paper 8

BIODIVERSITY CONSERVATION AND INDUSTRIAL PARTNERSHIPS: CHALLENGES AND OPPORTUNITIES

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ABSTRACT: Protecting biodiversity and whole ecosystems has become a major challenge for society. Ecosystems are continually transformed by pollution and human development at a very fast pace. Between 30 percent and 50 percent of the world's surface is under some form of human management. Many habitats are being altered dramatically and others are being completely transformed. This is resulting in many species being driven to extinction rapidly. For more than ten years, the Smithsonian Institution has established research partnerships with the energy industry and nongovernmental organizations that are proving to be very effective in addressing biodiversity challenges. Some of the large energy companies are integrating biodiversity conservation into oil and gas development. The partnerships have devised a process for developing biodiversity action plans to assist in the different phases of project life, from exploration to decommissioning.

Keywords: Biodiversity, research, monitoring, conservation, energy development.

1. Introduction

Assessing the impacts on biodiversity of humans and climate change is extremely challenging, and efforts to achieve a global approach to conservation are still in the preliminary stages. The good news is that technology is changing rapidly on many different fronts, from genetics and engineering to human welfare. In the meantime, the human population is increasing rapidly and habitats and ecosystems are being massively transformed. Currently, humans have 30 percent to 50 percent of the earth's surface under direct management, an area whose size is historically unprecedented (Foley *et al.*, 2005). Approximately 23 percent of mammals, 12 percent of birds, 4 percent of reptiles, and 32 percent of amphibians are already listed as endangered or threatened species (Baillie *et al.*, 2004). Managing ecosystems for sustainability is a difficult task, and approaches to do so are not clearly understood for complex environments. This generation of biologists and natural resources managers may be the last one to study natural ecosystems that have not been affected by humans.

Many groups are trying to determine human dependency on biodiversity. Almost every facet of human life is associated with biodiversity in one way or another. Humans depend on biodiversity for many core services and products, including wholesome food; drinkable water; breathable air; a stable climate for forestry, agriculture, and fisheries; waste decomposition; bioremediation; invasive species; pest control; ecotourism; pharmaceuticals; bioengineering; biotechnology; molecular design; renewable feedstock; and enviro-friendly manufacturing (Australian Department of the Environment, Sport and Territories, 1993).

Protecting biodiversity requires taking into account not only the big picture, but also the smaller ones. Today, society and the planet face several questions in terms of biodiversity and conservation biology.

- What species exist and how are they related?
- How and why has biodiversity changed over time?
- How do species live and how do they die?
- What explains species adaptations, distributions, and abundances?
- What forces drive ecosystem function and change?
- How can conservation science help manage the biosphere?

The different components of the ecosystem and the connectivity among these components that maintains environmental integrity need to be understood. With that knowledge, appropriate monitoring programs can be developed. How and why has biodiversity changed over time? How do species survive and what causes them to die out in unmanaged landscapes? There are some indications of these processes for key species, but for most species, the data is lacking. What explains adaptation, distribution, and abundance of organisms? With the current rapid movement of invasive species and infectious diseases because of human development, it is important to understand the mechanisms of species adaptation. Such an understanding will help scientists design and implement the best management and conservation initiatives.

How can protected habitats help manage the biosphere? Less than 10 percent of the earth's surface falls under a protected area conservation structure. For many of these protected areas, guidelines for their sustainable management do not exist and, over time, they will be reverted for development as societal priorities change. Ecosystem restoration, which is expensive relative to properly managed landscapes, will continue to grow as an important human-related activity. There is a need for reconciliation and adaptation of ecosystem management strategies for sustainable biodiversity. How can scientists achieve the integration of ecosystem management and sustainability? This question is receiving a lot of scientific input and consuming a large amount of resources.

