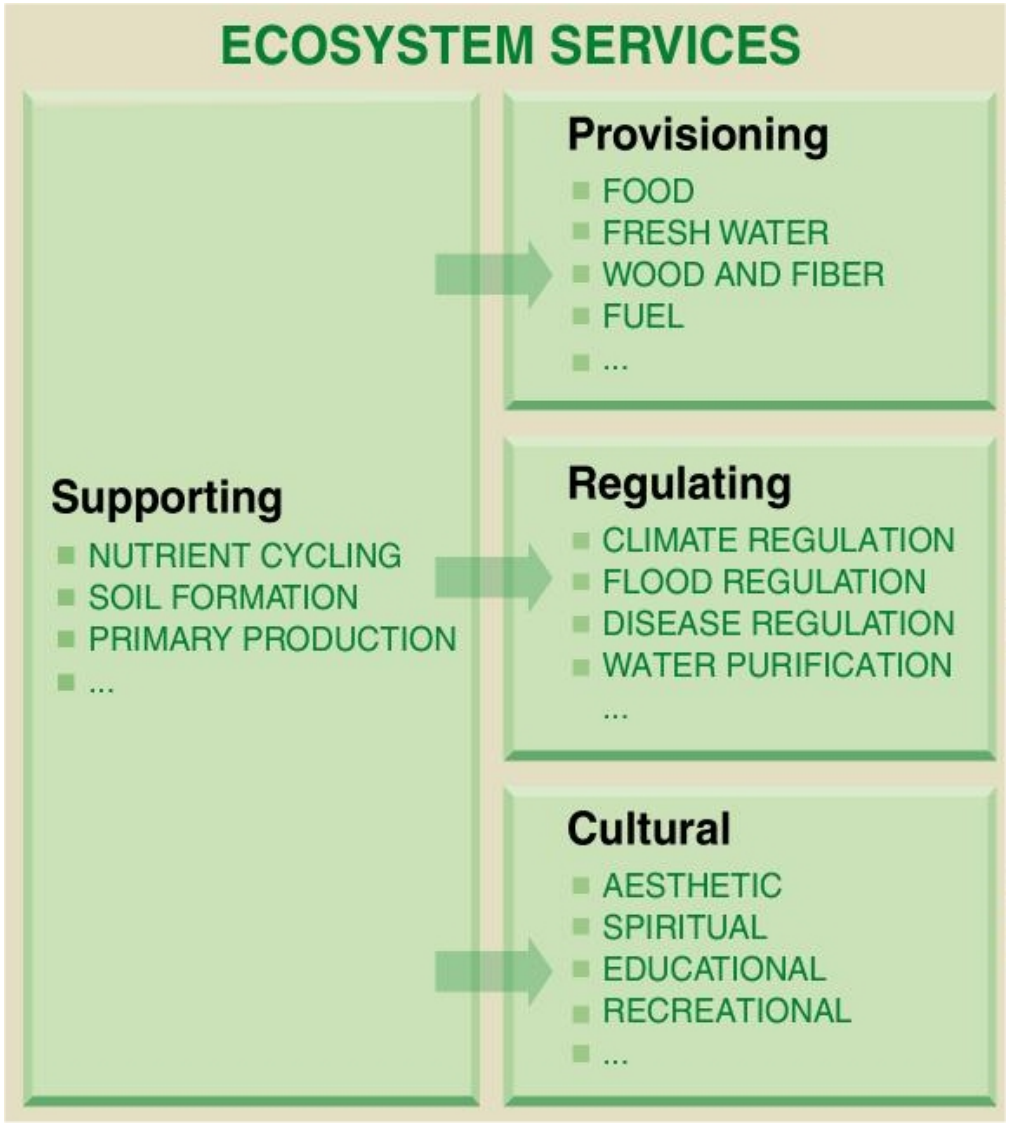
Ecosystem Services: Challenges and Opportunities

Steve Carpenter
University of Wisconsin-Madison
srcarpen@wisc.edu

Presentation for
“Transitioning to Sustainability through Research and Development on Ecosystem Services and Biofuels”

The National Academies’
First Federal Sustainability Research and Development Forum
October 17-18, 2007

Ecosystem Services: the natural ecological processes that sustain and fulfill human life.



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

S. R. Carpenter

Do We Have the Science Needed to Manage Ecosystem Services?

There are many important gaps.

Theory

Multi-scale analysis

Monitoring and indicators

Design of institutions or policies

Background:

(1) Carpenter and others, 2006, Science 314: 257-258
(2) Liu and others, 2007, Science 317: 1513-1517

Do We Have the Science Needed to Manage Ecosystem Services?

There are many important gaps.

