

A FRAMEWORK FOR  
SELECTION OF  
ECOSYSTEM INDICATORS  
FOR THE CALIFORNIA  
CURRENT AND PUGET  
SOUND INTEGRATED  
ECOSYSTEM  
ASSESSMENTS



Phillip Levin

Jameal Samhouri, Kelly Andrews, Greg Williams, Isaac Kaplan, Andy James, Jessi Kershner

Northwest Fisheries Science Center  
Seattle, WA



# The question

- How do we *meaningfully* measure ecosystem “health”?
  - i.e., how do we assess the status of the ecosystem or the effectiveness of management?



# What does meaningful mean?

Conservation Psychology (Saunders 2003)



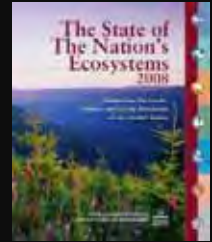
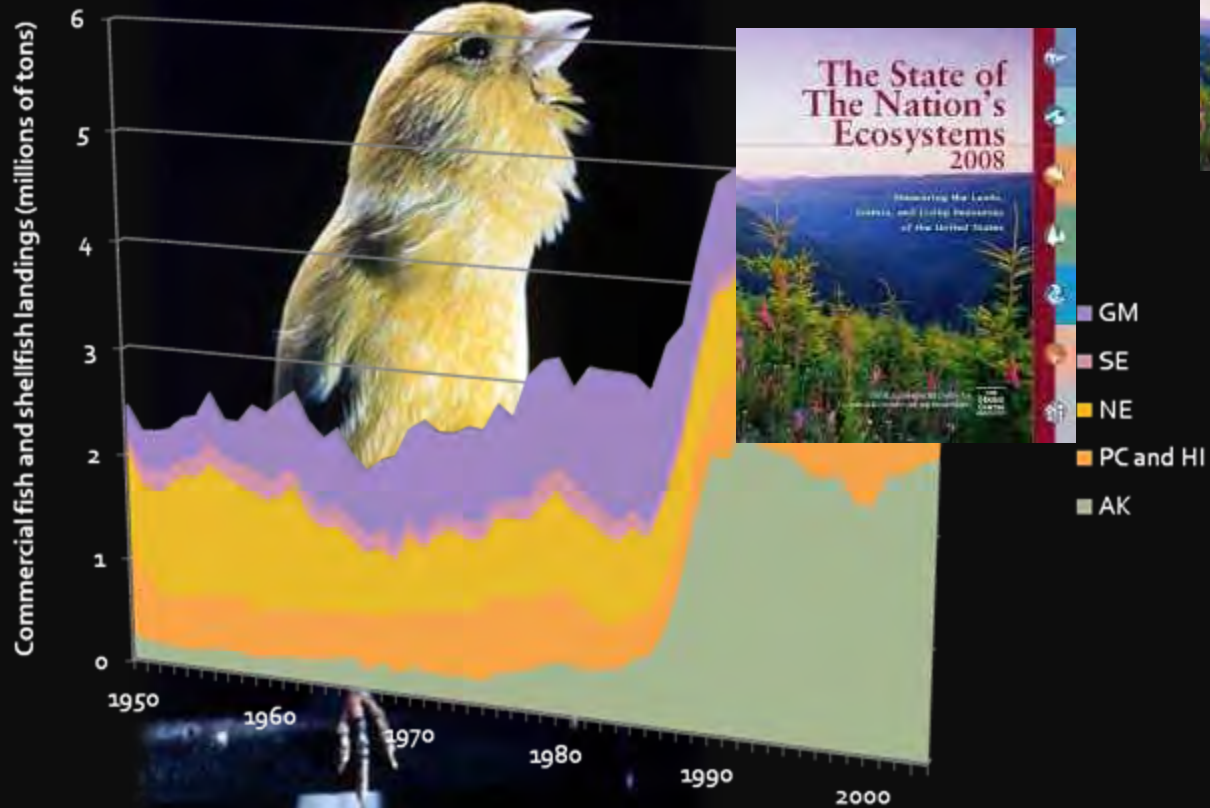
Personal  
connections  
to species,  
habitats,  
ecosystems,  
etc



