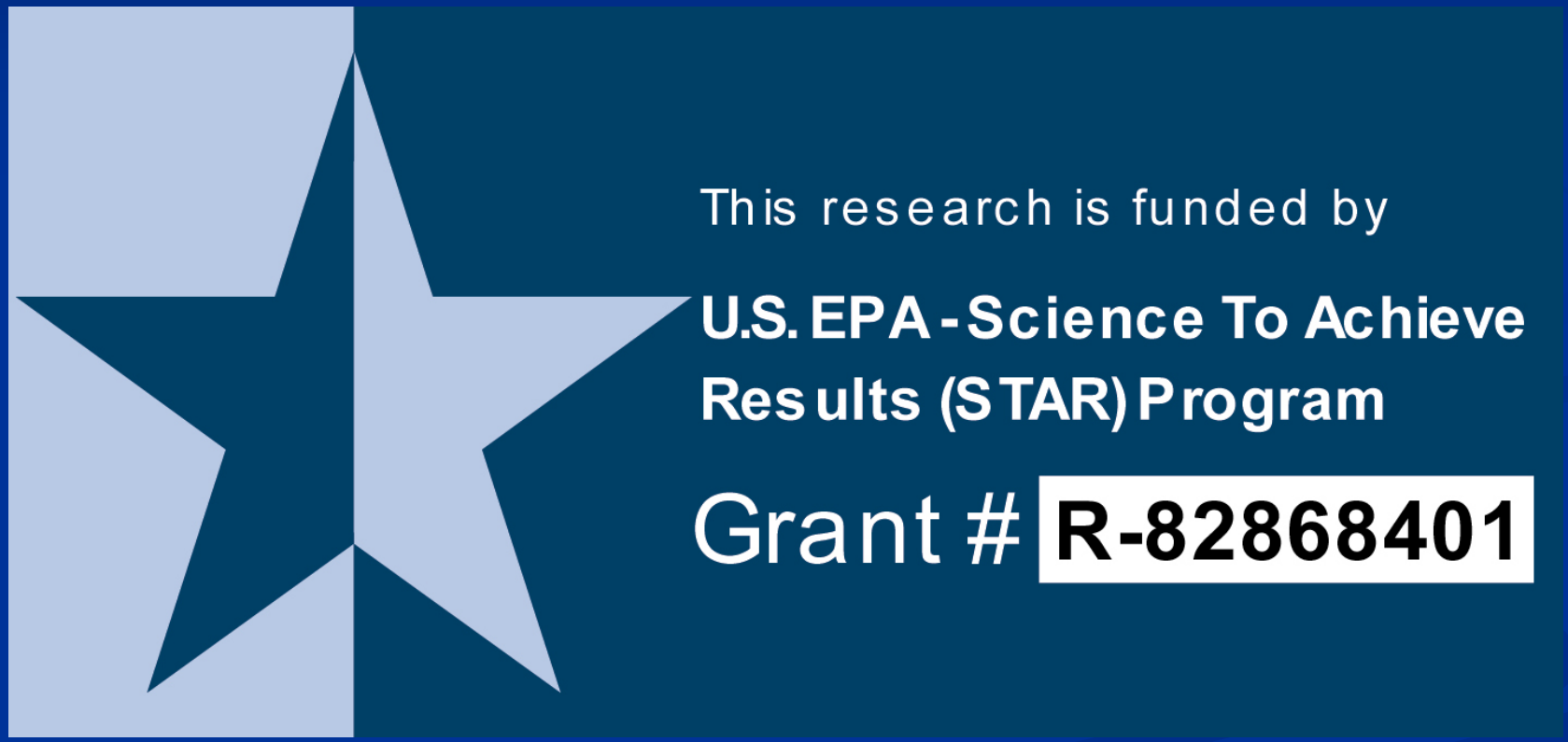
Indicator Development in the ASC Project Report to APNEP Science and Technical Advisory Committee

2 February 2005

D.H. Wardrop, Project Manager, on behalf of the ASC Team

Funding Source and Acknowledgements



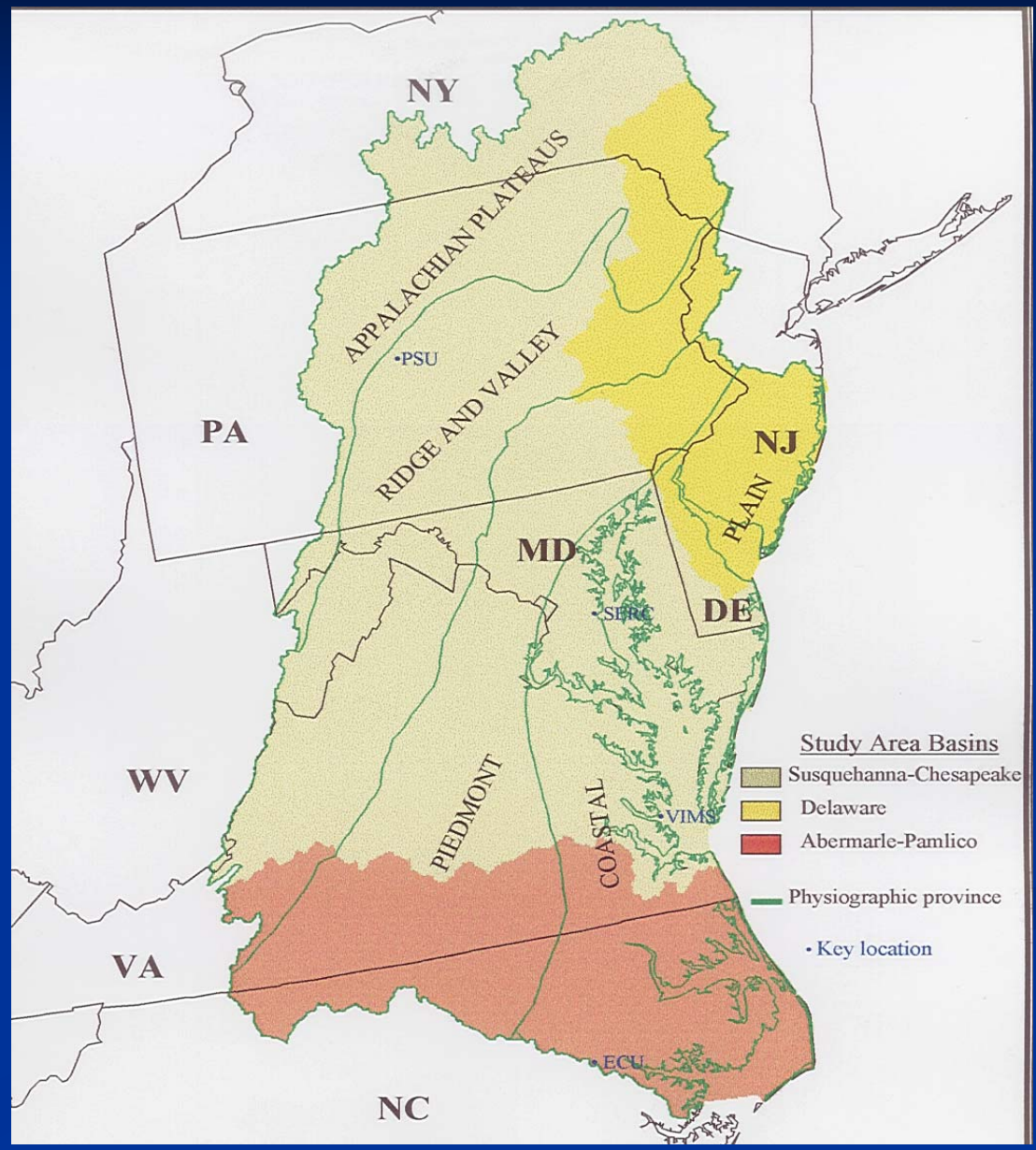
STAR Grants and Cooperative Agreements administered by Barbara Levinson

Four stories

- What's wrong with indicators?
- What happened on the way to develop new ones (the ASC story)?
- A taxonomy of indicators
- Analysis of the CBP indicators

Atlantic Slope Project

- Penn State University
- Smithsonian Environmental Research Center
- Virginia Institute of Marine Science
- East Carolina University
- Environmental Law Institute
- FTN Associates



What's the question?

- How do we develop a useful, relevant, and defensible set of indicators for the Atlantic Slope?
  - We know how to do "defensible"
  - This story is all about combining defensible ecology with "relevant" and "useful" in the Atlantic Slope

The Basic Questions

- How big is the problem?
- Is it getting better or worse?
- What's causing it?
- What can be done?
- Is management making a difference?
- How do I communicate any of the above to the public?

Why aren't we there?

- Lack of reliable, technically appropriate indicators
- Not effective at relevant spatial/temporal scale for management decisions
- Necessary to compare results of monitoring to a relevant and sustainable standard/benchmark

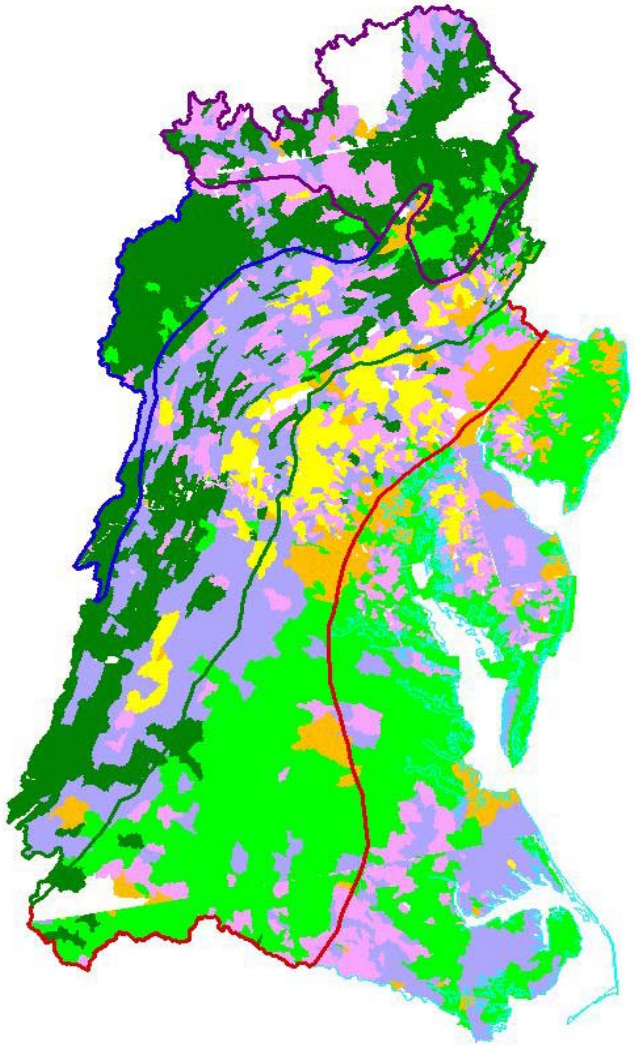
Where did the ASC have to start?

- Humans are part of, not apart from, ecological systems.
- Individuals and institutions make choices concerning the use of private and public property. These individually determined choices are reflected in land use.
- In a given community or area, these individual land use choices result in a collective pattern of land use on the landscape. This collective pattern of land use is termed social choice.
- When the desired condition of a common aquatic resource is affected by social choices, a conflict results.

Atlantic Slope Consortium
Vision Statement

ASC uses a universe of watersheds/estuarine segments, covering a range of social choices (i.e., land uses) and asks two questions:

- ✓ How “good” can the environment be, given those social choices?
- ✓ What is the intellectual model of condition within those choices, i.e., what are the causes of condition and what are the steps for improvement?



ASC Watershed Clusters

Legend

Clusters

- 1 - Forest/High Slope
- 2 - Urban
- 3 - Mixed /Low Nodal Var.
- 4 - Forest/Low Slope
- 5 - Agriculture
- 6 - Mixed /High Nodal Var.

Physiographic Province

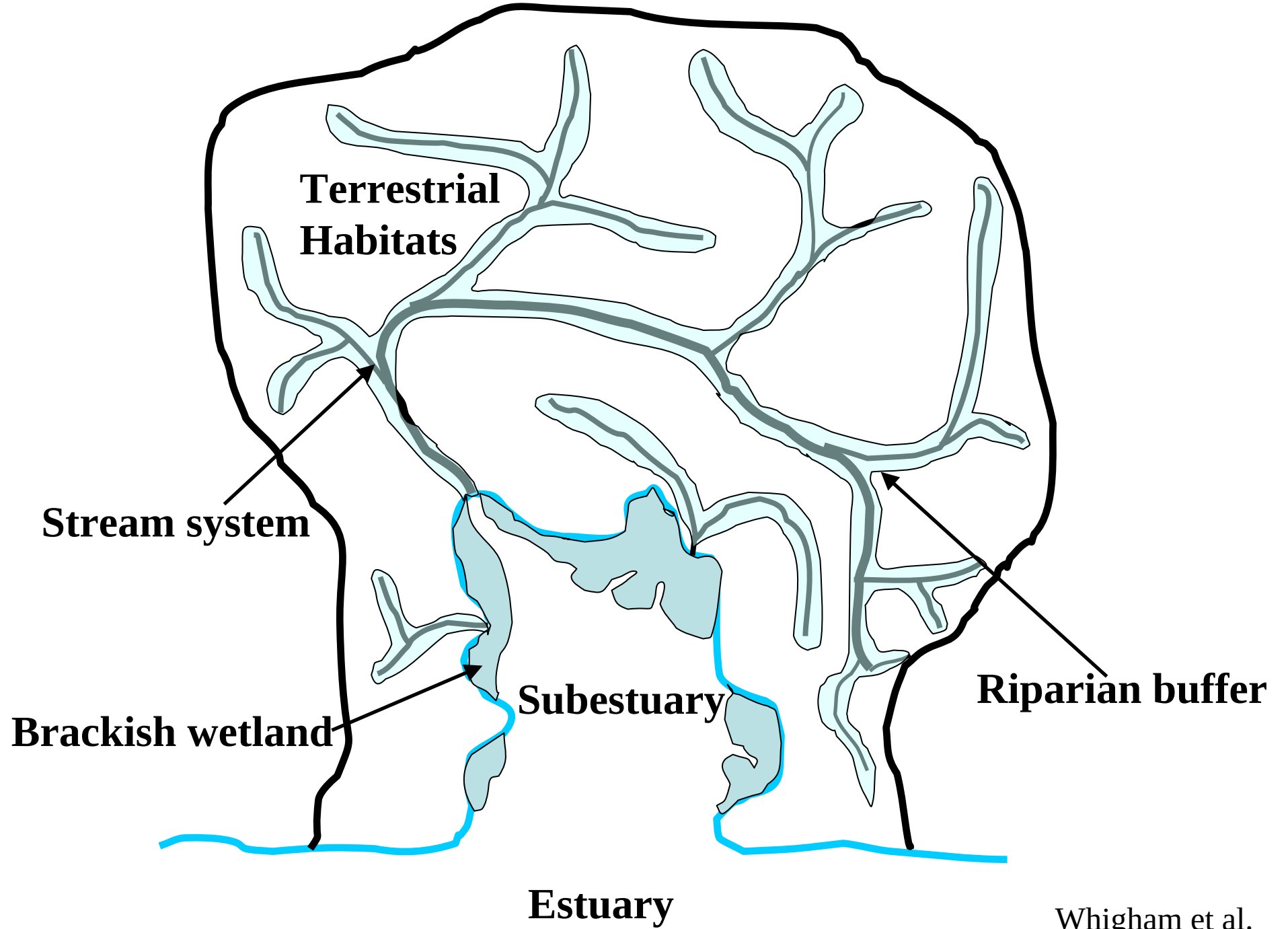
- COASTAL PLAIN
- PIEDMONT
- PLATEAU - GLACIAL
- PLATEAU - NON-GLACIAL
- RIDGE & VALLEY