Theory

Multi-scale connections and interactions

Monitoring and indicators

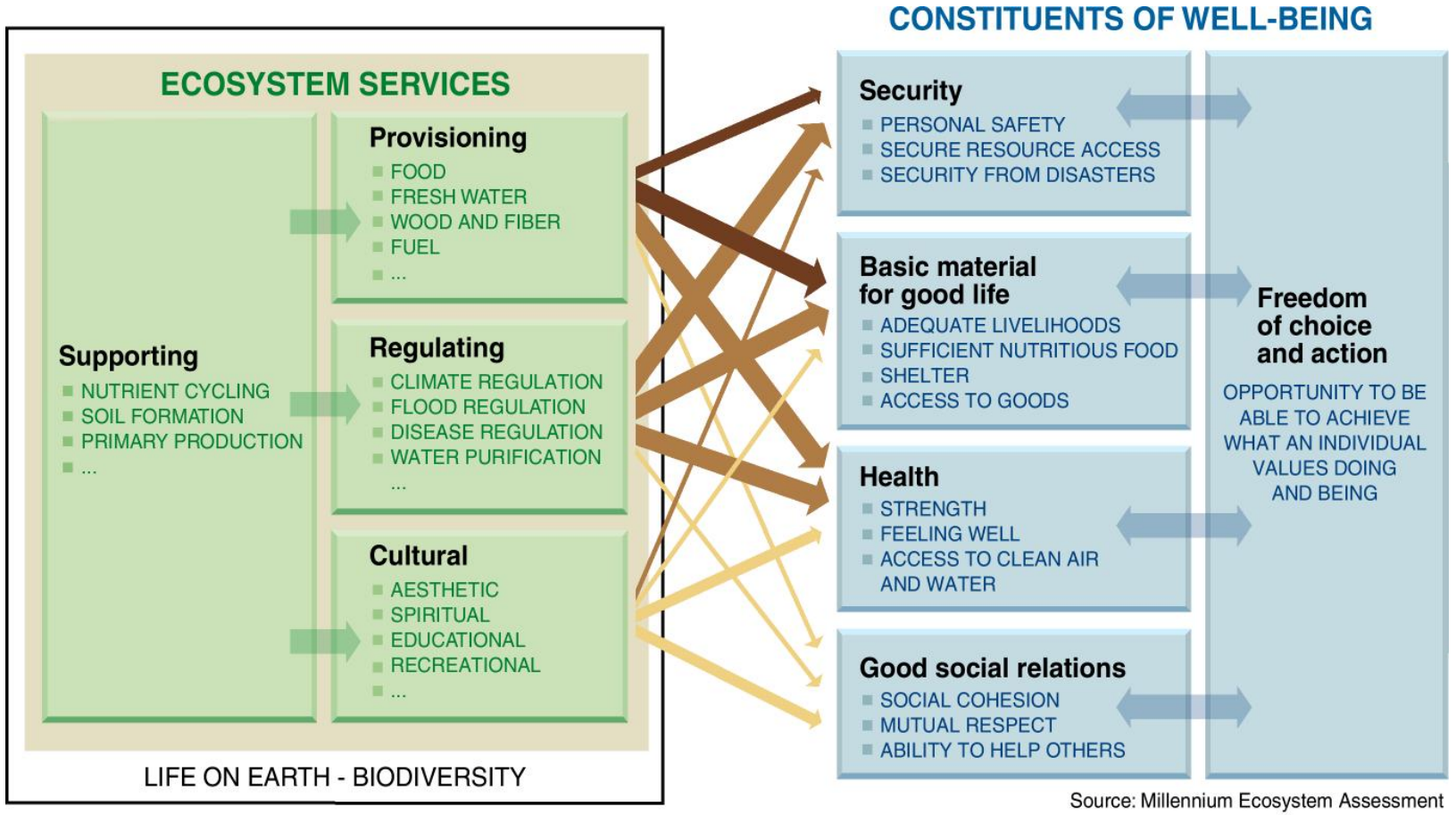
Design of institutions or policies

Background:

(1) Carpenter , DeFries, Dietz, Mooney, Polasky, Reid & Scholes, 2006, Science 314: 257-258
(2) Liu and others, 2007, Science 317: 1513-1517

Key Needs: Theory

How are ecosystem services connected to human well-being?



