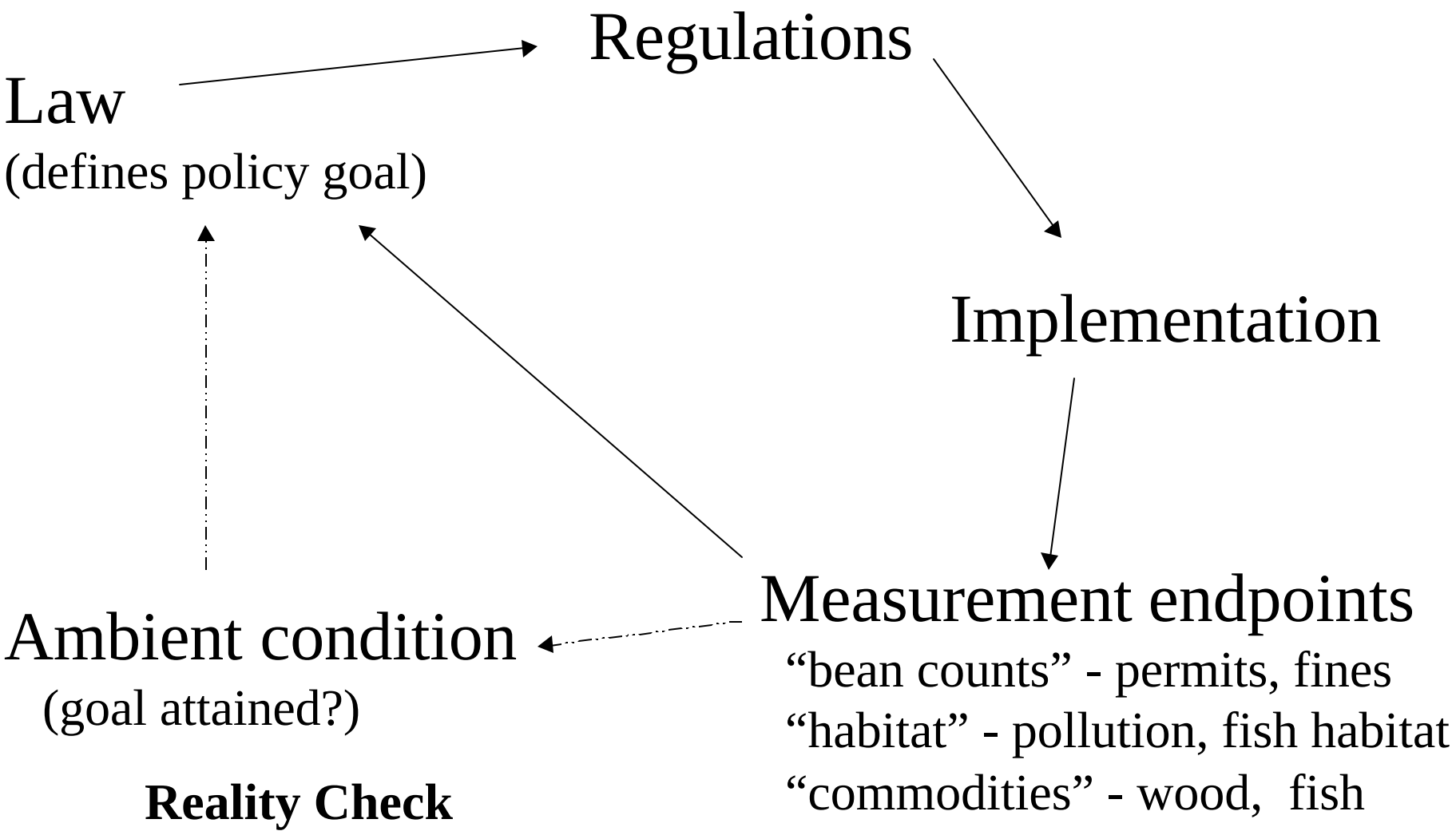
Technical achievements

- Biological responses/condition

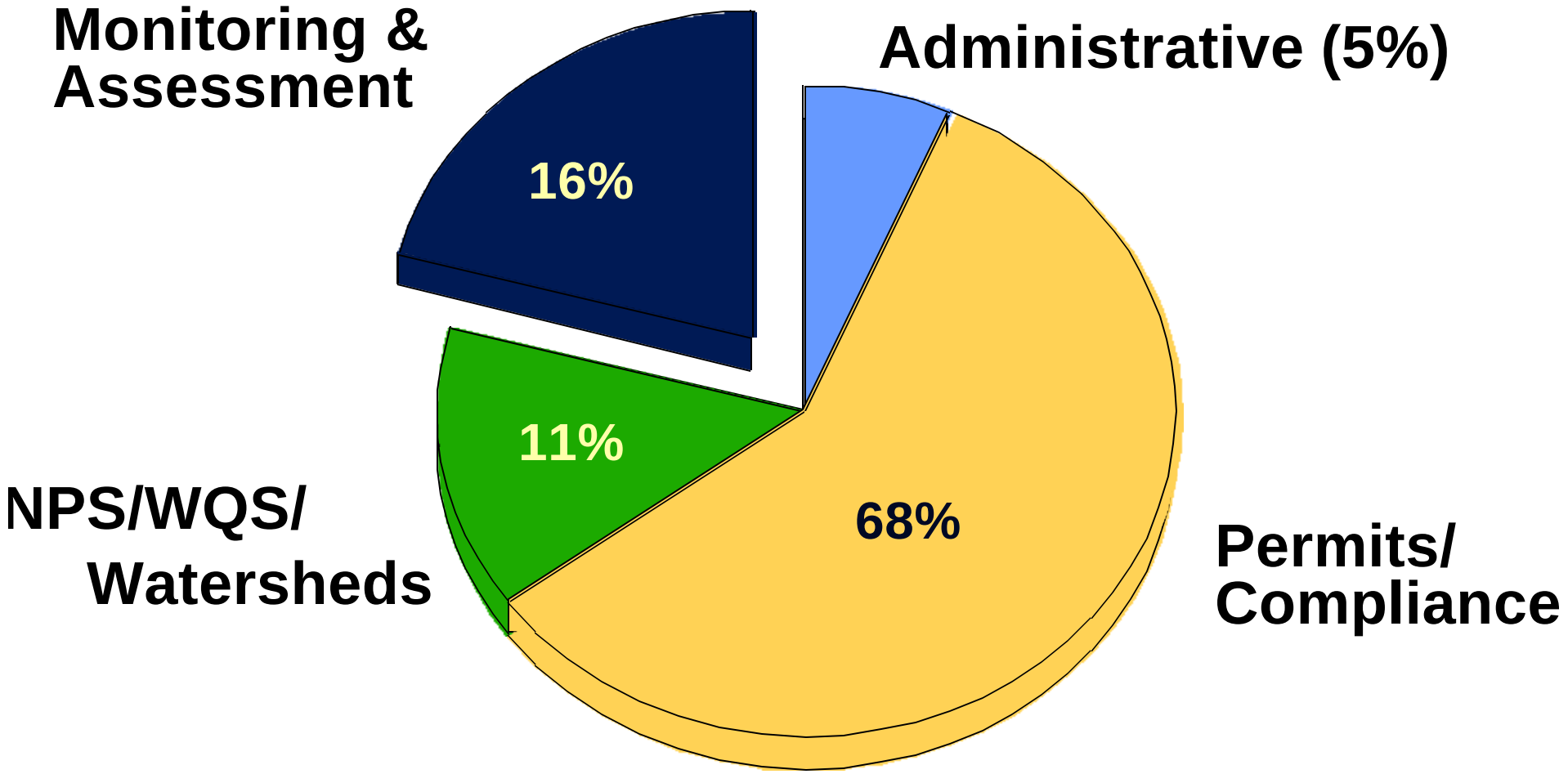
Environmental condition

