Chapter 1

CASE STUDIES ON CONSERVING AND SUSTAINABLY USING BIODIVERSITY IN ARID AND SEMIARID REGIONS OF SOUTHERN NATIONS

John Lemons[1] and Reginald Victor[2]
[1]Department of Environmental Studies, University of New England, Biddeford, ME 04005, USA, email jlemons@une.edu; [2]Reginald Victor, Department of Biology and Centre for Environmental Studies and Research, Sultan Qaboos University, PC 123, Sultanate of Oman

1. INTRODUCTION

This book is a compilation of case studies focusing on the conservation and sustainable use of biodiversity of global significance in arid and semiarid regions of Southern nations. The case studies were developed as part of the GEF/UNEP funded project "Promoting Best Practices for Conservation and Sustainable Use of Biodiversity of Global Significance in Arid and Semiarid Zones" (project number GF/1300–99–03) implemented by the Third World Network of Scientific Organizations (TWNSO) in Trieste, Italy.

An overall goal of the project was to more widely disseminate the lessons learnt and other findings from already existing projects and relevant work conducted by institutions of excellence on the conservation and sustainable use of biodiversity in arid and semiarid areas. We hope that this dissemination will accomplish the following. One, increase the availability and access to information on best practices for the conservation and sustainable use of biodiversity. Two, increase participation of local people in decision making about the use and management of fragile ecosystems.

J. Lemons, R. Victor, D. Schaffer (eds.), 2003. Conserving Biodiversity in Arid Regions, 1–25. Kluwer Academic Publishers, Boston, MA. 497 pgs.

Three, increase awareness of the values of the biodiversity of global significance in arid and semiarid ecosystems in accordance with the Convention on Biological Diversity (CBD). Four, increase coordination between institutions working towards the conservation and sustainable use of biodiversity, resulting in turn, in more effective programming of scarce financial resources and lesser duplication of activities. And five, increase partnerships of institutions in the South and their capacity to develop and implement successful programs to protect biodiversity.

Here, we provide some contextual issues pertaining to conceptual clarity about biodiversity and sustainability; prospects and problems of case studies; examples of lessons learnt from the case studies; and recommendations from the case studies.

2. CONCEPTUAL CLARITY OF KEY TERMS AND CONCEPTS

In literature and practice, concepts such as "biodiversity of global significance," "sustainable development" and/or "sustainability" and even "biodiversity" itself are "fuzzy." There are no commonly agreed–upon or a priori definitions that are sufficiently prescriptive or fully useable in scientific, public policy, or management. In this sense, the definitions are qualitative and stipulative and do not provide a firm foundation for precise decision making norms in science, public policy, or management. This might not be particularly troublesome because "fuzzy" concepts can provide convenient shorthand for discussing and analyzing complex phenomena and also can stimulate further discussion. However, if definitions are too fuzzy or if assumptions about them have not been sufficiently tested or critically analyzed this can limit problem formulation and solution and/or create conflicting formulations and solutions.

To our knowledge, the literature on biodiversity and/or sustainability contains few if any precise definitions for "biodiversity of global significance" or critical analyses of definitions. Proposed definitions of the term "sustainable development" include "the continued development as that which meets the needs of the present without comprising the ability of future generations to meet their own needs" (WCED 1987); "the continued satisfaction of basic human needs such as food, water, and shelter as well as higher–level social and cultural necessities such as security, freedom, education, employment, and recreation" (Johnson 1993); meeting the "...needs of the present as long as resources are renewed or, in other words, does not compromise the development of future generations" (Johnson 1993); to meanings that are so vague as to be ill–defined (Shearman 1990).

Increasingly, the meanings of sustainable development have emphasized social and economic development (IISD 2003). Despite the fact that most proposed definitions of sustainable development are centered on human needs, there is increasing support to protect biodiversity for intrinsic reasons (see e.g., Regan 1983, Hargrove 1992, Oates 1999).

Goodland and Daly (1995) have attempted to clarify the meaning(s) of sustainable development by distinguishing environmental sustainability (ES) from social sustainability (SS) and economic sustainability (ECS). Environmental sustainability seeks to improve human welfare by protecting resources used for human needs and ensuring that people do not cause long–term or irreversible damage to the environment. Social sustainability seeks to improve peoples' social systems and necessary infrastructure in ways that empower self and local control and increasing social justice and equity. Economic sustainability seeks to promote the maintenance of capital, human investments, and income for economic well–being. In Goodland's and Daly's view, if people do not clearly define the kind of sustainability they are concerned about and/or do not distinguish these types of sustainability from each other the definitions of sustainable development or sustainability become so vague that they are not capable of being operationalized.

Robinson (1993) provides examples where ES, SS, and ECS are in conflict. Many population levels at which a species can be harvested sustainably, and the extent to which a species can be harvested depends in large part on whether it exhibits density–dependent compensation by increasing its rate of growth. Species that exhibit density–dependent compensation tend to be found in earlier successional and less biologically diverse ecosystems. Consequently, it becomes more feasible for humans to utilize species from less mature ecosystems because their production can be maximized despite the fact that to do so requires the maintenance of earlier successional ecosystems containing less biodiversity. Alternatively, it can be problematic for indigenous peoples to utilize species from mature ecosystems for economic use because many such ecosystems do not appear to contain species with high enough densities and rates of population growth to support more than relatively low levels of utilization. Human use of species also is problematic for the overall conservation of biodiversity because harvest of one or more species can have significant and unpredictable ecological ramifications throughout the community. For example, managing the populations of some species for sustained harvest can lead to a shift in relative abundance of coexisting species, the extent of which will depend upon the tightness of coupling of harvested species to others in the food web and cycles of nutrients. Consequently, although species can be used to meet the goals of social and economic sustainability,

the fact that they can be used does not say anything about the very same use causing the loss of species and/or biodiversity.

Conflicts between ES, SS, and ECS also exist at the community or ecosystem level (see e.g., Lemons and Brown 1995, Westra and Lemons 1995). Theoretically, communities or ecosystems can be sustained at different levels of intensity of managed use. However, ecosystems managed at more intensive levels will be less biologically diverse than those managed at less intensive levels, although the former might be able to provide for peoples' needs. Conflicts between the different types of sustainability also derive from the fact that ecosystem services are used at the local, regional, and global levels. Conflicts may arise among the different types of sustainability because at the local or regional level communities or ecosystems might be used to meet the local needs for SS and ECS, whereas at the global level communities or ecosystems might be required to be preserved or used at lower levels of use in order to contribute to the maintenance of global ecosystems, or ES. Conflicts between ES, SS, and ECS also can exist because the time scales for their assessments can be different. For example, the needs of impoverished local people may require rapid improvements in their living conditions, and business decisions need to reflect certain rates of return for investments even under conditions of sustainability. The time scales for assessments for improving protection of biodiversity or for using biological resources often is slower than those for making decisions about SS or ECS because assessing the damage to biodiversity typically requires relatively long time periods. The fact that these different time scales exist has profound implications for our ability to correctly identify what constitutes "best practices for the conservation and sustainable use of biodiversity."