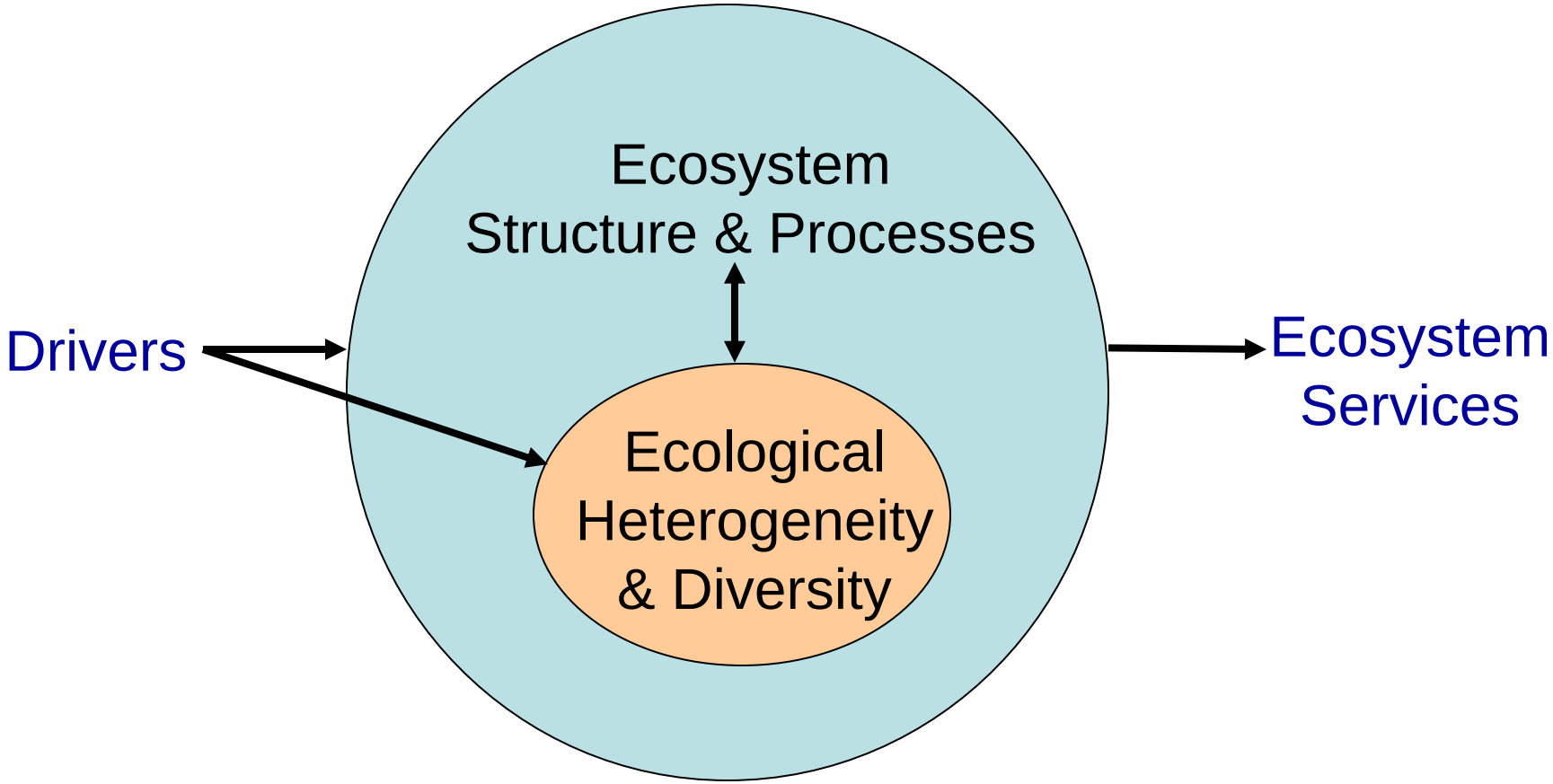
Source: Millennium Ecosystem Assessment

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

S. R. Carpenter

Key Needs: Theory

Role of heterogeneity or diversity:



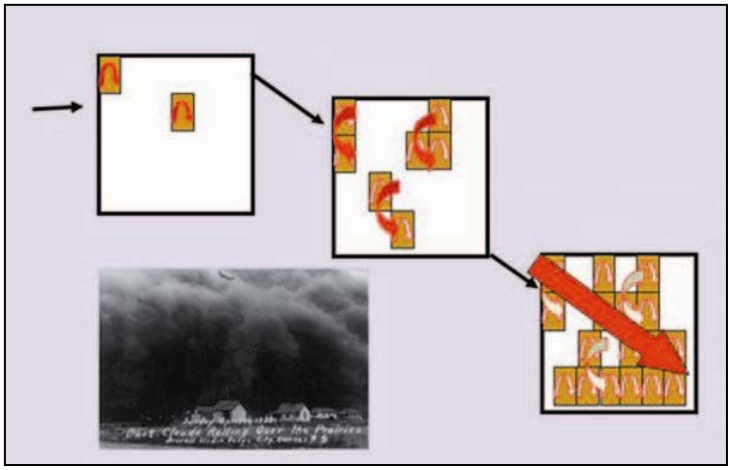
Carpenter, DeFries, Dietz, Mooney, Polasky, Reid & Scholes, 2006, Science 314: 257-258.
Ives & Carpenter, 2007, Science 317: 58-62.

