Natural Capital and Ecosystem Services

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The big question:

Is the global human-environment system on a trajectory that can maintain or advance human well-being over the long run?

This is a really hard question.

The earth system, and smaller ecosystems within the earth system, support human well-being in many different ways.

We have sparse knowledge of:

★How dimensions of human life-support interact and change over time

★ How human actions alter these dynamics

★ How policies affect human actions

Topics:

Ecosystem services and natural capital

System definition and the problem of scale

Thresholds and big changes

Unknown futures and scenarios

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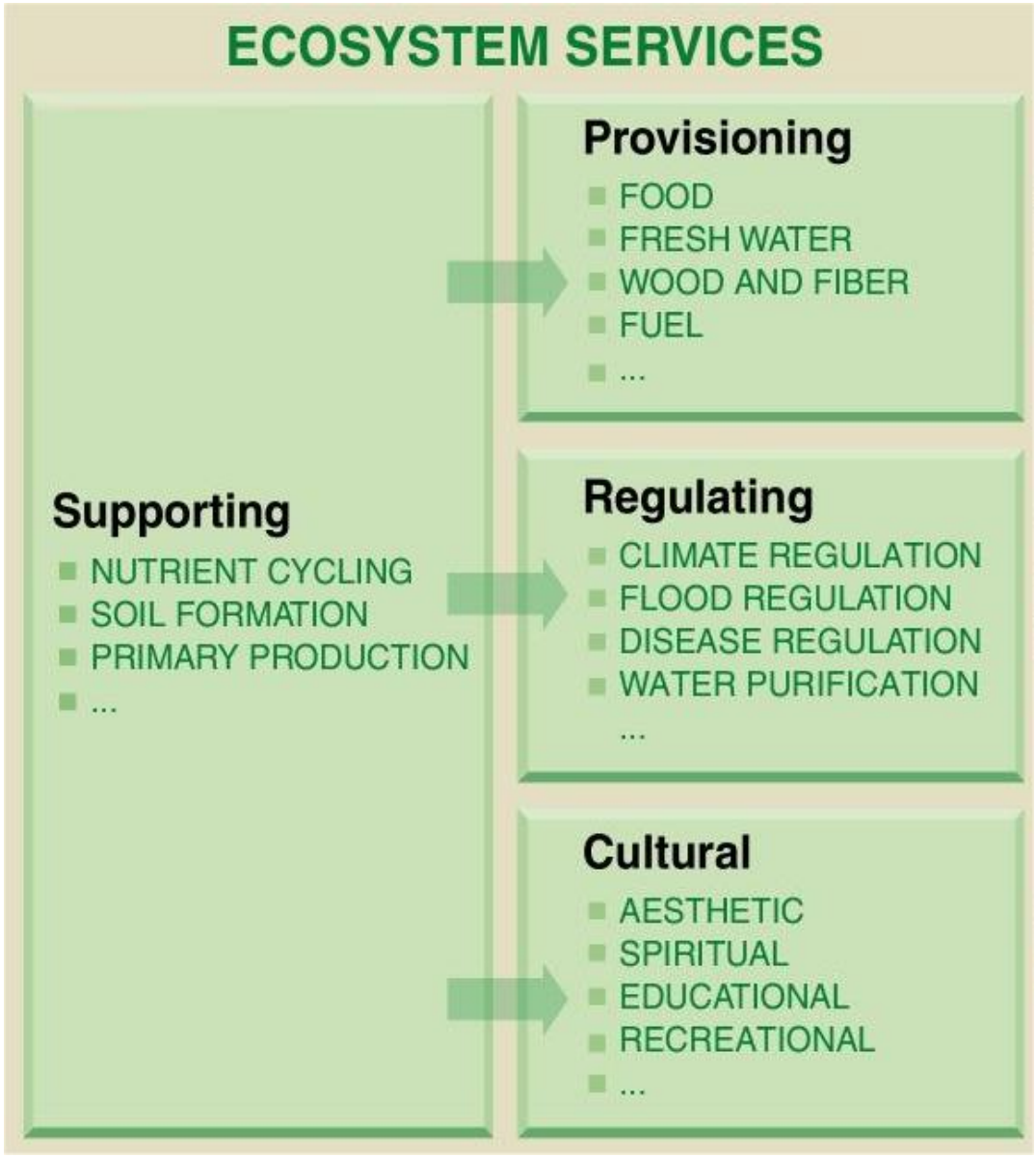
Ecosystem Services

Benefits that people obtain from ecosystems:

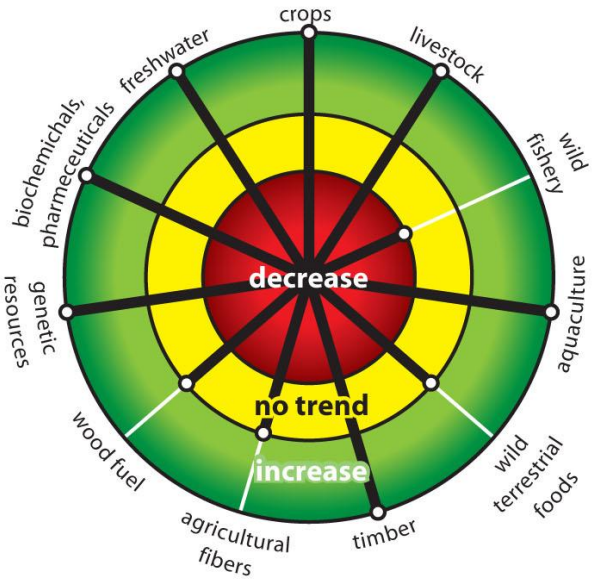
- ***Provision of food, fiber, water, pharmaceuticals etc.**
- ***Regulation of water flow and quality, air quality, climate, soil fertility, disease etc.**
- ***Cultural values**

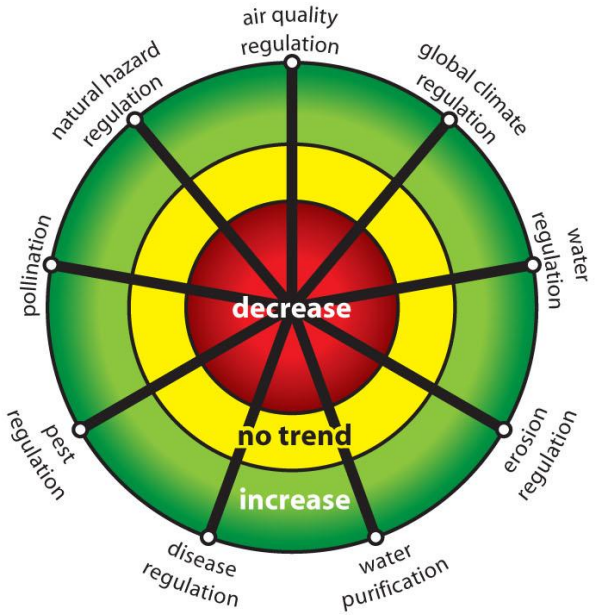
Ecosystem Services Addressed by the Millennium Ecosystem Assessment