In the case studies presented in this volume, few authors provide clear or precise definitions of "biodiversity of global significance," "sustainable development," "sustainability," or even "biodiversity" itself. Further, most case study authors do not clearly distinguish ES, SS, or ECS from one another, or comprehensively discuss known or potential conflicts between them. This reflects the aforementioned lack of clear or precise definitions found in literature or practice, as well as problems stemming from the complexity of assessing the different forms of sustainability and their conflicts. The absence of conceptual clarity for key terms and concepts should not deter scientists, decision makers and environmental managers from implementing practices that are believed to be the best for conservation and sustainable use of biodiversity of global significance in arid and semiarid regions. Each case study presented here uses terms and concepts with particular reference to its context (i.e., local or regional problems). We are confident that each reader will strive to find implicit meanings of the

terms and concepts in these case studies to evaluate their validity and usefulness.

3. PROSPECTS AND PROBLEMS OF CASE STUDY APPROACHES

What is a case study? We suggest the following: A case study is a detailed investigation of a specific problem or event where people reason deductively from general principles to reach the solution of that particular problem. One reason to use case studies is to help stakeholders with different perspectives, interests, and needs to understand and solve the problem. A second reason to use case studies is because lessons learnt might be useful beyond the immediate or more local or site–specific problems. If this could be accomplished it would help in the development of projects which might serve as models for the bilateral and multilateral funding communities. A third reason to use case studies is because, in part, they have been developed in response to the limitations of methods and techniques of ecological and biodiversity science to yield scientifically robust predictions based on hypothetic deductive hypotheses and testing (except for relatively simple systems). In other words, in most instances ecological and biodiversity theories are not generalizable and operationalizable (see, e.g., Shrader–Frechette and McCoy 1993). Finally, a fourth reason to use case studies is because of their heuristic value. In this sense, case studies focus on human judgments about practical environmental policy and management.

Strengths of the case study approach include enabling scientists and decision makers to: gain a measure of practical control over environmental problems; make rough generalizations about complex problems; and learn about problem solving from case studies conducted on similar but different cases. Case study approaches also are applicable to unique situations not amenable to statistical tests and hypothesis testing, and they provide an organized framework for developing alternative models and explanatory accounts of complex environmental phenomena. Case studies also allow for an ability to deal with imperfect evidence even though controls and manipulations and experimental tests are not possible; they provide a way to see a problem like other problems, and they offer a way to gather information in order to formulate hypotheses.

Case studies also have weaknesses. These include the fact that their analysis of examples does not follow any algorithms and therefore there might be inadvertent bias or different ways of framing a problem by the practitioner; they provide little basis for robust scientific predictions; they can suffer from the fact that they can only be used to evaluate those

interpretations the case study researchers presuppose and that such presuppositions typically are not testable; they do not follow pure hypothetic–deductive inference; and most real life decisions are made in dynamic contexts wherein many case studies describe static situations.

Despite the drawbacks, case study approaches are suitable for issues on biodiversity conservation and sustainable development because both these issues are globally diverse and do not allow direct comparisons using conventional scientific and ecological methodologies. However, we recommend that to be useful, case studies must sufficiently describe and analyze the threats to biodiversity and the causes of those threats. This does not mean that scientists are required to demonstrate proof about threats based on data with a high degree of statistical confidence, but rather have rational reasons for their conclusions. However, they should make explicit the assumptions their methods and techniques are based on, the sources of uncertainty, and the implications of uncertainty to their scientific reasoning and conclusions. A step–by–step description of how their information and data leads to conclusions should be attempted. Further, public policy makers and decision makers must not assume that scientific information is more certain than is warranted (see, e.g., Lemons 1996).

The usefulness of case studies also requires knowledge about the sources of threats to biodiversity and which governments at which scales have the authority to do something or are failing to do something or have little power to implement specific recommendations to avoid a threat. For example, if the threat to biodiversity is land use encroaching upon valued biodiversity, it will be helpful if case studies identify and analyze the threats caused by land use. The threats could stem from the lack of appropriate land use plans or lack of the legal authority of a regional government to develop such plans, or from the reluctance of a government to restrict people who are malnourished from using local resources. Where causation of threats is not well understood, case studies might contain recommendations on the need to do a strategic analysis of the causes of threats. In other words, it is difficult to make meaningful recommendations about how to protect biodiversity if one cannot ascertain which institutions have the responsibilities to implement a plan.

4. EXAMPLES OF LESSONS LEARNT FROM THE CASE STUDIES

The case studies in this book contain several types of lessons learnt and recommendations. One, is improving science used in biodiversity research, public policy, and management. Two, is making connections between local,

national, and global biodiversity efforts. Three, is building institutional capacity for research and protection of biodiversity in drylands and for sharing access and benefits of biodiversity resources. Four, is clarifying practical strategies to implement biodiversity protection in drylands. And five, is effectively using information obtained from this project to address GEF and other critical donor issues and positively impact their future activities and programs. Many case studies are highly concrete and are based on programs and practices that have been successfully implemented; others focus on recommendations to protect biodiversity based on scientific research or other experiences.

The examples of lessons learnt and recommendations from case studies provided below are grouped according to their primary focus, i.e., scientific, public policy and management, participation of local people in decision making, and partnerships and capacity. Despite this grouping, each case study transcends a narrowly defined focus as required to address the interdisciplinary nature of biodiversity and sustainability problems.

4.1 Case Studies Focusing on Science

S. Donaldson et al. ("Conservation Farming With Biodiversity In South Africa: A Preliminary Evaluation Of Ecosystem Goods And Services In A Semi–Arid Landscape In The Bokkeveld Plateau") describe the processes controlling habitat and ecosystem integrity essential to prevent biodiversity loss in agricultural landscapes. Their case study focuses on a study site in a semiarid region on the Bokkeveld Plateau (Northern Cape province) in South Africa. The data are presented as a preliminary model where land use options influence both biodiversity and the provision of ecosystem goods and services. Included are preliminary data on the risk of extinction for plant and animal species under different forms of land use, as well as ecosystem goods and services related to water infiltration, soil health, carbon sequestration, and production. The ecological components of the project will be integrated with social and economic studies to develop an ecological–social–economic model for the region that can be used to guide land use planning in the region.