Health endpoin

The Broken Science-Policy Cycle



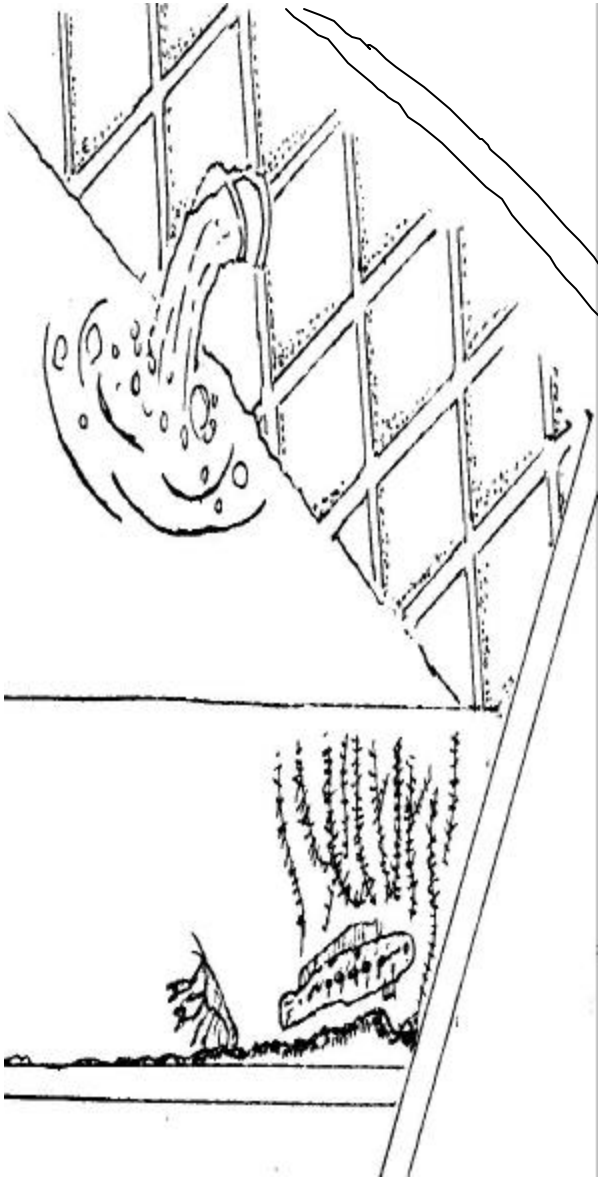
Ohio EPA Surface Water Program Resource Allocation