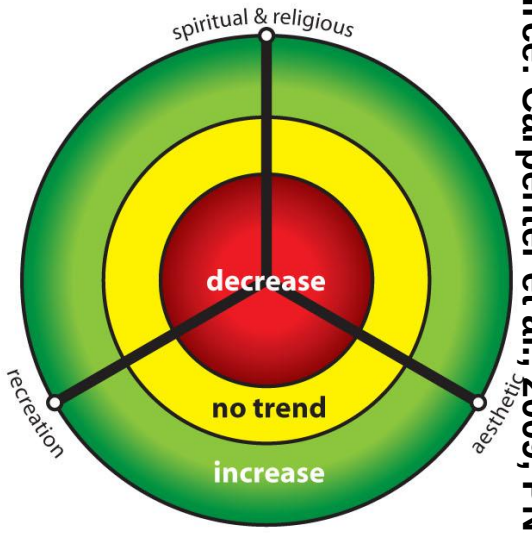


Millennium Ecosystem Assessment, http://www.MAweb.org

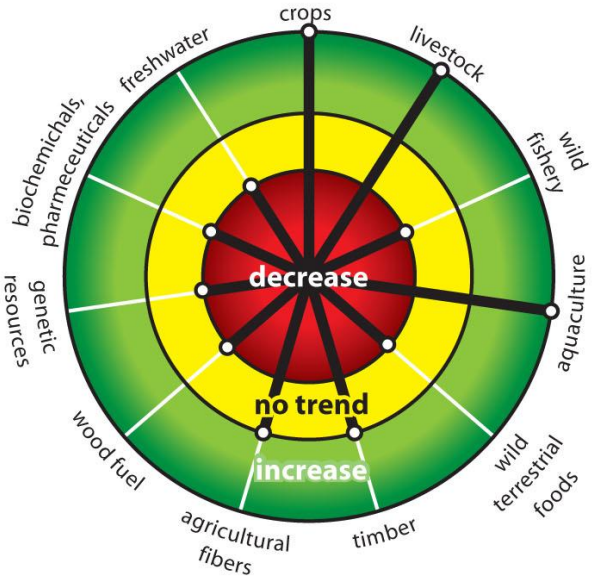
Human use

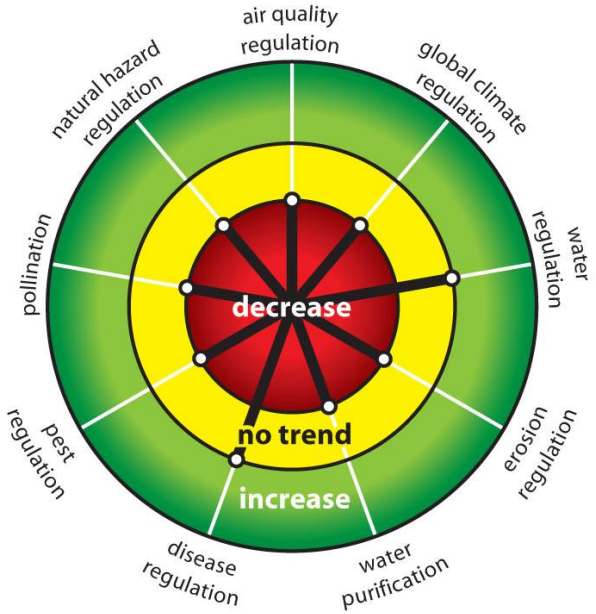


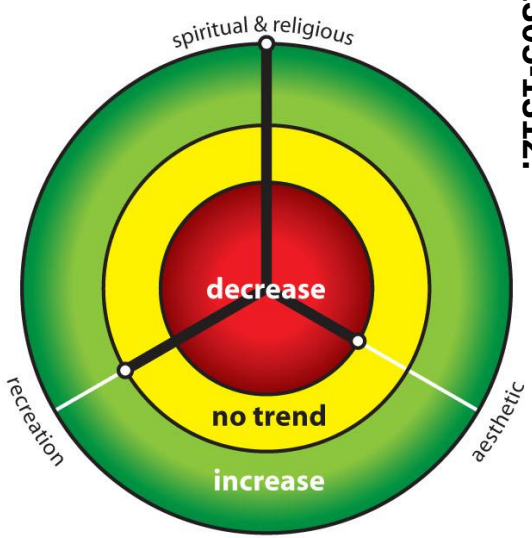




Condition







Provisioning services

Regulating services

Cultural services

Source: Carpenter et al., 2009, PNAS 106: 1305-1312.

Ecosystem Services

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- **Provision of food, fiber, water, pharmaceuticals etc.**
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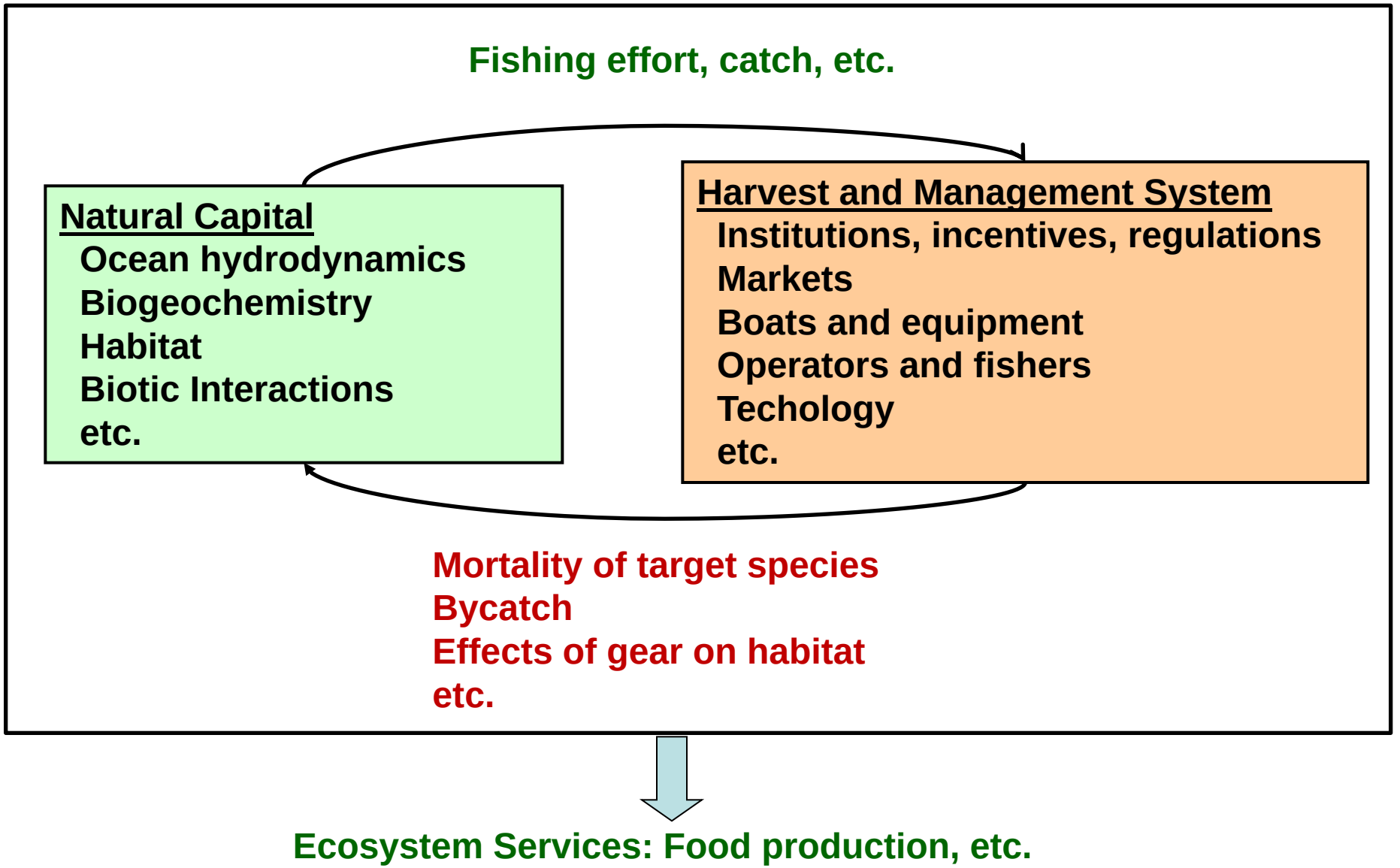
- **Cultural values**