60 0 60 120 Miles

N

ASC General Messages
(30 second version)

- Environmental indicators can be used to demonstrate the conflict between the cumulative impact of independent social choices on designated societal uses for aquatic ecosystems.
- New methods, analytical techniques, and indicators have demonstrated landscape patterns can be linked to the condition of aquatic resources, from headwater streams to estuaries.
- While there is no “best” landscape pattern to attain social and societal choices within watersheds, there are landscape patterns associated with non-attainment of societal choices for aquatic ecosystems.
- Efficient use of social, environmental and economic capital is not being attained in most Mid-Atlantic watersheds.

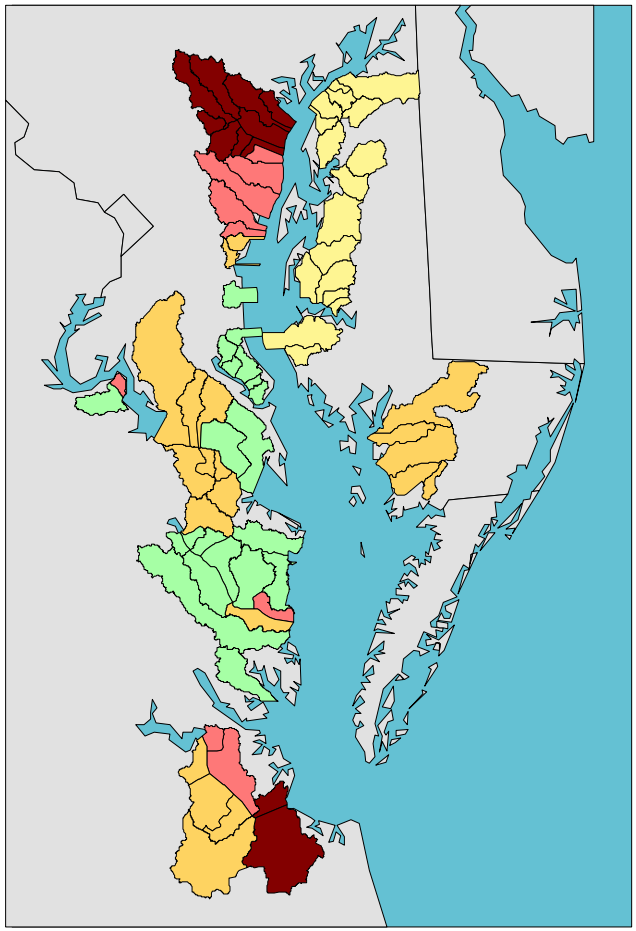


Whigham et al.

Message 1 - Concepts and Taxonomy

- Aquatic resources include wetland, streams, river, lakes and estuaries; and
- these aquatic resources are recognized as a common public resource available to all; and
- humans are part of, not apart from, ecological systems.
- Given this, some questions need to be answered:
  - Do ecological measures we make accurately describe condition?
  - Is there utility in those measures as indicators for managers?
  - Do perceptions of citizens agree with these scientific assessments?
  - Can we communicate condition to the public using versions of those indicators?

What types of estuarine segments will be selected and where will they occur?

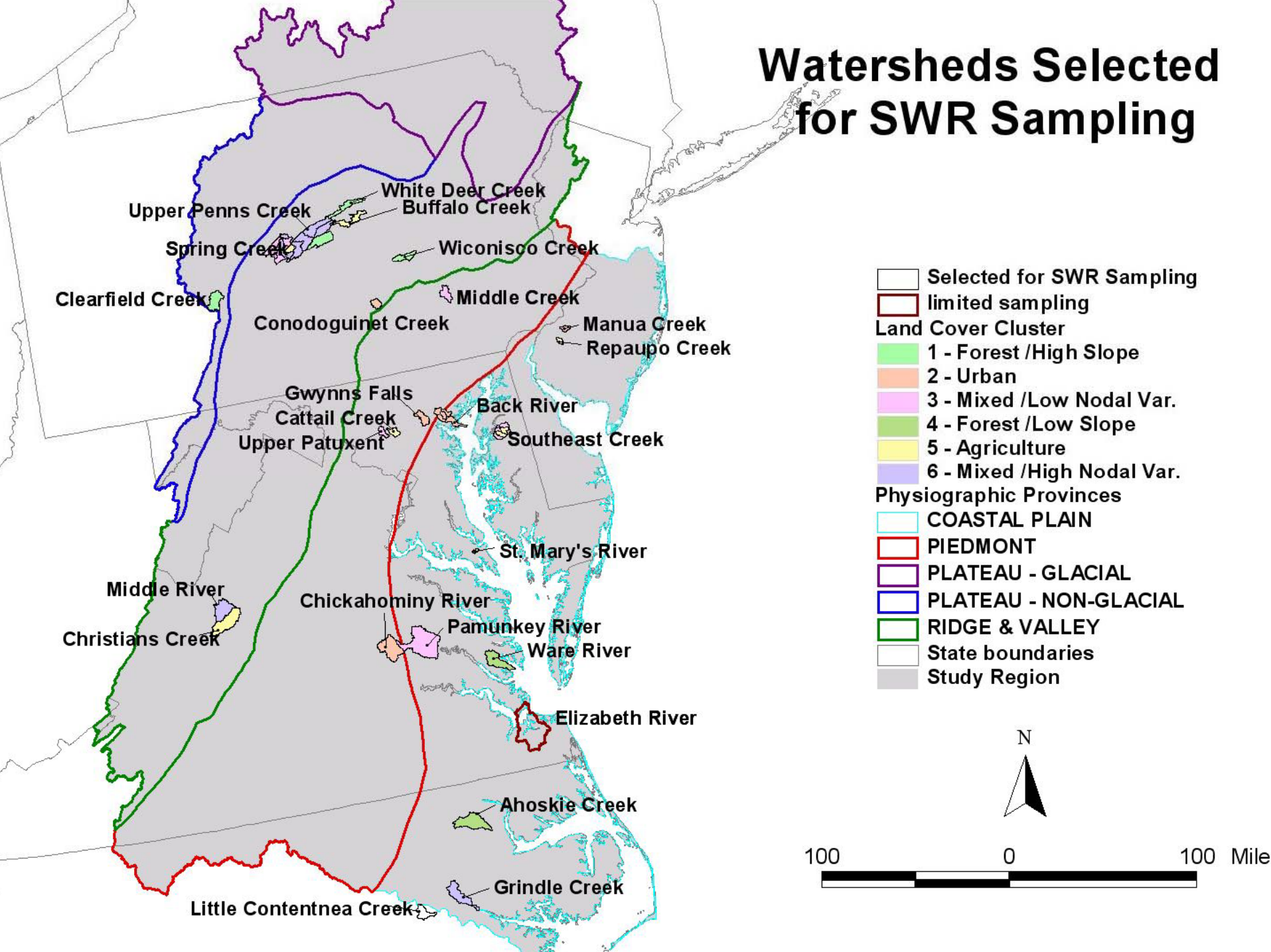


- Forested (> 65 % Forest)
- Agriculture (> 50 % Agriculture)
- Urban / Suburban (> 50 % Urban / Suburban)
- Mixed-Agriculture (20 - 50 % Agriculture)
- Mixed-Urban / Suburban (20 - 50 % Urban / Suburban)

Message 2 - Estuarine Systems

- Land use (particularly urban/suburban systems) affects the attainment of estuarine condition (i.e., designated uses).
- Measures of nutrients, fishes, crabs, birds, and shorelines can be translated into management indicators and communicated to the public.
- Example:

  Fish Community Index (a set of scientific measures) can be communicated as to citizens by providing information about fish species related to food and recreation


Watersheds Selected for SWR Sampling
White Deer Creek
Upper Penns Creek
Buffalo Creek
Spring Creek
Wiconisco Creek
Clearfield Creek
Middle Creek
Conodoguinet Creek
Manua Creek
Repaupo Creek
Gwynns Falls
Cattail Creek
Upper Patuxent
Back River
Southeast Creek
St. Mary's River
Middle River
Chickahominy River
Christians Creek
Pamunkey River
Ware River
Elizabeth River
Ahoskie Creek
Grindle Creek
Little Contentnea Creek
Selected for SWR Sampling
limited sampling
Land Cover Cluster
1 - Forest /High Slope
2 - Urban
3 - Mixed /Low Nodal Var.
4 - Forest /Low Slope
5 - Agriculture
6 - Mixed /High Nodal Var.
Physiographic Provinces
COASTAL PLAIN
PIEDMONT
PLATEAU - GLACIAL
PLATEAU - NON-GLACIAL
RIDGE & VALLEY
State boundaries
Study Region
N
100
0
100 Mile

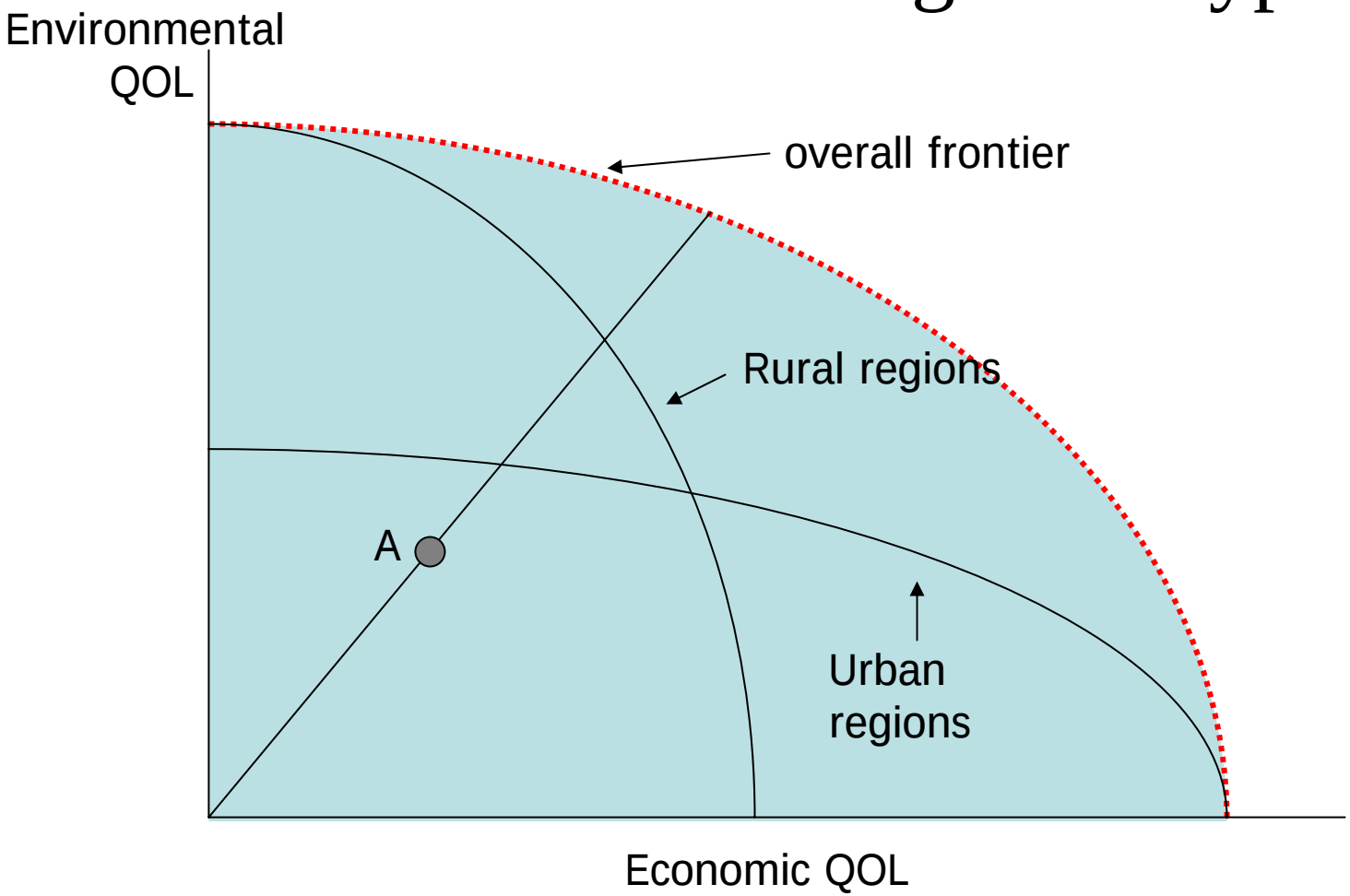
Message 3 - Freshwater Systems

- Land use (particularly agricultural systems) affects the attainment of stream and wetland condition (i.e., designated uses).
- Both amount and spatial arrangement of land uses can affect stream macroinvertebrates and watershed nutrient discharges.
- A Rapid Assessment Protocol was developed and implemented for streams, wetlands, and riparian areas (SWR) on 24 small watersheds.