S. R. Carpenter

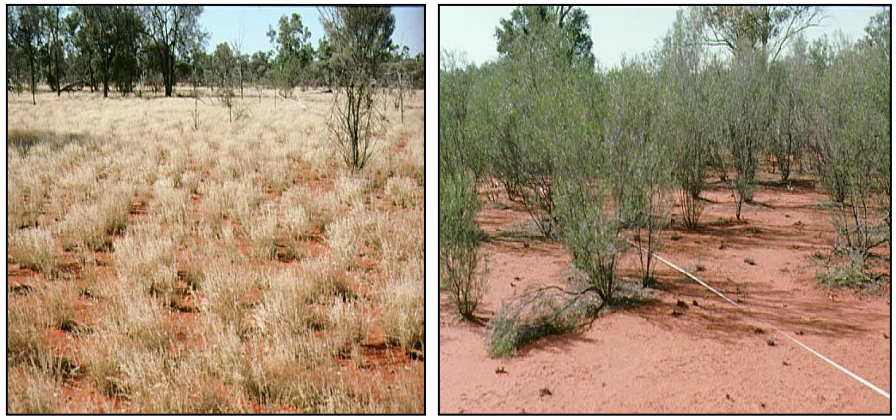
Key Needs: Theory

Large changes with persistent consequences:

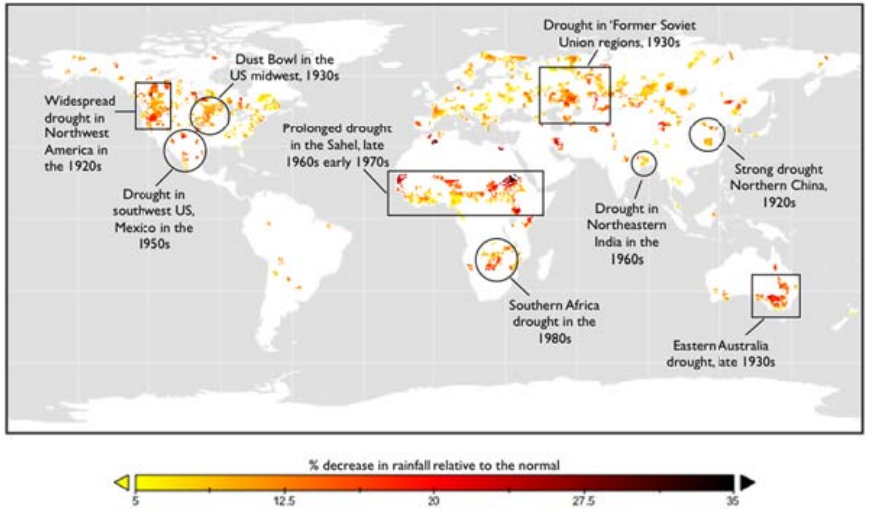
Photos: Steve Carpenter



Peters et al., 2007, Frontiers in Ecology & Environment 5: 221-224



Photos: David Tongway



Narisma & others, 2007, Geophys. Res. Lett.

Key Needs: Theory

Large changes with persistent consequences:

- Leading indicators?
- Probabilities?
- What is at risk?
- Can we build resilience to big changes?
- Can we adapt as drivers change?
- Can we build institutions for resilience and adaptation?

Do We Have the Science Needed to Manage Ecosystem Services?

There are many important gaps.

Theory

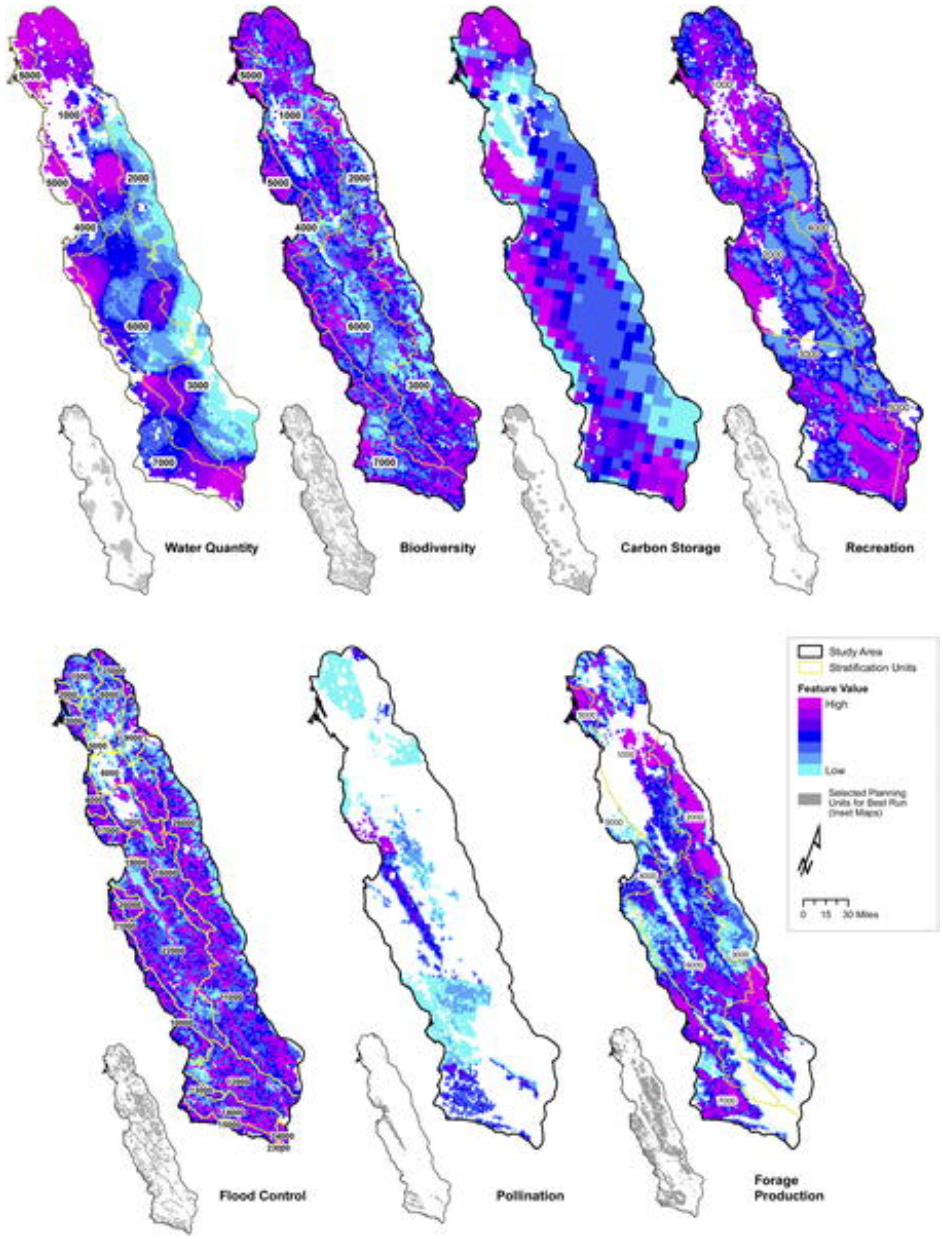
Multi-scale connections and interactions