Social norms  
and  
discourses

# What does meaningful mean?

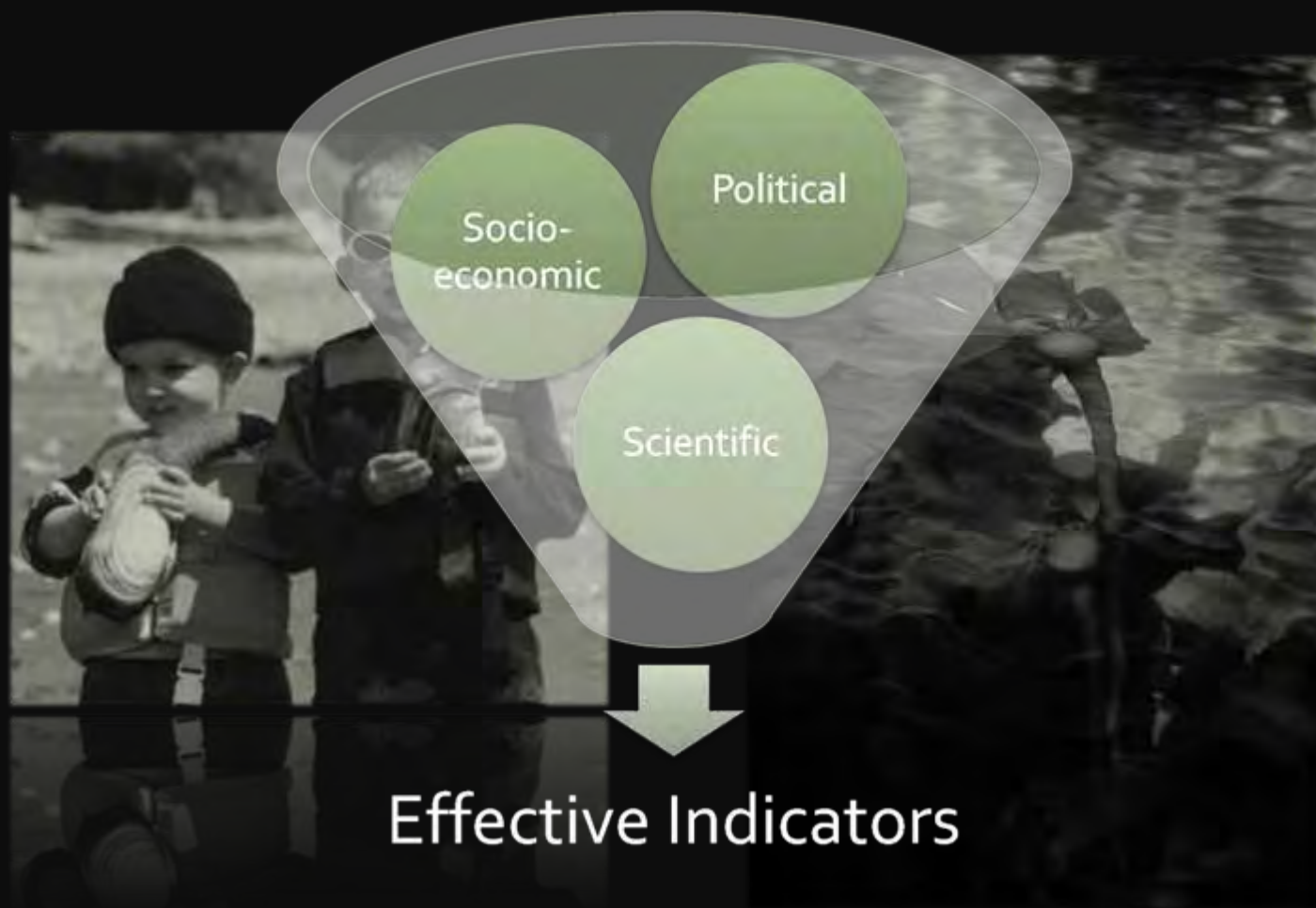
Ecology and Conservation Biology



Meaningfully evaluating ecosystems requires development of indicators that are meaningful

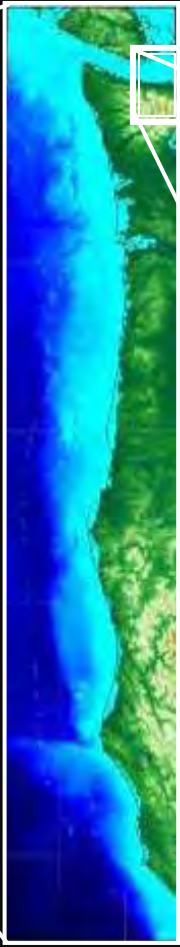
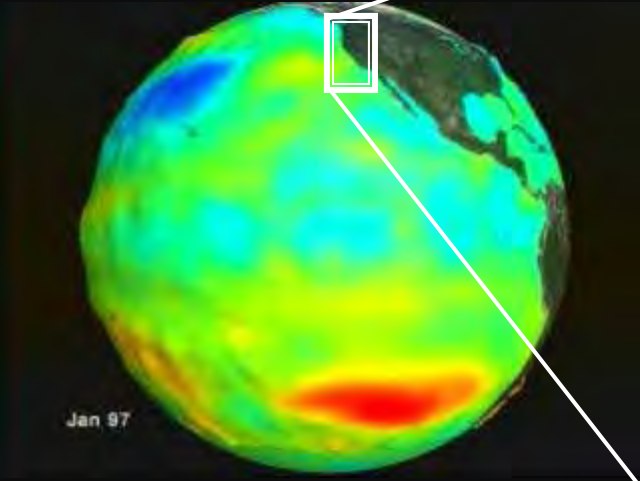


Meaningfully evaluating ecosystems requires development of indicators that are meaningful



# Overall approach

- Define and Operationalize objectives
- Generate list of potential indicators
- Map potential indicators on to framework
- Evaluate scientific rigor of indicators
- Rank indicators
- Generate indicator portfolios
- Assess social value of indicator portfolios





# Ecosystem check-up or Diagnostic Assessment

## VITAL SIGNS



## DIAGNOSTIC ASSESSMENT



# Overall approach

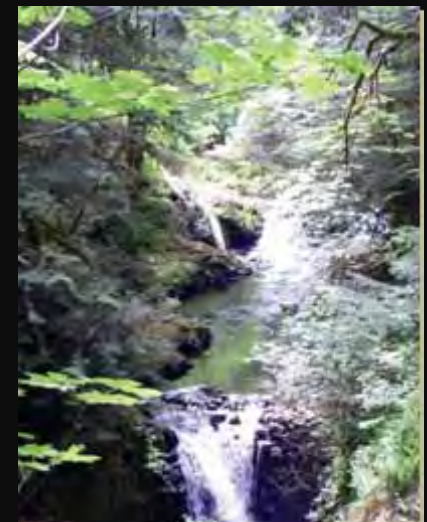
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# In Puget Sound...

