

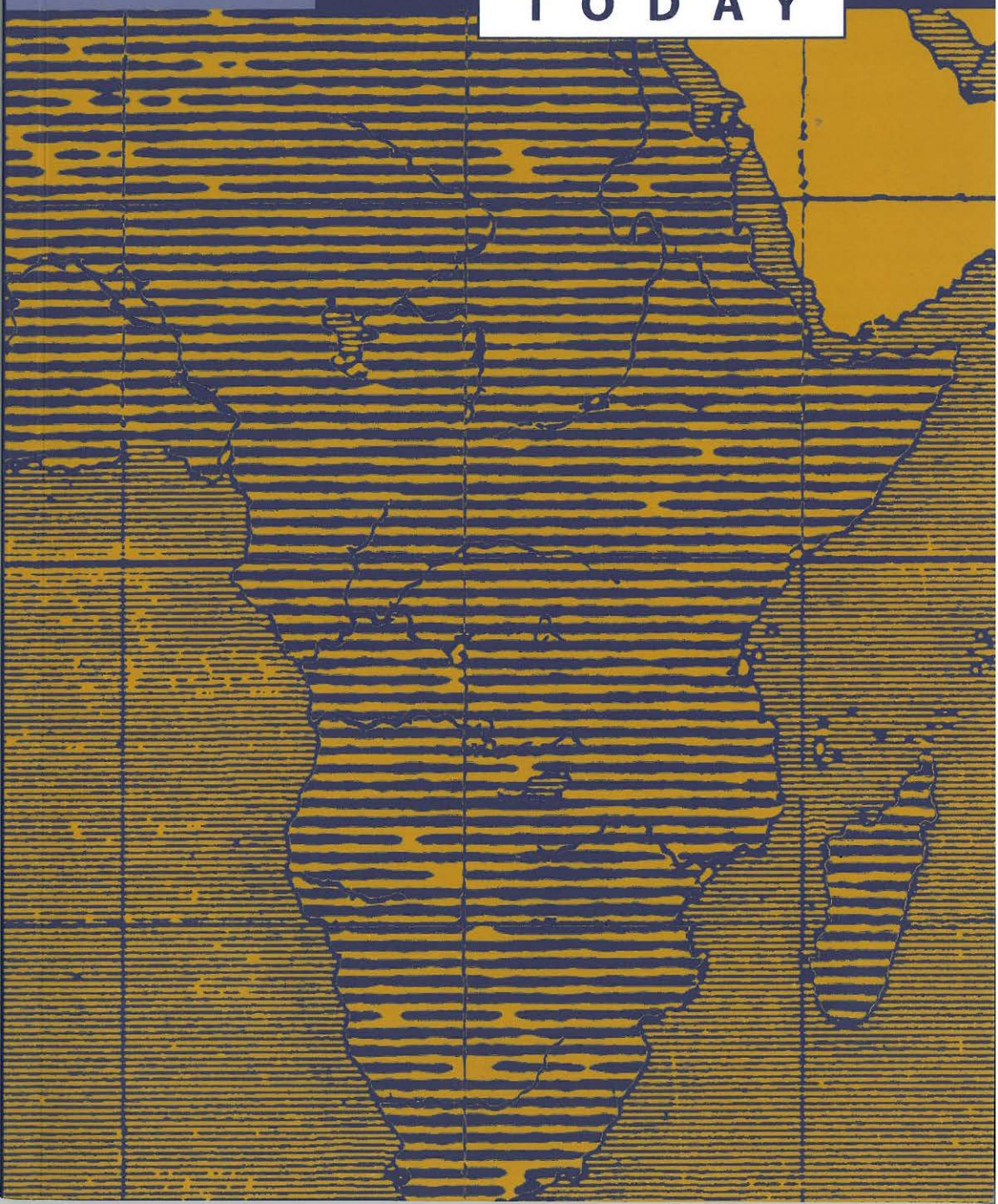
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Given that governments and people are in favor of development projects, with or without guidance on environmental management, conservation organizations must consider partnering with corporations to sustain biodiversity

The Gabon Biodiversity Program: A Conservation Research Collaboration

Alfonso Alonso, Francisco Dallmeier,
Lisa Korte, and Hadrien Vanthomme

Researchers from the Smithsonian Conservation Biology Institute, in collaboration with Gabonese scientists, are studying the biological diversity of the Gamba Complex of Protected Areas. Studies under the Gabon Biodiversity Program, a partnership with an oil company, first consisted of biological assessments of select plant, vertebrate, and invertebrate taxonomic groups. In its second phase, the program is addressing ecological questions and assessing effects of human activities. Information generated is disseminated via education and outreach activities for the town of Gamba (> 9,000 people), as well as at the national level, to promote the value of biodiversity. The program demonstrates the importance that the private sector can have in protecting the biodiversity that we all require for survival.