Monitoring and indicators

Design of institutions or policies

Background:
(1) Carpenter , DeFries, Dietz, Mooney, Polasky, Reid & Scholes, 2006, Science 314: 257-258
(2) Liu and others, 2007, Science 317: 1513-1517

Key Needs: Multi-scale Interactions and Tradeoffs

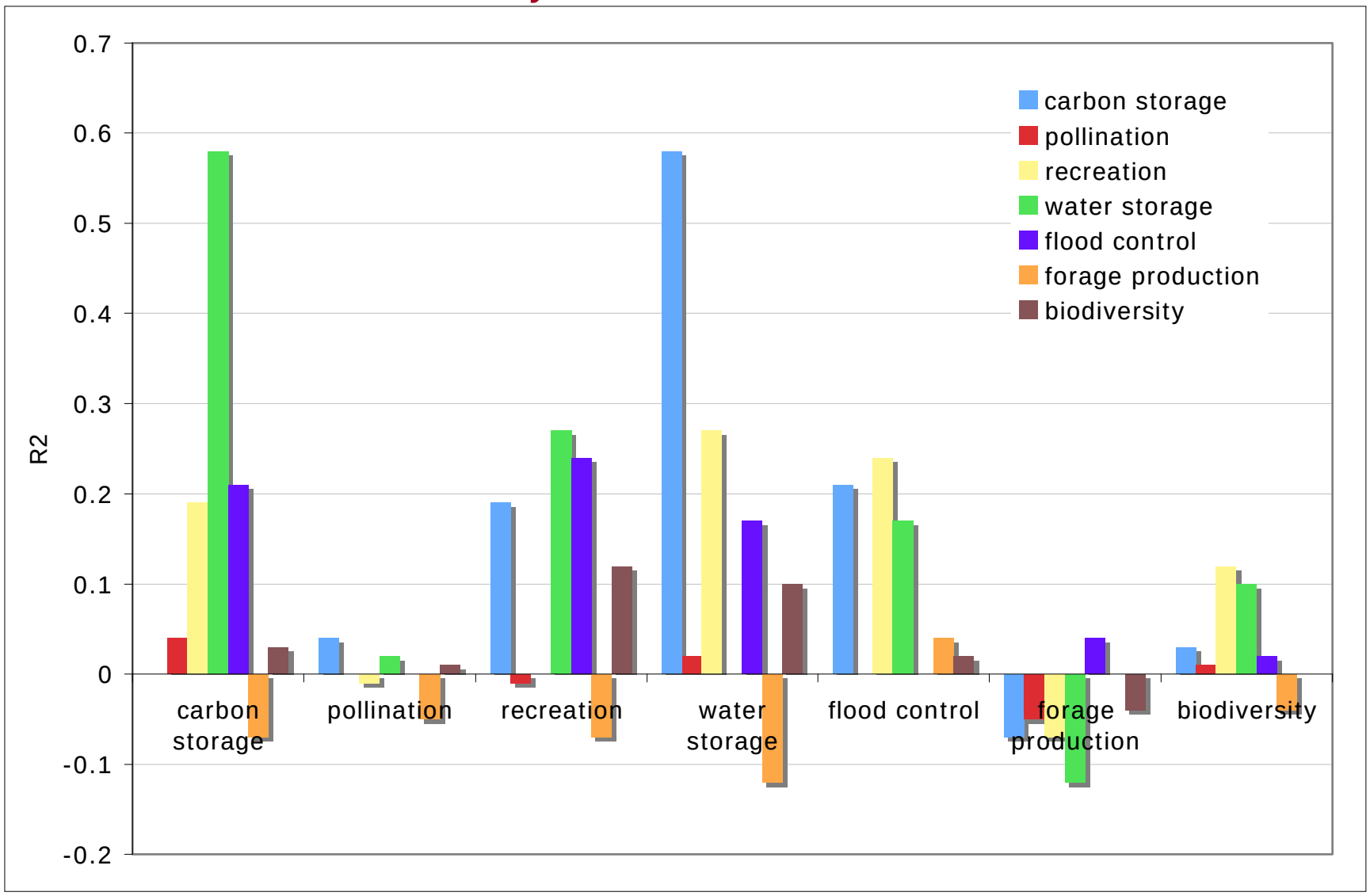


Chan et al., PLOS Biology 2006

S. R. Carpenter

Key Needs: Multi-scale Interactions and Tradeoffs

Correlations of Ecosystem Services: Central Coast, California



Source: Garry Peterson (McGill Univ.), based on data of Chan et al. PLOS Biology (2006)

