ECOSYSTEM MANAGEMENT IN THE 21ST CENTURY

By
Jeffrey A. McNeely
Chief Scientist
IUCN-The World Conservation Union
1196 Gland, Switzerland
email: jam@iucn.org

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INTRODUCTION

The 20th century was the seminal one for the field of ecology, as the science emerged from 19th century natural history into a discipline with numerous practitioners, significant journals, university departments, and major textbooks. As a science, ecology has reached a satisfying level of maturity.

But the 20th century also saw a remarkable expansion of the ecological impact of *Homo sapiens* and its associated species, with the human population quadrupling and consumption of resources increasing 20-fold. While mid-20th century ecologists often focused on "natural ecosystems" where humans were not a significant factor, by the end of the century it became obvious that making ecology relevant to decision making would require much greater attention to incorporating human considerations into research designs. Further, the multilateral environmental agreements, such as the Convention on Biological Diversity, the Convention to Combat Desertification, the Convention on the Law of the Sea, the Wetlands Convention, the World Heritage Convention, the Biosphere Reserves Programme, and various others, all call for a more significant contribution from ecosystem management. IUCN too has become even more dependent on advice from ecosystem-oriented scientists and practitioners. This short paper is presented to the CEM Steering Committee as a means of stimulating discussion on potential ways forward.

THE BASICS OF ECOSYSTEM MANAGEMENT

As bit of background may be helpful, simply restating issues that undoubtedly are well known to the CEM Steering Committee, I suggest 10 tools for implementing ecosystem management:

1. **Focus on management**. EM provides a basis for making land use decisions that satisfy both economic and environmental aspirations at the same time and on the same land. It calls for management action, based on science, monitoring, economics, and stakeholder involvement. The ecosystem services that nature provides require management interventions ranging from strict protection through to controlled harvesting. Some parts of an ecosystem will need to be protected against continuing direct human use in order to provide the services sought from them, while others may involve altering agriculture, forestry, or fishing practices, for example to ensure water catchment maintenance or wetland function for waste recycling in the landscape.

The first requirement of EM is clearly-stated management objectives and goals for the particular site or landscape. But generally, EM supports management for ecosystem processes, such as nutrient cycling, energy flow, and water flow; landscape processes such as succession, fire, and other natural disturbances; and native species processes, such as migrations, multiple life history strategies, multiple functional guilds, and evolution of species and other levels of biological diversity. Management should permit natural disturbances such as floods, fires, and droughts wherever practical. For example, in some parts of the world, the fragmentation of habitats has led to the suppression of natural fires that were necessary for maintaining biodiversity; and removing floods from rivers can lead to increases of predator-resistant grazing insects which divert energy away from the food chain supporting predatory fish that are economically important to humans (Wootton, Parker, and Power, 1996). EM would need to restore these landscape-scale processes as appropriate.

2. **Focus on people as part of the ecosystem**. Humans are fundamental influences on ecological patterns and processes and in turn are affected by them, so human values play a dominant role in EM goals. Indeed, it typically is humans that are managed, not ecosystems. EM has policy implications regarding changing power relationships and addressing diverse human values as part of the management process. EM draws on science, but more fundamentally is a political process involving many stakeholders to determine which values will dominate how ecosystems are to be managed, what goods and services are to receive priority, and how the costs and benefits are to be distributed.

3. **Focus on science**. EM must be based on the best available science and continually adapt to new information and knowledge. In this sense, EM is experimental, enabling it to adapt to changing local, national, and international realities and to recognize scientific, political, economic, and cultural dynamics. Science enhances the quantitative basis for decision making in EM. Scientists can work with planners to define hypotheses and reconcile statistical and practical designs and work with resource managers to select schedules, variables, and techniques for measurement.