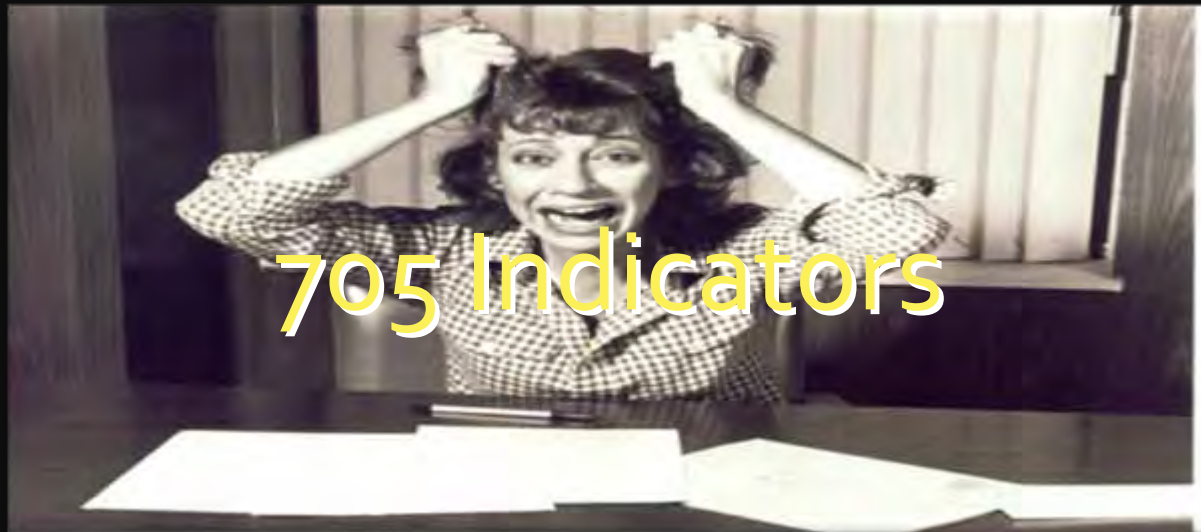
- What is a healthy Puget Sound?
- What is the status of Puget Sound, and what are the biggest threats?
- Public workshops, expert topic forums, and meetings with managers
- >1,600 people attended public workshops,
- 75 presentations were given to business and community organizations
- 11,182 public comments were received

# 6 goals emerged

- a) *Human health*
- b) *Human well being*
- c) *Species & food webs*
- d) *Habitats;*
- e) *Water quantity*
- f) *Water quality*



# Indicators



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# Goals

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- Combination of societal values and scientific understanding that defines a desired ecosystem condition
  - U.S. Environmental Protection Agency (2002). A Framework for Assessing and Reporting on Ecological Condition: A Science Advisory Board Report. T. F. Young and S. Sanzone. Washington, D.C.

# Focal ecosystem components

- The major ecological components of an ecosystem
- Emerge directly from management goals
  - Conservation Measures Partnership (2007). Open Standards for the Practice of Conservation, Version 2.0.





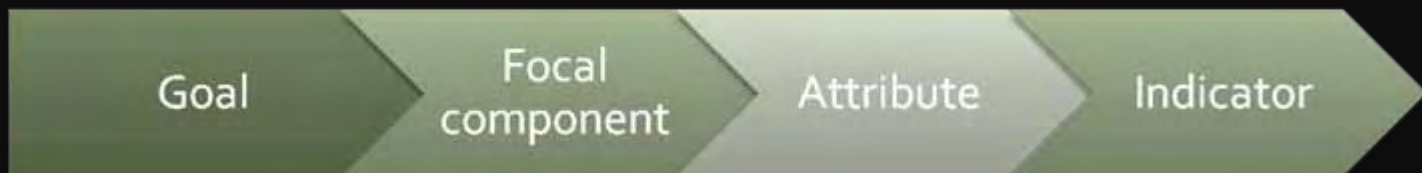
# Key attribute

- *Key attributes* are the characteristics that define the structure, composition, and function of focal ecosystem components
  - Harwell, M. A., V. Myers, et al. (1999). "A framework for an ecosystem integrity report card." Bioscience 49(7): 543-556.