Natural Capital

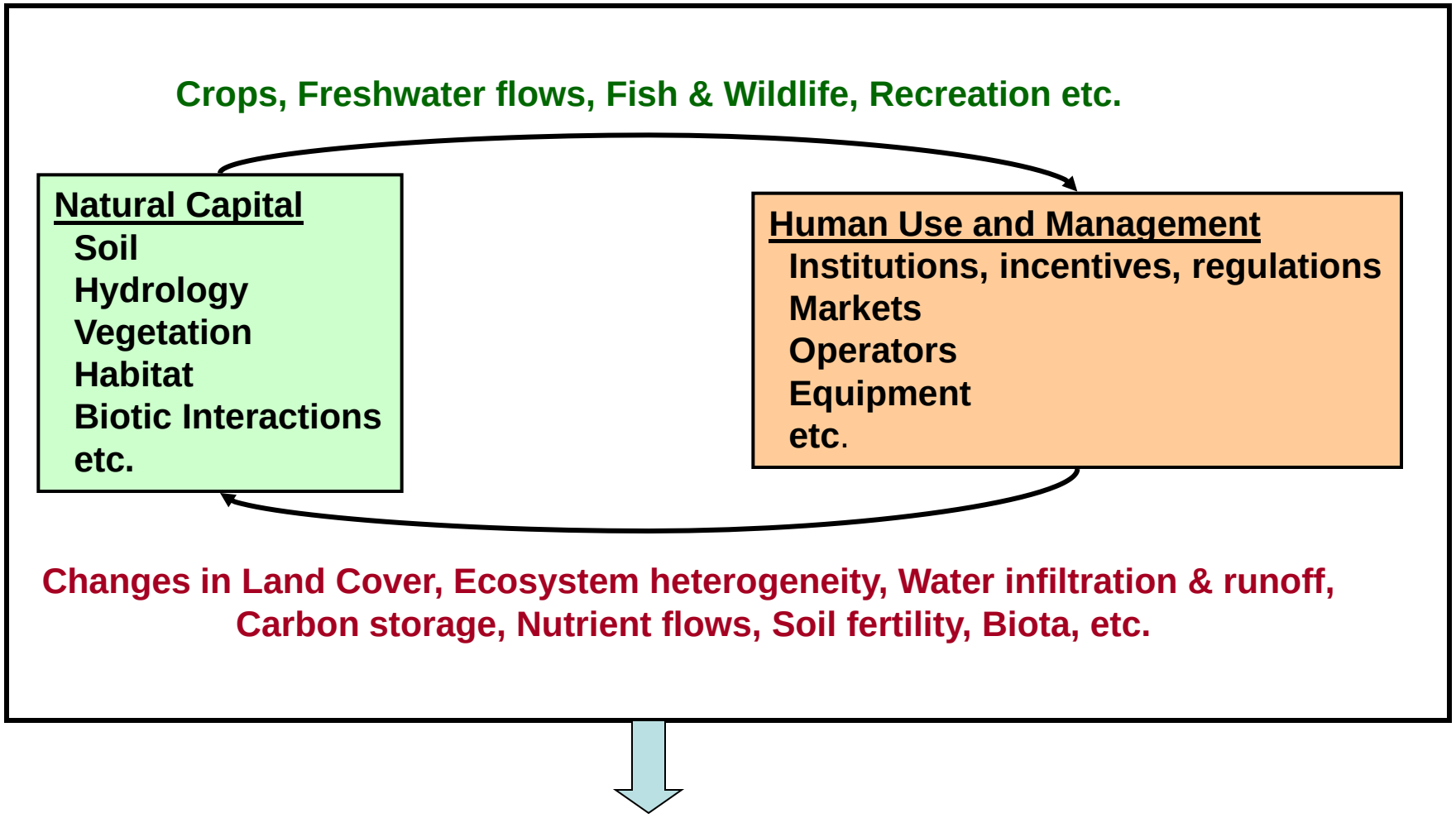
The capacity of an ecosystem to provide services