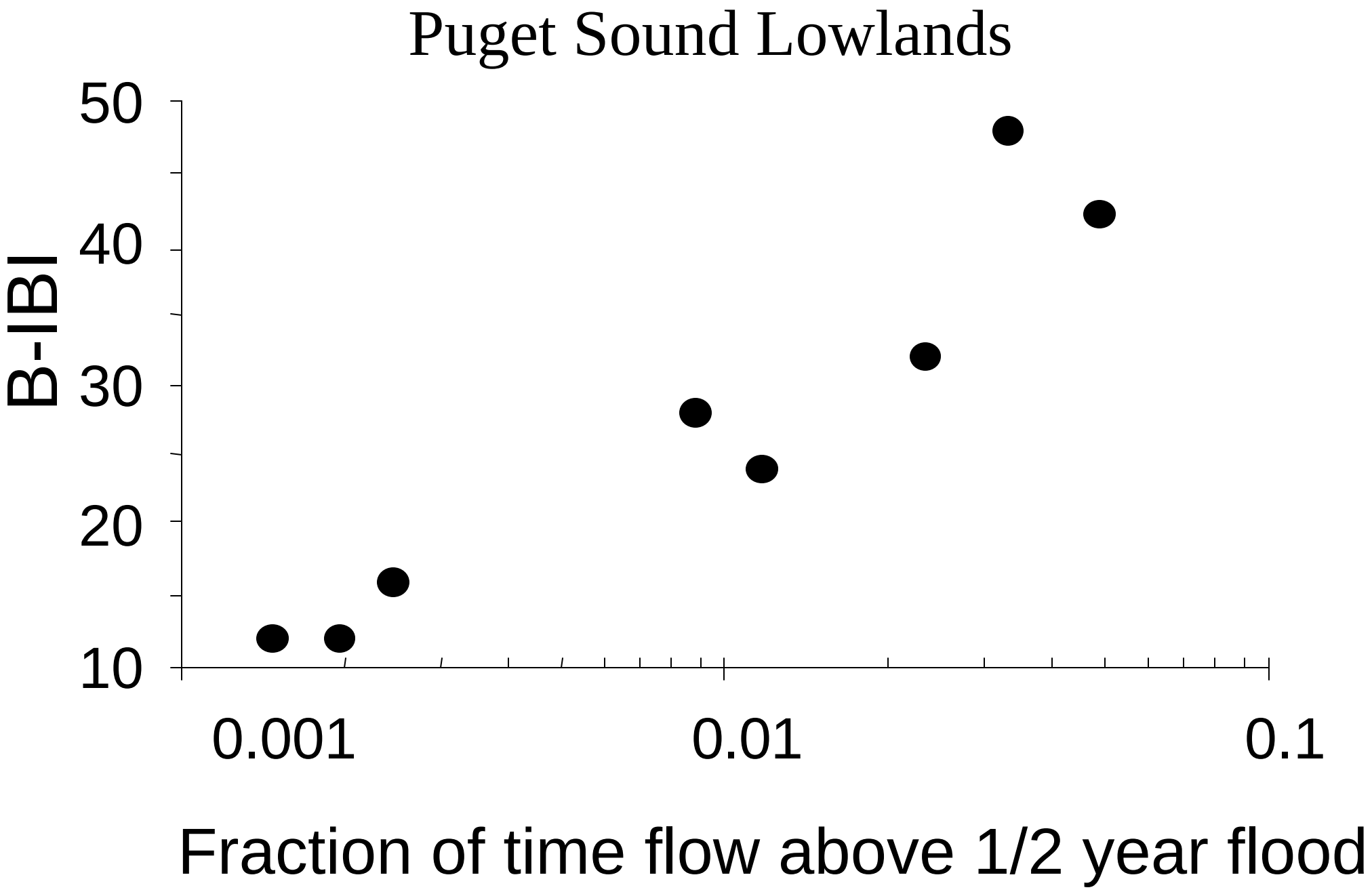


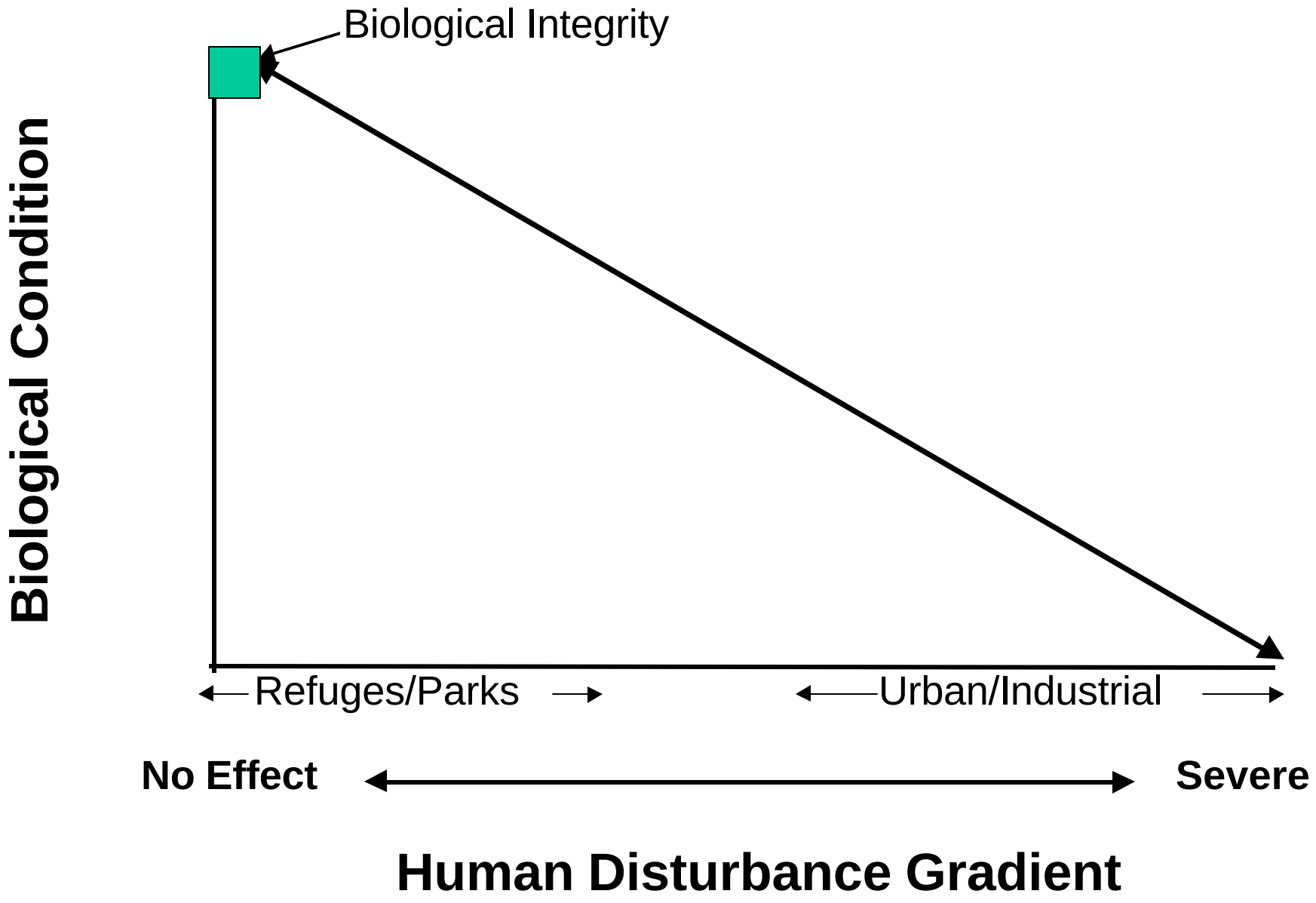
Multiple Causes of Degradation

- Focus on water pollution ill-conceived
- Key problem: changed physical and chemical foundation
  - altered drainage network
  - destruction of riparian corridor
  - disruption of surface-to-hyporheic connections
  - altered channel structure
