Adaptive Management of Ecosystem Services

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Main requirement - Key challenge - Ongoing problem

Main requirement: to integrate ecosystem services into everyday decision making around the world (Levin 1999; Heal 2000; NRC 2005, Daily et al. 2009)

A key challenge: relative to other forms of capital, assets embodied in ecosystems are often poorly understood, rarely monitored, and are undergoing rapid degradation (Heal 2000a; MA 2005; Mäler et al. 2008).

An ongoing problem: the importance of ecosystem services is often recognized only after they have been lost (Chambers et al. 2007; Zeng et al. 2009).
Katrina killed or destroyed about 320 million large trees in Gulf Coast forests. The damaged trees subsequently released large quantities of CO2 to the atmosphere - the equivalent of 60-100% of the net annual carbon sink in all US forest trees (Chambers et al. 2007).

Management of ecosystem services

THREATS: land-use and resource extraction strongly affect how these ES are provided by natural and managed landscapes (Lambin et al. 2003).

RISK: degraded or lost ES flows have been associated with environmental and economic crises, and conflicts among stakeholders and decision-makers (Carpenter and Gunderson 2001); for example, collapse of fisheries (Carpenter and Brock 2004) and timber-based economies (Trosper 2003); conflicts over water rights and regulation in agricultural systems (Cassman et al. 2005), and so on.

MANAGEMENT CHALLENGE: the protection of natural capital (ecosystem services, ES) that society depends upon, sustaining ES flows to stakeholders and economies in the face of many types of social and ecological change.
Ecosystem Services in social-ecological systems

Social-ecological systems are complex adaptive systems where society and nature interact at multiple temporal and spatial scales (Gunderson and Holling 2002; Westley et al. 2002; Berkes et al. 2003; Walker et al. 2004; Waltner-Toews and Kay 2005; Janssen and Ostrom 2006)
Ecosystem Services in socio-ecological systems

Source: Beier et al. 2008 - Ecosystems
Interaction among ESs

ESs interact with one another in complex, often unpredictable ways.
Knowledge of their interactions is necessary for making sound decisions about how society manages the services provided by nature.

Specific policy-relevant interactions among ecosystem services (MEA 2005)

Synergisms

Trade-offs
Synergism ecosystem services interact with one another in a multiplicative or exponential way. Synergisms can have positive and negative effects (Sala et al. 2000).

If society chooses to improve the delivery of an ecosystem service, and this service interacts in a positive and synergistic way with another ecosystem service, the resulting overall benefit could be much larger than the benefit provided by one ecosystem service alone.
<table>
<thead>
<tr>
<th>Trade-offs</th>
<th>the provision of one ecosystem service is reduced as a consequence of increased use of another ecosystem service.</th>
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<td>Trade-offs are critical for determining the outcome of environmental decisions.</td>
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<td>Trade-offs</td>
<td>may be the consequence of an explicit choice</td>
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<td>can happen without premeditation or even awareness that they are taking place</td>
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Trade-offs among ESs: Spatial and Temporal scales

Spatial scale: whether the effects of trade-offs are felt locally or at a distant location

- Use of water
  - Drinking water for a town
  - Irrigation water to an agricultural area
  - People downstream without water
Trade-offs among ESs: Spatial and Temporal scales

spatial scale
whether the effects of trade-offs are felt locally or at a distant location

Increasing fertilizer use

Increasing of agricultural production

Broad-scale effects on water quality
Interaction among ESs: Spatial and Temporal scales

temporal scale

whether trade-offs take place relatively rapidly or slowly

Ecological reason

Many natural processes, such as those that create soil or alter soil fertility and groundwater levels, occur at very slow rates

Many generations may pass before significant effects are perceived by humans
Interaction among ESs: Spatial and Temporal scales

Ecological reason

Dryland salinization in Australia (Anderies et al. 2001; Greiner and Cacho 2001; Briggs and Taws 2003)

To increase agricultural production

Regulating service by keeping the groundwater at low enough levels, avoiding salts carried upward through the soil

Water table moving toward the surface, bringing salts from the basement to the surface soils
Interaction among ESs: Spatial and Temporal scales

temporal scale whether trade-offs take place relatively rapidly or slowly

Political reason

Management decisions often focus on the immediate provision of an ES, at the expense of the same or other services in the future

↓

The term of elected officials is short enough that the ecological impacts of their decisions will probably be taken into account by others than themselves
Why the trade-offs happen?