Natural Capital and Ecosystem Services of a Marine Fishery



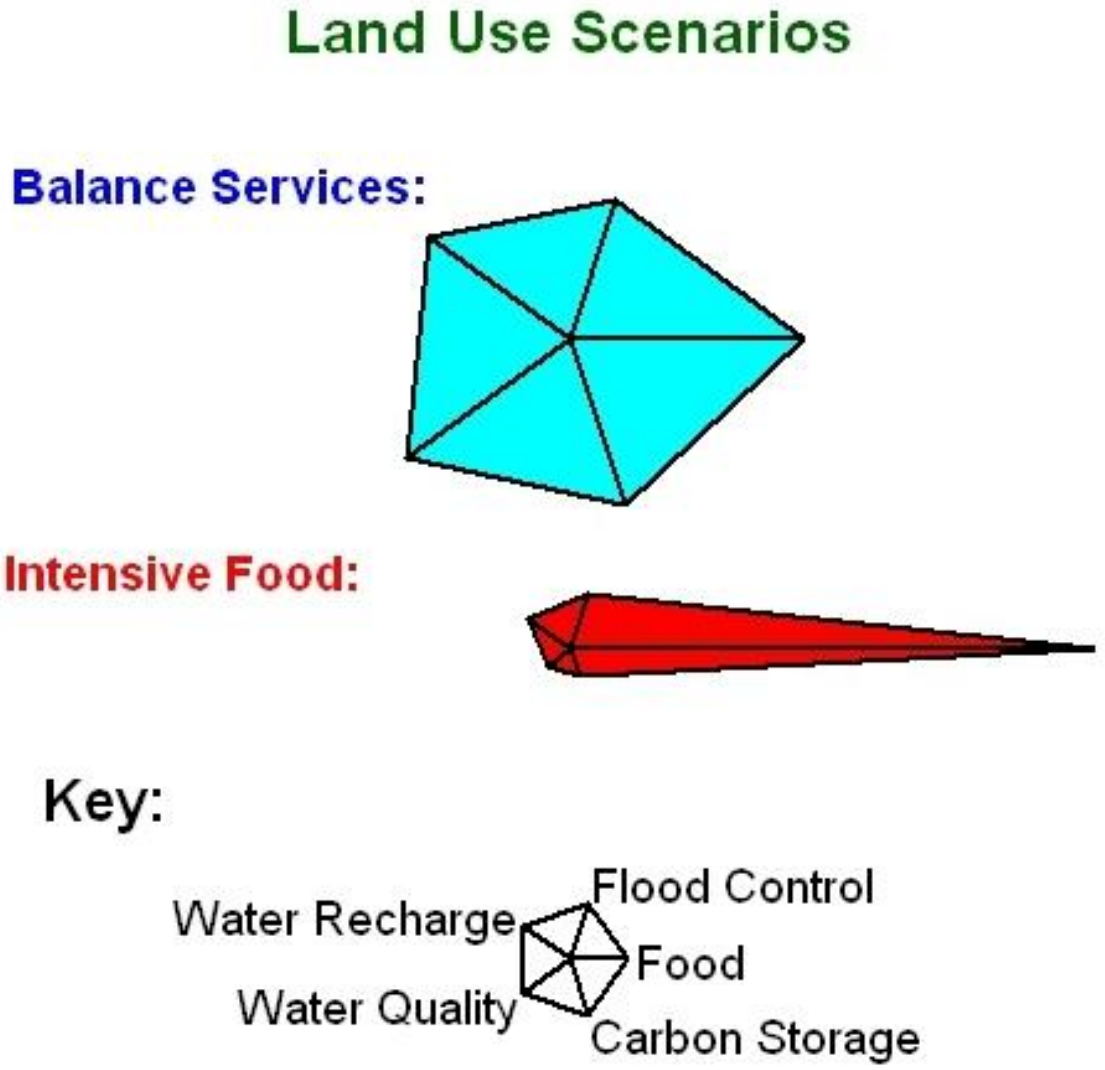
Carpenter , Matson, Turner, unpublished

Natural Capital and Ecosystem Services of an Agricultural Watershed



Carpenter, Matson, Turner, unpublished

Natural Capital and Service Flows Depend on How an Ecosystem is Used:



Carpenter et al., in review

Topics:

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Unknown futures and scenarios

Questions to ask at the start of (and periodically in the course of) analyzing a system:

1. What is the question?

2. What are the boundaries of the ecosystem?
What is the spatial grain of the analysis?

3. What is the time horizon?
What is the frequency of measurement or updating model solutions?

4. What are the inputs and drivers?

5. What are the outputs?

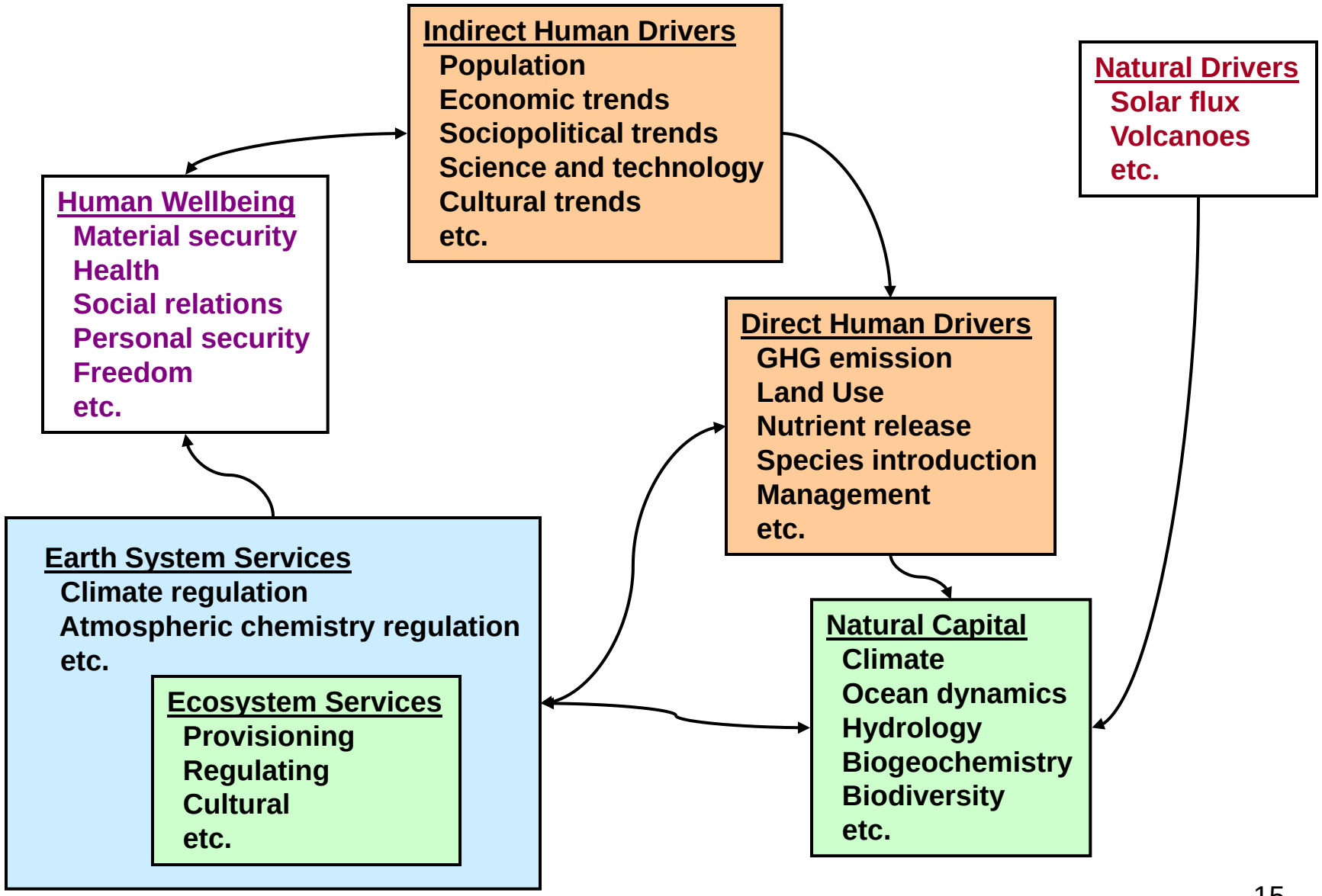
6. What are the components within the system?