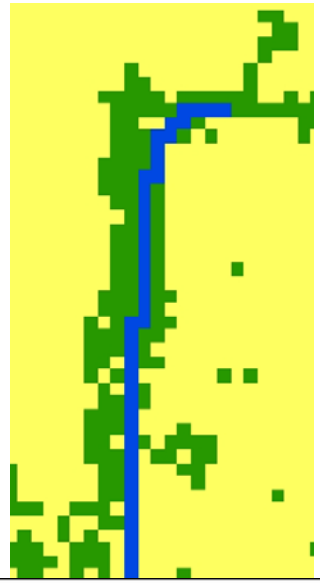
Message 4 - Human Dimensions

- Community efficiency can be assessed by combining ecological indicators with socio-economic indicators.
- There are institutional obstacles at all levels of government that affect the use of indicators.
- Surveys:
  - Suites of indicators are useful to environmental managers
  - A relatively small set of indicators are useful for communicating to the public

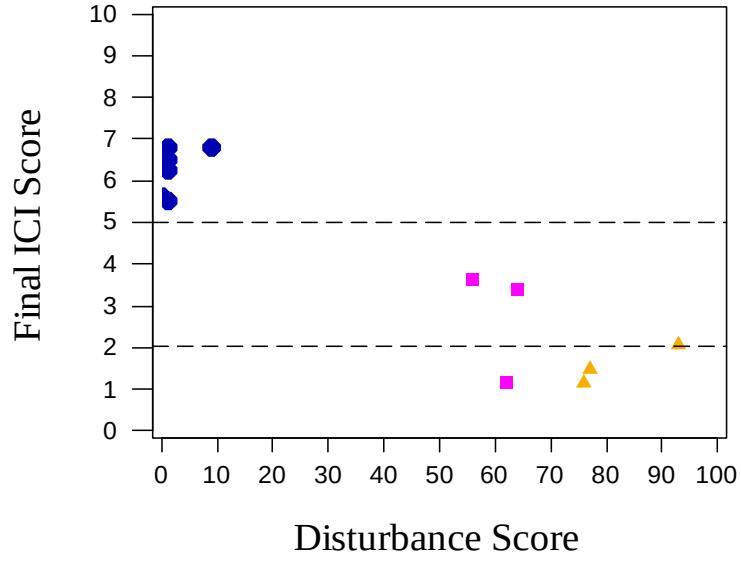
Difference in Regional Type

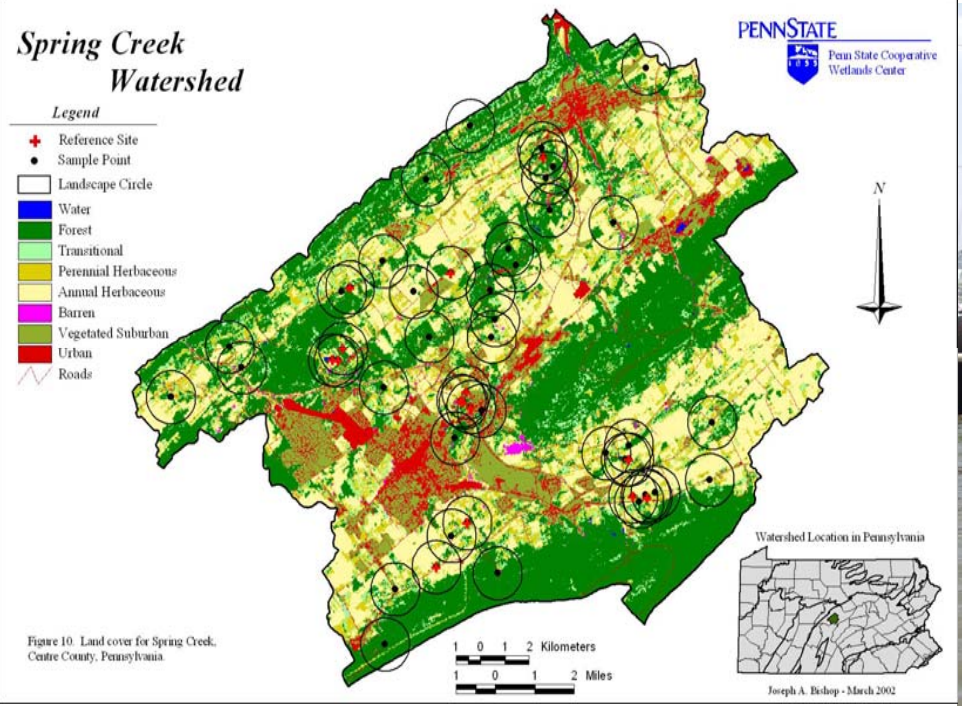


Riparian Metrics



IBIs





Developing and Communicating a Taxonomy of Indicators: An ASC Case Study

Wardrop, D.H.[1], C. Herschner[2], K. Thornton[3], K. Havens[2], D. Bilkovic[2], and M. Baker[4]

Why do we need a framework?

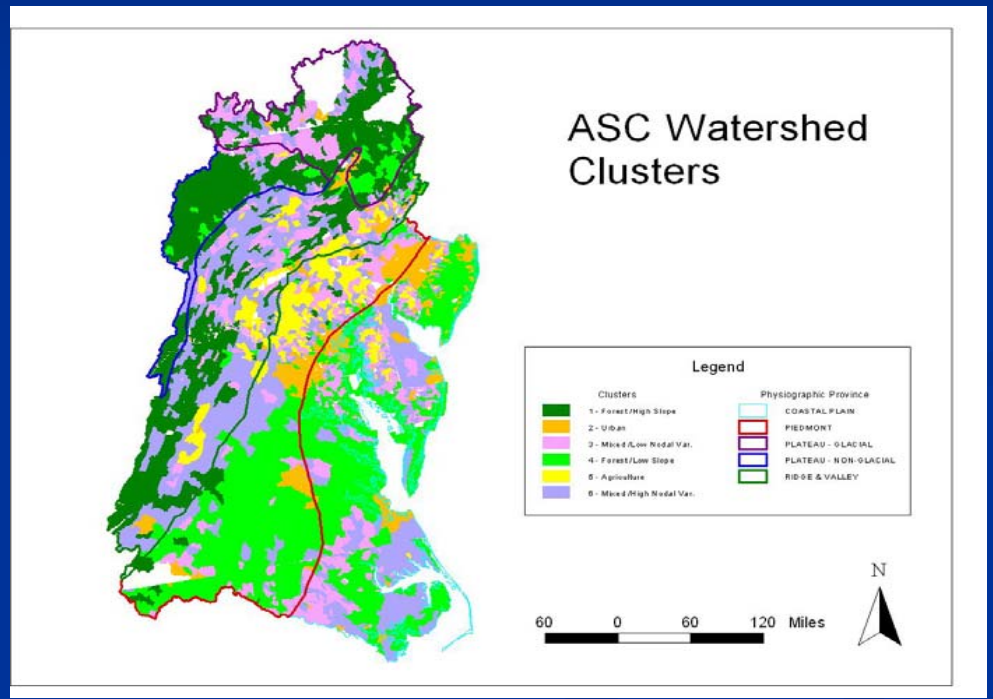
Why do we need a framework?

- If the indicators developed during the EaGLes projects are to be integrated into environmental decision-making, it is imperative to provide a comprehensive framework for indicator selection and use. The same framework would also be used to evaluate the utility of any given indicator.

- Environmental managers need a roadmap; project scientists need an organizing framework to identify gaps

The framework should follow our logic of indicator development

- Humans are a part of ecological systems
- Individual choices are represented by land use
- Collective land cover patterns emerge; we term them “social choice”



The framework should follow our logic of indicator development

- Within each social choice, managers are faced with answering one (or more) of the following:
  - How big is the problem?
  - Is it getting better or worse?
  - What's causing it?
  - What can be done?
  - Is management making a difference?
  - How do I communicate any of the above to the public?