   A critical element of EM is to ensure that results of science can be presented to non-scientific audiences; geographic information systems (GIS) can be extremely useful in this regard (Alpert, 1995). EM has long-term goals, whereas managers often need quarterly to annual measures by which to adjust prescriptions and report to investors or central budgetary authorities. Scientists might resolve this dual need with indicators that characterize goals (such as species richness or soil nitrogen pools) and variables by which to steer toward them (e.g., reproductive rates, nitrogen concentration in runoff). And both scientists and managers will want steering variables to reflect but not confound the effects of both management practices and natural fluctuations on a key system function or resource. For example, simultaneous measurements of variability in stream flow, variability in precipitation, and change in land-use would indicate the consistency of water availability to many organisms in a system and could be adjusted for unusual precipitation to assess the effects of forest clearing or soil compaction.

4. **Focus on biodiversity**. The biodiversity hierarchy, including genes, species, populations, ecosystems, and landscapes, needs to be addressed in totality, including connections between the levels using a systems perspective. The systems approach of EM argues that it is impossible to understand the components of an ecosystem except as parts of the system. Thus effective single-species management is only possible within an ecosystem framework that addresses all parts of the hierarchy.

   While evidence on the ecosystem function of biodiversity is still somewhat mixed, ecological processes are buffered from perturbation by redundancy among elements or components of biodiversity. But if many components are lost, any process can be impaired, and as stress on system organization accumulates, non-linear or threshold responses may result, leading to a fundamental change in the state of the ecosystem. Generally speaking, the functioning and stability of terrestrial ecosystems are determined by plant biodiversity and species composition, including various below-ground fungi and micro-organisms (van der Heijden *et al*. 1998), showing that microbial interactions can drive ecosystem functions such as plant biodiversity, productivity and variability. The results of such studies are important elements of EM, identifying the ecological mechanisms by which plant biodiversity and species composition are regulated, in order to design successful management programmes for conservation and restoration of diverse natural ecosystems.

5. **Focus on ecological boundaries**. Ecosystems cannot be easily and precisely defined, especially in such a dynamic world, but management requires defining ecological boundaries at appropriate scales. While the main focus of EM is on large ecosystems (= bioregions or landscapes), EM can also be applied at much smaller scales, even smaller than a protected area, depending on the problem being addressed. Geographical scale is not defined by the hierarchical level. Ecological elements are typically defined by their spatial extent, yet most levels can correctly encompass a wide range of spatial scales, with some ecosystems being tiny and others covering vast expanses. A significant obstacle remains defining the ecosystem for which planning and management are undertaken. Typically, management units bear little relation to the realities of ecological systems, their connections to economic and social processes, or the cultural and political identity of local people. Too often, protected areas and other management units are arbitrarily defined by lines drawn on a map. Humans often use rivers as boundaries to mark jurisdiction and property, but rivers are the centres of drainages, not their edges, so using rivers as borders has a fundamental flaw, separating human interests along lines where human concerns should be much more coherent.

6. **Focus on ecological processes, services and functions**. Within the EM framework, biodiversity is part of the engine generating the ecosystem services, and at the same time provides a service to those same geographic spaces. Biodiversity conservation is thus part of the landscape along with by-products such as carbon storage and water protection. EM treats ecosystems as dynamic, focusing on resilience and adaptability rather than stability. Biodiversity is closely linked to ecosystem processes, functioning, and resilience, though the linkages are as yet poorly understood.

7. **Focus on ecological integrity**. Ecological integrity involves protecting total native biodiversity at all levels, as well as the ecological patterns and processes that maintain that diversity. This may include conserving viable populations of native species, maintaining natural disturbance regimes, reintroducing of native extirpated species, representing ecosystems across natural ranges of variation, and so forth. This perspective may sometimes conflict with the traditional standard of providing goods and services for humans. By definition, naturally evolved assemblages possess integrity but random assemblages do not. Adding non-native species or genes from distant populations may increase local diversity but reduce integrity. The functional and evolutionary limits of the native biota provide objective bases for selecting appropriate integrity benchmarks. For example, when forest harvest rates exceed regeneration rates, integrity is reduced, resulting in loss of late-successional communities. When a river is dammed, integrity is reduced, resulting in declines of populations adapted to the natural hydrological regime. Biodiversity is an important indicator of biological integrity, because components of biodiversity are more sensitive to degradation, better understood, and less expensive to monitor than are processes. Adopting ecological integrity as a primary management goal provides a workable framework for sustainable resource use, but fostering integrity requires societal commitment well beyond government regulations and piecemeal protection.