The Inter-American Institute for Global Change Research is trying to determine the processes needed to build the capacity for global change research and biodiversity for the Americas (IAI, 2006). Capacity needs to be built into the measurement of environmental and ecosystem processes in order to improve the ability to predict change and in order to define parameters to adapt to environmental stresses. Professional and technical training will also be required to implement and manage integrated networks.

Many environmental stresses affect biodiversity, such as pollution of air, soil, and water; large-scale soil degradation by agriculture practices; hurricane and typhoon disturbances; rapid snow and ice melting; an increase in invasive species; and avian flu and other pandemics. Rapid human population growth and the need to generate resources to support that growth pose major challenges for society. The loss of biodiversity is increasing rapidly, and the global change events are adding complexity to approaches aimed at addressing these challenges.

This paper highlights the experience of the Smithsonian Institution's biodiversity program in working with industry and nongovernmental organizations to conserve biodiversity. It also briefly describes the Energy and Biodiversity Initiative (EBI) and the National Ecological Observatory Network (NEON), two innovative approaches to ecological monitoring and sustainability.

2. The Smithsonian Institution

The Smithsonian Institution is the leading museum system, with the largest biological collections in the world, comprehensive data sets, world-class facilities and laboratories, a global network of researchers and research institutions, a tradition of innovation, the most visited museum complex in the world, and a central location in the Washington, D.C., metropolitan area. Its collections include 50 percent, or more than 250,000, of all "type specimens" in American museums and universities—the specimens used to formally identify individual species.

Rounding out this capacity is the world's largest concentration of conservation and biodiversity scientists—150 research staff and 100 affiliated researchers, all with doctoral degrees. The Smithsonian Institution's main biodiversity-related research and conservation units include the National Zoological Park, the National Museum of Natural History, the Smithsonian Tropical Research Institute, and the Smithsonian Environmental Research Center, of which a short description follows.

- **National Zoological Park -** zoological and conservation studies, habitat and wildlife ecology and conservation programs, research on the biology of extinction, and conservation partnership development.
- **National Museum of Natural History -** inventory, taxonomic, and evolutionary studies and a Naturalist Center that invites visitors aged 10 and older to use its hands-on collection of 36,000 natural history objects, 6,500 books, and scientific equipment to identify natural objects and curiosities as part of structured learning programs in environmental education.
- **Smithsonian Tropical Research Institute** (terrestrial and marine stations located in Panama) - tropical ecology and evolutionary studies.
- **Smithsonian Environmental Research Center** (located on the Chesapeake Bay, Maryland) - estuarine and terrestrial ecological studies.

The Smithsonian is one of the top branded institutions in the world. It attracts more than 20 million visitors each year to its 18 museums and research centers and more than 30 million visitors each year to its traveling exhibits and public programs. More than 20 million unique visitors reach the institution's various Web sites every month.

The Smithsonian Institution Monitoring and Assessment of Biodiversity Program (SI/MAB), part of its National Zoological Park, is applying adaptive management principles to address research and conservation questions. Key ecological indicators are defined for monitoring. These indicators provide important information by:

- identifying status and trends in ecosystem health;
- providing early warnings to reduce costs and uncertainty;
- defining the normal limits of variations;

- suggesting remedial treatment that can be taken into consideration;
- framing research hypotheses to answer conservation questions; and
- determining compliance with the applicable laws and regulations.

3. Conservation and Development Partnerships

For the past ten years, SI/MAB has fostered partnerships with the energy and mining industry to advance the integration of sustainable biodiversity conservation into company operations. Programs have been established in Perú with Repsol YPF and with Shell Prospecting and Development Perú, B.V.; in Madagascar with the Rio Tinto Mining Company; in Ecuador with the Ministry of Energy and Mines; in Gabon with Shell Gabon; and on Russia's Sakhalin Island with the Sakhalin consortium. Exploratory projects have also been established in Trinidad and Ecuador with Repsol YPF. In addition, SI/MAB has been actively engaged with the Energy and Biodiversity Initiative (EBI) and the National Science Foundation's National Ecological Observatory Network (NEON).