1. we are ignorant of the interactions among ES (Tilman et al. 2002; Ricketts et al. 2004)

2. our knowledge of how ES work is incorrect or incomplete (Walker et al. 2002)

3. when the ES involved have no explicit markets (Rodríguez et al. 2006)

4. many management actions affect more than one ecosystem service at a time and may operate at different scales simultaneously (Daily et al. 2009)

Scale mismatch between the intent of a particular management decision, the expected outcome, and the long-term or broad spatial scale of the decisions (van Jaarsveld et al. 2005)
The problem of management

Ecosystem and resource management, conservation, restoration, and development decisions are often made without considering ecosystem services or the possible impacts on services.

The reasons why ecosystem services are not considered into decision making can be grouped into four fundamental categories (Hogan et al. 2009):

1. Ecological,
2. Geographic,
3. Socioeconomic, and
4. Institutional.

The problem of management

Ecological: we do not have an adequate understanding of the ecological processes that produce ecosystem services, and there may be currently unrecognized processes.

Geographic: we do not fully understand the spatial and temporal dimensions of ecosystem service production, use, and values.

Socioeconomic: we do not have adequate information on the monetary and non-monetary value of ecosystem services.

Institutional: institutional processes, structures, and instruments do not adequately facilitate the routine consideration of ecosystem services in decision making.

The overview of adaptive management


The basic concept of AM is that if human understanding of nature is imperfect, then human interactions with nature [e.g., management actions] should be only experimental (Lee 1993).

Adaptive management

Passive (models)

Active (to test hypotheses about ecosystem states and responses)
Adaptive management diagram

- Identify clear, measurable, and agreed-upon management **objectives**
- Identify a set of potential management **actions** for decision making
- Identify models that characterize different ideas (**hypotheses**) about how the system works

**Indicators** are monitored to determine how effective actions are in meeting management objectives
Adaptive management: cross-scale interactions
Adaptive management: cross-scale interactions and ecosystem services

Stakeholders and Decision-makers

Spatial scale

Local

Regional

National

European/International

Temporal scale

Assess problem

Adjust

Design

Evaluate

Monitor

Implement
Adaptive management: cross-scale interactions and ecosystem services

Policy to increase biofuel production by 10% 2020 (DIR. 2003/30/EC)

Low production of food
Over-use of water
Effects on biodiversity
Reduction of forests

Temporal scale

Spatial scale

European/International

Stakeholders and Decision-makers

Adaptive management: cross-scale interactions and ecosystem services

Assess problem
Design
Evaluate
Implement
Monitor

Adjust
Stakeholders and Decision-makers

Economic incentives

National

Regional

Local

Spatial scale

Temporal scale
Cross-scale interactions among the different plans in the same country

Energy
- Local
- SH and DM
- Stakeholders and Decision-makers
- Regional
- National
- European/International

Tourism
- Local
- SH and DM
- Stakeholders and Decision-makers
- Regional
- National
- European/International

Agriculture
- Local
- SH and DM
- Stakeholders and Decision-makers
- Regional
- National
- European/International

Cross-scale interactions among the different plans in the same country
Strategic Environmental Assessment (SEA) for Adaptive Planning and Management

SEA Directive 2001/42/EC  \rightarrow  National Law in European countries (Italy Law n. 152/2006)

Plans and Programs that may have a significant impact on the environment

“Scoping”, defining the boundaries of assessment and setting the development objectives of the plan
“Documentation of the state of the environment”, effectively a *baseline* on which to base judgments
"Determination of the likely *environmental* impacts", usually in terms of direction of change
“Identifying the coherence” with other plans and programs
“Informing and consulting the public”, participatory approach
“Influencing Decision taking” based on the *assessment* and,
“Monitoring” of the effects of plans and programmes after their implementation (performance indicators).

Adjust plans and programs
Conclusions

Effective decision making, which allows policy makers to include a comprehensive view of ES trade-offs, should address the cumulative and synergistic effects of their decisions.

Managers need to acknowledge that short-term demands on ES will affect the longer-term, larger-scale provision of them.

Successful management policies will be those that incorporate lessons learned from previous decisions into future management actions (learning-by-doing).
Conclusions

Managers should implement their actions with monitoring programs that, in addition to monitoring the short-term provision of services, also monitor the long-term evolution of slowly changing variables.

Policies can then be developed to take into account ES trade-offs at multiple spatial and temporal scales.

Successful strategies will recognize the inherent complexities of ecosystem management and will work to develop policies that minimize the effects of ES trade-offs.
Some Open Questions

Is it possible to identify the scales at which policies should be targeted for managing ESs?

Is it possible to determine how far-reaching the effects of particular decisions can be?

Adaptive management (flexibility) can be a good panacea for solving the problem of ecosystem services’ management?

Considered the central role of stakeholders and decision-makers in AM how can we integrate the set of preferences, the possible roles of information, and individual perceptions and reactions?
Thank you for your attention