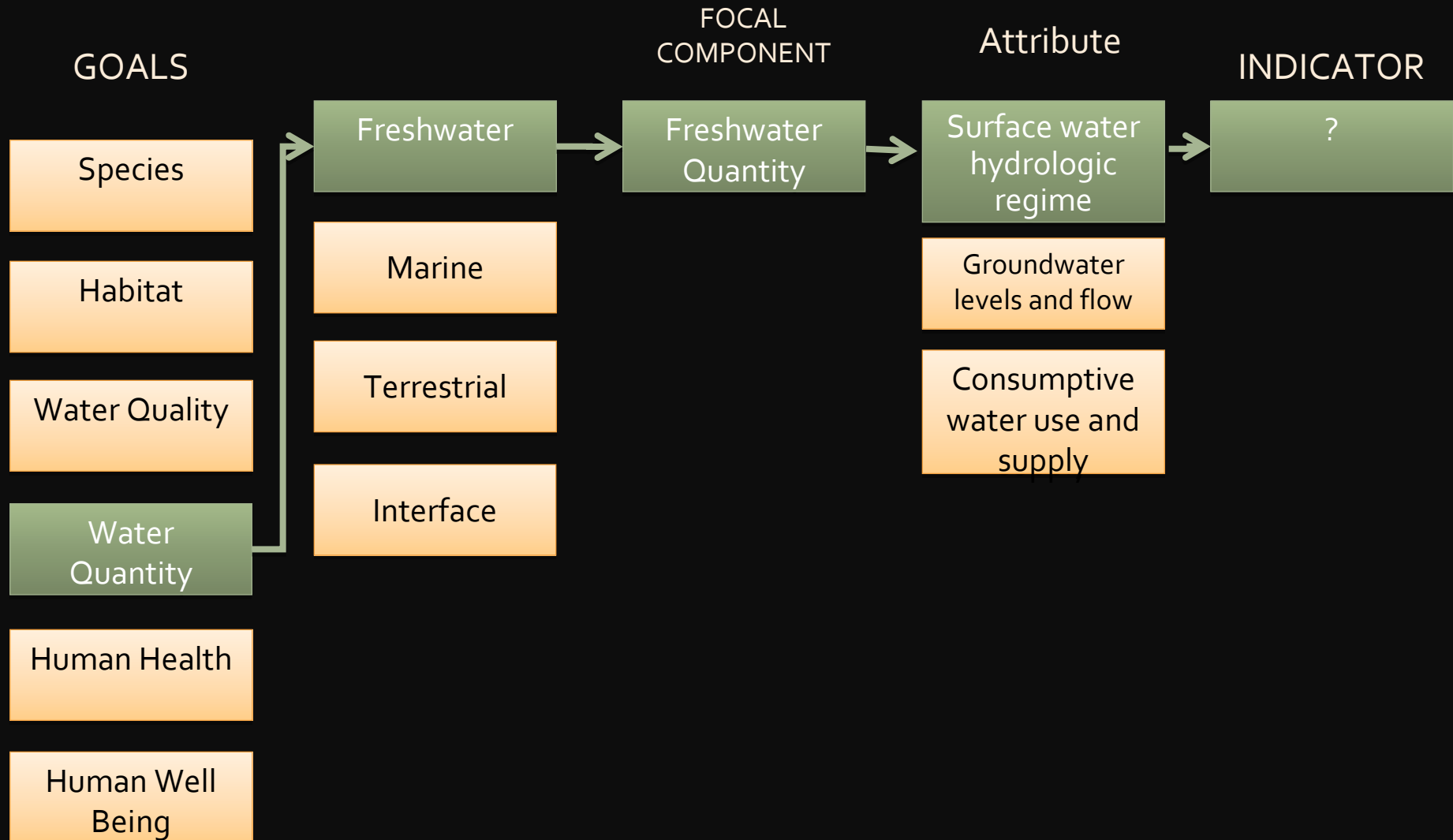
# Indicator

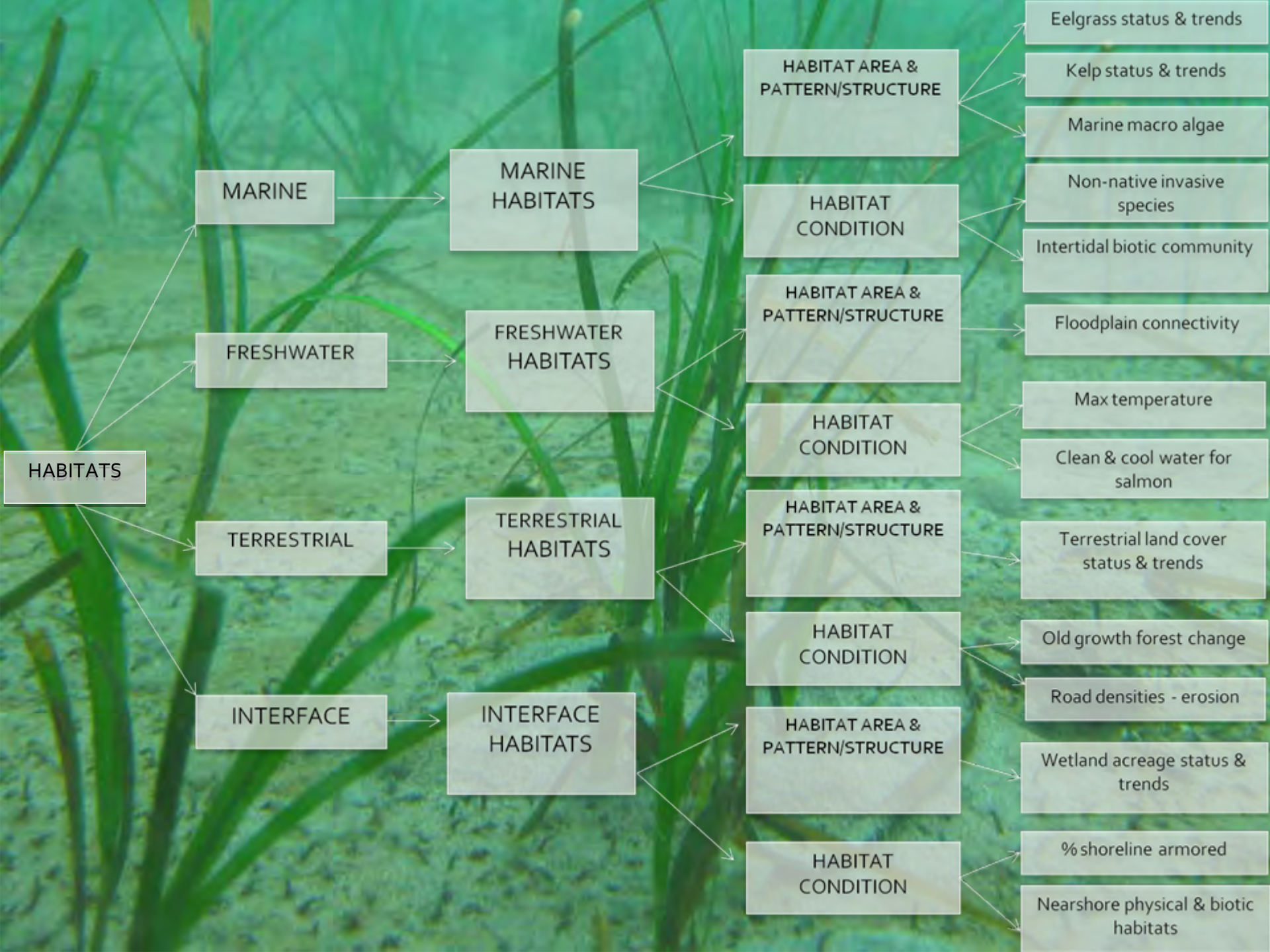
- Quantitative measurements that serve as proxies for characterizing key attributes of natural and socioeconomic systems
  - Heinz Center (2008). The State of the Nation's Ecosystems 2008: Measuring the Lands, Waters, and Living Resources of the United States, Island Press.