Condition Assessment/State

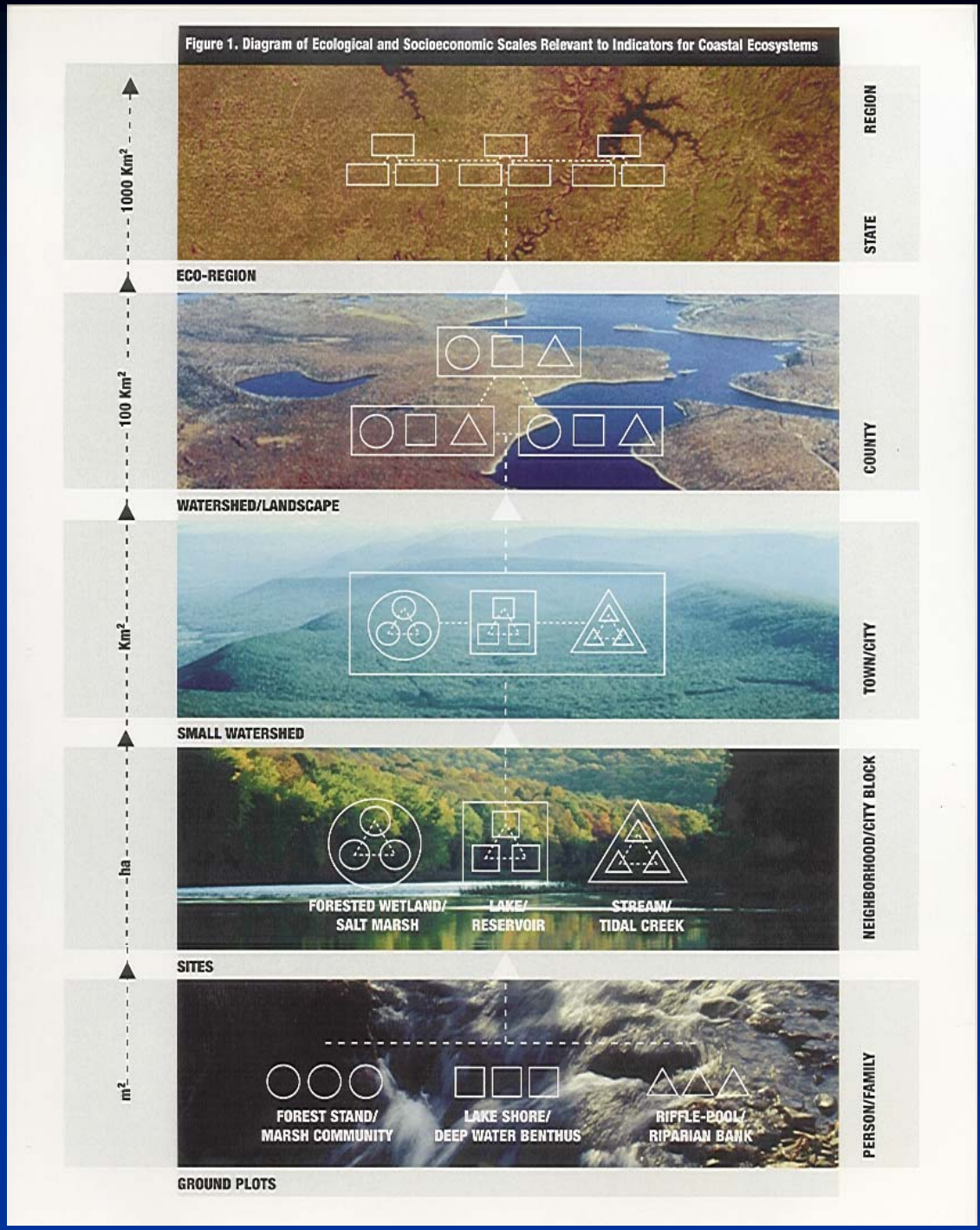
Diagnose Stressors/Pressure

Futures Forecast/Restore

Evaluate Performance

Communication w/ Public

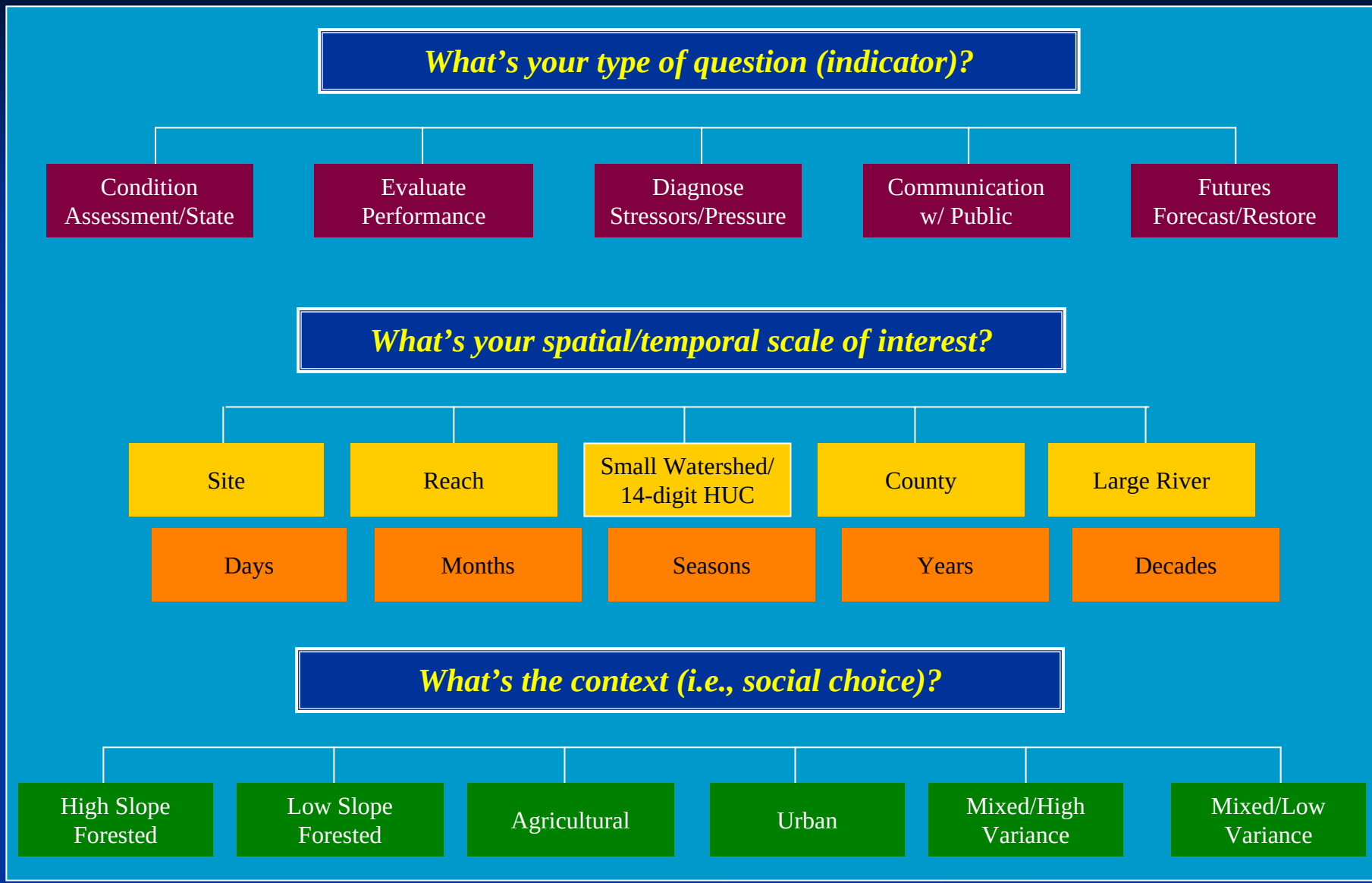
Spatial/Temporal Scales



Human Scales

Any framework must therefore be based upon three primary elements:

- The type of question being asked (how big, better or worse, etc.)
- The relevant spatial/temporal scale at which the question is asked
- The context (i.e., social choice) of the question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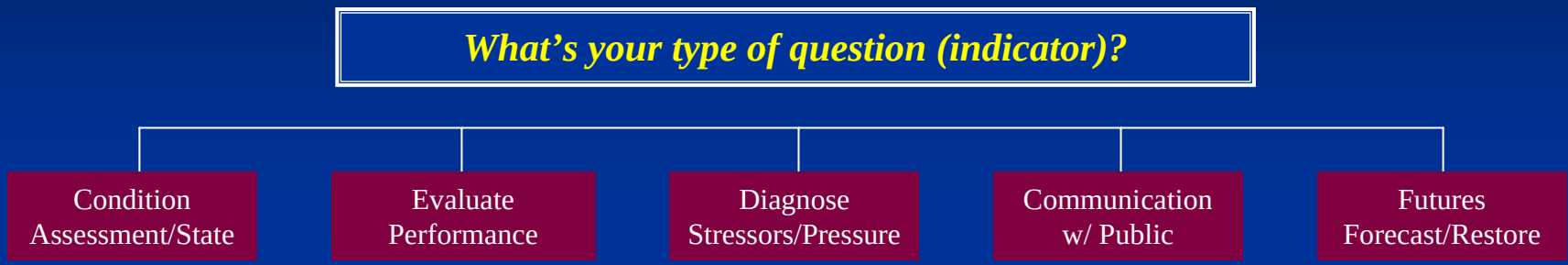
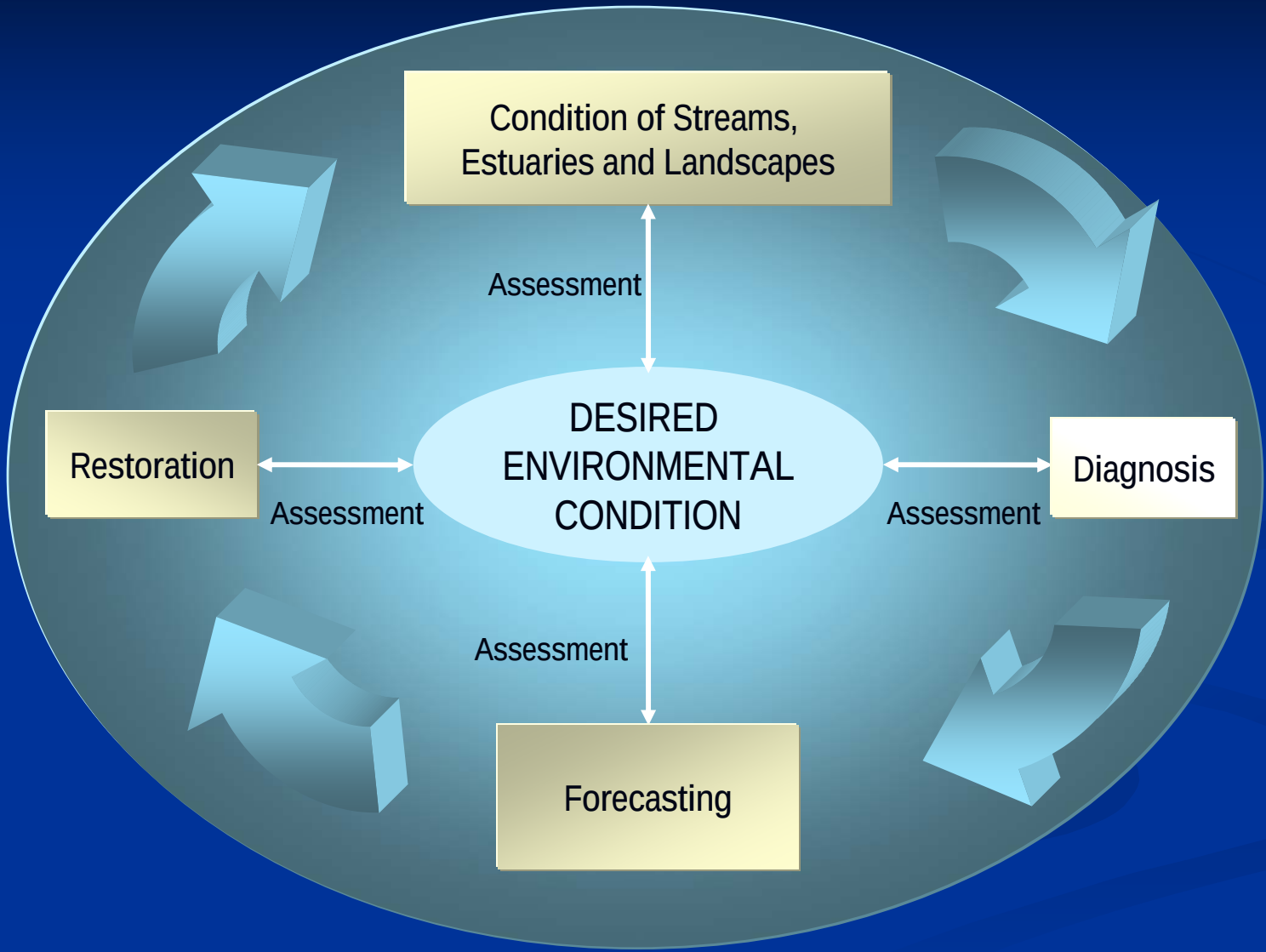
Diagnose Stressors/Pressure
Communication w/ Public
Futures Forecast/Restore
What's your spatial/temporal scale of interest?
Site
Reach
Small Watershed/ 14-digit HUC
County
Large River
Days
Months
Seasons
Years
Decades
What's the context (i.e., social choice)?
High Slope Forested
Low Slope Forested
Agricultural
Urban
Mixed/High Variance
Mixed/Low Variance

Why is the question important?

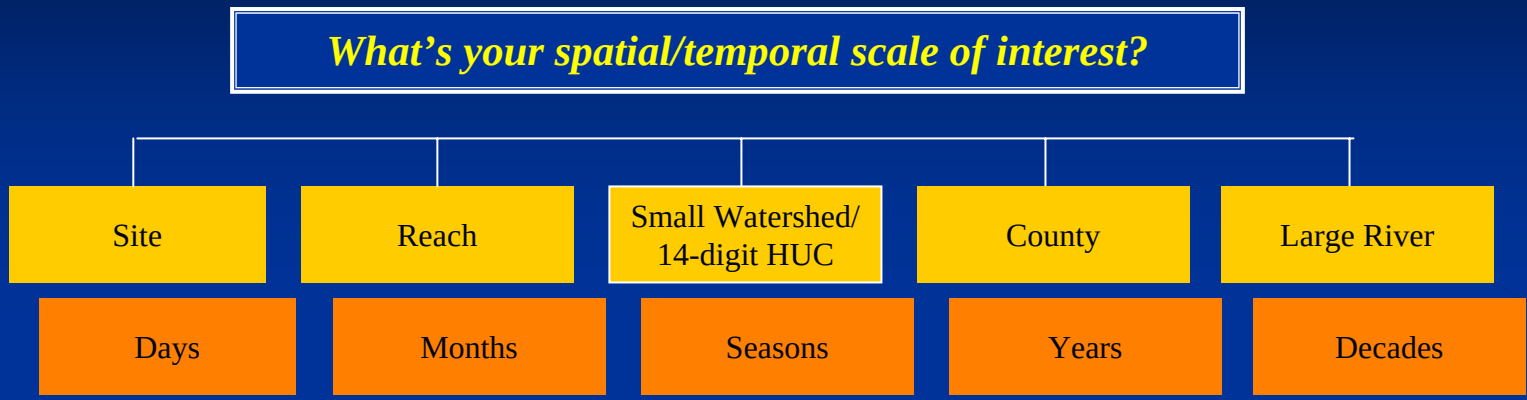


- Indicator types are congruent with the types of environmental questions being asked
- Specific indicators may be used to answer more than one type of question (indicators may be of multiple types)
- EPA's goal*: To provide the scientific understanding to measure, model, maintain, and/or restore, at multiple scales, the integrity and sustainability of highly valued ecosystems now and in the future*

FRAMEWORK FOR ECOLOGICAL RESEARCH AT EPA

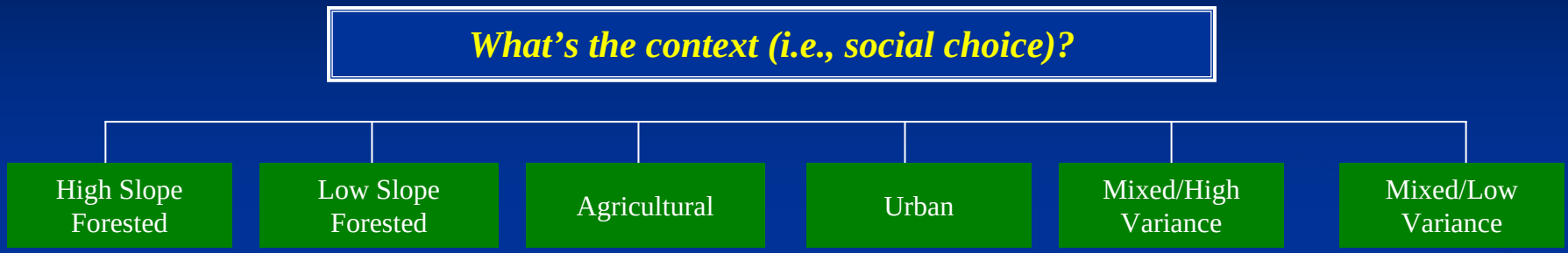


Why is scale important?



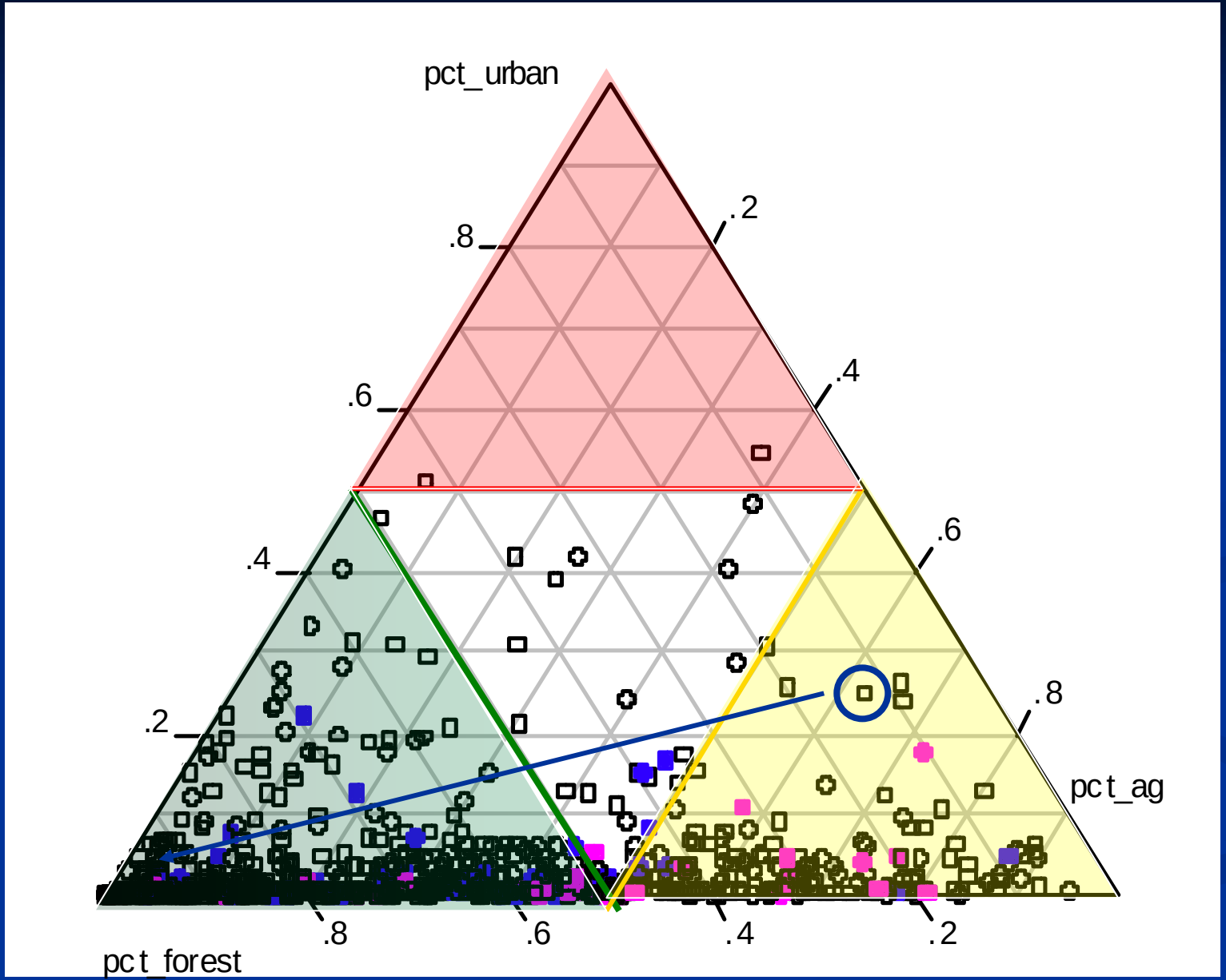
- Indicators are developed at a very specific spatial and/or temporal scale, and may not be defensible at other scales
- Scale of management actions needs to be matched to the scale of the pattern or process being measured
- EPA's goal*: To provide the scientific understanding to measure, model, maintain, and/or restore, at multiple scales, the integrity and sustainability of highly valued ecosystems now and in the future*

Why is context important?