P.D. Gunin and S.N. Bazha identify the most serious risks of ecosystem degradation to Mongolia's ecosystems and their potential impacts on the Russian part of the Baikal basin ("Ecological Assessment Of Degradation Processes In The Ecosystems Of The Mongolian Part Of Baikal Basin"). This case study had three objectives: to conduct an inventory of the ecosystems of the southern part of the Lake Baikal basin and classify them according to economic utilization and modification by humans; to analyze processes affecting the Lake Baikal basin's ecosystems and components

such as vegetation, soil, topographical relief, etc.; and to assess integrated zoning of the southern part of the basin to help mitigate environmental degradation. The authors describe the results of an inventory of the ecosystems of the southern (Mongolian) part of the Lake Baikal basin at the level of mesoecosystems and classify the ecosystems according to their economic use and level of modification by humans; they also describe the spatial distribution of ecosystem degradation processes and the levels of their impacts on the biota of both the Lake Baikal territory within Mongolia as well as in contiguous areas in Russia. This information can be used in the monitoring of anthropogenic pressures on the ecosystems of the Lake Baikal basin. Gunin and Bazha provide a strong scientific basis for recommendations to protect the Baikal basin's biodiversity and environment. These include: ensuring that social and economic public polices are consistent with national and international biodiversity laws and the area's status as a World Heritage Site; establishing a network of strictly protected areas; and improving monitoring of the dynamics of aquatic and solid runoff in bottom sediments of the area's important rivers.

Two case studies are from China. One is "Plant Production And Diversity At Desertification Stages In Horqin Sand Grassland Region, China" by C. Xueli and Z. Halin illustrating the functions and effects of biodiversity in the region so decision makers will have a better theoretical and practical scientific foundation for decisions to restore and rehabilitate vegetation. The relationships between plant productivity and diversity depend on the specific structural or functional indices chosen at different desertification stages. Ecologists and natural resource decision makers not always recognized by ecologists and natural resource decision makers. For example, the desertification process distinctly affects the numerical values of the diversity indices calculated for sandy grassland vegetation. The various stages of desertification affect species richness change differently by influencing the species and life form composition, the frequency and abundance of different functional groups, and species and functional group productivity. Some of the study's results conflict with others published in the open literature, and this points to the need to refine studies on the relationships between plant productivity and diversity at different desertification stages so that scientific capability can better inform decision makers to protect arid and semiarid grassland biodiversity.

In the second case study from China, L. Xin–Rong et al. (Plant Diversity In The Process Of Succession Of Artificial Vegetation Types And Environment In An Arid Desert Region Of China) provide a theoretical basis for further understanding of ecological mechanisms of reversing desertification trends and restoring biodiversity in desert regions in China. Their study documents plant diversity changes in desertified areas where

attempts have been made to restore vegetation. In the areas studied, after more than 40 years of succession the composition of restored vegetation species tends to become dynamically balanced; the plant diversity increases with the succession of plant communities; and the plant diversity index of the restored vegetation reaches is higher compared to the corresponding figures of the restored vegetation planted 10 years ago. Beta diversity measurements show that the succession of restored vegetation experienced two relatively rapid stages of species turnover, as when, e.g., restored shrub species became less abundant while the percentage of annual herbaceous plants increased as succession progressed. These finding have implications to management attempts to restore vegetation because they contribute to the theoretical understanding of vegetation restoration in desertified areas.

The case study "Theoretical Models Of Regeneration For Medicinal Plants: An Example Of The Use Of Science In Promoting Sustainable Wild–Harvesting" (G. Montenegro et al.) demonstrated that by working closely with people selling medicinal plants in local markets in Chile, researchers were able to study the harvest areas to calculate the biomass produced for market. They were then able to determine the frequency of plant collection and shared that information with their local partners. The researchers went on to develop a model for regeneration based on the location and dispersion of the plants' renewal buds. Plant growth both in the field and in clipping pots was measured to evaluate post harvest regeneration rates and plant response to biomass extractions. Theoretical models led to predictions of potential plant regeneration in different ecological zones on the Andes coast, and data sheets were produced for each species. Subsequent cultivation and reforestation programs have followed recommendations from the scientific studies described in this case study.

J. Wheeler et al. (Genetic Diversity And Management Implications For Vicuña Populations In Peru) demonstrate how advances in population genetics research are an important tool for monitoring the impacts of programs to preserve the vicuña. Results of the research indicate that individual Peruvian vicuña populations are characterized by relatively low levels of genetic diversity and that high levels of genetic differentiation exist between these populations. Such patterns are commonly observed in threatened species with formerly large ranges which have become isolated from each other, and in species which have suffered drastic demographic contraction in recent generations. These patterns may be becoming more predominant in populations of the Peruvian vicuña and therefore should be taken into account in future conservation strategies designed to minimize further loss of genetic diversity. In Peru, four demographically distinct vicuña population groups have been identified which should form separate management units. Preservation of this vicuña genetic biodiversity is

becoming critical because Peru's vicuña management programs have increased the overall numbers of animals but this, in turn, has caused greater control over the species through construction of fences, intensive rearing and growing selection. Such approaches are inherently not sustainable and represent a serious threat to survival of the vicuña. Population genetics research represents an important tool for monitoring the impact of these activities and designing best management practices.

P. Lima et al. (Choice Of Species For Recovering A Degraded Mining Area In The Semiarid Zone Of Brasil) present the results of a project designed to analyze the processes of species and ecosystem recovery in an area degraded by copper mining and the prospects for choosing multipurpose trees for the recovery. The first phase of the project consisted of soil analysis, characterization of climate and vegetation, and descriptions of local and commercial farming systems; the second phase consisted of experimental planting of possible species for recovery; and the third phase validated innovative technological alternatives for rehabilitation of the degraded area. Flora in the degraded mining area and surrounding unaffected areas were identified and characterized as to their species, structure, frequency, abundance, dominance, value index of importance, vulnerability to mining operations, and potential for use in rehabilitation.

J. Araya–Valenzuela and R. Espero–Guasp (Use Of Creeping Fog Water As A Non–Traditional Water Resource In Chile) describe experiments utilizing creeping fog water as a non–traditional water resource in Chile's high deserts. They describes creeping fog formation and characteristics; factors influencing collection of fog; different fog collector designs and their technical advantages and disadvantages; and recommendations on which fog collectors are most efficient and economical in different environments and situations. Results of the experiments help in assessing the availability of water for species and ecosystem recovery, help in establishing new areas with endemic species cover, and help in establishing small communities around stable water (fog collected) resources or in supplying some existing communities with such water.