# Indicator

## FRAMEWORK/ORGANIZATION





HABITATS

MARINE

FRESHWATER

TERRESTRIAL

INTERFACE

MARINE  
HABITATS

FRESHWATER  
HABITATS

TERRESTRIAL  
HABITATS

INTERFACE  
HABITATS

HABITAT AREA &  
PATTERN/STRUCTURE

HABITAT  
CONDITION

HABITAT AREA &  
PATTERN/STRUCTURE

HABITAT  
CONDITION

HABITAT AREA &  
PATTERN/STRUCTURE

HABITAT  
CONDITION

HABITAT AREA &  
PATTERN/STRUCTURE

HABITAT  
CONDITION

Eelgrass status & trends

Kelp status & trends

Marine macro algae

Non-native invasive  
species

Intertidal biotic community

Floodplain connectivity

Max temperature

Clean & cool water for  
salmon

Terrestrial land cover  
status & trends

Old growth forest change

Road densities - erosion


Wetland acreage status &  
trends

% shoreline armored

Nearshore physical & biotic  
habitats

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A photograph of an orca breaching the water surface. The orca's dark, sleek body is visible above the water, with its white underbelly and a prominent white patch on its side. The water is splashing around the orca's head and tail, creating a dynamic scene. The background shows the dark, choppy water of the ocean.

5 Scientific Criteria  
8 Data Criteria  
5 Other Criteria

## Objectively Evaluate Indicators

Each indicator evaluated on 18 criteria based on **peer reviewed science**

Criteria based on lit. review

O'Connor and Dewling 1986; Landres, Verner et al. 1988; Noss 1990; Harwell, Myers et al. 1999; Jackson, Kurtz et al. 2000; Kurtz, Jackson et al. 2001; Rice 2003; Jennings 2005; Jorgensen, Costanza et al. 2005; Rice and Rochet 2005; Niemeijer and de Groot 2008; Doren, Trexler et al. 2009

# Primary considerations

Primary considerations	Data Considerations	Other
Theoretically sound		
Relevant to management goals		
Responds to changes in attributes		
Responds to changes in management actions		
Linkable to management reference points		

# Primary considerations

Primary considerations	Data Considerations	Other
Theoretically sound	Concrete	
Relevant to management goals	Historical data available	
Responds to changes in attributes	Operationally simple	
Responds to changes in management actions	Numerical	
Linkable to management reference points	Spatial and temporal variation understood	
	High signal-to-noise ratio	



# Primary considerations

Primary considerations	Data Considerations	Other
Theoretically sound	Concrete	Understood by public & policy makers
Relevant to management goals	Historical data available	History of reporting
Responds to changes in attributes	Operationally simple	Cost-effective
Responds to changes in management actions	Numerical	Anticipatory or leading indicator
Linkable to management reference points	Spatial and temporal variation understood	Nationally /internationally compatible
	High signal-to-noise ratio	