3.1 The Perú-Camisea I Experience

In 1996, Shell Prospecting and Development Perú, B.V. (SPDP) began a natural gas exploration project in the Lower Urubamba Region of Amazonian Perú, near the Camisea River. This area is home to indigenous peoples and is rich in biodiversity. SPDP initially intended to construct four well sites, followed by additional well sites, flow lines connecting the well sites, a gas processing plant, and two pipelines to transport gas and liquid condensates to the coast (Dallmeier and Alonso 1997; Alonso and Dallmeier 1998; Alonso and Dallmeier 1999; and Dallmeier *et al.*2002). Because of company and international concerns about potential social and environmental impacts in Perú, SPDP decided to take a novel approach to the development of energy resources that emphasized long-term societal and environmental benefits in addition to financial gains (Dabbs and Bateson, 2002; May *et al.*, 2002).

The forests of the Lower Urubamba Region extend across 600 square kilometers from the Amazon Basin to the foothills of the Andes Mountains. These tropical forests are among the most biologically diverse forests in the world (Gentry 1988; Alonso *et al.*, 2001). The river valley is situated between Manu National Park, a UNESCO Biosphere Reserve, and the Apurimac Reserve Zone.

Despite the region's isolation, this unique and biologically diverse forest area faced a major threat from SPDP's large-scale gas development, with potentially significant irreversible effects. The biodiversity of this wilderness had yet to be assessed. If development of the gas reservoir were not approached cautiously and sensitively, it could trigger events leading to critical losses of biodiversity, such as unmanageable human migration, deforestation, expansion of the agrarian frontier, soil erosion, unsustainable timber extraction, and pollution of air, soil, and water (Bowles and Prickett, 2001).

SPDP asked SI/MAB to help develop a framework to integrate science and biodiversity conservation with exploration and development of natural gas resources. The Smithsonian-based program used an adaptive management framework as the foundation for this multifaceted, interdisciplinary project. The examination and actions related to social variables as well as the biodiversity monitoring and assessment component of the Camisea I project operated within the context of the adaptive management framework.

During project development, institutional commitment was critical for the success of the research and monitoring activities. Research and monitoring was incorporated as a routine component of energy development operations and endorsed by high-level managers. Professional and technical expertise, as well as resource allocation, matched the project needs.

Partnerships with a wide spectrum of community and nongovernmental organizations and government agencies facilitated various aspects of the project, including the definition of sampling protocols and strategies, site selection, and training support for technical personnel. Communication strategies heightened public understanding that led to increased support and acceptance of the Camisea I project.

The project benefited greatly from an interdisciplinary team of experts with an integrated vision. Early stakeholder consultation and a strong baseline biodiversity assessment had a significant impact on the final project design and provided assurance of sustainable development. Adaptive management approaches were critical for the Camisea I project. Following this model ensured that important biodiversity issues were evaluated and decisions made during each key project implementation phase.

SI/MAB's biodiversity findings guided Shell's operational planning to minimize the impact of the location of the oil drilling facility and the burial of pipelines. The right-away was reforested with native species, and the use of helicopters reduced the need for road construction to support oil field development. Shell's early withdrawal from its Perú site cut short the application of the energy-biodiversity model of ecological monitoring.

3.2 The Gabon-Gamba Experience

To expand on what SI/MAB learned from the Camisea I experience, with support from the Shell Foundation and Shell Gabon, in 2000 the program initiated a project in the Gamba Complex in Gabon, Central Africa. This region has been a major supplier of hydrocarbon for more than 40 years. Several oil companies have been operating in this area, which contains the largest known reserves for the country. Gabon is also known for its magnificent plant and animal life, including many charismatic species of conservation concern.

The country offers a great opportunity for conservation because large portions of the forest remain intact, even as much of the rest of Africa is losing forests and biodiversity at an alarming rate. The Gamba Complex has high biodiversity value, with two recently created national parks, two Ramsar sites, and a key area for oil exploitation. This makes Gabon a timely and unique conservation opportunity.