Soil criteria for selecting suitable transplanting sites for mangrove trees (*Avicennia marina*) in the Sultanate of Oman were studied and assessed by P. Cookson and T. Shoju ("Site Selection Criteria For Mangrove Afforestation Projects In Oman"). The extension and conservation of mangrove forests has recently been declared by Sultanate of Oman's Ministry of Regional Municipalities, Environment and Water Resources to be of national importance to maintaining biodiversity in the country. Consequently, a long–term afforestation project of some twenty coastal sites has been proposed, in addition to conservation measures for the over 1000 ha of existing mangrove forests in Oman. Commencing in 2001, mangrove

seedlings have been raised in constructed nurseries and transplanted to a number of sites. Transplanting activities are already into their second year and seedling survival rates at different sites have ranged from 0.1 to over 80 percent. In this study, salinity and soil physical properties at four transplanting sites with a range of seedling survival rates were compared. Seedling survival rates were higher in soils with ratios of fine to very fine sand particles higher than unity. As the proportion of fine to very fine sand fell below one, the saturated hydraulic conductivity of sand decreased leading to anaerobic soil conditions in the seedling root zone. The study concluded that anaerobic soil conditions were closely associated with seedling death. Based on the study's conclusions, recommendations were made for some soil criteria for selecting suitable transplanting sites when transplanting mangrove seedlings.

M.D. Robinson also focuses on trees in the Sultanate of Oman in his case study "The Importance Of Native Trees In Sustaining Biodiversity In Arid Lands" by considering how trees develop microclimates, their interactions with other plants and animals, and their roles in sustaining below–ground soil fauna and flora. This latter aspect is given special emphasis because of its central importance in ecosystem function combined with the fact that soil biota has received far less attention by ecologists, managers and planners than the more visible species above the ground. Robinson ends his case study with a review of the possible benefits arid ecosystems can offer societies.

4.2 Case Studies Focusing on Public Policy and Management

The problems and prospects of domesticating indigenous trees in drylands are assessed by R.R.B. Leakey's in "The Domestication Of Indigenous Trees As The Basis Of Sustainable Land Use In Africa" for the purpose of developing national strategies for sustainable land use. The sustainability of land use in the tropics has typically been lost when species–rich natural vegetation has been cleared to make way for monocultures of improved staple food crops grown intensively with high inputs of agrochemicals. These intensive farming systems have helped to feed growing human populations, but at an environmental cost that cannot be sustained into the future. As Leaky suggests, an acceptable alternative that both feeds the people and restores some of the diversity found in natural vegetation is the development of lower input agroecosystems that combine the cultivation of "Green Revolution" staple food crops with a number of the indigenous food–producing tree species that can restore ecosystem function. This return towards more traditional land use practices can be enhanced by

the judicious development of high quality, high yielding cultivars of the trees through the adaptation of standard horticultural practices and planting of these cultivars in agroforests. In dryland Africa, there are many traditionally important tree species producing marketable non–timber forest products, which have potential to be domesticated in this way. The techniques, methodologies and strategies exist and are being implemented in small ways. There is the potential to expand these programs to a scale where they can begin to have meaningful impact on land use and create new and more biologically diverse functioning agroecosystems which also support and enhance the livelihoods of local people.

In his case study "Strategies For In Situ Conservation Of Crop Genetic Resources In Dryland Areas Of Africa," M. Grum describes a program designed to reduce the loss of genetic biodiversity caused by drought and desertification in the dryland ecosystems of Africa. The aim is to mitigate the impact of temporary drought–induced conditions through the development of comprehensive community–based strategies for monitoring, analyzing, assessing and addressing the desertification phenomenon. The project attempts to understand the complex role that genetic diversity plays in coping strategies of farmers. This research focuses on a description of the crop genetic diversity, its extent and distribution, the socioeconomic situation of farmers, environmental factors, and on opportunities for stakeholder participation in decision making. The project also examines the positive and negative dynamics influencing the status of genetic resources and loss, including traditional management practices for selection, conservation and multiplication of the genetic resources. Finally, the project is testing models of community–based activities, such as community gene banks, improved seed storage systems, seed diversity fairs, farmer field schools, and on–farm seed production systems.

In "Aquatic Biodiversity In Arid And Semiarid Zones Of Asia And Its Linkages With Water Resource Management," B. Gopal points out that many scientific studies of arid lands biodiversity and its management focus on terrestrial species and ecosystems and overlook the aquatic habitats. Management which focuses on aquatic biodiversity in arid and semiarid zones often fails to take into consideration the unpredictable variability in precipitation and its relationships with native biota and consequently results in loss of biodiversity. Whereas natural aquatic habitats are being lost due to excessive withdrawal of water for various purposes, overexploitation of natural resources and changes in land use, numerous aquatic habitats have been created by transporting water through extensive networks of canals and water storage reservoirs. These water bodies are causing salinization, loss of biodiversity and a plethora of socioeconomic problems; loss of biodiversity from such practices is not sufficiently recognized by natural resource

decision makers and managers. Pollution of water from industrial wastes, increasing salinity in coastal areas, and introduction of exotic species are other major problems affecting native biodiversity. This case study highlights the importance of public policy makers and decision makers to take into account understudied characteristics of aquatic habitats and their biodiversity in Asia's arid and semiarid regions.

Two other case studies from India focus on minimizing conflicts between local people and public policy and management of biodiversity. K. Chandrasekhar et al. ("Traditional Management Of Biodiversity In India's Cold Desert") describe areas of agreements and/or conflicts between local peoples' traditional use of biodiversity and government public polices and management of biodiversity in cold deserts in India. Their study shows that local peoples' concepts of the values of biodiversity have been key organizing principles in their traditional and sustainable landscape management and practices. However, the importance of local peoples' practices is diminishing largely because of government conservation policies and programs which fail to take into account the traditional practices. Specifically, policy and management driven changes establishing government rights in areas traditionally used by local communities have not enhanced either the economic values of biodiversity and/or its protection, for example, in the transfer of decision making powers from the village communities to government institutions and in government incentives to increase the yields of food crops. According to this study, the reason is because government policies and management practices fail to take into account local peoples' wide–ranging knowledge and uses of biodiversity. Accordingly, Chandrasekhar et al. conclude that the goals of biodiversity conservation and its sustainable utilization can be better achieved if conservation and development policies build on strengths and weaknesses of local peoples' traditional knowledge and institutions.

