tion systems (GIS) are used by local people to consolidate, store, and analyze their data to make resource management decisions. In the Sandwe area, for example, after extensive discussion of GIS analyses, the community decided to relocate 58 families that had recently settled in the richest wildlife areas of their community land (*16*). Equally important to CBNRM is the fact that science can help integrate analyses and policy formulation across ecological and sociopolitical scales. In Madagascar, for example, scientists and villagers developed social and biological monitoring programs for an area that had complex overlapping ecological and social units (*17*).

Partnerships between academic scientists and villagers require that scientists solicit and heed the knowledge and opinions of local women and men. The role of the scientist is to provide knowledge and political leverage to enable communities to implement their own decisions and affect decision-making at higher levels (*18*). The goal is policies and institutions that enable local people to have sustainable livelihoods where they live and an effective voice at higher sociopolitical levels.

Scientific methods can also evaluate the potential for reestablishing native species that have disappeared and maximizing long-term sustainable use rates for existing species (*19*). Such evaluations involve estimates of carrying capacities under different environmental conditions (wet years versus drought years, for example) and projected average long-term offtake rates and income flows. Such estimates are important in providing benchmarks for community leaders to judge the benefits of sustainable wildlife utilization against alternative competing land use options, typically dryland cropping.

Wherever villagers are willing participants, collaboration should result in a bridge across the technology gap that presently inhibits local communities from using low-end technologies. This bridge could be provided by local individuals with the skills and training to maintain equipment for monitoring environmental and biological population variables, use hardware and software for data management, and use and interpret output from decision analysis algorithms for assessing the effects of different policies on animal populations and the ecosystem. To be effective, collaboration between villagers and scientists must involve locally controlled experimentation and adaptation, rather than be a blueprint for the transfer of technology (*20*).

Conservation and the sustainable use of natural resources are two sides of the same coin. CBNRM accepts that much of the state of ecosystems rests with local people and, therefore, the technology that can contribute to the sustainable use of natural resources is best used by local people. This will require partnerships between professional scientists and their "civil scientist" counterparts at the village level (*21*). Scientists who wish to be effective in conserving biodiversity for further generations will have to learn how to operate in this new arena.

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POLICY FORUM: CONSERVATION

Capitalizing on Nature: Protected Area Management

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Recent debate in *Science* (*1*) and elsewhere reveals the financial difficulties of government agencies responsible for biodiversity conservation in the developing world. It reflects a growing paradox. On the one hand, such agencies hold embarrassingly large land assets (often in excess of 5% of the total area of a country), which are expensive to maintain but can in some cases create the majority of their earned revenues through tourism. On the other hand, many protected areas (PAs) are by definition socially exclusive, a point receiving growing criticism from an increasingly democratized populace at home and from the international community. Many agencies have responded through new initiatives, such as outreach, rural development, and Community-Based Conservation (CBC). But these activities are expensive, their conservation benefits are ambiguous, and they have little prospect of generating income to cover their costs. The result has been more or less uniform: Biodiversity agencies throughout the developing world remain financially strained.

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Costs of the PA Estate

International conservation organizations such as the World Conservation Union (IUCN) propose that 10 to 12% of the total land area of each nation or each ecosystem should be set aside for conservation (*2*). With apparent sincerity, Soule and Sanjayan (*3*) suggest that closer to 50% of the total land area is necessary "to represent and protect most elements of biodiversity." Neither of these estimates enlightens us about the cost implications of PAs to people in the developing world.

One country that has achieved the IUCN target is Kenya, where 10% of the land area, about 60,000 km^2, is under PA status. To illustrate the costs of putting the land under protection, a recent study calculated that this estate could support 4.2 million people and agricultural and livestock production with a net return of $203 million, or 2.8% of gross domestic product (*4*). In contrast, the net revenues from

the PAs are currently $42 million. We believe that these figures represent a reasonable order-of-magnitude indication of the costs of conservation. In this context, it is remarkable that sub-Saharan Africa and South America together devote 2.4 million square kilometers of their territories to protection, representing 5.2 and 6.4% of their respective land areas (*5*).

Data on conservation expenditure show that most agencies, at least in Africa, have insufficient resources to meet the aspirations of effective park management. During the 1980s, a rough estimate of adequate investment in PAs was $200 per square kilometer per year (*6*). Actual investment falls far short of this figure in many countries: Tanzania currently invests $27, Cameroon $20. Zimbabwe does better, investing $132 (*7*).