  - increased supply of sands, silts, and clays
  - increased chemical pollution

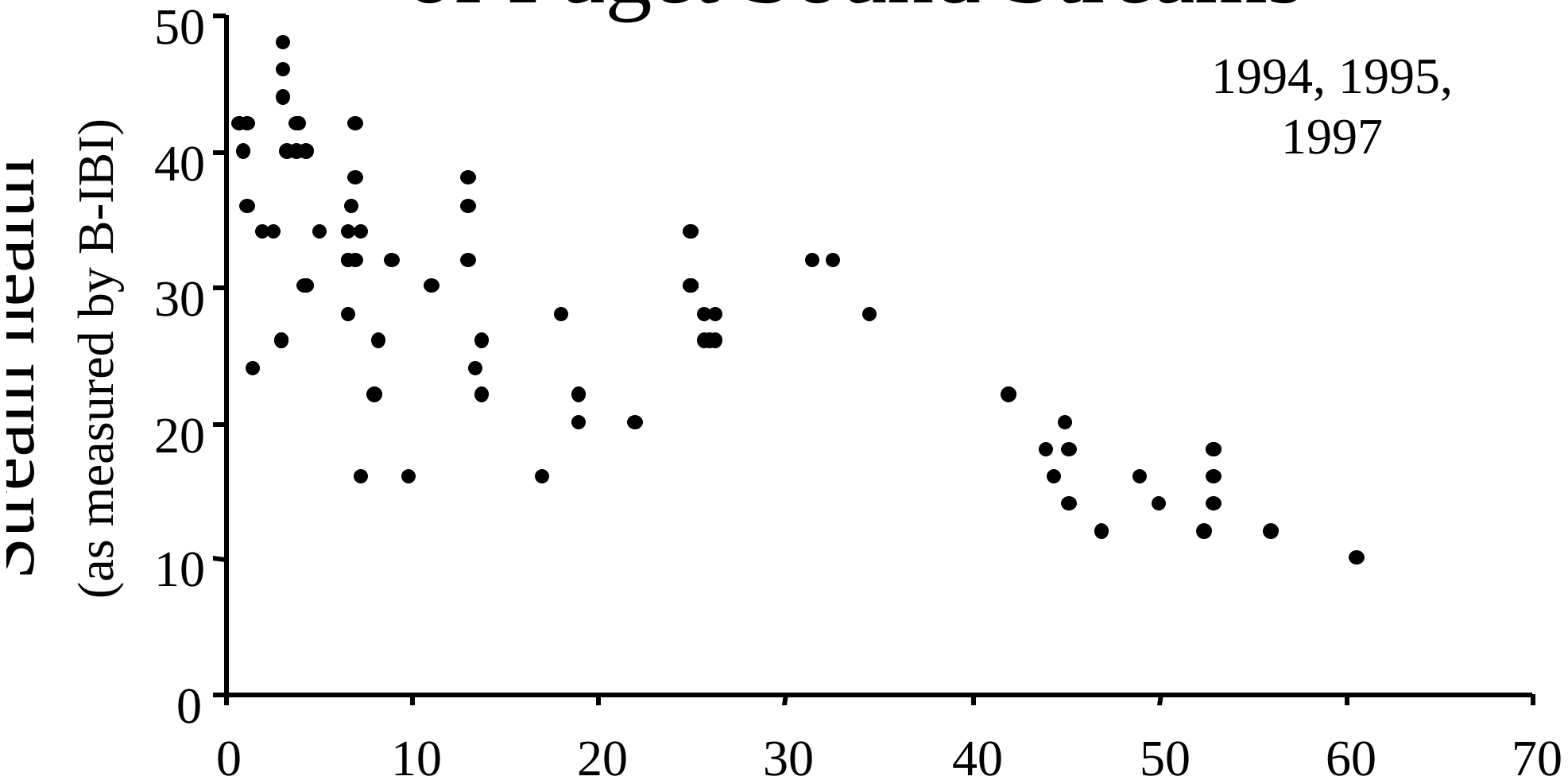
leaves and twigs	**Energy source**	domestic wastes
natural	**Chemical variables**	excess nutrients, toxins
natural flows	**Flow regime**	extreme flows
pools and riffles	**Habitat structure**	uniform
native taxa	**Biotic factors**	exotic taxa