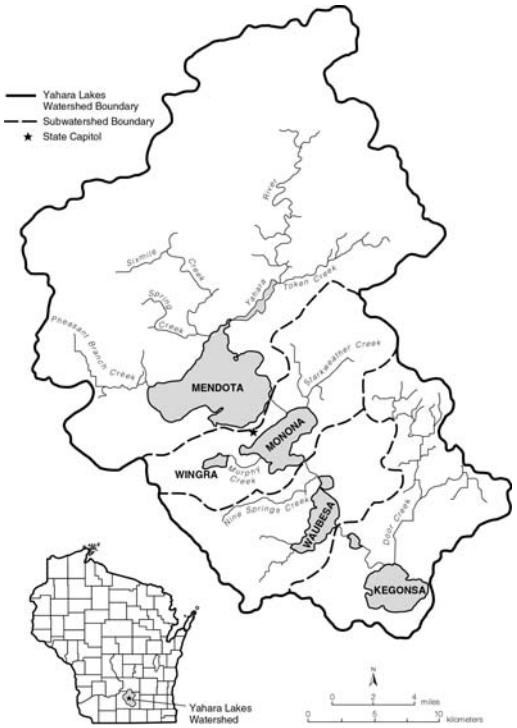
Key Needs: Multi-scale Interactions and Tradeoffs

Yahara Watershed:
Some Major Ecosystem Services

Provisioning E.S.:
Food
Freshwater
Fuel

Regulating E.S.:
Water regulation & purification
Erosion regulation
Climate regulation
Natural hazard regulation (flood, drought)

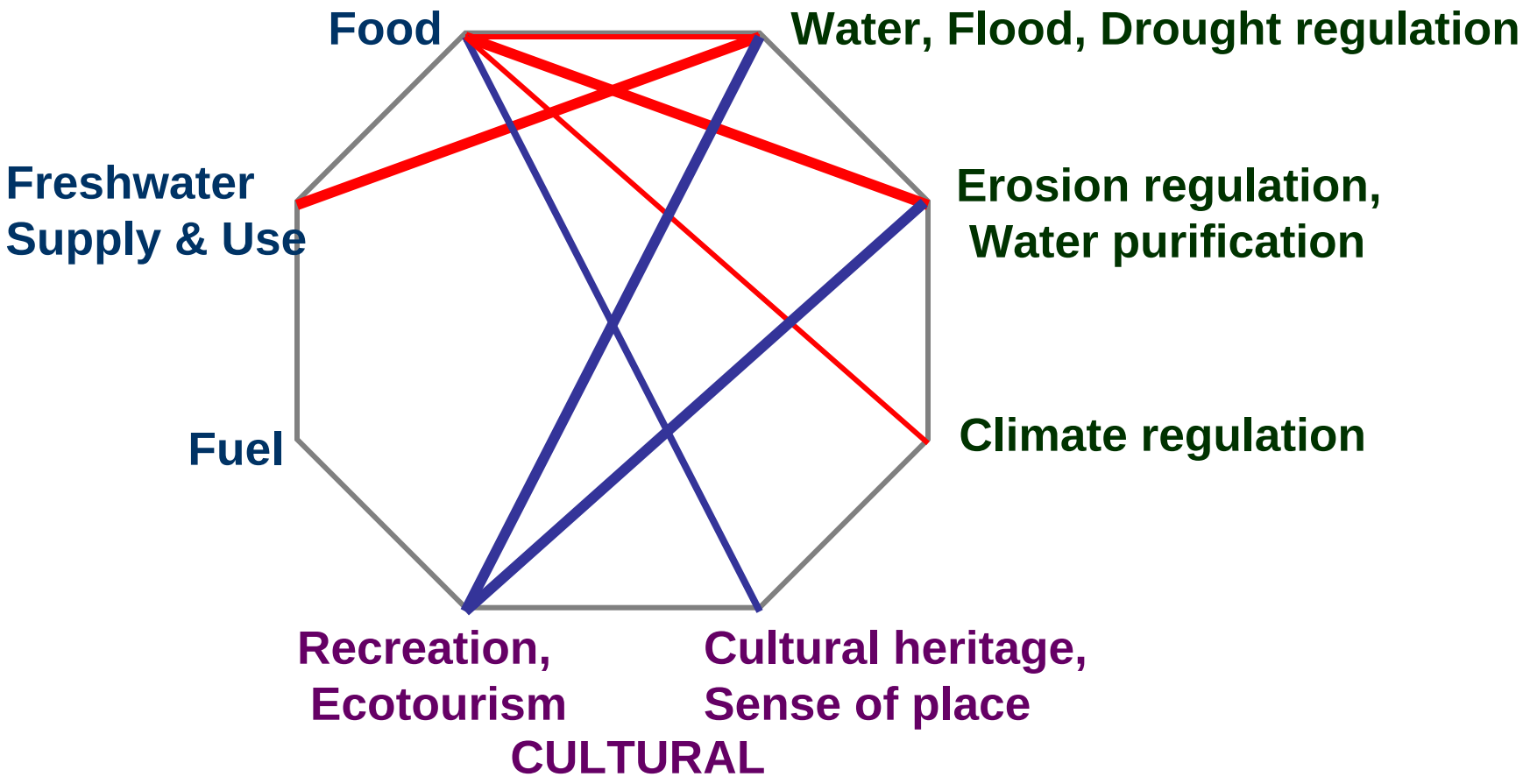
Cultural E.S.
Recreation, ecotourism
Cultural heritage, sense of place
Knowledge systems, education
Inspiration, aesthetics