The main lessons learnt from M. Chauhan's "Conserving Biodiversity In Arid Regions: Experiences With Protected Areas In India" is that protected area management in the arid regions of India is not necessarily enhanced by simply leaving them alone. An understanding of the science behind the resilience of the protected areas in the face of occasional human disturbance and the fact that the areas have thrived in continuous interaction with human and domestic animal populations is required. The continuation of ecological linkages of protected areas with surrounding areas and their biotic communities may be necessary for ecosystem health.

Recommendations contained in the case study "Conservation And Sustainable Use Of Globally Significant Biodiversity In The Trans Altai Gobi Desert In Mongolia" (Ch. Dugarjav and B. Tsetseg) have laid a foundation for the further development of conservation activities in this

region. The Trans Altai Gobi Desert, which includes the UNESCO Great Gobi Strictly Protected Area (SPA) Biosphere Reserve (largest protected area in Asia and the fifth largest in the world), is one of the world's most extreme arid and biodiversity unique deserts. This desert has remained relatively intact ecologically because small numbers of nomadic people and their animals have historically used it in traditional ways. However, intensification of desertification and threats to biodiversity are increasing due to greater industrialization and collectivization of animal herds; economical difficulties encountered by Mongolia during its transition to a free market economy; increasing poverty; and increasing demand for profit making by industries. Based on analyses of renewal of biodiversity legislation, establishment of the Great Gobi SPA, development of international cooperation and funding to support biodiversity protection, and the active involvement of scientists and broad application of research, lessons learnt from this case study can provide a foundation for the further development of conservation activities.

C. Richard discusses how Tibetan pastoralists face a number of natural, socioeconomic, organizational and policy challenges, especially "one size fits all" policies and development programs that have promoted intensification and private land tenure models that are more appropriate to moister lowland regions ("Co–Management Processes To Maintain Livestock Mobility And Biodiversity In The Diverse Alpine Rangelands Of The Tibetan Plateau: Rationale And Practice"). According to Richard, "indigenous common property regimes" (CPR's) have been shown to be an effective means to manage and protect common pool resources, especially among pastoral communities in dryland regions where survival and the maintenance of a healthy rangeland ecosystem is dependent upon collective action to maintain livestock mobility. Richard describes a set of hypothetical rangeland tenure models along an ecological gradient from the Tibetan Plateau in China to highlight the distinction between local autonomous control of pasture, top–down imposition of policy, a co–management model, and the influence that environment plays to enable tenure and management options. In today's complex and rapidly changing pastoral landscapes, participatory processes will not be sustained without a supportive external environment that protects the rights of users, facilitates conflict resolution, and promotes timely financial, marketing and technical inputs. A conceptual framework and set of strategies that foster a more collaborative organizational and policy environment within which pastoral communities can more effectively influence the course of their own development are proposed, based on the experiences of the International Centre for Integrated Mountain Development's (ICIMOD) Regional Rangeland Programme on the Tibetan Plateau.

Two case studies focus on the management of vicuña and other species in Bolivia, Chile, and Peru. C. Bonacic and J. Gimpal ("Sustainable Use Of The Vicuña [Vicugna Vicugna]: A Critical Analysis And The MACS Project) describe the current status of the vicuña's sustainable use status in the region. In their view, the vicuña conservation program in South America is entering a critical stage, and the direction that the program takes could conflict with the original objectives of the Vicuña Convention (i.e., to use the species in the wild for local communities' benefits). The trend for exploiting in captivity by fencing wild vicuña or captive breeding programs is not compatible with the initial criteria of sustainable use. Alternatively, a sustainable use program based on capture and release of small groups of vicuña with minimal interference on the natural populations should be considered the method of choice, to which other methods should be compared. Some of the main aspects to compare between methods of management are: the impact of capture, handling and shearing on different systems of use; the comparative studies of carrying capacity in different regions of the altiplano and livestock competition; and the social and potentially evolutionary consequences of captive programs.

B. Peredo ("Sustainable Use Of Andean Wildlife And Local Development Of Rural Communities In Dry Areas Of Latin America: A Commentary") discusses how population recovery programs based on sustainable use have increased the number of vicuña but threats to other Andean species such as the quirquincho and Andean Ostrich remain; the numbers of the latter two species may be declining due to unrestricted use. Studies and plans are being developed to improve the quality of vicuña fiber and distribute the benefits of the animal's sustainable use as well as to enable the sustainable use of the quirquincho and the Andean Ostrich, respectively, in traditional cultural activities. In this way, local communities are being provided with alternatives that will contribute to the conservation of these species as well as to the biodiversity of the Andean region of Bolivia.

In "Conflicts And Dilemmas Between Poverty And Biodiversity In The Semi–Arid Serido Of Northeast Brazil," E. Beaugrand examines the prospects and problems of reducing conflicts between long–term goals of sustainable development and short–term economic goals. She analyzes the current "Plan for Sustainable Development of the Serido Region" of northeastern Brazil, particularly with respect to the ceramics sector which is one of the region's most important social and economic sectors. Many government and nongovernmental institutions and stakeholders representing 28 municipalities in the region were involved in development and implementation of the plans. The ceramics industry is the primary source of jobs and income for local people in the region; few other opportunities exist for the livelihood of local people. However, the practices of the industry

have significantly degraded both terrestrial and aquatic resources of the region. Based on an analysis of the plan's environmental, scientific, economic, social, political, and administrative indicators of sustainable development and their efficacy in achieving sustainable development goals, the study reveals a wide participation of local people in its development and implementation. Based on analysis of the indicators, conditions of poverty and lack of social and economic opportunities for local people of the region create pressures for public policy and management of the region to focus on short–term employment and economic opportunities without undertaking necessary precautions to protect the long–term sustainability of the region's environment.

The case study "In Situ Conservation Of On Farm Crop Biodiversity In Morocco: A Case Study," by F. Nassif and A. Birouk focuses on strengthening the scientific basis of in situ conservation of agricultural biodiversity. This in situ on–farm conservation project in Morocco involves nine countries with participating farmers, scientists, development workers and many others. The most important lesson learnt is that the in situ conservation of on farm agrobiodiversity is a very complex and multifaceted process. Scientific lessons learnt include: the need to establish multidisciplinary teams which include not only agricultural and genetic scientists but social scientists as well; the need to include a balance of gender perspectives in the study of in situ conservation of on–farm crop genetic diversity; the need to understand that landraces of crops are used by farmers because they represent the best options from the farmers' points of view. Public policy and management lessons learnt include: the most important gap between Morocco's official policy and implemented measures towards conservation and sustainable use of crop biodiversity stems from the absence of a national strategy plan on biodiversity as well as from the absence of a national gene bank. The main lessons learnt to assist local populations in utilizing and managing biodiversity are: that it takes time and effort on the part of researchers to understand and respect local knowledge systems and management practices and farmers' points of view; and, that there is a need to empower the local population by recognizing the key contributions of farmers in the management of crop biodiversity.