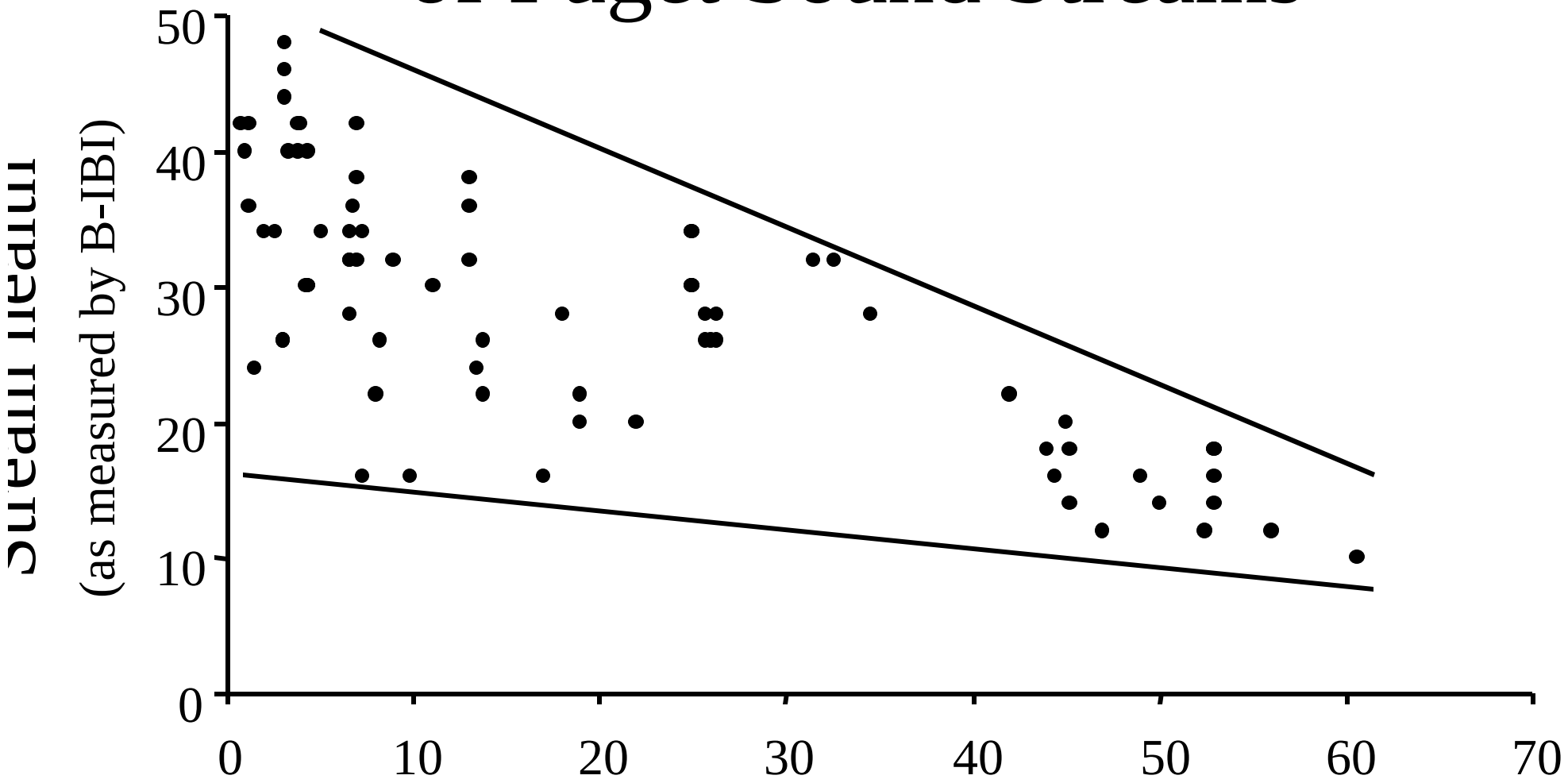

Puget Sound Lowlands
B-IBI
50
40
30
20
10
0.001
0.01
0.1
Fraction of time flow above 1/2 year flood