Images: North Temperate Lakes LTER
http://lter.limnology.wisc.edu

S. R. Carpenter

Interactions of Ecosystem Services
Current Conditions

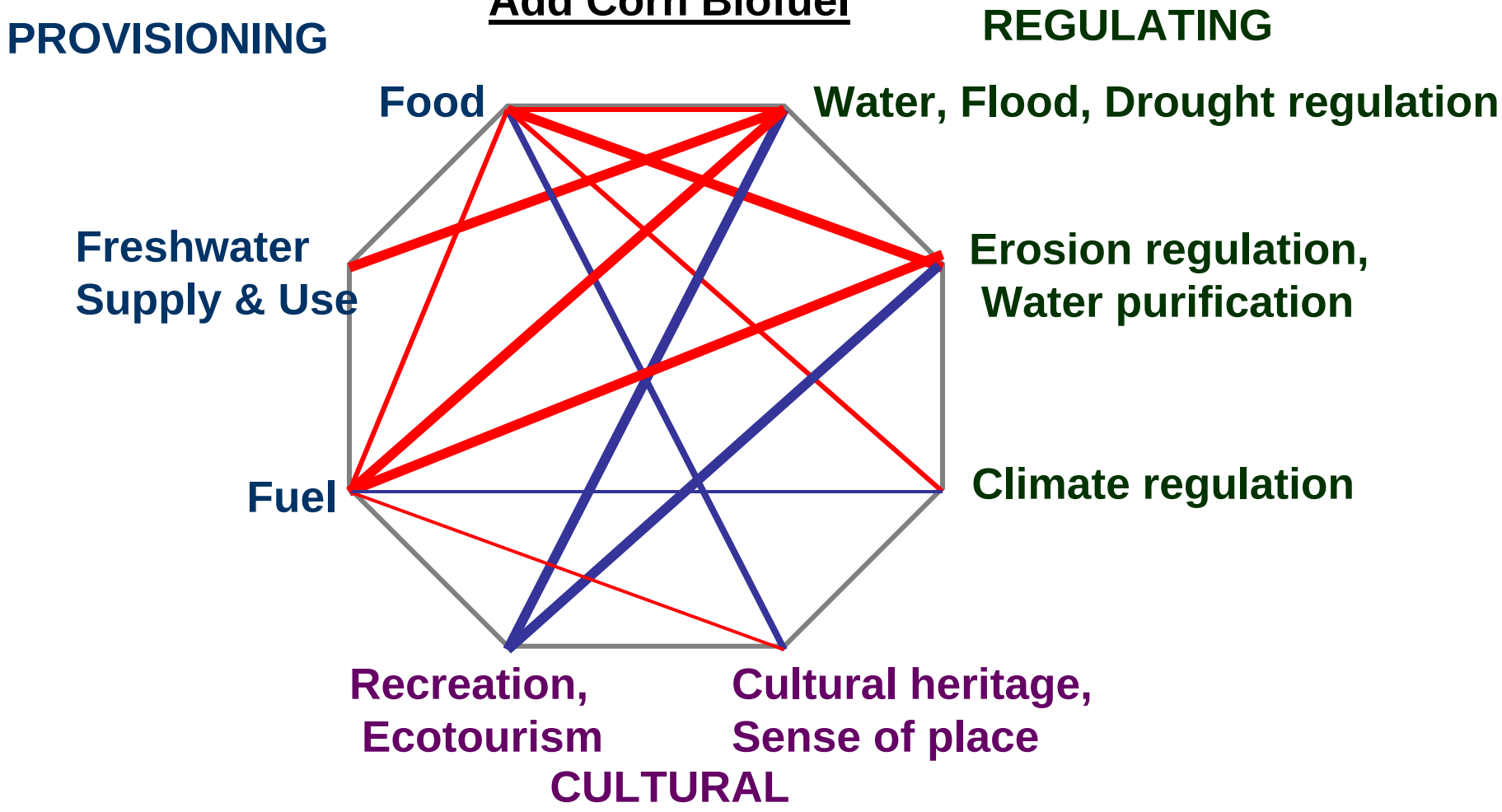


Positive interaction (line width indicates the
Negative interaction strength of the interaction)