A stakeholder consultation process was used to formulate the project goals. Biodiversity baseline information was limited, and biodiversity assessments generated the sensitivity biodiversity map for the Gamba Complex. Following these assessments, research sought to identify the ecological connectivity of the landscape as well as to measure the impacts of oil operations on the area's biodiversity. Ecological indicators for monitoring the biodiversity also were developed. The five project goals initially defined were to (1) increase knowledge of biodiversity through research, assessment, and monitoring; (2) increase in-country scientific and technical capacity through technical training on established protocols; (3) promote links among biodiversity research, monitoring, conservation, and development with all Gabon stakeholders; (4) disseminate the scientific information generated to a wide audience; and (5) advance the energy and biodiversity model.

As the baseline information was completed, several areas were identified for research associated with the impact of Shell Gabon operations on biodiversity. The research included the impact of roads and habitat fragmentation on biodiversity; the connectivity of the industrial areas in relation to the adjacent national parks and its implications for conservation and sustainability; potential decommissioning effects on the conservation of the Gamba Complex; assessment of the new planned areas for development; and design of the monitoring plan. All of these research activities are now in progress.

To help ensure the ecological integrity and biodiversity of the industrial corridor, eight indicators were proposed for monitoring biological priority and operational impact (Dallmeier *et al.*, 2006). Complementary research is conducted, as necessary, in the adjacent protected areas.

The eight biodiversity impact indicators to measure and monitor operational impact are:

1. habitat degradation on species of conservation concern;
2. invasive species threatening habitats and native species in industrial areas;
3. bushmeat hunting;
4. ecological connectivity of protected areas;
5. forest fragmentation because of industrial operations;
6. coastal oil pollution;
7. aquatic system changes because of industrial activity; and
8. impact of hydrocarbon pollution on wildlife.

These indicators were selected following four years of field observations by project scientists and after an extensive consultation process involving national and international stakeholders that sought to ensure collaboration and buy-in from many partners, including the government. Impacts to be monitored respond to a range of primary and secondary impacts, touch terrestrial and aquatic systems, and are both species-level (that is, for legally protected and endangered species) and landscape-scale (that is, to ensure protection integrity for adjacent national parks). Measuring these indicators will have several direct benefits, including providing information for protected area management, oil impact management, and the advancement of science and conservation models and training in Gabon. Establishing long-term monitoring and mitigation of known impacts on the environment is one way to leave a legacy of sustainable development.

The Gabon program is beginning to fill a wide knowledge gap on biodiversity in the region and biodiversity in association with energy development. Distribution of findings from the field has served to inform on-site managers and industry personnel worldwide, local communities, governments at all levels, nongovernmental organizations, and the general public. As a result, increased attention is being paid to this special part of the world and the potential it has to conserve an important segment of global biodiversity. The program is advancing the model for conservation and resource development through partnerships among local stakeholders, scientists, and industry. The management practices established and implemented by Shell Gabon and its operators promote biodiversity conservation and sustainable development.

3.3 Energy & Biodiversity Initiative

Leading energy companies increasingly perceive the value of integrating biodiversity conservation into upstream oil and gas development. To develop and promote biodiversity conservation practices that will achieve this goal, several of these companies have joined with leading conservation organizations to form the Energy & Biodiversity Initiative (EBI) EBI is a partnership designed to produce tools, models, and guidelines to improve the environmental performance of energy operations, minimize harm to biodiversity, and maximize opportunities for conservation wherever oil and gas resources are developed (Visit http://www.theebi.org for more information).

For two and one-half years, the EBI member organizations worked together to produce several reports. In addition, the group has consulted with key stakeholders from industry, academia, and the environmental community. Currently, the EBI members are testing, refining, and promoting the guidelines and recommendations outlined in the various reports.