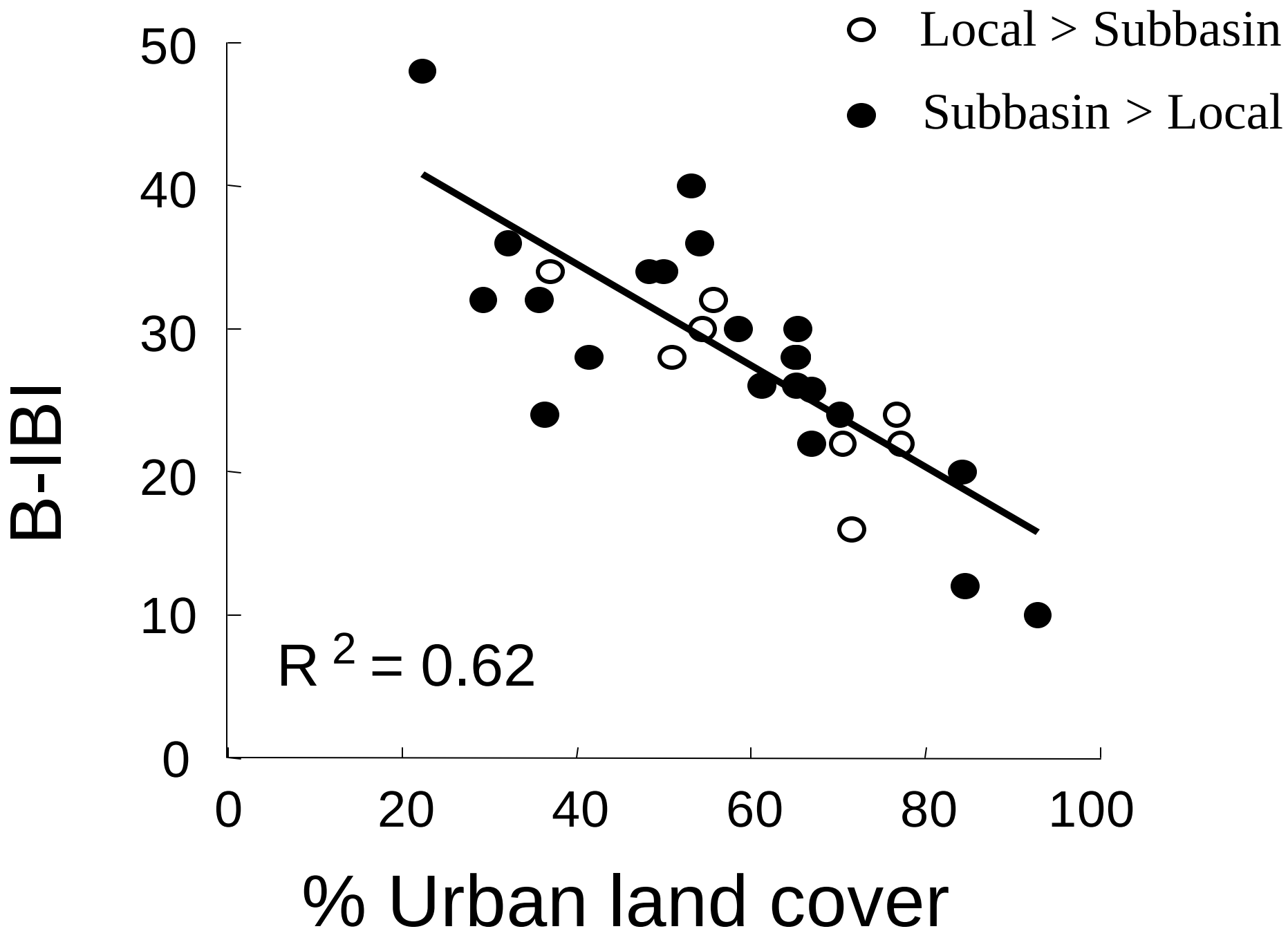

Biological Integrity
Biological Condition
Refuges/Parks
Urban/Industrial
No Effect
Severe
Human Disturbance Gradient

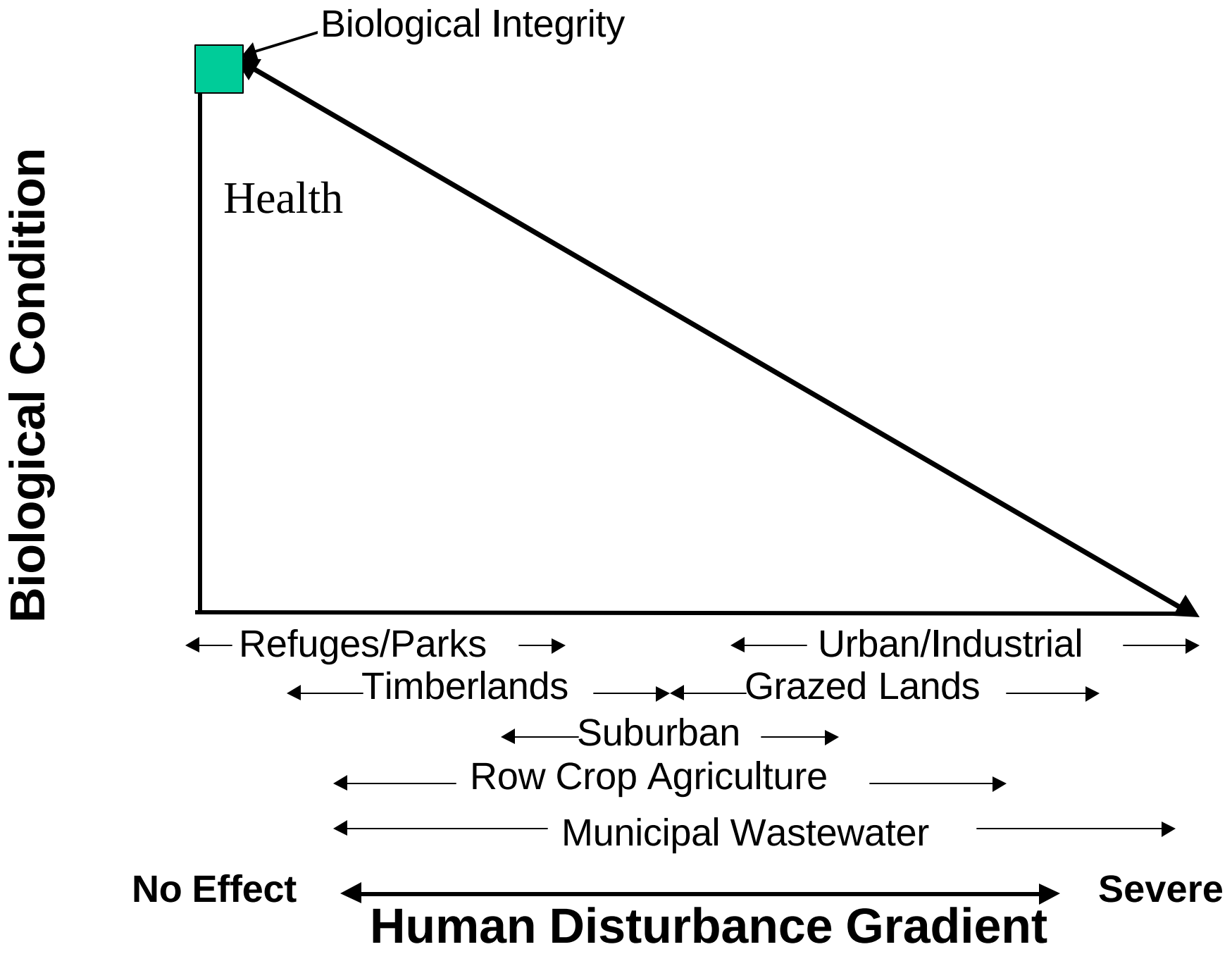
Health, or Biological Condition, of Puget Sound Streams