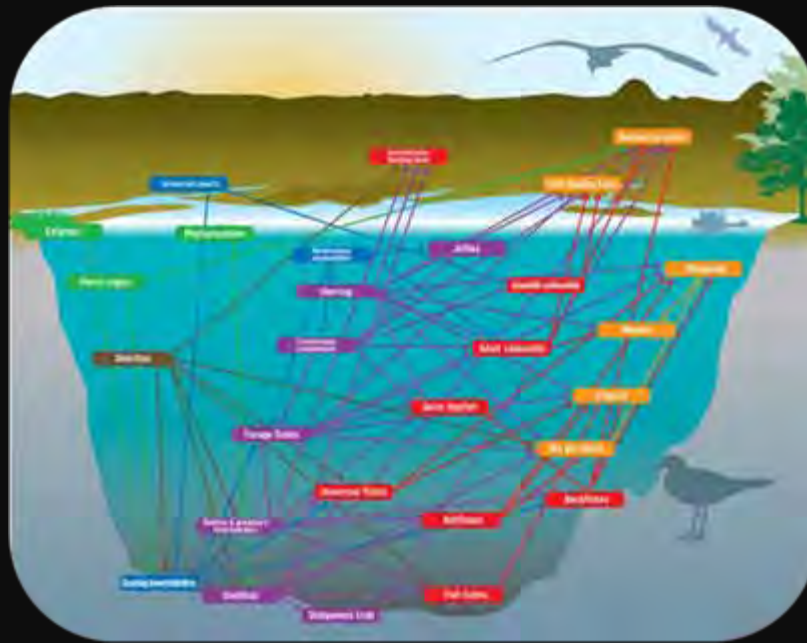
18 criteria



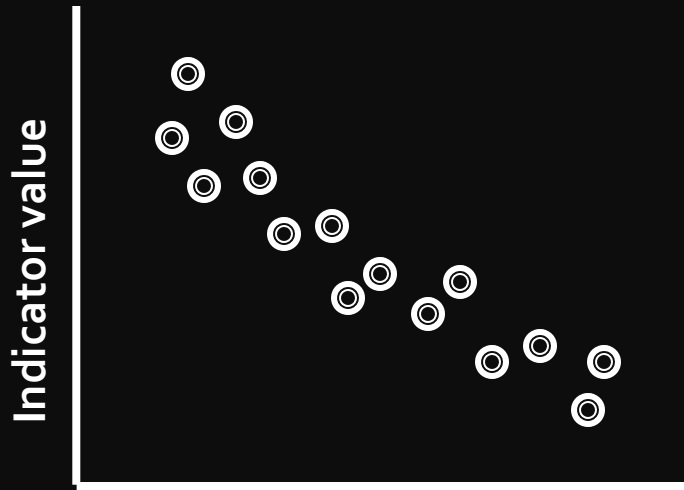
705 Indicators

Peer reviewed evidence?

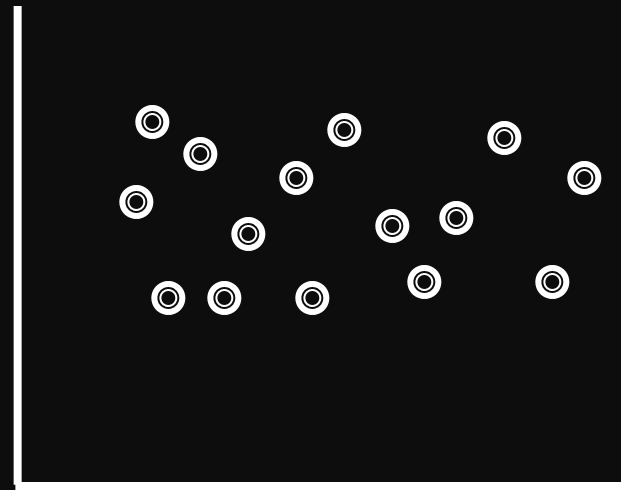
# Test indicator performance by perturbing food web models $\rightarrow$ $\Delta$ attributes, indicators



Meaningful indicator



Not so meaningful indicator



Attribute value

# Northern British Columbia



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# Coarsely Rank Indicators

- Weight Evaluation Criteria – not all are equally important
- For CC IEA we polled managers to get weightings
- For Puget Sound, a mixed science-policy group generate weightings in a workshop setting

Understood by public and policy makers	Spatial and temporal variation understood	Broad spatial coverage
1	0.25	0.5