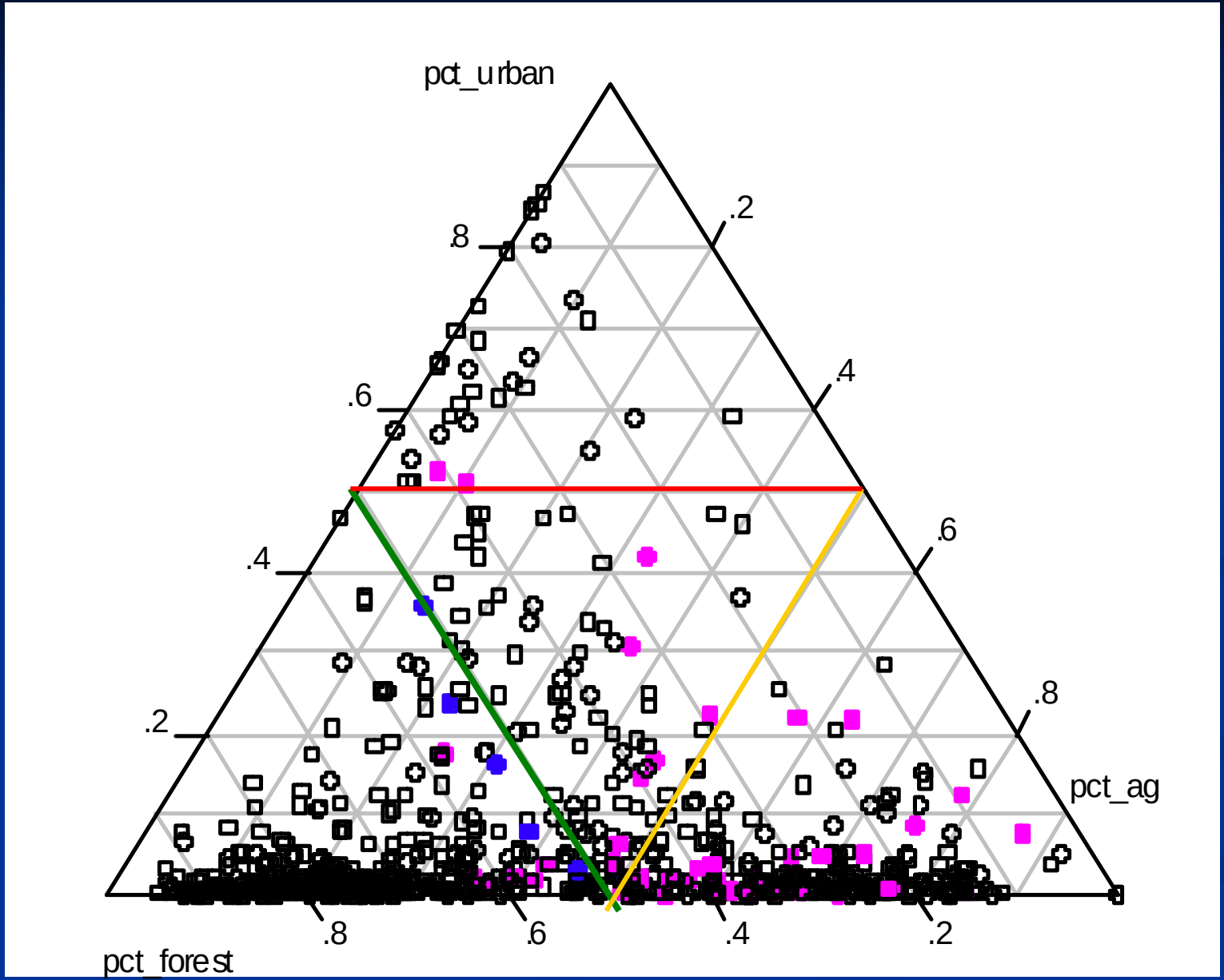


- There are both multiple ecological states and multiple reference conditions that satisfy various social choice categories
- Context determines the sustainability and feasibility of any restoration or management action
- EPA's goal*: To provide the scientific understanding to measure, model, maintain, and/or restore, at multiple scales, the integrity and sustainability of highly valued ecosystems now and in the future*

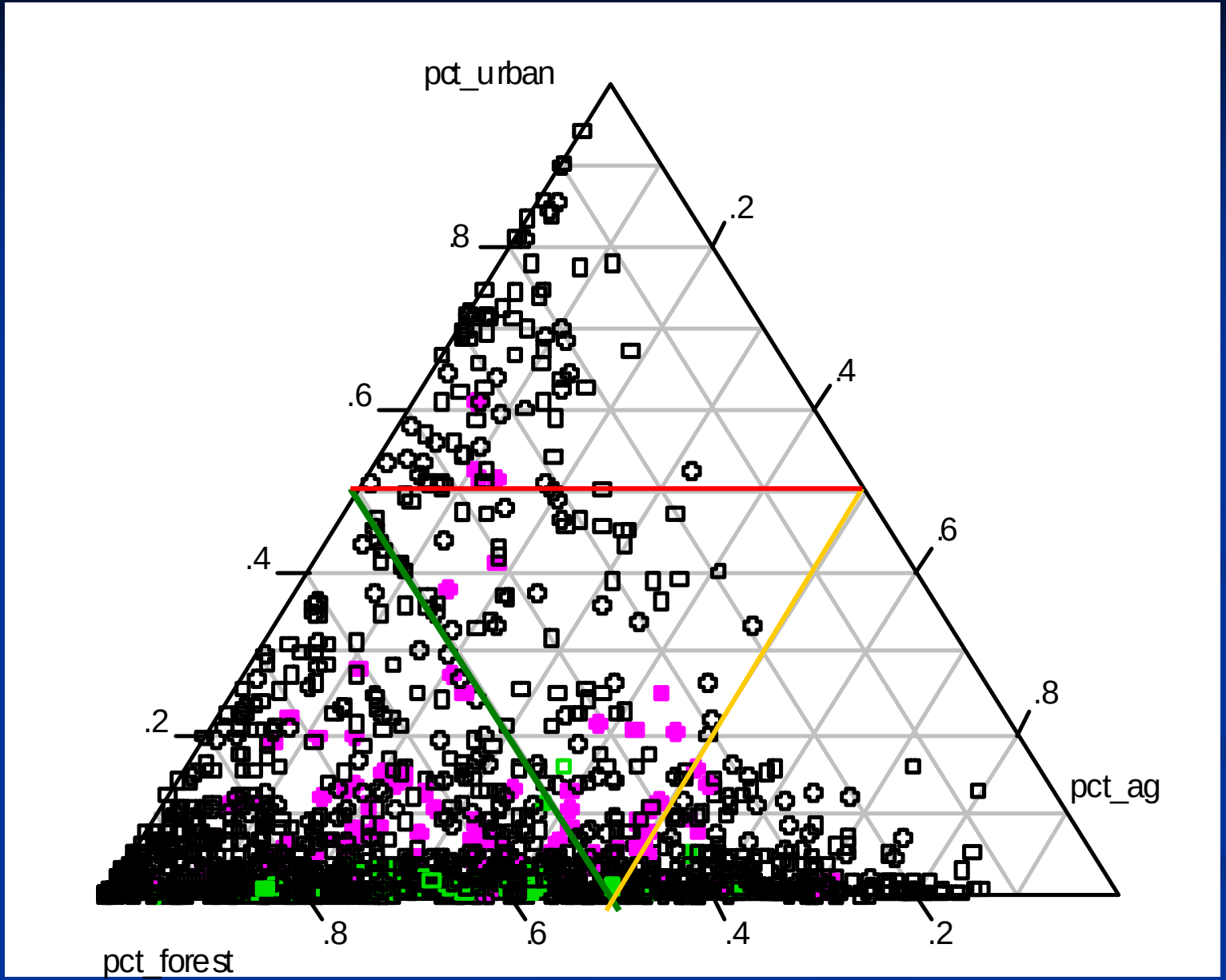
Ridge and Valley Watersheds



Piedmont Watersheds



Coastal Plain Watersheds



Using the Framework

- The framework can be used to either:
  - Select either an individual or a set of indicators
  - Describe the utility of any given indicator
- Examples
  - Fish Index of Biotic Integrity (IBI) for use in mid-Atlantic estuaries
  - Distance-weighted land use in mid-Atlantic watersheds

What's the management issue?

- Fisheries are declining across the mid-Atlantic. Questions are:
  - What's the current condition of fisheries in the mid-Atlantic?
  - What are the stressors?
  - What are feasible management activities?

Fish Community Index (FCI)

Fish Community Metrics	Reference
Species Richness/Diversity Measures	
Species Richness	this paper
Proportion of benthic-associated species	Deegan et al. 1997
Number of dominant species (90% of total abundance)	Deegan et al. 1997
Number of resident species	Deegan et al. 1997
Fish Abundance	
Ln Abundance	Deegan et al. 1997
Trophic Composition	
Trophic Index	Jordan and Vaas 2000
Nursery Function	
Number of estuarine spawning species	Deegan et al. 1997
Number of estuarine nursery species	Deegan et al. 1997

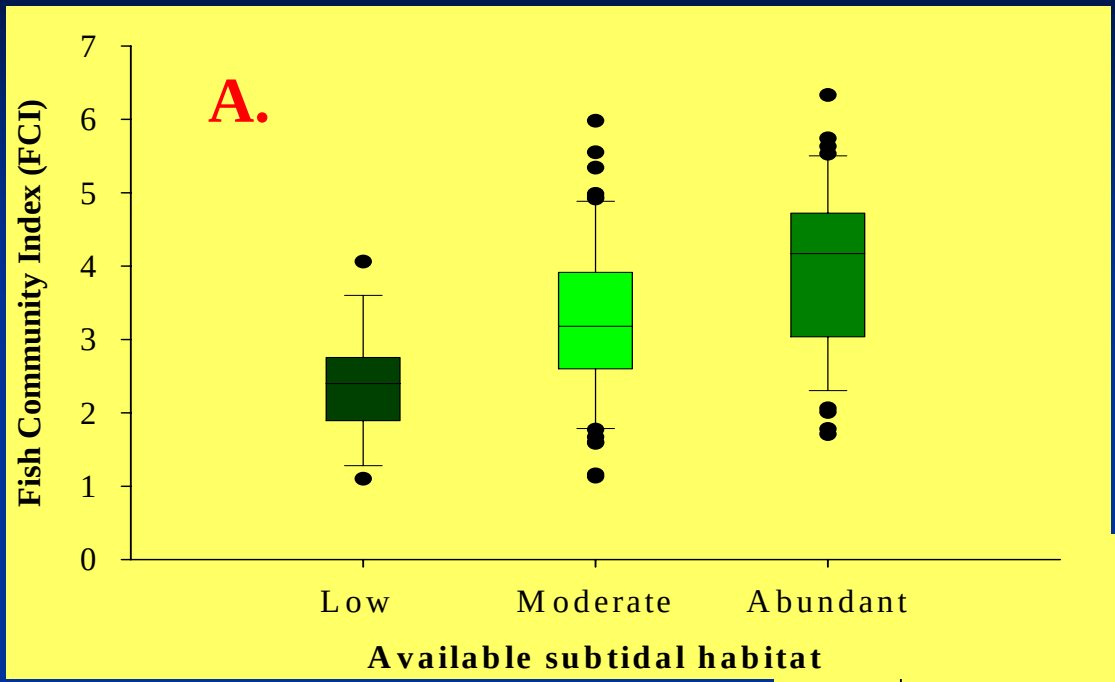
With the developed Fish Community Index, it is possible to explore the relationship between the biota and habitat condition (diagnostic)

Do Fish Respond to Variations in Riparian Condition?

