

ECOLOGY

Millennium Ecosystem Assessment: Research Needs

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The Millennium Ecosystem Assessment (MA) was designed to meet the needs of decision-makers for scientific information on the consequences of ecosystem change for human well-being (1–3). Even though the intended audience is decision-makers, the scientific community is involved as assessments are being made, especially when research and data gaps become apparent. Here we summarize the most important information needs encountered in the MA work.

Basic Theory

We lack a robust theoretical basis for linking ecological diversity to ecosystem dynamics and, in turn, to ecosystem services underlying human well-being. We all need this information to understand the limits and consequences of biodiversity loss and the actions needed to maintain or restore ecosystem functions.

The most catastrophic changes in ecosystem services identified in the MA involved nonlinear or abrupt shifts. We lack the ability to predict thresholds for such changes, whether or not a change may be

reversible, and how individuals and societies will respond. Thus, the risks of ecosystem catastrophes are poorly quantified. Major ecosystem degradation tends to occur as syndromes of simultaneous failure in multiple services. For example, the populous dry lands of the world are facing a combination of failing crops and grazing, declining quality and quantity of fresh water, and loss of tree cover. Similarly, many rivers and lakes have experienced increases in nutrient pollution (eutrophication), toxicity, and biodiversity loss.

Relations between ecosystem services and human well-being are poorly understood. One gap relates to the consequences of changes in ecosystem services for poverty reduction. The poor are most dependent on ecosystem services and vulnerable to their degradation. Empirical studies are needed.

Local to Global Scales

Local processes sometimes spread to become important regionally or globally, but ecosystem services at more aggregated scales are seldom simple summations of the services at

The research community needs to develop analytical tools for projecting future trends and evaluating the success of interventions as well as indicators to monitor biological, physical, and social changes.

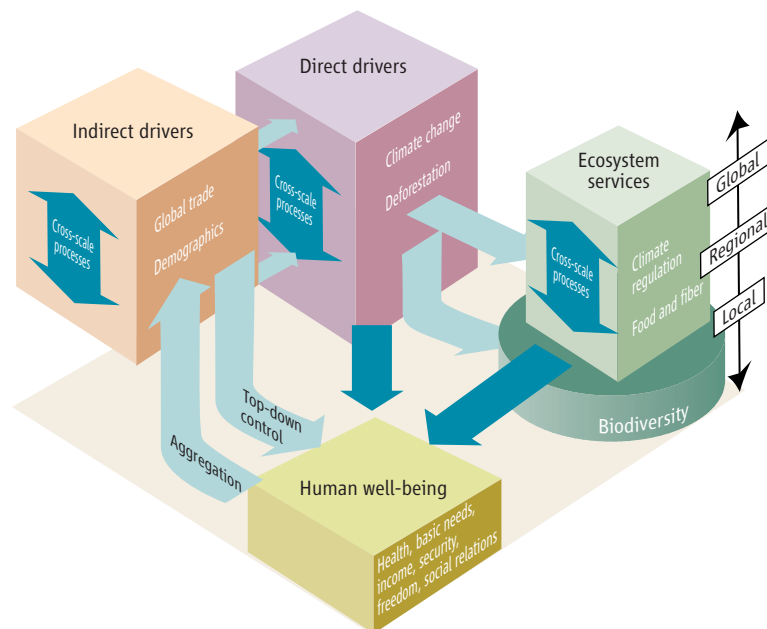
finer scales. An example of a cross-scale effect is the loss of buffering coastal ecosystems that exposed extensive regions to catastrophic damage in the 2004 Asian tsunami and the 2005 Gulf of Mexico hurricanes. Conversely, most services are delivered at the local scale, but their supply is influenced by regional or global-scale processes (see figure). Although there are many case studies, our capability of predicting emergence of cross-scale effects and their impacts on ecosystem services is limited. A related problem is the mismatch between the scales at which natural and human systems organize. These lead to failures in feedback, when, for instance, benefits accrue at one scale, but costs are carried at another. We need robust, manageable frameworks for analyzing ecosystem services at multiple scales. Inclusion of “subglobal” assessments in the MA was a tentative step in this direction.

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. For example, hydrology monitoring networks in many countries are deteriorating, and institutions to maintain long-term records of Earth observations from satellites are not in place.

Specific data gaps that posed serious constraints in the MA analysis include the lack of (i) global time-series information on land cover change; (ii) adequate information on location and rate of desertification; (iii) global maps of wetlands distribution; (iv) systematic information

Enhanced online at
www.sciencemag.org/cgi/
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The MA conceptual framework (2), modified to illustrate connections among local, regional, and global scales for a few processes. Light blue arrows indicate actions that are amenable to policy interventions.

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