Retrospective  
→  
←  
Early warning

Lagging, diagnostic

Lagging, broadly informative

Leading, diagnostic

Leading, broadly informative

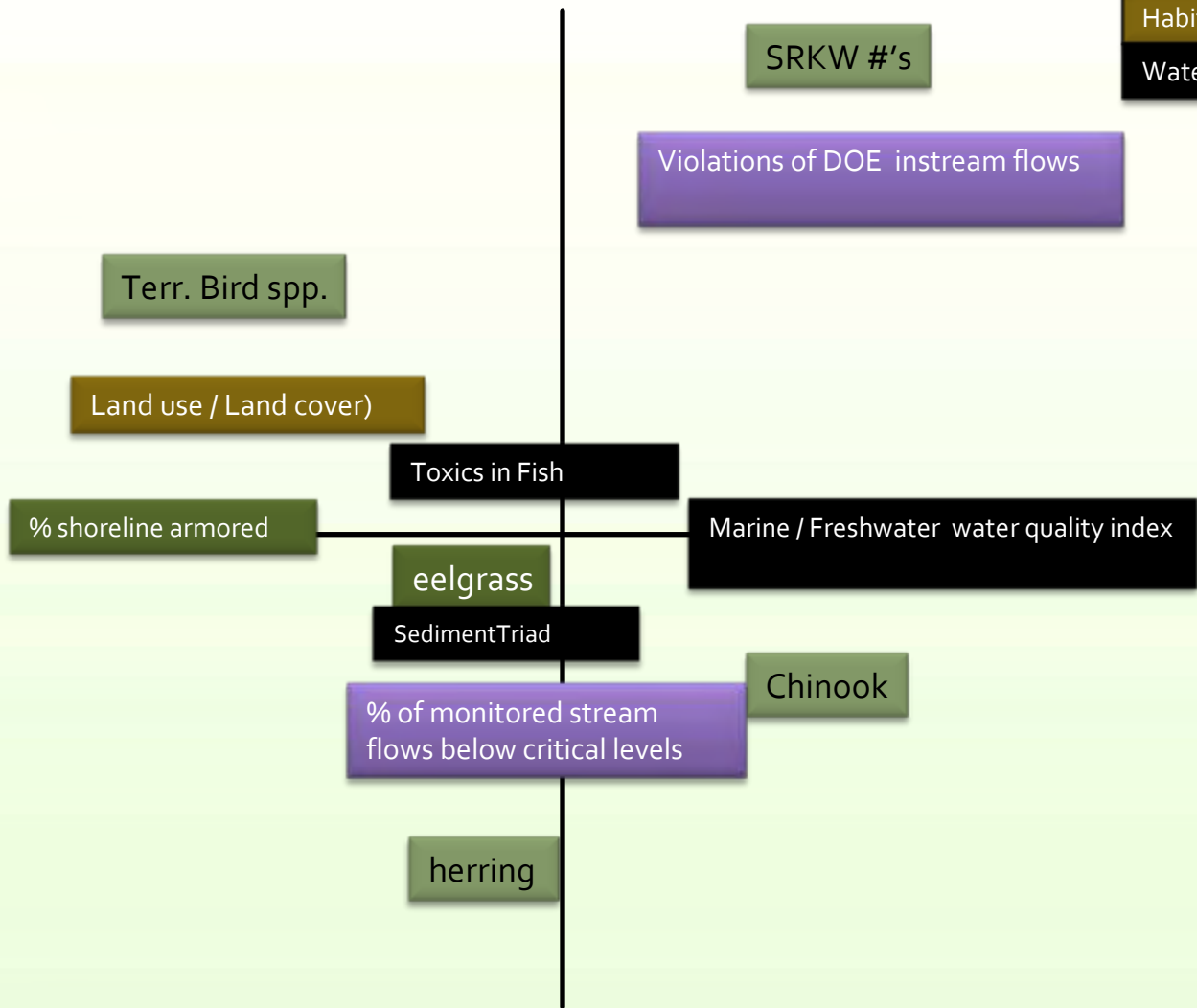
Diagnostic ←-----→ Non-specific



# Portfolio A

Retrospective →  
← Early warning

Species & foodwebs
Water quantity
Habitat
Water quality

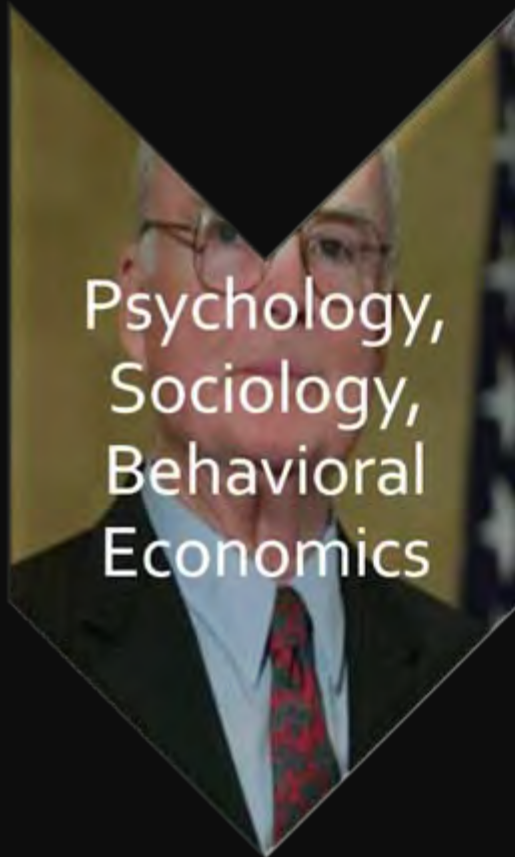


Diagnostic ←-----→ Non-specific

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# Assessing social value of indicators



- Evaluate currently held values related to ecosystem indicators
- Focus groups, phone surveys, internet surveys

# Goodhart's Law

*"Any observed statistical regularity will tend to collapse once pressure is placed upon it for control purposes"*

- Charles Goodhart - Chief Adviser to the Bank of England in the 1970s.


*"When a measure becomes a target [for management], it ceases to be a good measure"*

-Hoskin 1996.