R. Victor ("Biodiversity Conservation And Sustainable Development: A Case Study Of Oman's National Biodiversity Strategy And Action Plan") discusses how concepts of biodiversity and sustainable development have evolved over the years but nevertheless remain vague and ambiguous; some concepts emphasize development while other emphasize biodiversity protection. This has led to an inability to explain the link between biodiversity and sustainable development in unambiguous terms. Examples are the national biodiversity strategies and action plans produced by the

nations signatory to the CBD. The worst–case scenarios in some of these strategies and action plans indicate very remote, if at all any, links between biodiversity and sustainable development. Victor describes a study of a fragile mountain ecosystem in the Sultanate of Oman with reference to the country's National Biodiversity Strategy and Action Plan– Oman 2001. He provides a critical overview of biodiversity conservation and sustainable development in order to compare the past and present day thinking on biodiversity conservation and sustainable development and recommend a balanced perspective while formulating important instruments such as national strategies and action plans. Victor concludes with recommendations on methodologies to use to identifying the state of threatened habitats and best practices to mitigate the threats.

In "The Globally Threatened Corncrake *Crex Crex* (Egypt)" A. Grieve and W. Salama focus on the corncrake (*Crex crex*) which is a globally threatened and vulnerable species due to a long–term and steep decline of its breeding numbers and range. They describe a project in Egypt comprising the following activities: to carry out field surveys to calculate the number of corncrakes trapped in autumn on the Mediterranean coast of Egypt; to try to reduce the number of corncrakes killed in Egypt during the autumn migration period by talking to hunters, local people, decision makers and distributing information to support the releasing of corncrakes; to carry out a study program on migrant corncrakes to provide biometric data from trapped birds and feather samples for DNA analysis; to provide training for personnel of the Egyptian Environmental Affairs Agency in survey techniques, public awareness campaigns and management of protected areas for migrant corncrake; and to assist with the development of a visitor center and educational program at Zaranik Protected Area, north Sinai, Egypt, to raise public awareness for the corncrake.

4.3 Case Studies Focusing on the Participation of Local People in Decision Making

The case study "The Value Of Local And Indigenous Knowledge For The Development Of Information Systems For Conservation Management" by K. Kellner and O.J.H. Bosch provides an overview of the need to develop and disseminate more effective tools and methods to obtain information for conservation and sustainability programs, especially where the use of local indigenous knowledge is important or essential. Kellner and Bosch discuss how the development of inventories and information systems where indigenous and scientific knowledge are incorporated into single expert knowledge systems will not only help in the connection of science and community action but also in the awareness, education, training and capacity

building of agriculturalists and conservationists. Accordingly, this will provide support for land users and managers in their future decision making and will also enhance the adoption of the management options by the end–users. Kellner and Bosch go on to discuss how important it is that information systems also include the verification and validation of local knowledge which can be based on literature, statistical analysis and scientific experimentation, as well as sampling theory and logical analysis of data collected by different methods. Finally, they discuss the difficulties of sustaining long–term funding in arid and semiarid environments and how this often leads to discontinuity in the research process. It is therefore essential to develop mechanisms whereby knowledge–building processes such as community–based research, adaptive management, monitoring, feedback and community dialogue can be institutionalized or embedded in the community before funding is ceased. In this way, knowledge building becomes an ongoing process and the information system in which the knowledge is captured evolves as more information becomes available through either research or management.

M.B.K. Darkoh ("Agriculture And Biodiversity Conservation In Africa Through Indigenous Knowledge") explores some of the important relationships between agriculture and biodiversity. Often, indigenous or local farmer knowledge about production systems has been largely overlooked despite the fact that indigenous people and farmers are as a matter–of–fact partners to conserve and manage biodiversity whether for nature reserves, or to improve crops and livestock yields. Darkoh discusses how local knowledge systems, traditions, institutions and environmental conditions are fundamental to biodiversity conservation and management. As a matter of policy, he advocates that the promotion of agricultural programs and biodiversity conservation projects should ensure that indigenous knowledge is incorporated in their design and implementation. A blend of modern science and indigenous knowledge will be required to face the challenges of increasing agricultural production and managing the environment on a sustainable basis in the decades ahead in Africa. It is also important to ensure that the relevant local communities are given appropriate control over and access to land and other resources as well as management responsibility for the natural areas upon which their continued prosperity depends. Furthermore, development assistance to agriculture and biodiversity conservation and land management will be most beneficial when it attempts to enhance existing agricultural systems.

The purpose of N. Gichuki's and J.M. Macharia's case study "Participation Of Local Communities In The Management Of Wetlands In Magadi Area, Kenya" is to show how wetlands in the arid zone of Magadi, Kenya, provide essential resources that sustain local economies and

livelihoods of people. They also discuss how the full range of wetland benefits is not well understood and appreciated. Approaches to management have been focused on a few resources (e.g., water, land for agriculture or minerals). This narrow approach has led to unsustainable exploitation of wetland resources, thereby threatening ecological integrity of these ecosystems. Arid zone wetlands, however, have immense potential for supporting sustainable development and fighting poverty. Gichuki and Macharia discuss how local communities should be empowered to participate in shaping their own destiny through management of environment and resources according to their need and visions of the future in ways that will produce sustainable outputs, integrate environmental concerns and livelihood issues and establish mechanisms for long–term management of environment and natural resources.

L.G. Ouedraogo et al. demonstrate using traditional knowledge of crop seed storage to conserve forest genetic resources in Burkino Faso ("A Participatory Approach For Conservation Of Forest Genetic Resources"). In Burkina Faso as well as in the other Sahelian countries people rely on trees and shrubs for their daily life. Despite the importance of the forest resources to the livelihood of rural people, Burkina Faso loses approximately 32,000 ha of forest annually. In order to protect forest genetic resources and improve the well–being of local populations, the National Forest Seed Center of Burkina Faso developed and implemented methods to utilize local peoples' knowledge of crop seed storage and improve on this knowledge and ability to better protect forest genetic resources. All of the management areas were located in the Sudanian and Sahelian zones of Burkina Faso and part of the semiarid zones of West Africa. Based on local people's traditional knowledge of crop seed storage and subsequent experimentation, Ouedraogo et al. describe innovative methods for characterizing and mapping of forest areas for management; selecting the most important tree species whose growth and production should be increased; improving handling and storage of forest seeds; determining practical and reliable methods to maintain forest seed viability and direct sowing efficiency; identifying simple traditional forest seed storage which allow protection of the seeds and control of parasite attacks during storage; and evaluating direct sowing impact on forest regeneration. Finally, the study shows how involvement of local people in developing strategies to improve forest seed storage can generate jobs and income in rural areas while at the same time contributing to forest biodiversity protection.