S. R. Carpenter

North Temperate Lakes LTER, http://lter.limnology.wisc.edu

Interactions of Ecosystem Services
Add Corn Biofuel



Positive interaction (line width indicates the
Negative interaction strength of the interaction)

S. R. Carpenter

Key Needs: Multi-scale Interactions and Tradeoffs

How do ecosystem services “add up” across scales?

How do regional processes affect local ecosystem services?

How do local events alter large-scale ecosystem services?

How do policies aimed at a particular ecosystem service cascade to affect other ecosystem services?

What “bundles” of ecosystem services are possible from a given region?

What policies can shift a region from one bundle to a different bundle, with minimal disruption?

S. R. Carpenter

Do We Have the Science Needed to Manage Ecosystem Services?

There are many important gaps.

Theory

Multi-scale connections and interactions

Monitoring and indicators

Design of institutions or policies

Background:
(1) Carpenter , DeFries, Dietz, Mooney, Polasky, Reid & Scholes, 2006, Science 314: 257-258
(2) Liu and others, 2007, Science 317: 1513-1517

S. R. Carpenter

Key Needs: Monitoring and Indicators

"Despite advances in monitoring technology, the lack of uninterrupted time series of sufficient length to reflect social-ecological dynamics is a major problem. More disturbingly, the information available today is sometimes of poorer quality than historical information."

Carpenter , DeFries, Dietz, Mooney, Polasky, Reid & Scholes, 2006, Science 314: 257-258

Key Needs: Monitoring and Indicators

Some specific data gaps:

Comprehensive time-series information on land cover change

Locations and rates of desertification

Spatial dynamics of freshwater quantity and quality

Stocks, flows, economic value of ecosystem services

Trends in human use of ecosystem services

Key Needs: Monitoring and Indicators

Indicators of status & trends of ecosystem services:

No agreement on a manageably small set that can be applied consistently to serve the needs of researchers and decision makers

Significant issues:

- Indicators that reflect both ecosystem services and human-well being
- Indicators that are forward-looking
- Indicators that are scalable for different regions and across the US, or across the earth
- Methods for quantifying and communicating uncertainties

Do We Have the Science Needed to Manage Ecosystem Services?

There are many important gaps.

Theory

Multi-scale connections and interactions

Monitoring and indicators

Design of institutions or policies

Background:
(1) Carpenter , DeFries, Dietz, Mooney, Polasky, Reid & Scholes, 2006, Science 314: 257-258
(2) Liu and others, 2007, Science 317: 1513-1517

Key Needs: Design of Institutions or Policies

*"A key constraint in identifying what works and what does not work to create economic incentives for ecosystem conservation is the lack of empirical data supporting or refuting the effect of **any** approach"*

Millennium Ecosystem Assessment, Vol. 3, "Policy Responses"
(emphasis in original)

Key Needs: Design of Institutions or Policies

How can we

* Build institutions to manage use and tradeoffs among ecosystem services?

* Manage ecosystem services for resilience and adaptability in the context of pragmatic real-world problem solving?

* Coordinate ecosystem service tools across sectors and agencies to address current and future challenges to managers?

SUMMARY

Do we have science needed to manage ecosystem services?

No.

But some significant beginnings:

Recent efforts to quantify ecosystem services:

- What are they?
- How do people use them?
- How much of ecosystem capacity do people use?
- What aspects of human well-being are supported?

Growing recognition of the utility of ecosystem services for organizing information

Need to provide current and future livelihoods while maintaining the ecological foundations of life

S. R. Carpenter

SUMMARY

Do we have science needed to manage ecosystem services?

Specific Research needs:

Theory:

- Linkage of ecosystem services and human well-being
- Role of heterogeneity and diversity
- Large persistent changes

Connections and interactions

- Cross-scale feedbacks (local $\leftrightarrow$ regional)
- Synergies or conflicts among ecosystem services

Monitoring and Indicators

Institutions for resilience and adaptability of multiple ecosystem services

S. R. Carpenter

Ecosystem Services: Challenges and Opportunities

Steve Carpenter
University of Wisconsin-Madison
srcarpen@wisc.edu

Presentation for
“Transitioning to Sustainability through Research and Development on Ecosystem Services and Biofuels”

The National Academies’
First Federal Sustainability Research and Development Forum
October 17-18, 2007