The EBI guidelines and recommendations focus on:

- integrating biodiversity into environmental management systems;
- integrating biodiversity into environmental and social impact assessment processes;
- designing a framework for integrating biodiversity into the site selection process; and
- identifying biodiversity indicators for monitoring impacts and conservation actions.

Two discussion papers also are available: "Negative Secondary Impacts from Oil and Gas Development" and "Opportunities for Benefiting Biodiversity Conservation."

3.4 National Ecological Observatory Network (NEON)

The National Ecological Observatory Network (NEON) will be the first national ecological measurement and observation system designed both to answer regional to continental scale scientific questions and to have the interdisciplinary participation necessary to achieve credible ecological forecasting and prediction. Social scientists and educators will join ecologists and physical scientists in NEON planning and design and participate as observatory users, recognizing that all habitable landscapes are, to varying degrees, human-dominated ecosystems. (Visit http://www.neoninc.org for more information.)

To respond to "grand challenges" in ecology and the environmental sciences, the National Science Foundation (NSF) has proposed that Major Research Equipment and Facilities Construction (MREFC) funds be used to implement this new and unprecedented research and education platform. NEON will include cutting-edge lab and field instrumentation, site-based experimental infrastructure, and natural history archive facilities and/or computational, analytical, and modeling capabilities. All components will be linked via a computational network to facilitate the integration of research and education.

Scientists and engineers will be able to use NEON to conduct real-time ecological studies spanning all levels of biological organization and temporal and geographical scales. Disciplinary and multidisciplinary programs of NSF will support NEON research projects and educational activities. NEON-generated data will be publicly reported.

4. Grand Challenges in the Environmental Sciences

The National Research Council has identified several "grand challenges" in the environmental sciences that are central to providing the environmental knowledge needed by the next generation to manage Earth in a sustainable fashion. These challenges are recommended for immediate investment by funding agencies and others and require a national to continental scale research platform (NRC, 2001). These "grand challenges' include:

- **Biodiversity**—"The challenge is to improve understanding of the factors affecting biological diversity and ecosystem structure and functioning, including the role of human activity."
- **Biogeochemical Cycles**—"The challenge is to further our understanding of the Earth's major biogeochemical cycles, evaluate how they are being perturbed by human activities, and determine how they might better be stabilized."
- **Climate Change**—"The challenge is to increase our ability to predict climate variations, from extreme events to decadal time scales; to understand how this variability may change in the future; and to assess realistically the resulting impacts."
- **Hydroecology**—"The challenge is to develop an improved understanding of and ability to predict changes in freshwater resources and the environment caused by floods, droughts, sedimentation, and contamination."
- **Infectious Disease**—"The challenge is to understand ecological and evolutionary aspects of infectious diseases; develop an understanding of the interactions among pathogens, hosts/receptors, and the environment; and thus make it possible to prevent changes in the infectivity and virulence of organisms that threaten plant, animal, and human health at the population level."
- **Invasive Species**—[The challenge is to understand species invasion] "as an ecological process sufficiently to allow forecasting of the invasiveness of species and prediction of which potential biological agents would both be effective in controlling an exotic species and have the fewest detrimental effects on natural and managed ecosystems."
- **Land Use**—"The challenge is to develop a systematic understanding of changes in land uses and land covers that are critical to ecosystem functioning and services and human welfare."

5. Conclusions

Conserving biodiversity and whole ecosystems has become a major challenge for society. Ecosystems are under stress from human development, and large areas continue to be subjected to human management and incorporated for direct use every year. Research partnerships with industry and nongovernmental organizations are proving to be very effective in developing novel approaches and best practices for sustainable development while integrating biodiversity conservation into the life cycle of sensitive projects. Continental-scale monitoring programs such as NEON will transform the ecological sciences. Moreover, the emerging National Ecological Observatory Network provides a means to observe national-scale impacts of invasive species, the advance of infectious diseases, climate change, large-scale variability such as El Niño, and large-scale transport phenomena such as Asiatic dust and pollution.

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