4.4 Case Studies Focusing on Partnerships and Capacity Building

"Best Practices In The World's Oldest Desert" by M.K. Seely and J.R. Henschel describes informal public and private NGO organization partnerships and their contributions to long–term research and protection of biodiversity in the Namib Desert, Namibia. The public sector manages established national parks and more recently in partnership with NGOs is promoting community based natural resource management on farmlands, while the private sector is involved in tourism that provides the foreign exchange income motivating the public sector to retain interest in biodiversity protection. Long–term ecological research in support of best practices covers a wide range of basic and applied research. For example, lessons learned concerning environmental variability include the role of ephemeral rivers that cross desert areas while supporting a riparian forest with its associated fauna and farming opportunities and recharging underground aquifers upon which urban coastal development depends. Several research projects undertaken with the indigenous community focus on developing markets for fruit products, on community based tourism and on harvesting fog. Public policy is driven by changing global perceptions of biodiversity values and this in turn fuels international tourism. The tourist value of the Namib Desert has been enhanced by research and dissemination of the results of biodiversity research. As vast protected mining areas are opened up to alternative use, their status as a biodiversity hotspots influences public policy and future use. Seely's and Henschel's case study focuses on the Desert Research Foundation of Namibia and on the roles of other institutions participating in the government's biodiversity task force.

G. Prance ("Plants Of Northeastern Brazil: A Programme In Sustainable Use Of Plant Resources") describes an eight state program run by a consortium of governmental and nongovernmental organizations in the semiarid region of northeast Brazil which helps local people to use plants resources sustainably. The program "Plantas do Nordeste" or plants of northeastern Brazil is run by a consortium of Brazilian governmental and NGOs in the region in cooperation with the Royal Botanic Gardens, Kew, England, and led by the Brazilian NGO, Associação Plantas do Nordeste, based in Recife in the state of Pernambuco. The goal of the project is to promote sustainable use of the plant resources of the eight state arid regions of northeastern Brazil. Activities are divided into three subprograms: biodiversity, economic botany and information. The biodiversity subprogram works on the basic survey of plants and vegetation types of the region to facilitate their identification and use. The economic botany subprogram seeks to promote the sustainable use of regional plants and has had projects

on medicinal plants, fodder plants, and fuel wood. The information subprogram has set up a Plant Information Centre in the Botany Department of the Federal University of Pernambuco in Recife that collects and disseminates the information resulting from the other subprograms, so that it may be used effectively by those aiming to improve the region's environment. More recently the Program has focused on integrated projects that combine the elements of the different subprograms.

In their case study ("Latin American Plant Sciences Network: A Higher Education Program For The Development Of Plant Sciences And Conservation Of Biodiversity In Latin America") S. Maldonado et al. describe a program for increasing the number of qualified botanists capable of protecting the biodiversity of native flora in the region. Many arid and semiarid areas in Latin America are losing native species and ecosystem services at an unprecedented rate due to factors such as ecosystem conversion, inefficient agricultural and grazing practices, and exploitation of timber resources. Often, these factors are driven by poverty, economic marginalization and undervaluing of natural resources, and low participation of local people in decision making about conservation and use of natural resources. In turn, these factors are exacerbated by constraints to educational opportunities at all levels. Ironically, despite the large amount of biodiversity in the Neotropics there is a dearth of human scientific and technical capacity. This case study describes the development and design of the Latin America Plant Sciences Network, which is a consortium of 23 academically prestigious institutions in Argentina, Brazil, Chile, Costa Rica, Mexico, and Venezuela which have worked together collaboratively since 1988 to offer graduate level training to students from Latin America; to organize scientific meetings and workshops; and to undertake collaborative research projects. Through these activities, the consortium is helping to increase the number of well–trained people capable of protecting the biodiversity of the region's native flora.

Érica Speglich and Carlos Alfredo Joly discuss how a major problem confronting biodiversity scientists and decision makers is the fact that available information regarding biological resources is fragmented, dispersed, difficult to access and underused. As a consequence of the lack of an updated cartographic base, key information such as the location of sampling sites is usually inaccurate. In their chapter "The Brazilian Biodiversity Virtual Institute," Speglich and Joly describe the creation process for an institute and the strategies being applied for connecting research projects, researchers, research students, the data they produce as well as how to qualify people for working with biodiversity conservation. In particular, they pay close attention to the "lessons learned on creating partnerships and capacity building."

In his case study "Conservation Of Fig (*Ficus Carica* L.) And Pomegranate (*Punica Granatum* L.) Varieties In Tunisia," M. Mars shows that the conservation of local cultivars is improved by strengthening relationships between all partners (research institutions, development agencies, local organizations, local communities, authorities, growers). However, conservation of local genetic resources also requires new approaches and collaborative efforts, especially if the conservation is to be integrated in sustainable rural development programs. The project also has shown that it is necessary to emphasize more in situ preservation of local genetic resources because ex situ collections of perennial woody plants present many technical problems particularly in arid zones with scarce water resources.

L. Berry critically analyzes prospects and problems of improving institutional partnerships and capacity for biodiversity conservation in Latin America and the Caribbean ("Capacity Building To Sustainably Use Biodiversity In Dryland Regions Of Latin America And The Caribbean"). He discusses how these regions are well known for their high biodiversity, but the focus of attention is most often on the admittedly important world heritage of the tropical and mountain rainforests and wetlands of the regions. Nevertheless, there is an increased need to improve funding, the development of partnerships, and capacity building to better protect biodiversity in the arid and semiarid zones of the regions. Berry reviews investments in the conservation of biodiversity in the regions; the need for improved networking of scientists; the need for networks to focus more efficiently and comprehensively on particular arid and semiarid ecosystems; the need for development of networks which make greater use of ethno scientists; the need for more effective networks of scientists and public policy makers with educational institutions; the need for greater balance between regional, national, and global networks; and the need for institutional development to make greater use of practical but innovative communication methods and technologies to promote capacity building. Based on this review, Berry recommends more effective processes to build on and expand the already sound capacity of the region to conserve biodiversity.