Recent reviews of community attitudes toward wildlife reveal that the actual and perceived costs of protected areas have resulted in almost universal unpopularity (*8*). The international community has followed suit—purely protectionist approaches to biodiversity conservation are widely criticized. Throughout Asia, Latin America, and Africa, PAs are suffering from a public relations crisis.

Community-Based Conservation

In recognition of some of the failures associated with exclusive PAs, initiatives such as CBC attempt to find "win-win" scenarios in which rural communities generate financial and other social benefit flows from wildlife while maintaining wildlife populations at desirable levels. The details of CBC approaches differ from case to case: Some attempt to compensate local communities for their loss of access to resources, whereas others look to develop business opportunities through tourism or wildlife cropping. CBC has become a mainstream conservation activity from Argentina to Zimbabwe.

Many CBC initiatives were already in place when 150 countries signed the Convention on Biological Diversity (CBD) in 1992 at the Earth Summit in Rio de Janeiro, Brazil. In explicit recognition of the limitations of the PA approach to conservation, the CBD has three objectives: the conservation of biodiversity, the sustainable use of natural resources, and the equitable sharing of benefits that arise from activities such as bioprospecting or ecotourism.

In reality, although the aspirations of conservation, sustainable use, and benefit sharing are laudable, it has been difficult to demonstrate tangible success on the ground. CBC initiatives have been expensive and have generated few measurable benefits in terms of either conservation or rural development. A recent review by the World Bank in Indonesia concluded that "few Integrated Conservation and Development Projects can realistically claim that biodiversity conservation has been or is likely to be significantly enhanced as a result of current or planned activities" (*9*). At least part of the reason for the failure of CBC in Indonesia has been the government's reluctance to recognize the importance of property rights, with a resulting lack of security of tenure over land and resources by local people.

The wide-ranging goals of the 1992 CBD have done much to increase the responsibilities of biodiversity agencies, but this growth has had important implications. Primarily, the agencies have had to become more accountable to a wider group of constituents than they were previously. The welcome process of democratization has meant that any organization holding large areas of rural land is increasingly answerable to rural communities and the electorate.

The tradeoffs between conservation and development mean that only a small subset of development opportunities exists that is truly environmentally, economically, and socially sustainable. Under some circumstances, local communities will reject conservation as a solution to their development needs, because the transaction costs of managing and monitoring ecologically fragile resources may exceed the benefits available from them.

Rationalizing Conservation

The problem of meeting the expectations of multiple and sometimes conflicting constituents is by no means a unique one. Organizations in the private sector commonly have to meet the demands of their shareholders, customers, staff, suppliers, and regulators. The solutions to the current financial difficulties facing biodiversity institutions are perhaps more mundane than many people admit: They lie in rationalizing expenditure and increasing productivity. In short, they require biodiversity agencies to become more like accountable service providers, generating public benefits through effective regulations and market forces.

Rationalizing expenditure requires that agencies be clear about who their constituents are and establish a balanced framework of expectations for each of them. Setting agreed targets against which both agencies and the outside world can measure their success would go a long way toward improving their financial and political viability. Business tools, such as a balanced scorecard of indicators and measures for each constituent, will help managers to track and modify their progress, ensuring that they can meet biodiversity, social, and financial objectives.

The need to set in place a realistic strategy to finance meeting the objectives of PA agencies is as important as the process of defining those objectives. Rather than oscillating between PA and CBC, a more sophisticated strategy would be to manage a portfolio of approaches to ensure the highest level of appropriate cross-subsidy. This strategy explicitly recognizes the difficulty of attempting to undertake CBC and protection at the same time and in the same place. It accepts that simply fencing in all PAs is an untenable strategy. It also faces the reality that under many circumstances, tradeoffs will have to be made between conservation and development objectives.

The ability to adopt a portfolio of approaches will depend on the land assets that agencies have, the market capacity for those assets, and their ability to develop innovative methods to achieve conservation more cost-effectively through partnership and incentives. Some options include the following:

1) Prioritizing, consolidating, and rationalizing the PA network

2) Facilitating multiple use of PAs and enhancing existing capacity among rural people to harvest natural resources sustainably. Often this means devolving ownership of natural resources to land users and owners (*10*)

3) Privatizing some aspects of PA services, through public sector reform in both the developed and developing worlds.

4) Developing a broader range of user-pays mechanisms to recover the costs of management, including innovative pricing that takes full acount of the variety of PA services—for example, PAs often provide carbon sequestration and water catchment functions as well as harboring biomedical resources.

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