# Goodhart's Law

a known widespread issue

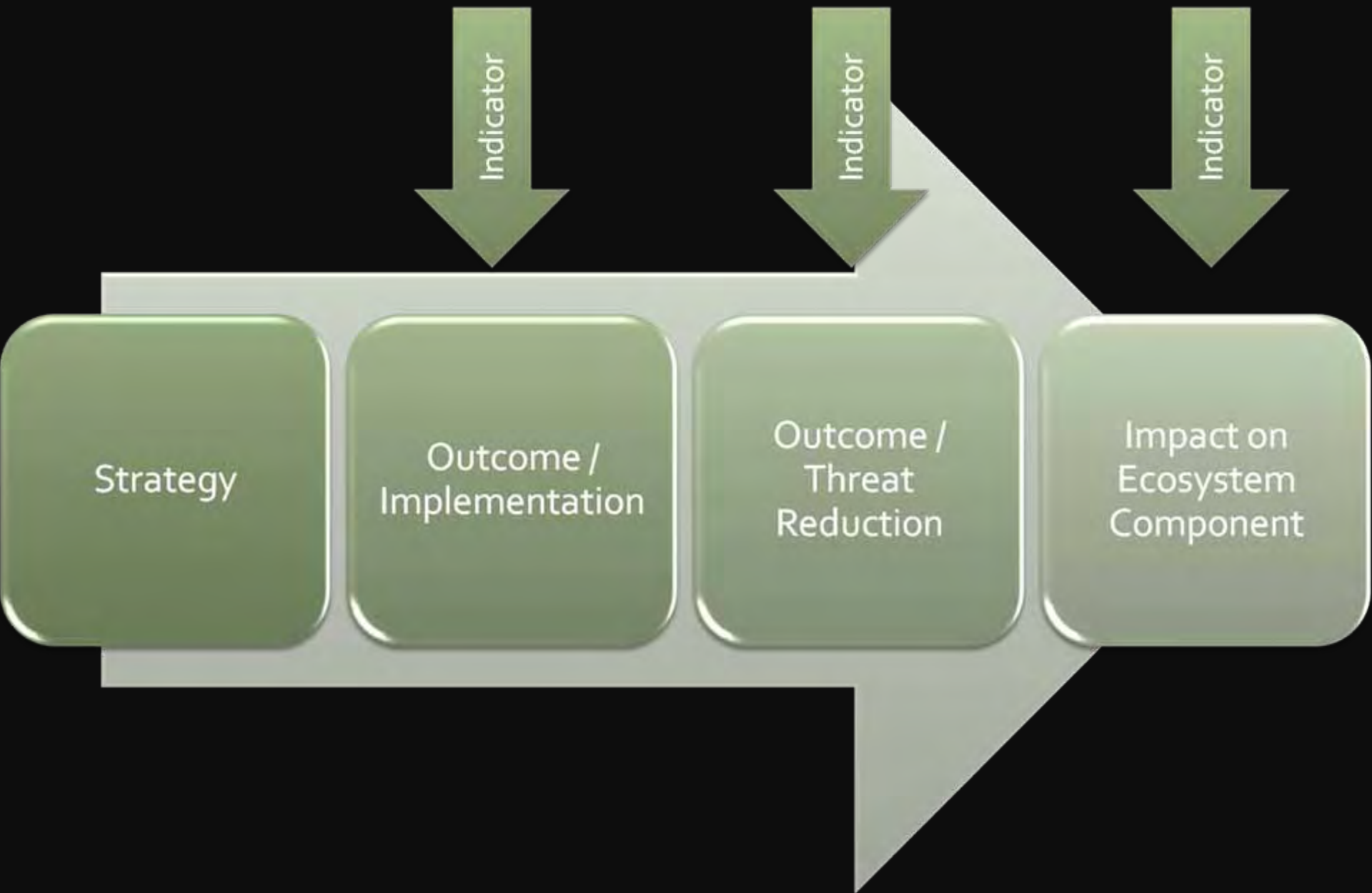
- Health care
- Education
- Monetary policy
- Social welfare (e.g. indices of happiness)
- Traffic management
  
- Conservation of European bird diversity

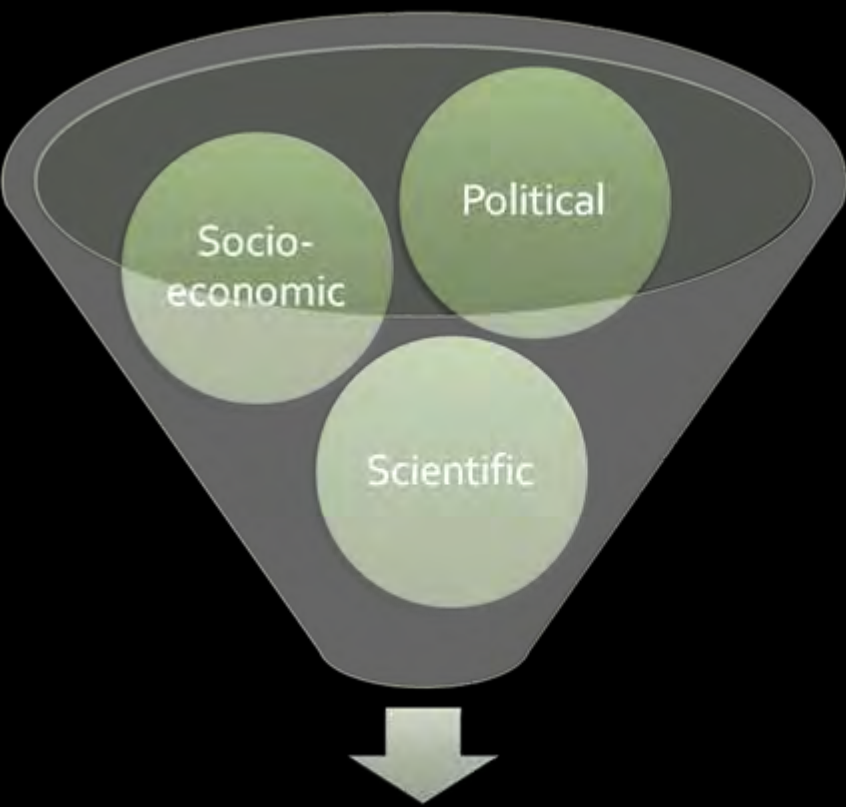


I only want ONE  
indicator for food  
webs!



But you need 700





# Effective Indicators