H. Hassan ("A Commentary On Strategies And Incentives To Improve Biodiversity In Arid And Semi–Arid Zones") argues that policies and programs to sustain biodiversity in arid and semiarid zones have been misdirected because they have been designed to combat desertification. Alternatively, Hassan argues that solutions to improve biodiversity should aim at improving the peoples' livelihood in a sustainable manner while conserving biodiversity. Specifically, Hassan argues for a greater recognition of the underlying causes of biodiversity loss in arid and semiarid regions of

Southern nations. This includes understanding that: the poor depend on biodiversity and also utilize it more than the more affluent; macroeconomic policies shape possibilities for resource management and biodiversity conservation of which the poor often are excluded; market failure often leads to unsustainable patterns of resource use and consumption; appropriate institutional and social settings are needed to provide conditions for achieving resource conservation and sustainable development; unclear and insecure land tenure systems can be major deterrents to long term sustainable use of resources; and lack of ownership and participation by local people, especially women, in decisions about resource use is highly problematic.

D.A. Brown ("Achieving Institutional Cooperation For Implementation Of Sustainable Development Plans And Strategies") identifies barriers to obtain better cooperation between institutions trying to achieve sustainable development. First, is the failure to fix responsibility for rigorous interdisciplinary strategic planning to solve sustainable development problems; this can stem from a lack of institutional focus on strategic planning, or from institutional fragmentation about the scope of responsibilities. Second, is the failure to understand or consider what is necessary for implementation of sustainable development plans and strategies. Often the plans or strategies are prepared by organizations that have no legal authority to implement them. Where cooperation is needed among many institutions to implement plans or strategies, they often are prepared without full agreement by all the persons who must implement them and this limits their efficacy. Third, is a failure to match the scope of scientific investigation with the scale of the problem. Sustainable development problems often transcend ecological boundaries and political jurisdictions. Yet, decision makers who authorize the development of plans and strategies only have authority over decisions within their jurisdiction. For this reason, plans and strategies that match the scale of problems often are not implemented. In order to achieve sustainable development it is necessary to understand and control human activities that will threaten the entire social and ecosystems of concern. Fourth, is a failure to build an information base which is practicable to use in implementation plans and strategies. Often the information collected lacks understanding of the need to use it at different spatial and temporal scales. For instance, many countries have developed their own methods and indicators that cannot be aggregated at global scales because of incompatibility with the United Nations' indicators. Fifth, is a failure to consider prior plans, decisions, or information in decision making. Many international bodies meet and discuss problems with insufficient understanding of the prior legal or institutional decision making that has considered the same or similar issues. For instance, for many years various international institutions have placed the conservation of

freshwater on their agenda, including UNCSD, UNEP, WHO, UNDP, and the Global Water Forum. As each new institution has considered global water issues they have often begun deliberations without an understanding of prior decisions on the very same subjects under consideration.

5. SUMMARY OF RECOMMENDATIONS

Recommendations contained in some case studies were site or area specific; many others were applicable to similar problems in different locations. Most recommendations focused on the following issues.

Sound scientific, public policy, and social science research should be used to inform public policy and decisions makers. This research should draw on disciplinary expertise when needed but overall be interdisciplinary in its nature and focus. The research, where appropriate, should address linkages between biodiversity and related problems. Two such examples are climate change and desertification, and poverty reduction and capacity for biodiversity protection. The research should be long–term because most biodiversity research questions cannot be answered sufficiently with information from short–term studies. The research also should be designed and conducted on the appropriate spatial scales, e.g., local habitat, landscape, or regional. Accomplishing this kind of research requires not only an increase in overall funding, but greater recognition by funding agencies of the need to fund interdisciplinary research, long–term research, and research which is focused on appropriate spatial scales.

Local, national, and regional governmental policies and plans need to be developed and implemented based on the best scientific and other research available. This requires local, national, and regional governments to promulgate policies and plans based on interdisciplinary research; on the recognition that one problem often is linked to others; on long–term studies; and on appropriate spatial scales.

The participation of local people and other stakeholders in policy and decision making should be increased, including the roles of women.

In order for institutions to enhance the relevance and applicability of their work there must be more effective means developed to obtain the views of key personal working on high–quality national plans and strategies of the CBD as well as the CCC and CCD regarding priorities for implementing the conventions in areas that link with protection of biodiversity. A similar need exists to obtain more comprehensive information about priorities for biodiversity protection from GEF and other donor groups so that institutions can enhance the relevance of their work to the priorities.

Education at all levels on the values of biodiversity should be increased. This means reform of education at the primary, secondary, and university levels; the development of out–research and extension education for civil society; educating public policy and decision makers about the values of biodiversity and the capabilities and limitations of science; and educating scientists and other specialists to more effectively communicate their findings to members of the general public and nonspecialists.

Finally, coordination and collaboration between public and private stakeholders should be increased, including the formation of regional networks and greater interaction between institutions of Southern nations.

6. REFERENCES

Goodland, R., and Daly, H. 1995. Universal environmental sustainability and the principle of integrity. Pages 102–124 In: Westra, L., and Lemons, J. (Editors) Perspectives on Ecological Integrity. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Hargrove, E. 1992. The Animal Rights/Environmental Ethics Debate. State University of New York Press, Albany, NY.

(IISD) 2003. A Summary Report from "Biodiversity After Johannesburg." Sustainable Development 81: 1–7.

Johnson, S.P. 1993. The Earth Summit. The United Nations Conference on Environment and Development (UNCED). Graham & Trotman/Martinus Nijhoff, London.

Lemons, J. (Editor). 1996. Scientific Uncertainty and Environmental Problem Solving. Blackwell Science, Cambridge, MA.

Lemons, J., and Brown, D.A. (Editors) 1995. Sustainable Development: Science, Ethics, and Public Policy. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Oates, J.F. 1999. Myth and Reality in the Rain Forest. How Conservation Strategies Are Failing in West Africa. University of California Press, Berkeley. 310 pages.

Regan, T. 1983. The Case for Animal Rights. University of California Press, Berkeley, CA.

Robinson, J.G. 1993. The limits to caring: Sustainable living and the loss of biodiversity. Conservation Biology 7: 20–28.

Shearman, R. 1990. The meaning and ethics of sustainability. Environmental Management 14: 1–8.

Shrader–Frechette, K.S., and McCoy, E.D. 1993. Method in Ecology. Cambridge University Press, Cambridge.

(WCED) World Commission on Environment and Development. 1987. Our Common Future. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Westra, L., and Lemons, J. (Editors). 1995. Perspectives on Ecosystem Integrity. Kluwer Academic Publishers, Dordrecht, The Netherlands.