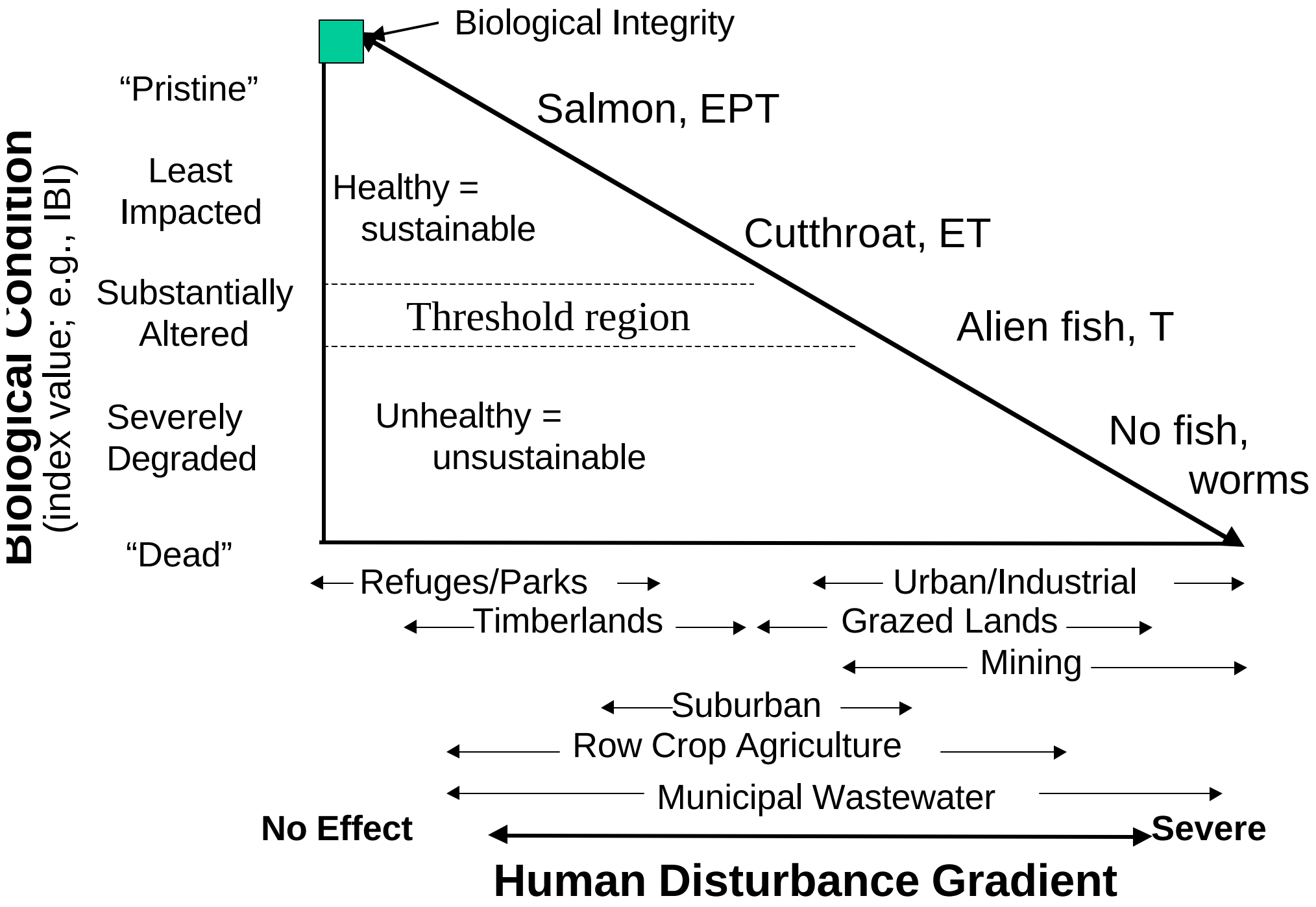


Health, or Biological Condition, of Puget Sound Streams

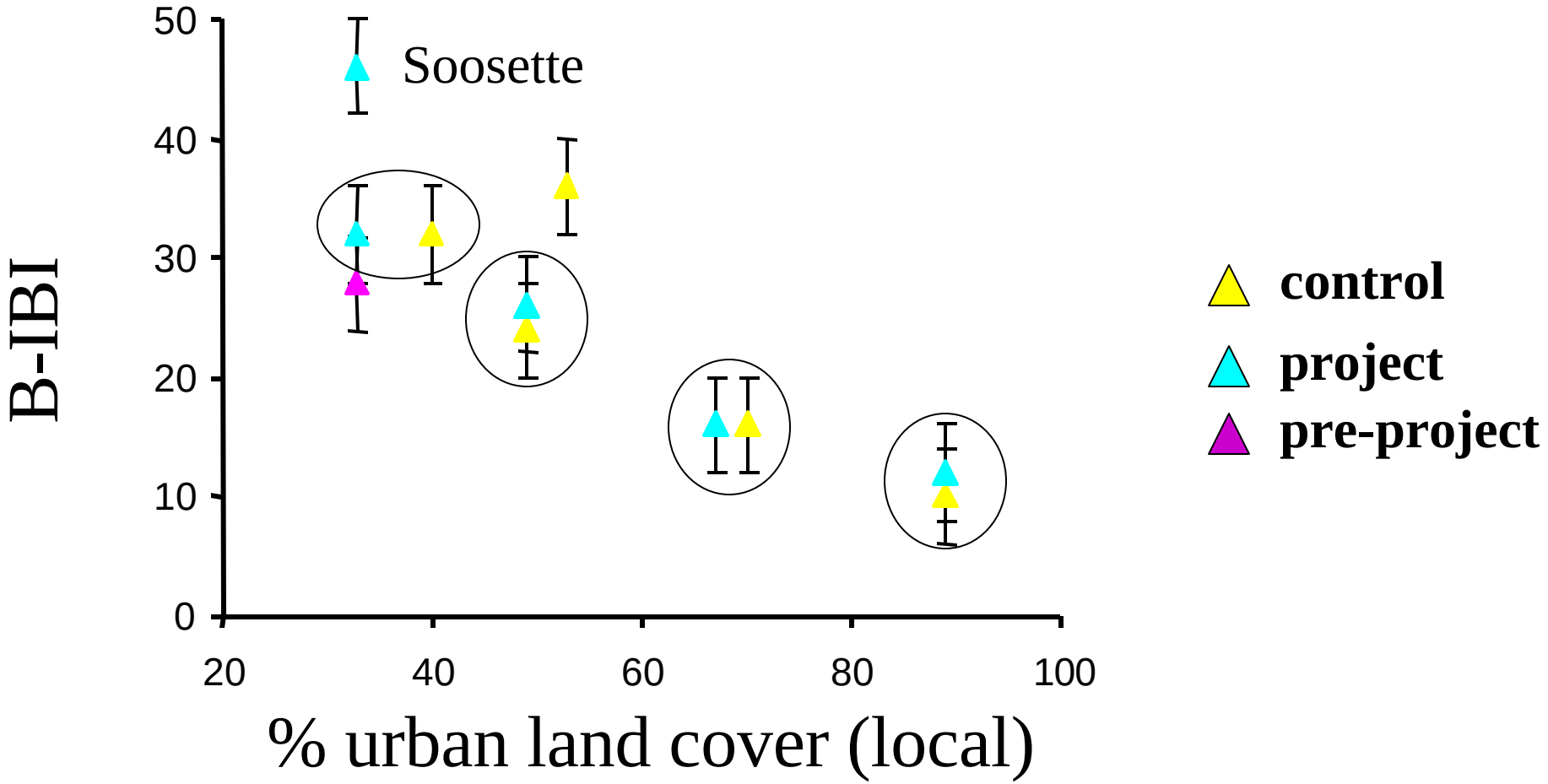



Local > Subbasin
Subbasin > Local
B-IBI
50
40
30
20
10
0
R 2 = 0.62
0
20
40
60
80
100
% Urban land cover


Biological Integrity
Health
Biological Condition
Refuges/Parks
Urban/Industrial
Timberlands
Grazed Lands
Suburban
Row Crop Agriculture
Municipal Wastewater
No Effect
Severe
Human Disturbance Gradient


Biological Integrity
"Pristine"
Salmon, EPT
Least Impacted
Healthy = sustainable
Cutthroat, ET
Substantially Altered
Threshold region
Alien fish, T
Severely Degraded
Unhealthy = unsustainable
No fish, worms
"Dead"
Biological Condition
(index value; e.g., IBI)
Refuges/Parks
Urban/Industrial
Timberlands
Grazed Lands
Mining
Suburban
Row Crop Agriculture
Municipal Wastewater
No Effect
Severe
Human Disturbance Gradient

Biological Results of Project Evaluation



B-IBI scores not significantly different (paired t-test, $p > 0.10$)

Conceptions and Misconceptions

- Key contexts
  - theoretical vs. empirical foundations
  - statistical significance vs. biological consequence
  - human influence gradients

- Applications: appropriate and inappropriate
  - design
  - analysis
  - sampling
  - interpretation

Place the biosphere first as the basis for human life and activity

Plan as if biology matters!

Scurvy and Citrus: Making Connections

1601: 4 ships from England to India

Captain James Lancaster

Lemon juice everyday for the crew of one ship;
most remained healthy

Crew of other three ships not given lemon juice;
110 of 278 sailors died of scurvy

Scurvy and Citrus: Taking Action Takes Time

1601: Lancaster experiment

1747: British navy does experiment

1795: Navy stocks citrus on ships

1865: British merchant marine ships stock citrus