8. **Focus on adaptive management**. Adaptive management requires data collection on a continuing basis, monitoring of management actions as a basis for evaluation, and feedback of improved scientific knowledge to improve management. Monitoring is essential to provide information for assessment and adaptive management. Selecting appropriate indicators and designing effective monitoring programmes is critical, but difficult due to the complexity of the task. Useful native plants may be appropriate indicator species because monitoring them provides information simultaneously on both ecological and socio-economic change. In addition, monitoring useful species is necessary for establishing management plans for their sustainable use.

9. **Focus on cooperation among stakeholders**. The success of EM depends on establishing a voluntary partnership of the groups, landowners, organizations, individuals, and corporations having a stake in the future of the target ecosystem. Ecological boundaries may require cooperation between a number of government agencies at various levels, the private sector, NGOs, scientists, and local land owners, leading to fundamental changes in the structure of resource management agencies and the way they operate. Stakeholders include any individuals or groups who have rights of access and ownership to the ecosystem, recognized under modern legal or traditional tenurial regimes. Stakeholders must become full partners in planning and implementing programmes if they are to be successful, often selecting issues of common interest for action and investment.

   Stakeholder cooperation is not easy. For example, a high proportion of threatened species are affected by either fire suppression within their fire-maintained habitats or by non-native species. Such threats must be addressed through active, "hands-on" management of the habitat, such as pulling up alien plants and trapping alien animals or using prescribed fire to regenerate early successional habitats. Conservation legislation may prohibit actions that directly harm listed species, but typically it does not require land owners or concession holders to take affirmative actions to maintain or restore habitats for them. Thus, a land owner is under no obligation to control exotic weeds, undertake a programme of prescribed burning, or do any of the other things that may be essential for the long-term survival of many threatened species. In fact, it may be possible for a land owner to rid himself of an endangered species "problem" by literally doing nothing and waiting until the habitat is no longer suitable for the species in question. Even those land owners who wish to protect endangered species face considerable costs of undertaking these management actions. EM can provide a framework for defining and supporting conservation action on private land.

Management through dialogue and cooperation among stakeholders will be quite different from the traditional management imposed from a centralized government agency. The implied stakeholder consultations will need to consider the changing role of professional, trained resource managers; building a common information base among people with widely varying levels of knowledge and disparate values; assigning responsibility for implementation; dealing with multi-cultural aspects of values; and reconciling potentially time-consuming consultation processes with judgements that demand speedy resolution (Grumbine, 1994).

10. **Focus on values**. Grumbine (1994) concludes that the main long-term implication of the concept of EM is a transformation of personal and social values. EM can be seen ultimately as a political imperative, searching for broad consensus for objectives that are morally compelling and able to support a politically sustainable framework for action within the ecosystem.

NEW DIRECTIONS FOR CEM

Having defined the toolbox, how can CEM enhance its relevance to the key issues facing modern society? Here are a few suggestions:

- **Agriculture**. A vicious cycle of poverty affects 1.5 billion people in developing countries who depend on low-productivity food production systems, and at the same time stands in the way of achieving globally sustainable biodiversity. Poor rural people often seek their livelihoods in areas of the greatest biodiversity value as well as the greatest biodiversity and ecosystem decline. To break the cycle, new investments to reach the Millennium Development Goals agreed by governments in 2000 must pursue agriculture and biodiversity objectives jointly, while enhancing their contribution to the MDGs on water, health, and other issues. Ecosystem management, focusing at the landscape scale, can seek to use unfarmed areas to develop habitat networks that support or expand the habitat of wild species, design protected areas in agricultural regions in ways that also benefit local farming communities, and develop ways to modify the management of soil, water, and vegetation to enhance habitat quality in and around farms. CEM could provide useful technical advice for implementing such measures.