7. What are the connections and feedbacks within the system?

8. Recheck:

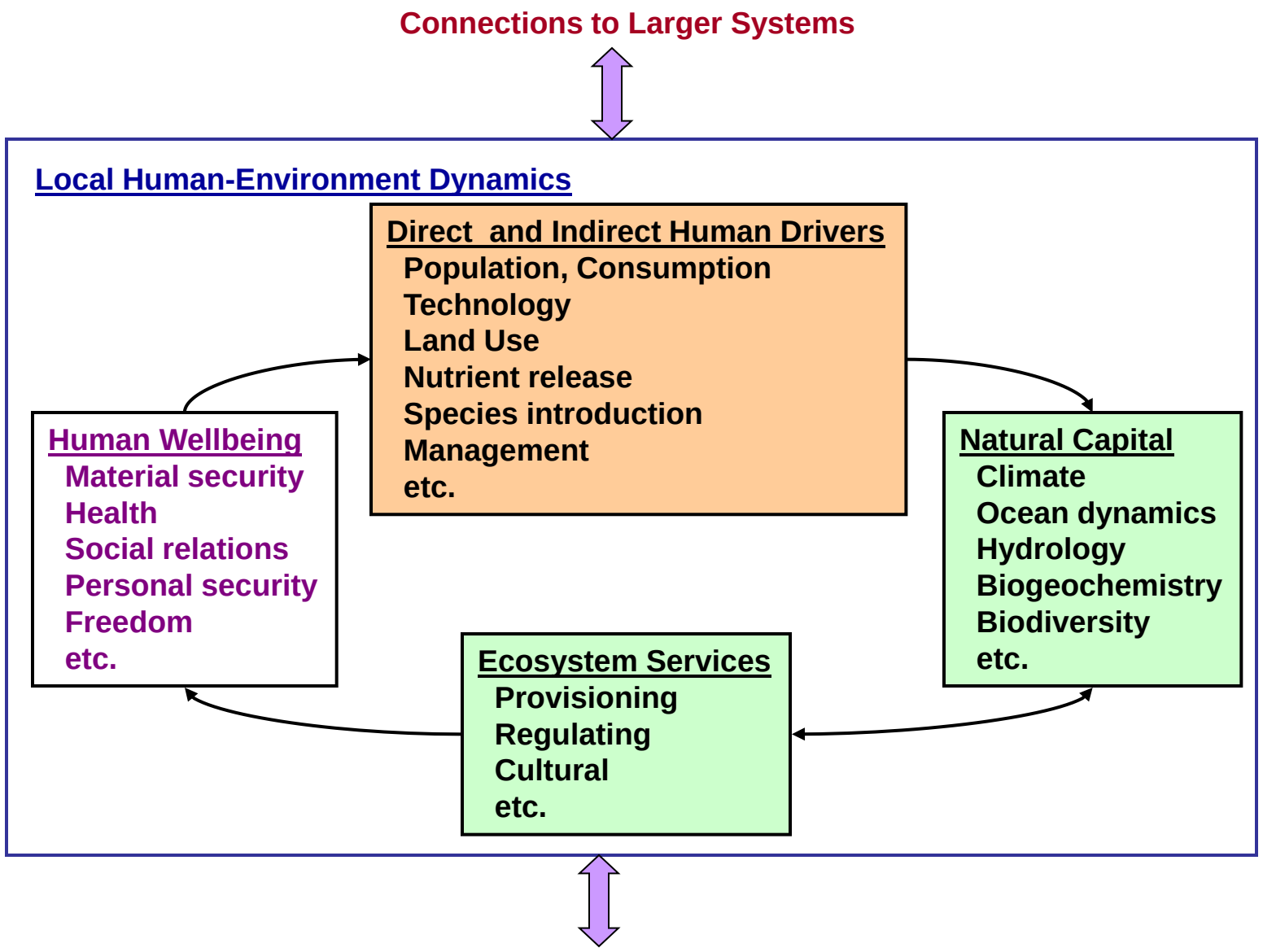
- **Is it the right question?**
- **What information do we need to answer the question?**
- **Will we get the information we need from this analysis?**
- **Repeat the sequence as needed.**

Key Interactions Involving Natural Capital and Ecosystem Services



Carpenter, Matson & Turner, unpublished

Natural Capital & Ecosystem Services: Connections Across Scales



Carpenter, Matson, Turner, unpublished

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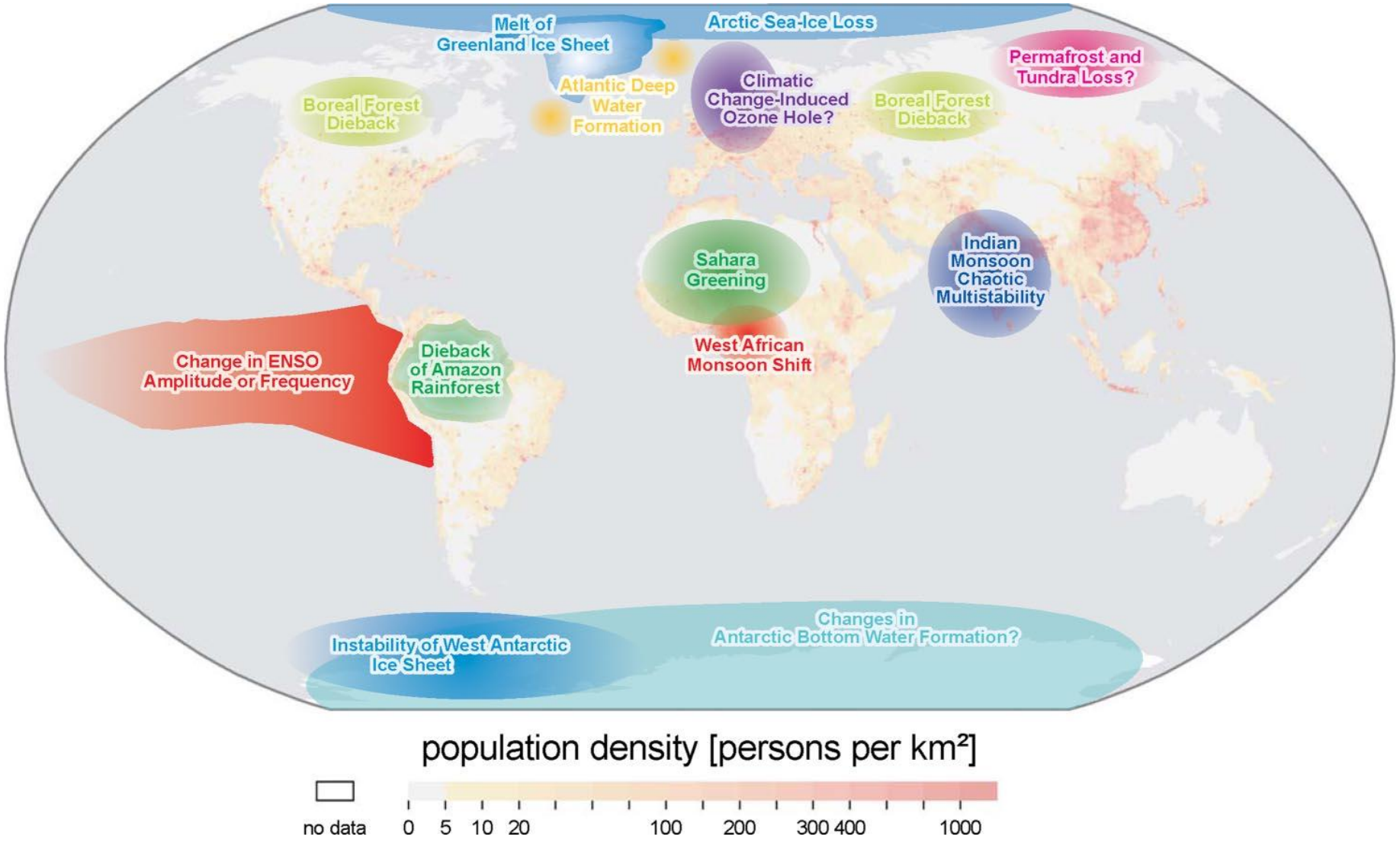
Changes in Natural Capital and Ecosystem Services Can be Big, Fast and Inconvenient.