At Each Site, We Assessed

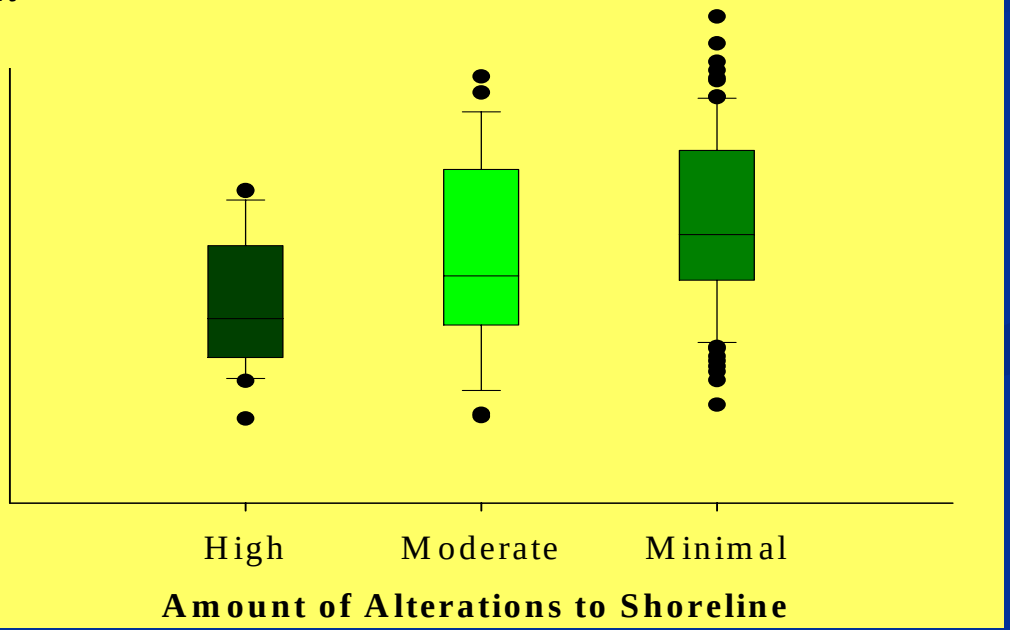
- Shoreline Land Use
- Shoreline Structures
- Subtidal habitat
- Fish and Macrobenthic Communities

Diagnostic Indicators

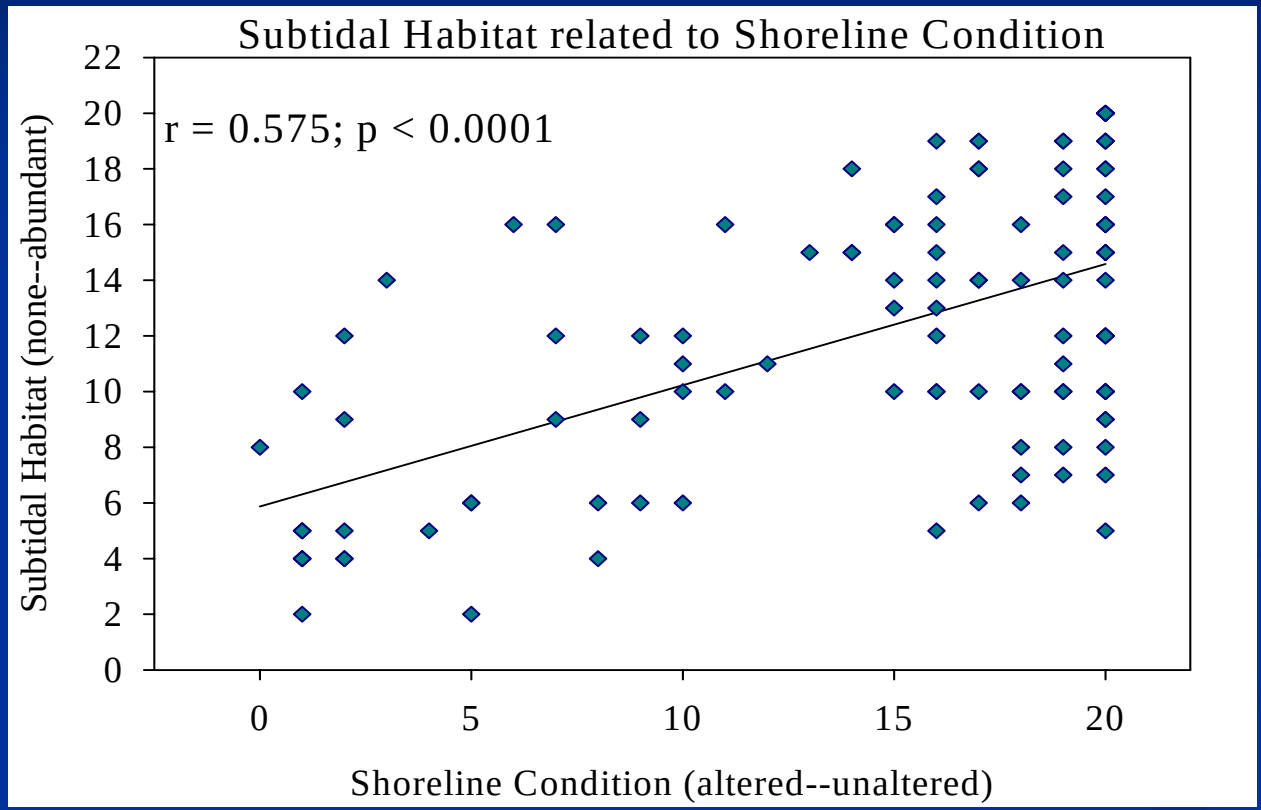


A) FCI scores were significantly different among all subtidal habitat conditions (minimal, moderate and abundant habitat).

B) Highly altered shoreline had lower associated FCI values in relation to moderately or minimally altered shoreline



Restoration



- As shoreline condition increased, the amount of available subtidal habitat increased (includes: woody debris, SAV, shell)

What's your type of question (indicator)?

- Condition Assessment/State
- Evaluate Performance
- Diagnose Stressors/Pressure
- Communication w/ Public
- Futures Forecast/Restore

What's your spatial/temporal scale of interest?

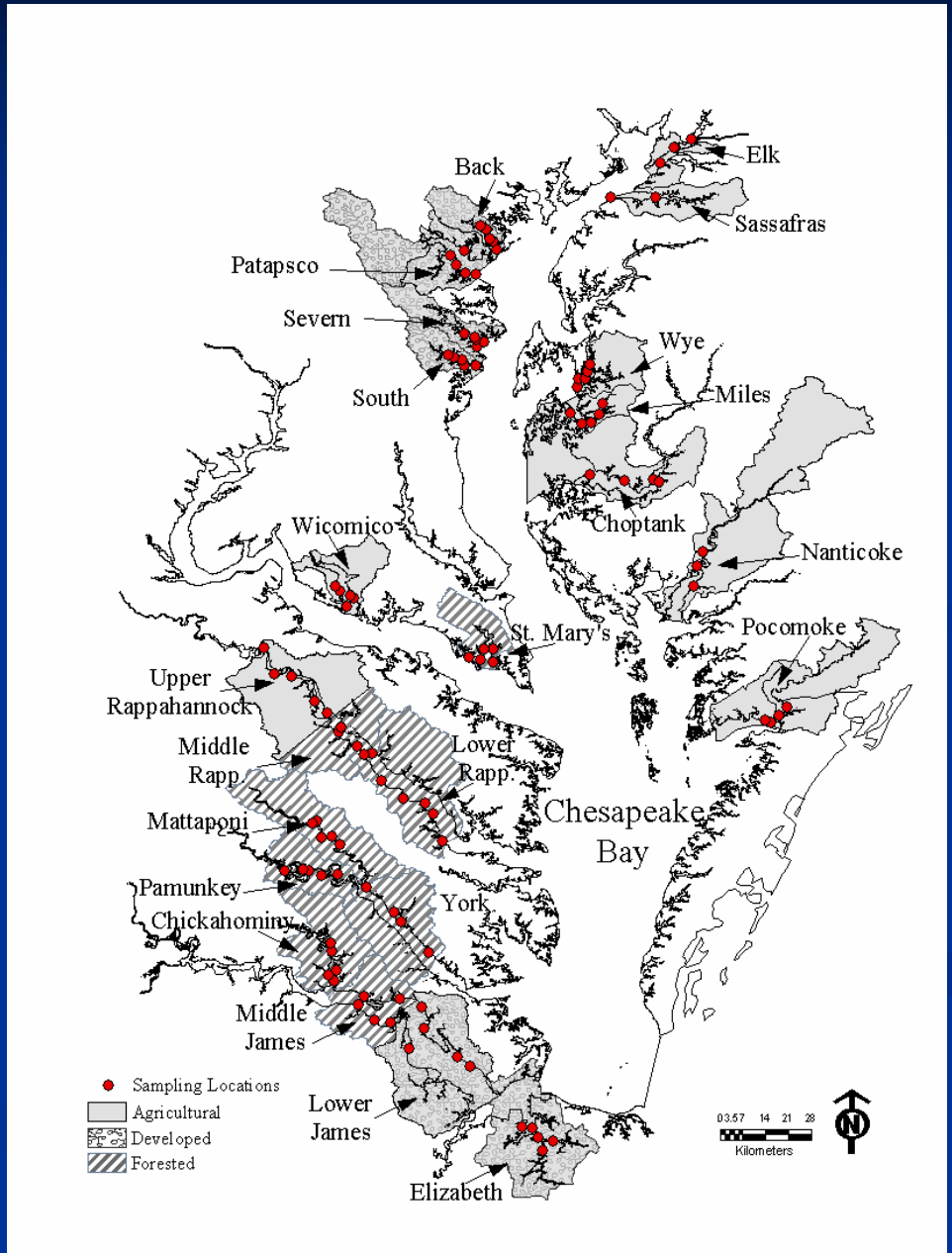
Site	Reach	Small Watershed/ 14-digit HUC	County	Large River
Days	Months	Seasons	Years	Decades

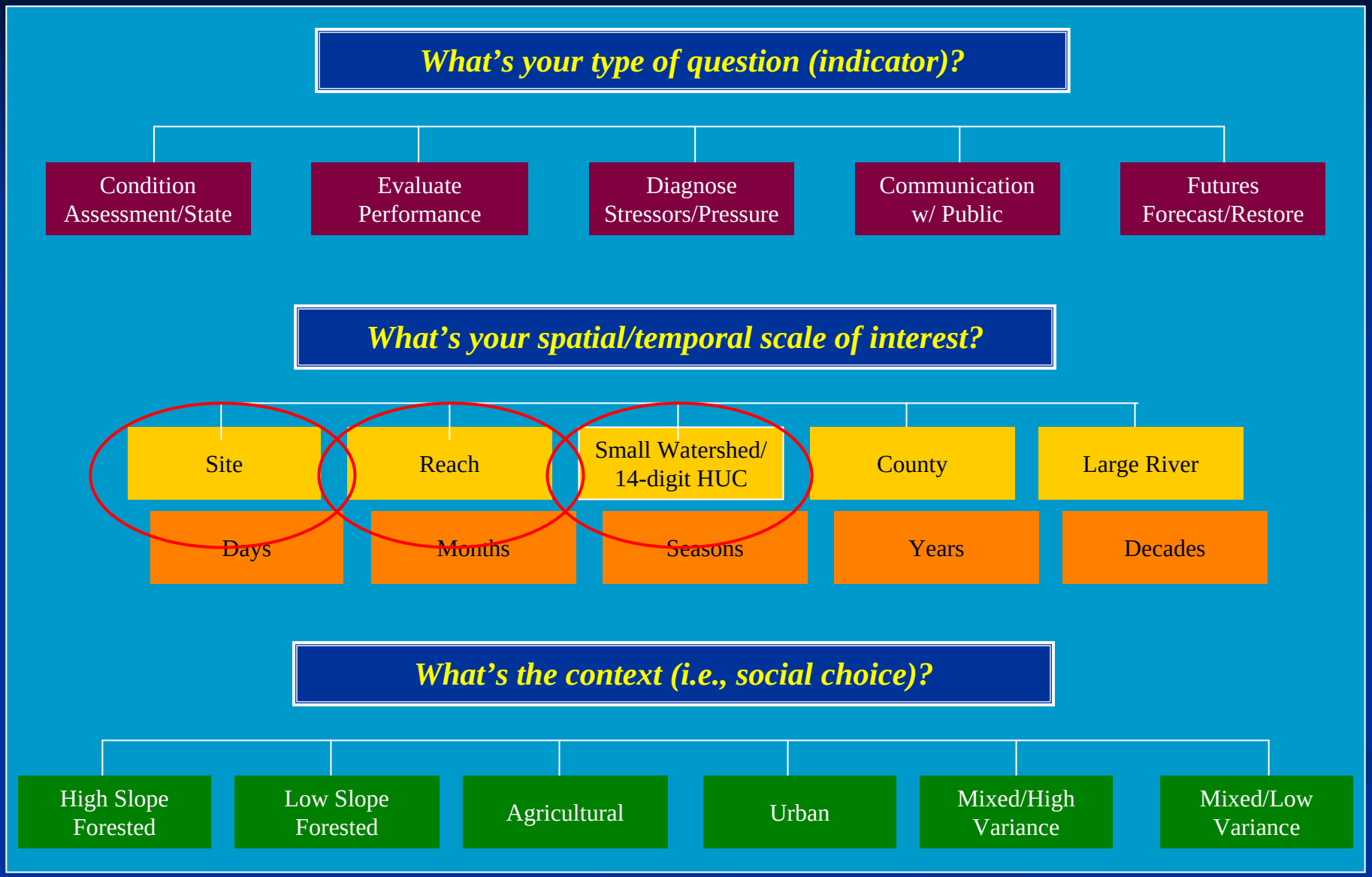
What's the context (i.e., social choice)?