- **Invasive alien species**. The general global problem of invasive alien species has been brought to the world's attention only relatively recently by ecologists who were concerned that native species and ecosystems were being disrupted. Over the past several years, the issue of invasive alien species has risen remarkably on the global conservation agenda, driven especially by the desire to implement Article 8(h) of the Convention on Biological Diversity. While the problem is global, the nature and severity of the impacts on society, economic life, health, and natural heritage are distributed unevenly across nations and regions. Thus some aspects of the problem require solutions tailored to the specific values, needs, and priorities of individual nations while others call for consolidated action by the larger world community. CEM could make a powerful contribution to the global effort to address this problem by supporting the IUCN linkage to the Global Invasive Species Programme (GISP). GISP has prepared a global strategy on invasive alien species (McNeely, *et al*., 2001) and a toolkit of best prevention and management practices (Wittenberg and Cock, 2001). A secretariat has recently been established in South Africa, but a stronger scientific foundation at the ecosystem and landscape level could be provided by CEM (working in collaboration with the species-oriented approach of the SSC Invasive Species Specialist Group).

- **Ecosystems and human health**. Ecosystem management has a long history of incorporating health concerns in its work, including the role of parasites in maintaining ecosystem diversity, habitat management to reduce health impacts, the role of secondary compounds in resisting leaf predators, and so forth. But new challenges are now arising, and an entire new field of ecosystem health has recently emerged, with conferences, journals, and other publications. CEM might wish to consider appointing a task force to explore options for working in ecosystem health, perhaps building on the recent publication to which IUCN contributed (Chivian *et al*., 2002). Activities that jointly address biodiversity and human health at the ecosystem level, and where CEM could provide useful contributions could include: linkages among climate change, changes in biodiversity, and changes in disease vectors; the value of conserving ecosystem services as a contribution to human health (for example, air purification, binding toxic elements, detoxification of sediments and soils); ecosystem effects of collecting medicinal plants from natural ecosystems; ecosystem disturbances and their effects on infectious diseases; and the effects of biodiversity changes on infectious diseases.

- **Ecosystems and violent conflict**. Much evidence indicates that current patterns of resource exploitation are not sustainable. The rates at which modern societies are using water supplies, forests, grazing lands, agricultural lands, and energy are approaching natural limits in many regions, and are rising both through increasing individual consumption and growing numbers of people. Competition over resources is causing increasing social and political tension, and this is likely to spread and deepen along with increased resource utilization. The violent conflicts that plague today's world suggest that IUCN should give urgent priority to addressing the environmental roots of such tension as a means of seeking to reduce the likelihood of violent conflict. Community livelihoods -- especially among traditional communities in areas rich in natural resources -- are fundamentally dependent on environmental services and renewable resources, and are highly vulnerable to changes in that resource base. People living in remote resource-rich areas often are the main victims of conflict, as recent violence in Brazil, Colombia, Indonesia, New Caledonia, Congo, Sierra Leone, Ivory Coast, and Myanmar, among many others, illustrate. Conflicts can be even worse in resource-poor areas, especially when they are exacerbated by drought and other disasters; Afghanistan, Somalia, and various parts of the Sahel are dramatic recent examples. At the World Conservation Congress in Amman, Resolution 2.40 called for a greater understanding of the underlying cause of conflict, especially as they affect biodiversity. CEM could make important contributions by helping to define new approaches for increasing environmental security as a basis for sustainable development. CEM could also make a useful contribution by helping to design appropriate approaches for dealing with watershed and transboundary river basins, thereby bringing areas of potential conflict under more collaborative forms of management. CEM might also consider how it can best contribute to post-conflict recovery, which all too frequently ignores the environmental dimensions that could provide the best basis for sustainable recovery.

The above are just a few examples among many activities that would enable CEM to move into significant new areas of work that will help IUCN to both implement its programme, promote its mission, and make a more useful contribution to sustainable development.

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