Tipping Elements of the Earth System



Lenton TM, et al. ***(2008) Tipping elements in the Earth's climate system. Proc Natl Acad Sci USA 105:1786–1793.***

Big changes in ecosystem services are hard to predict.

- **Lack of information**
- **Nonlinearity**
- **Stochasticity**
- **Human volition**

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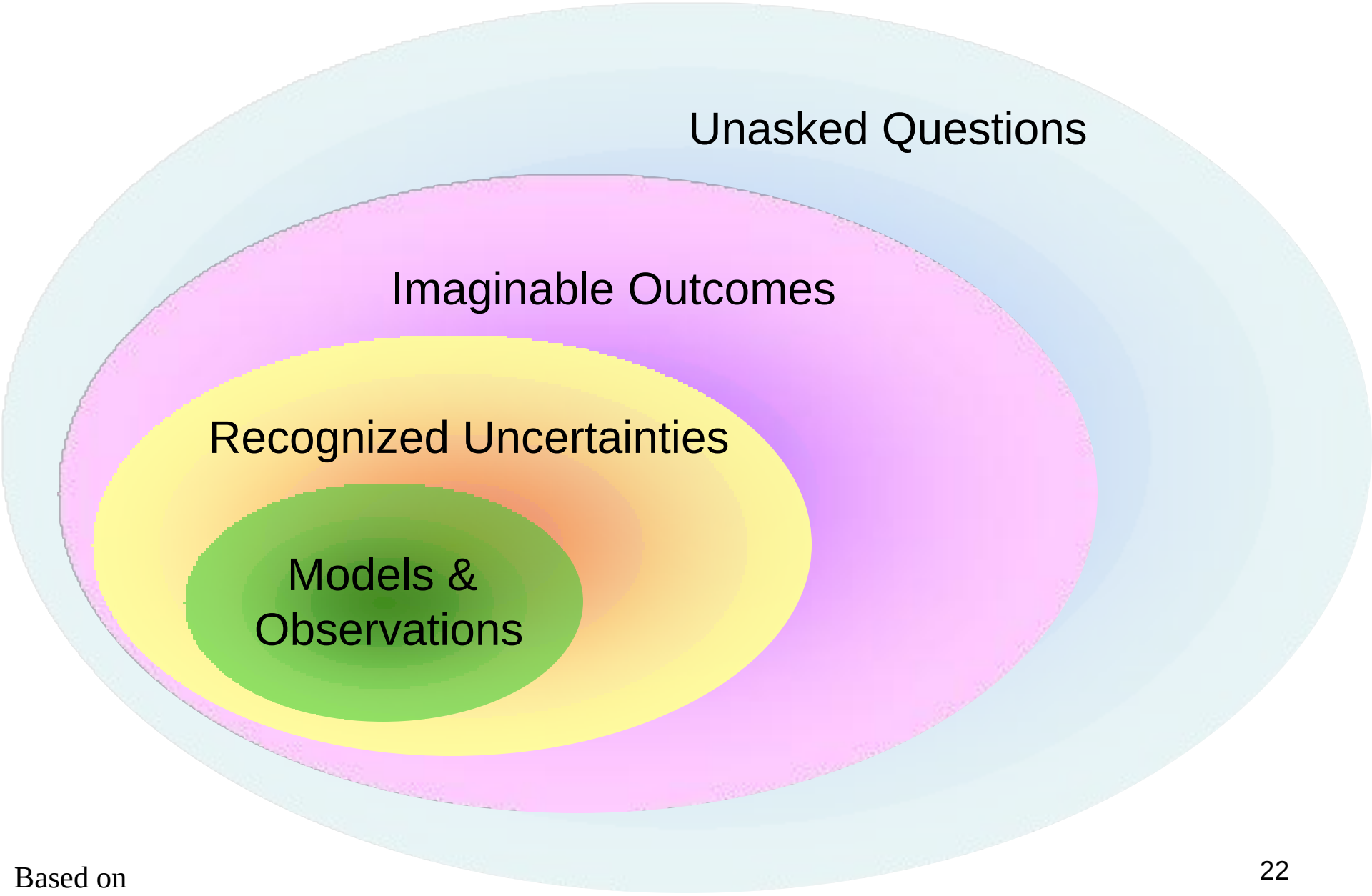
All Possible Futures



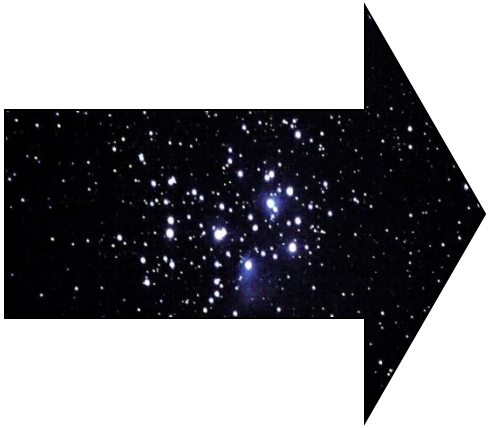
Based on
Carpenter, Bennett, & Peterson., 2006, Ecology & Society http://www.ecologyandsociety.org/vol11/iss1/art29/