- High Slope Forested
- Low Slope Forested
- Agricultural
- Urban
- Mixed/High Variance
- Mixed/Low Variance

Spatial scale

- Twenty-five watersheds (14-digit HUCs), each placed into categories of developed, agricultural, or forested land cover, based on principle land use percentages over the entire watershed

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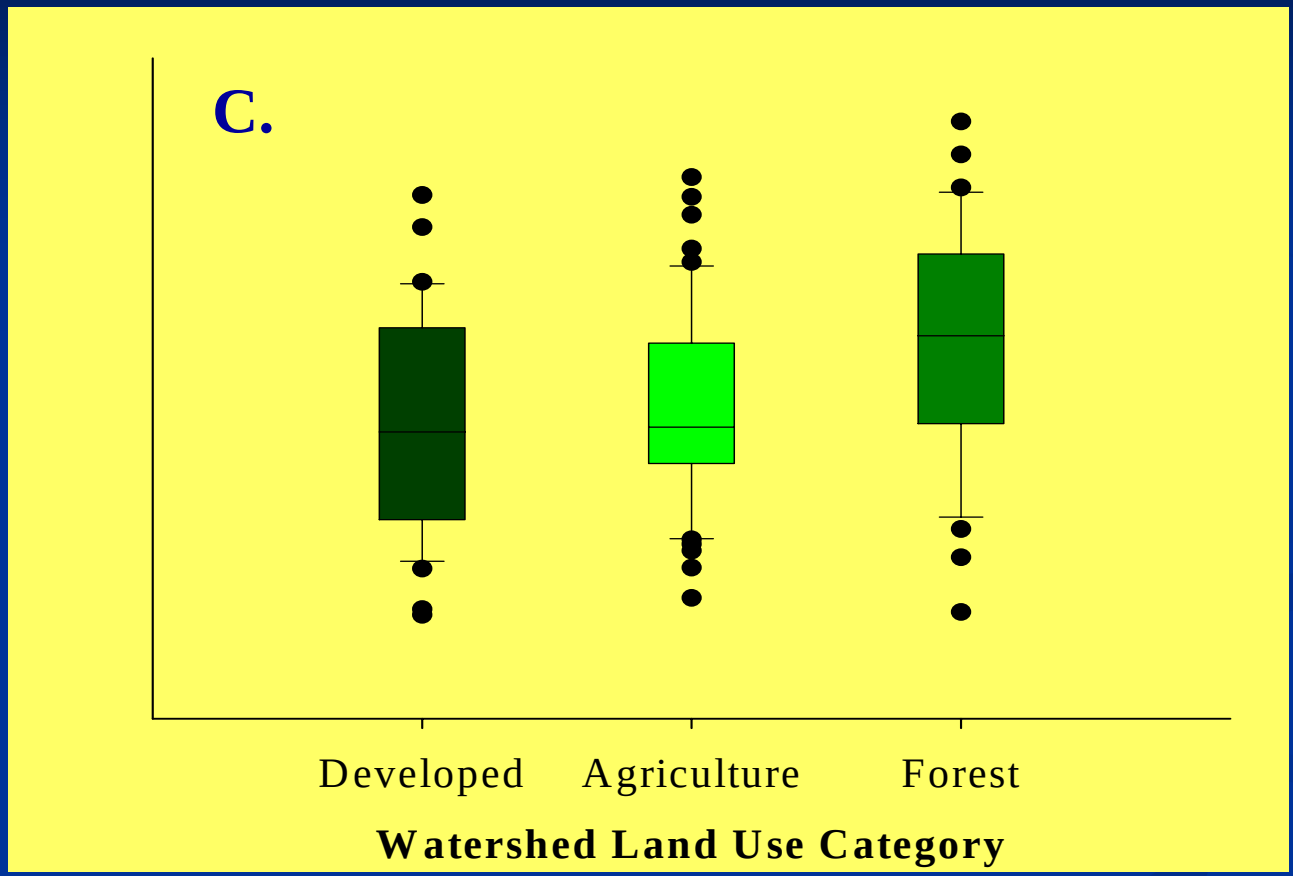
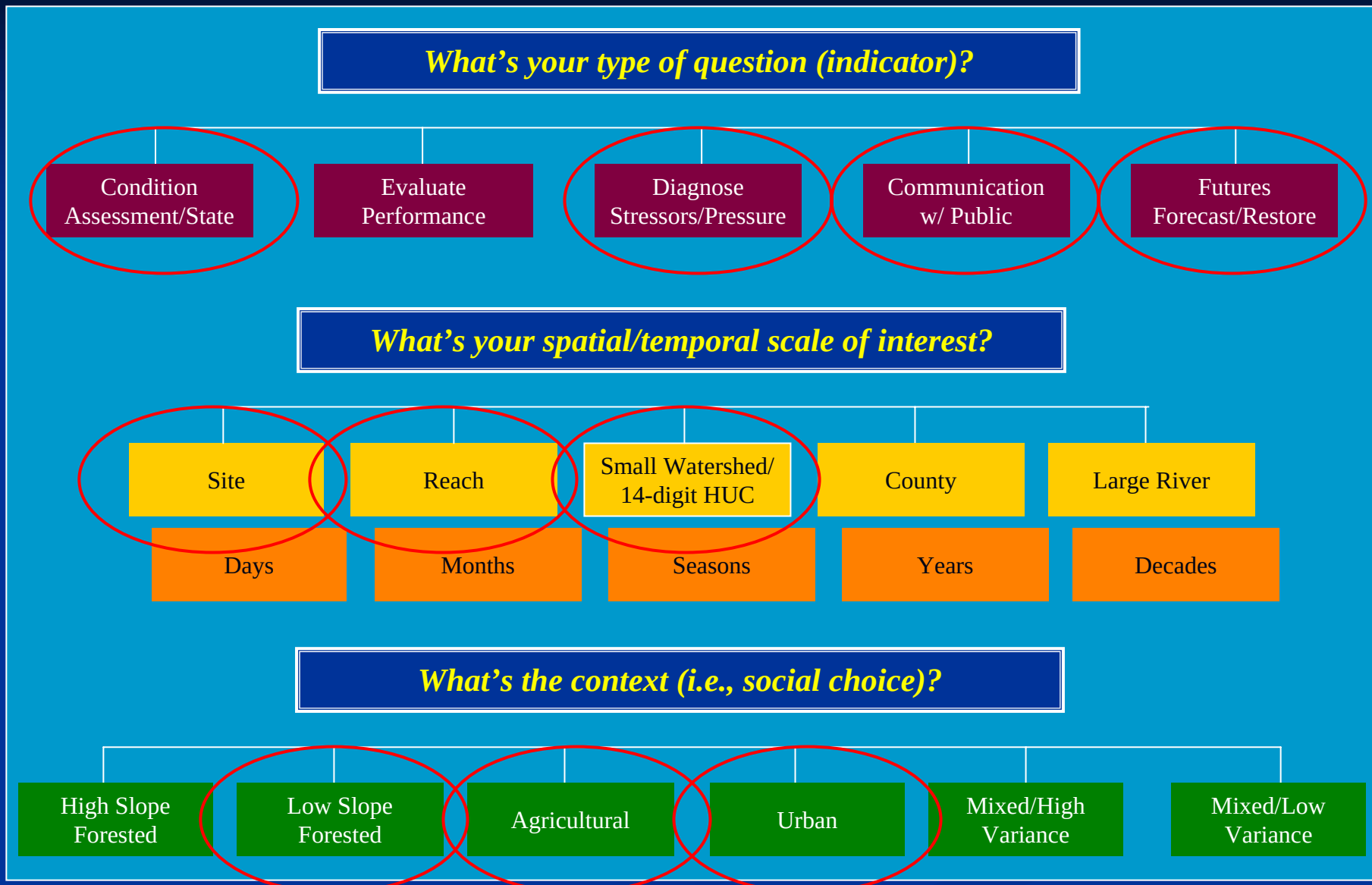
What's the context?



Developed and Agricultural watersheds had lower FCI values compared to Forested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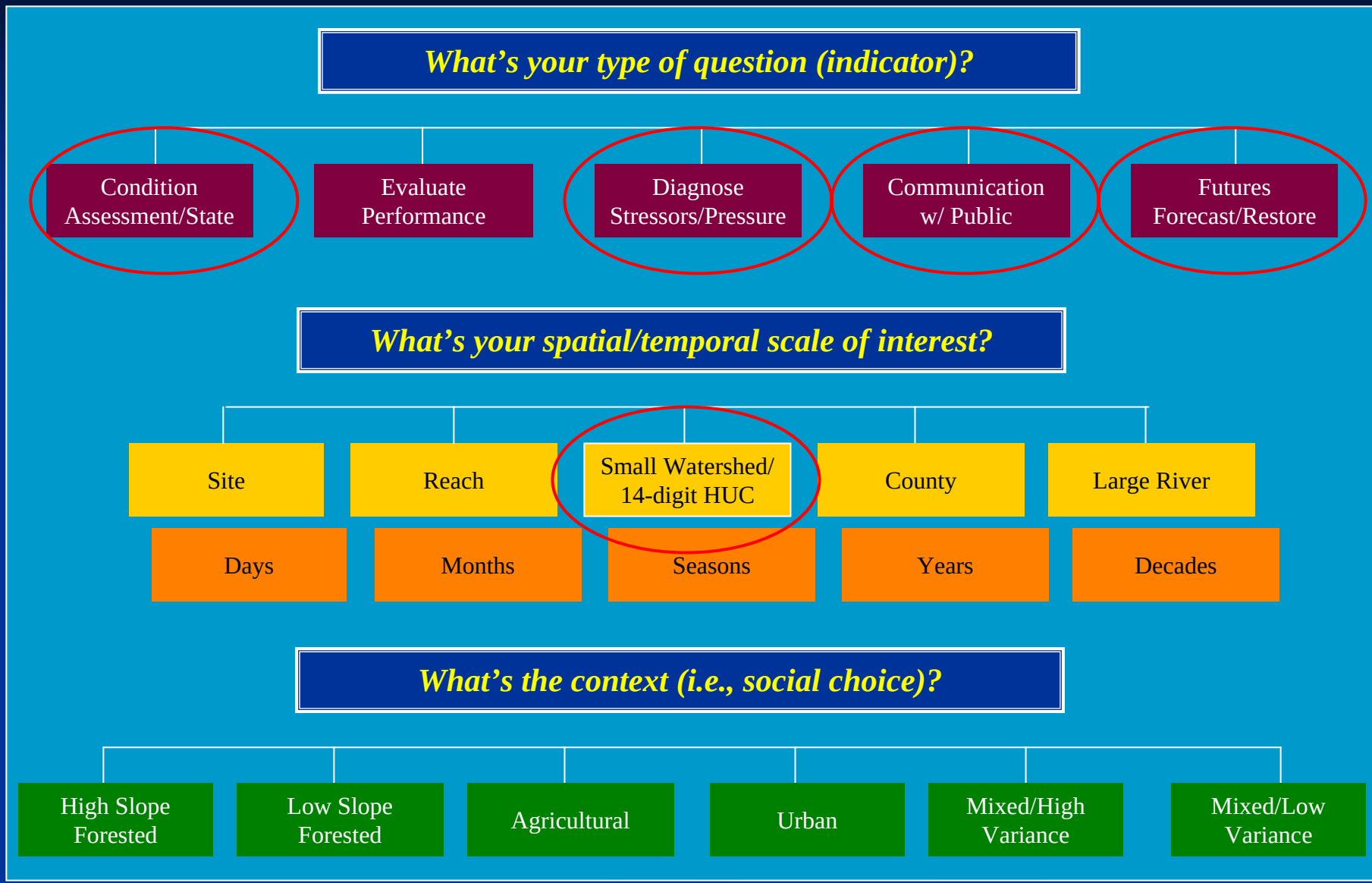
Mixed/Low Variance

What's the management issue?

- Impacted stream biology is associated with the presence of cropland in the watershed. Questions are:
  - Does the spatial arrangement of land cover help to explain nitrate concentrations and/or macroinvertebrate assemblages in streams?
  - Is the relationship different for watersheds of varying size?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Distance-weighted land cover may be most useful in mixed land use patterns.

Land Use Patterns

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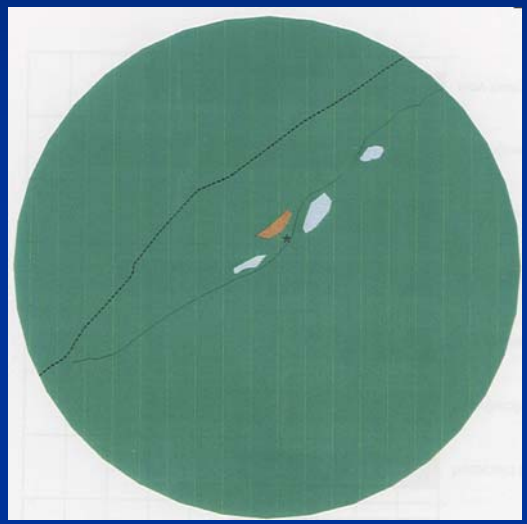

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- Futures Forecast/Restore

What's your spatial/temporal scale of interest?

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What's the context (i.e., social choice)?

- High Slope Forested
- Low Slope Forested
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Indicator Worksheet

- Which of the following questions does your indicator address:
  - How big's the problem
  - Is it getting better or worse
  - What's causing it
  - What can be done
  - Is management making a difference
- At what spatial and temporal scale was your indicator developed?
- At what spatial and temporal scale of application would you feel comfortable with? Why?

Indicator Worksheet (cont.)

- What is your concept of what is a good system?
- How does your indicator help to describe a good system?
- Why is your good system one that a manager would be trying to manage to?
- Does your indicator provide meaningful guidance to an environmental manager?