The World

Lots of Perspectives

Sample Perspectives

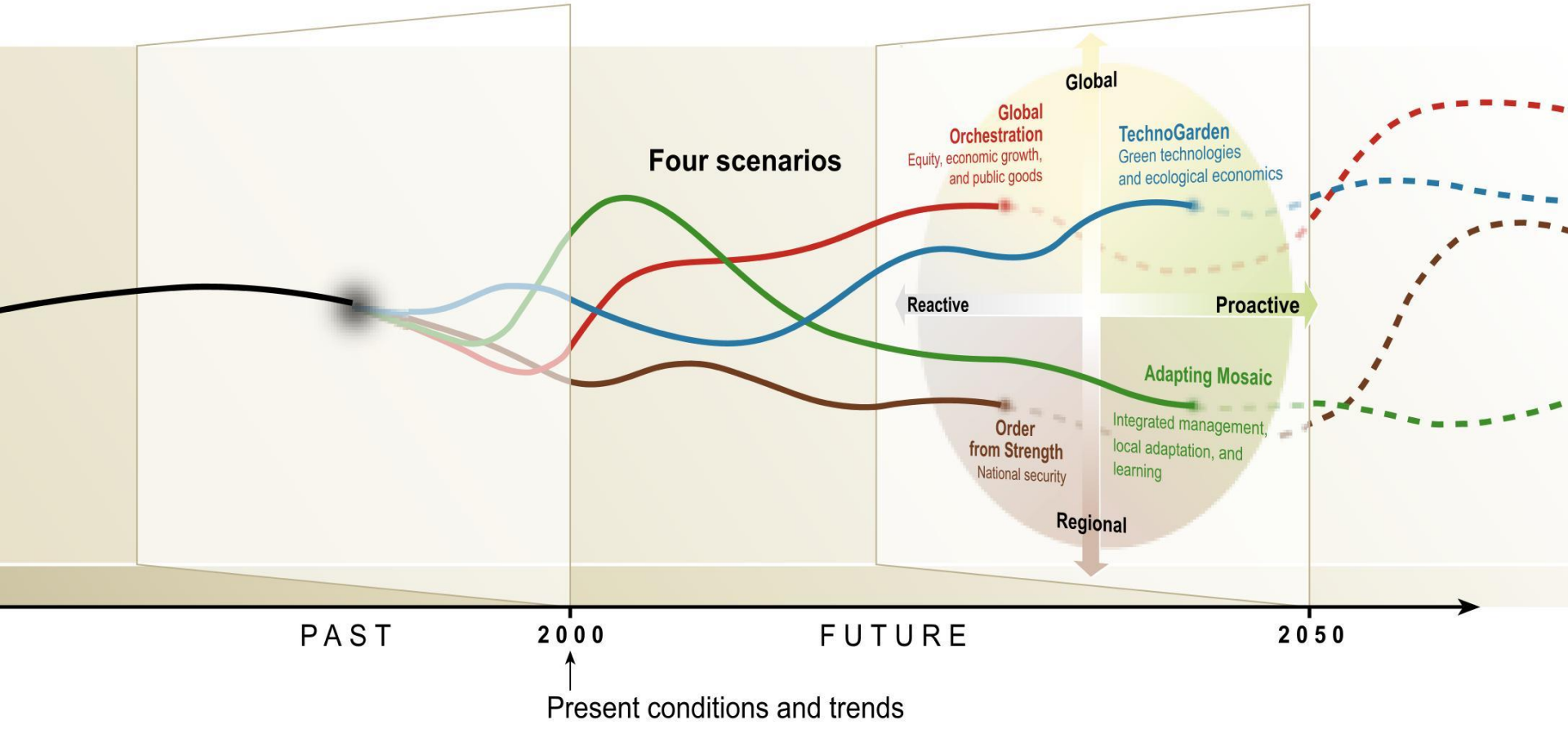
Cluster the Samples

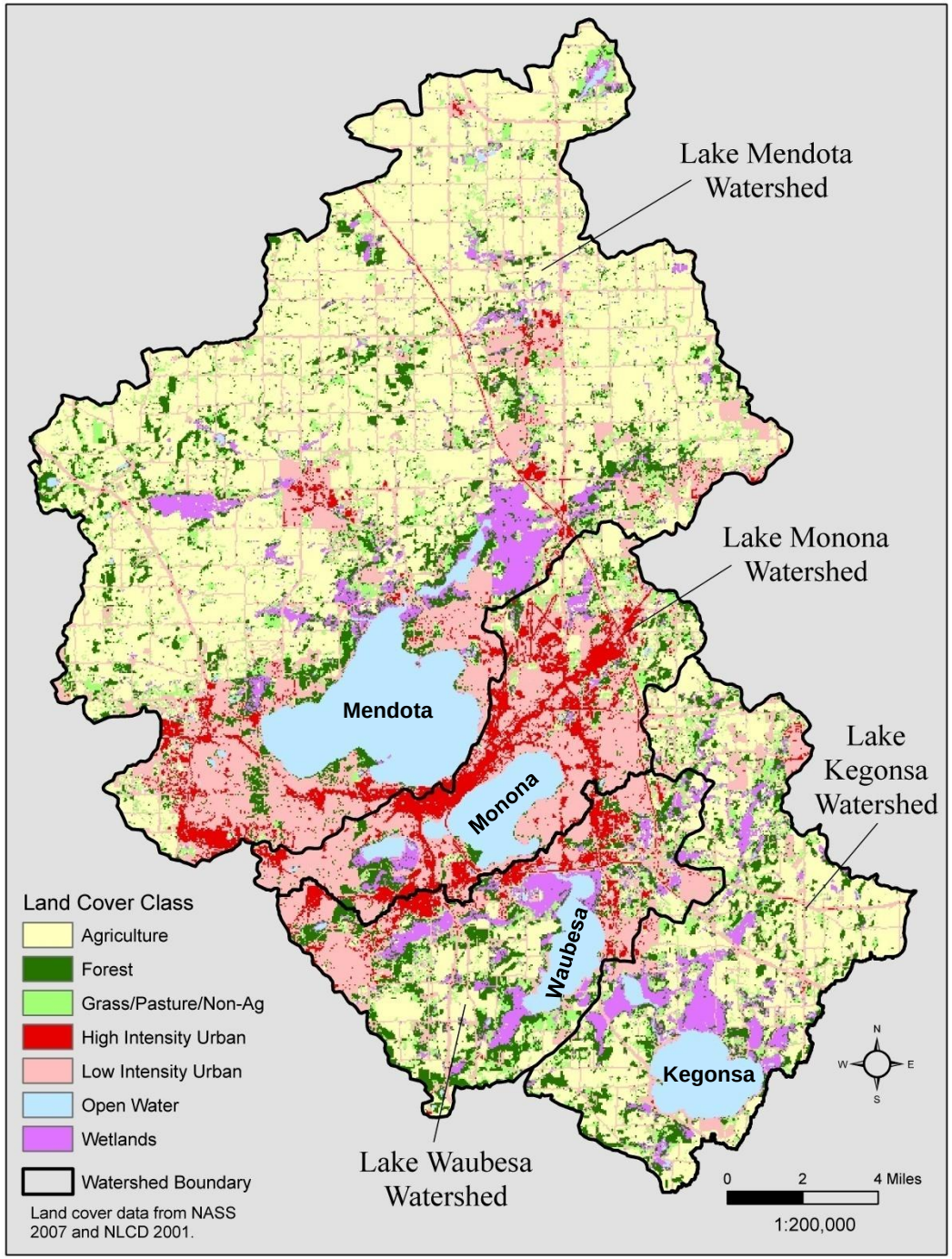


Condense to a few Scenarios

Next, evaluate the trajectory of each scenario over time, and compare the results.

Example from Millennium Ecosystem Assessment, http://www.MAweb.org





REGIONAL EXAMPLE:

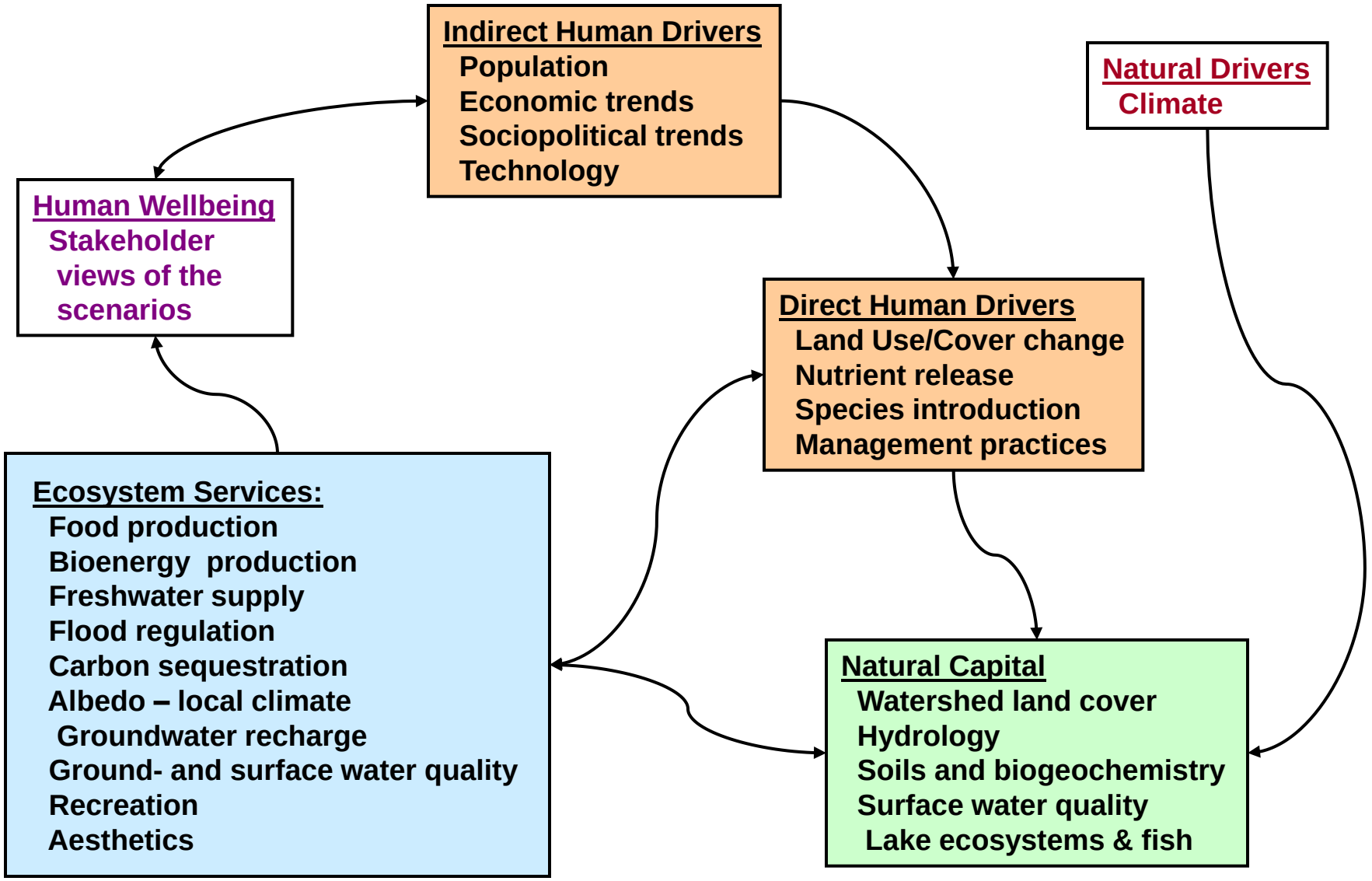
Yahara Lake District

North Temperate Lakes LTER

Madison, Wisconsin

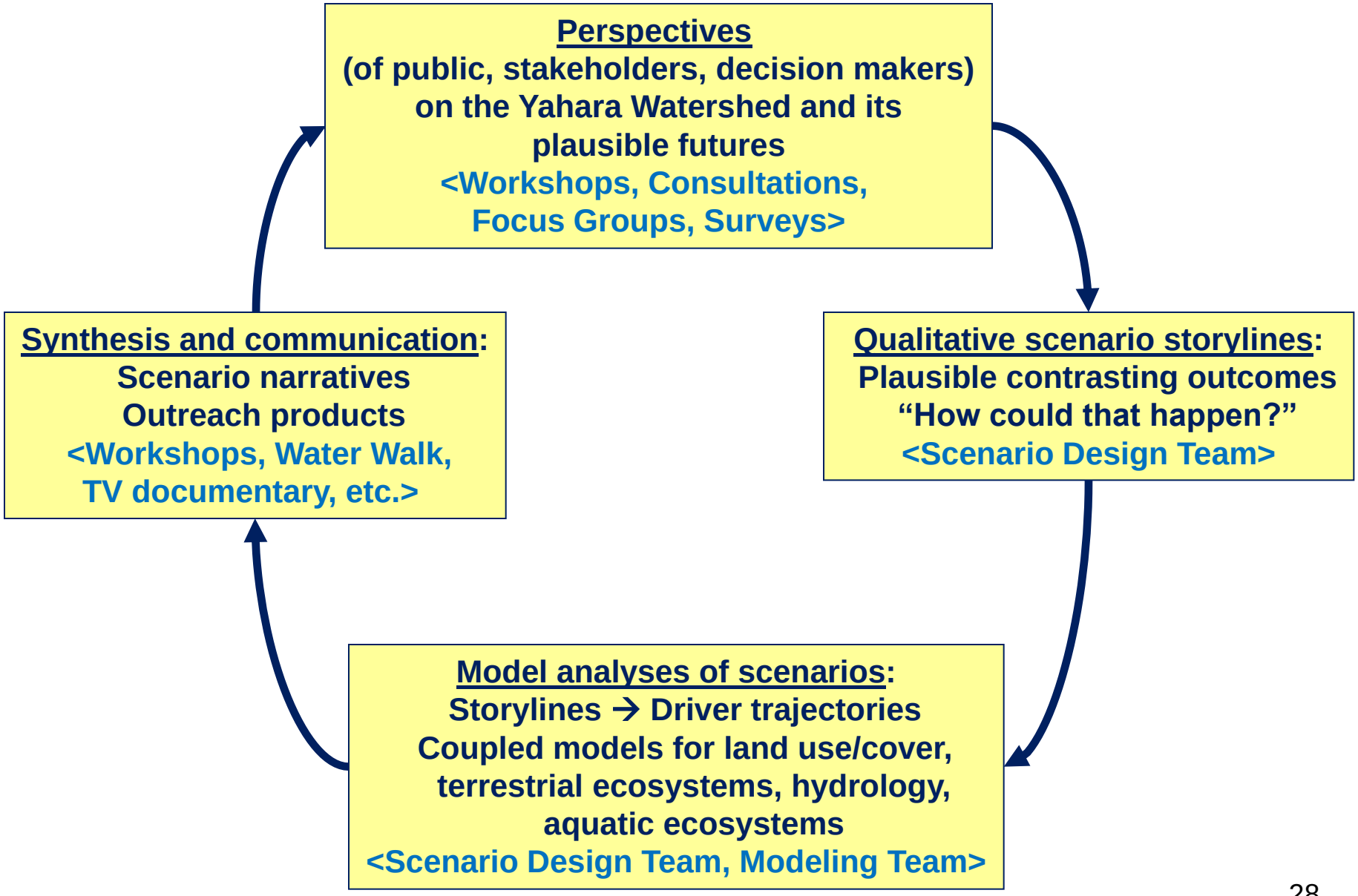
http://lter.limnology.wisc.edu

Framework for Yahara Watershed Assessment



Carpenter, Kucharik, Loheide, Rissman, Turner unpublished

Yahara Scenario Assessment: Approach



Carpenter, Kucharik, Loheide, Rissman, Turner unpublished

Conclusions

At present, no approach has a monopoly on answering the big question:

"Is the global human-environment system on a trajectory that can maintain or advance human well-being over the long run?"

Systematic analysis of ecosystem services (benefits that people obtain from nature) and natural capital (capacity of a system to generate ecosystem services) is one promising approach.

Conclusions (2)

We need coordinated, interdisciplinary, place-based studies of

★How dimensions of human life-support interact and change over time

★ How human actions alter these dynamics

★ How policies affect human actions