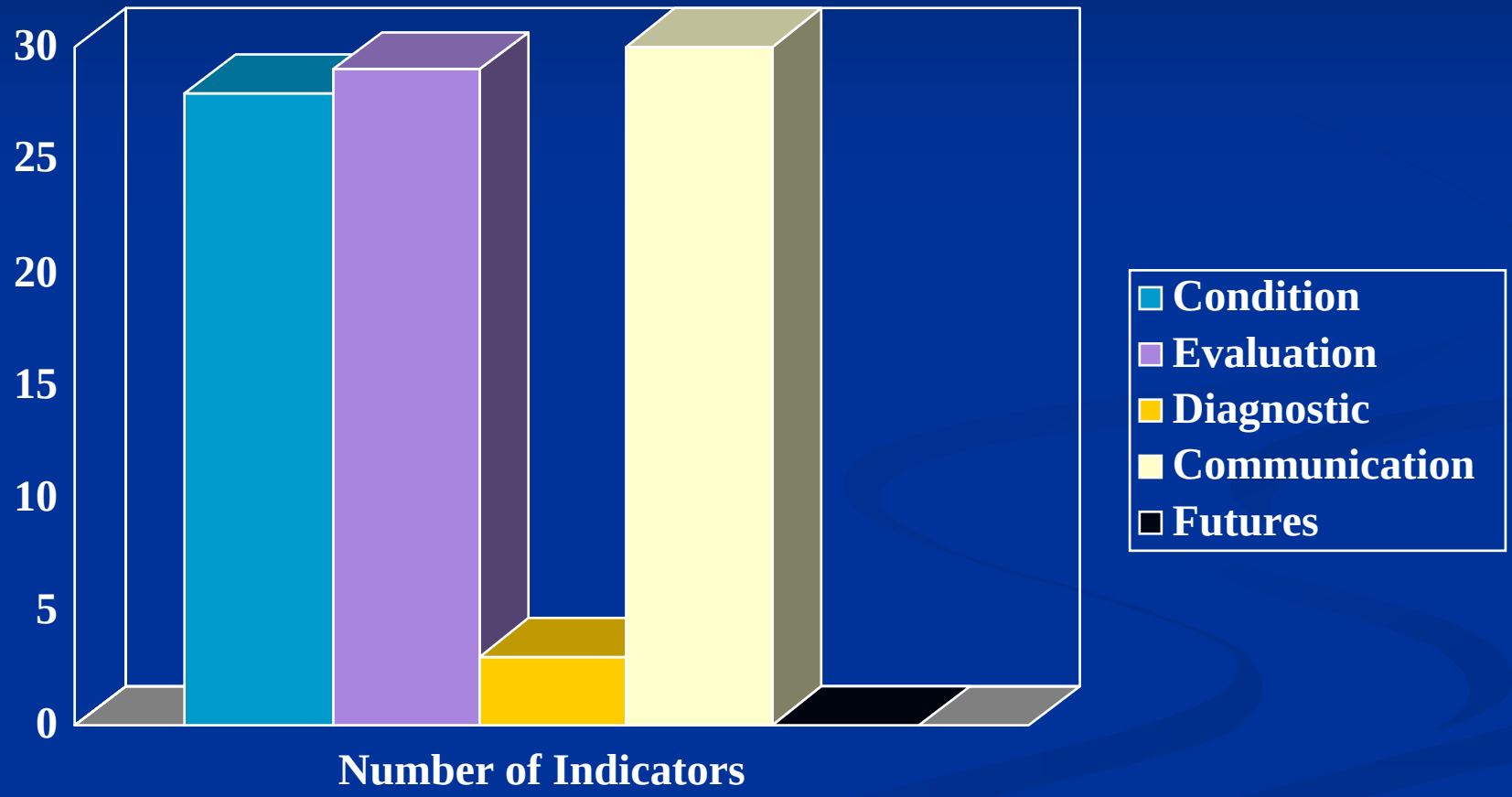
Framework for Indicator Selection

- Useful for selecting indicator(s)
- Same framework can be used to describe an indicator, or to quantify its utility
- Elements of framework are question, scale, and context

Application of the Framework to a Program

- Chesapeake Bay Program has 82 metrics; 30 assumed to be indicators
- Developed over 20 years
- How do these indicators “map” onto the framework?
- What can we learn from “mapping”?

Chesapeake Bay Program Indicator Distribution (n=30)



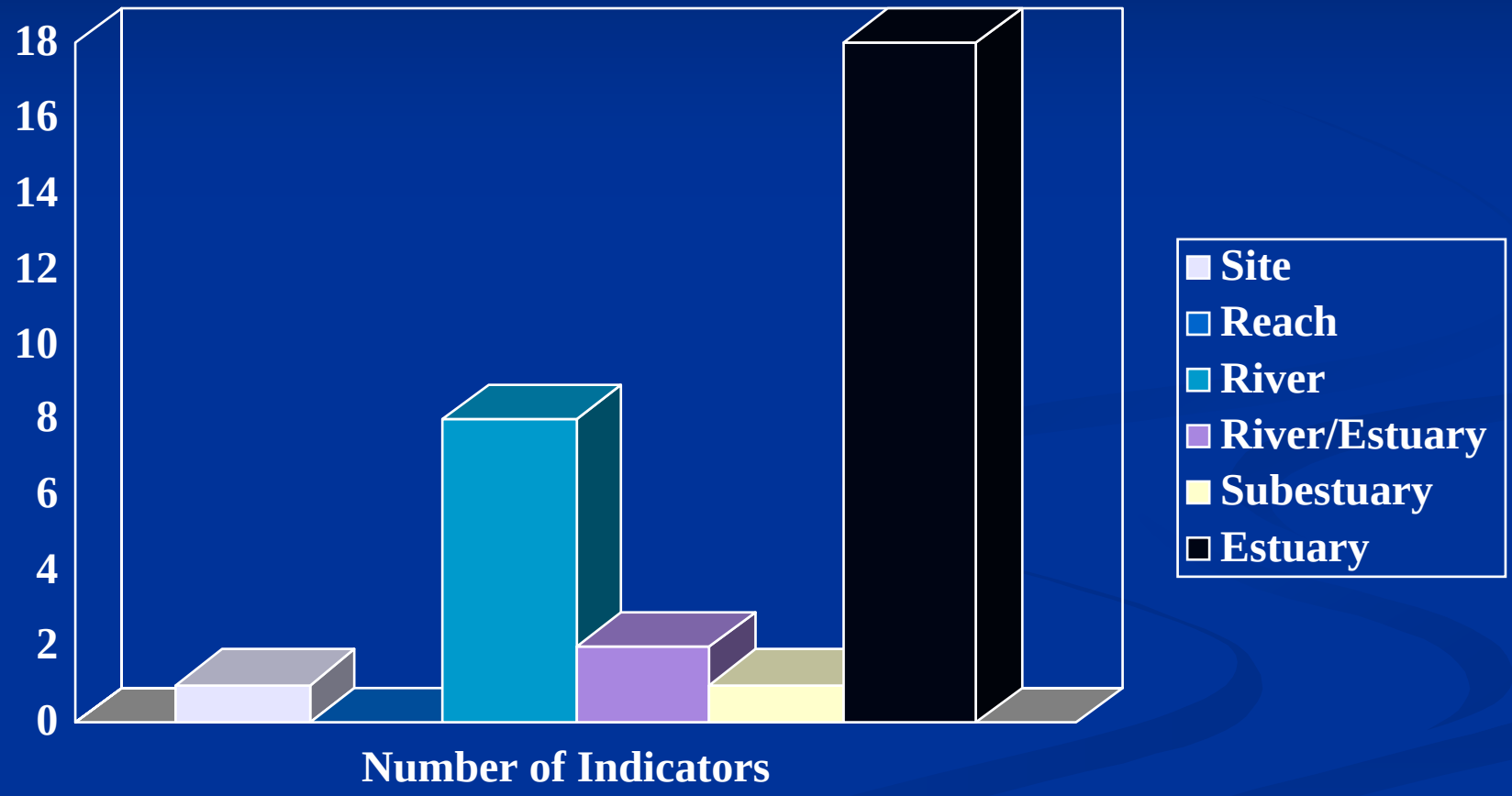
Indicator Function

Chesapeake Bay Program Indicators	Condition	Evaluate	Diagnose	Communicate	Futures

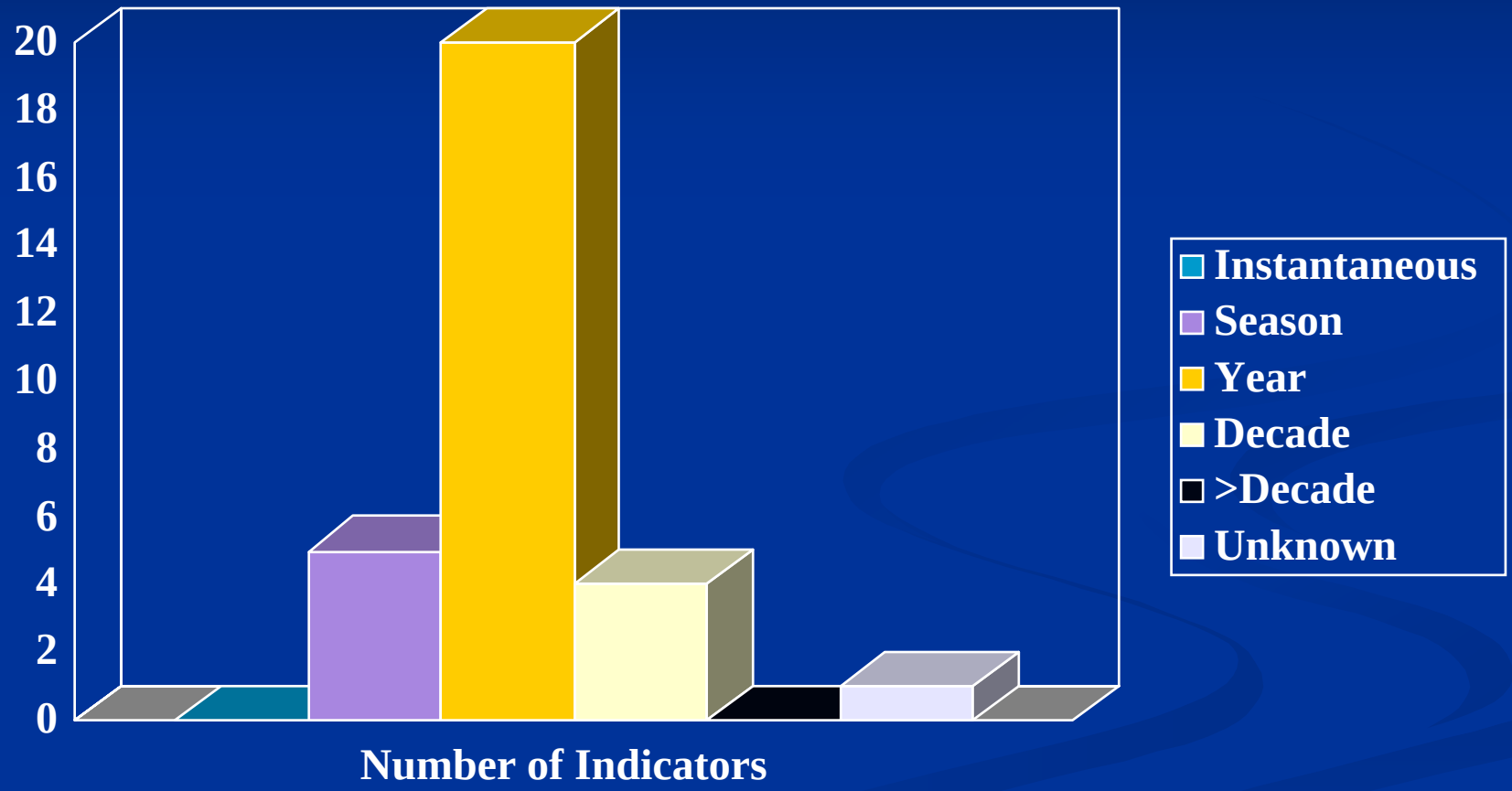
Mapping of CBP Indicators

- 28 of 30 CBP Indicators are “condition” ones; 2 have no reference standard
- 29 of 30 are “evaluation” indicators, tied to specific management actions
- 0 of 30 are “futures” indicators
- 3 of 30 are “diagnostic” indicators
- 30 of 30 are “communication” indicators

Spatial Scale of CBP Indicators (n=30)



Temporal Scale of CBP Indicators (n=30)



How do the four stories end?

- Happily, with defensible, useful, relevant indicators
- Happily, with humans as part of the system
- Happily, with a useful taxonomy
- Happily, with more diagnostic and futures indicators for the CBP

Example

(1) *Where are you?* (social choice/landscape setting)

- High Slope Forested
- Low Slope Forested
- Agricultural
- Urban
- Low Nodal Variance Mixed
- High Nodal Variance Mixed

(2) *What's your question?* (type of indicator)

- Condition Assessment/State
- Regulatory Performance
- Diagnosis of Stressor/Pressure
- Communication with Public

(3) *What level of spatial/temporal resolution do you need? What confidence interval is necessary for your decision-making?*

Resource Type

	Upland	Wetland	Stream	Riparian Corridor
Level I	Watershed-wide Land Use	Surrounding Land Use	Nodal Land Use Buffer Land Use	Buffer Land Use
Level II	Breeding-Bird Atlas Data	Stressor Checklist VIMS/ECU Rapid Assessment	RBP Habitat Assessment Buffer Characteristics	RBP Habitat Assessment SWR Protocol
Level III	Bird Community Index	HGM Assessment Plant IBI Macro IBI	Fish IBI Macro IBI	IBIs

Increasing Confidence/Effort/Cost ↓

↑ Increasing Spatial Scale

Example: *Condition Assessment (type of indicator) in a High Slope Forested Watershed (social choice)*

RESOURCE TYPE

INCREASING EFFORT/CONFIDENCE/COST

INCREASING SPATIAL SCALE

	UPLAND	WETLAND	STREAM	RIPARIAN CORRIDOR
LEVEL I	❖ Watershed-wide Land Use	❖ Surrounding Land Use	❖ Nodal Land Use ❖ Buffer Land Use	❖ Buffer Land Use
LEVEL II	❖ Breeding-Bird Atlas Data	❖ Stressor Checklist ❖ VIMS Rapid Assessment ❖ ECU Rapid Assessment	❖ RBP Habitat Assessment ❖ Buffer Characteristics	❖ RBP Habitat Assessment ❖ SWR Protocol
LEVEL III	❖ Bird Community Index	❖ HGM Assessment ❖ Plant IBI ❖ Macro IBI	❖ Fish IBI ❖ Macro IBI	❖ IBIs

Example: *Condition Assessment (type of indicator) in a High Slope Forested Watershed (social choice)*

RESOURCE TYPE

INCREASING EFFORT/CONFIDENCE/COST

INCREASING SPATIAL SCALE

	UPLAND	WETLAND	STREAM	RIPARIAN CORRIDOR
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LEVEL III	❖ Bird Community Index	❖ HGM Assessment ❖ Plant IBI ❖ Macro IBI	❖ Fish IBI ❖ Macro IBI	❖ IBIs