Introduction

In 2000, the Smithsonian Conservation Biology Institute (SCBI) accepted an invitation from the oil company Shell Gabon (SG) to study the biodiversity of the Gamba Complex of Protected Areas (GCPA) in southwest Gabon. The company sought SCBI's expertise to conduct biodiversity monitoring and assessments (Dallmeier, Alonso, and Campbell 2002) and help it develop standards and environmental awareness for the conservation of biodiversity. SG met SCBI's criteria for collaboration: that SCBI has total control of data gathered and independence for publishing it without restrictions, that the area of study has the potential for making a major contribution to biodiversity conservation, that both collaborating organizations agree to work toward achieving mutual goals, and that SCBI's commercial collaborator adopts and follows a plan to conserve biodiversity.

At that time, biological work conducted in the country included vegetation studies (Breteler 1996; Reitsma 1988; Tutin et al. 1994), ecological studies (Barnes et al. 1991; Dubost 1984; Emmons 1980; Emmons, Gautier-Hion, and Dubost 1983; Gautier-Hion, Emmons, and Dubost 1980; Tutin,

White, and Mackanga-Missandzouu 1997; White 1994), and evaluations of marine turtles (Fretey 1998) and marine mammals (Rosenbaum et al. 2002) off the coast of Gabon. In the GCPA, the World Wildlife Fund (WWF) had conducted bushmeat surveys (Thibault and Blaney 2003) and monitored nesting marine turtles (Billes et al. 2006), and primatologists from Kyoto University had studied gorillas in the lowlands of Moukalaba-Doudou National Park (Ando, Iwata, and Yamagiwa 2008). The SCBI's assessments are the first in-depth studies of the biota of the GCPA. Its expeditions investigated the species of plants and animals found near areas where SG is operating as well as Loango and the Moukalaba DouDou national parks. The results indicated that the Rabi-Ndogo Lagoon corridor of the GCPA, in regard to species numbers and relative abundances, was on par with the two adjacent national parks (Alonso et al. 2006; Basset et al. 2008).

As a result, SCBI and SG partnered to form the Gabon Biodiversity Program (GBP), in consultation with the government of Gabon and other stakeholders. Under this collaboration, SCBI has completed thirteen years of activities to date. Here, we present results of research projects that generated information about the GCPA, and how these results were disseminated via environmental outreach activities to the local community and the rest of the country and used to make recommendations to SG to minimize its effects on biodiversity. These activities have proved useful in Gabon, and we think they can be applied to other large industrial projects that would like to have minimal effects on biodiversity. Given that tropical areas will probably host more large-scale development projects, we recommend using best practices, improving these practices regularly, and widely reporting the improvements.

Benefits of this type of collaboration have three components. First, the host country obtains detailed biological information about areas of conservation concern, increases national biodiversity awareness and capacity, and can use these environmental standards for other industrial operations. Second, the SCBI works toward its mission to understand and sustain a biodiverse planet; generates objective biodiversity knowledge in understudied regions; disseminates gained knowledge and lessons learned; formulates and implements biodiversity monitoring and conservation programs; provides a science-based framework for carrying out biodiversity mitigation, restoration, and offset actions; and supports capacity building. Third, the industrial operator increases its ability to document, manage, and reduce environmental risks; attains an impartial, independent, and transparent way of obtaining biological data; uses international standards and best practices to manage biodiversity; and produces results that increase trust among stakeholders.

Context and History of the GBP

The GCPA is a mosaic of protected areas in the Ndougou Department, including two national parks, internationally recognized wetlands, and the Rabi-Ndogo Lagoon industrial corridor, with logging and oil concessions,

including the largest oil-producing field in Gabon (Alonso et al. 2006). This 11,320 km² area is part of a larger ecological landscape known as the Gamba-Conkouati Landscape, which in turn is part of the Congo Basin Forest, recognized internationally for its expanse of contiguous tropical rainforest and viable populations of large, charismatic species, including African forest elephants (*Loxodonta cyclotis*), western lowland gorillas (*Gorilla gorilla*), and central African chimpanzees (*Pan troglodytes*; Lee et al. 2006). Loango National Park (1550 km²) occupies about 14 percent of the western part of the GCPA, and Moukalaba-Doudou National Park (4500 km²) occupies about 40 percent of the GCPA, east of the Rabi-Ndogo Lagoon corridor. Designated as Category II protected areas by the International Union for the Conservation of Nature (IUCN 2011), these parks are natural areas set aside to protect large-scale ecological processes. In addition, the government of Gabon values all thirteen national parks in the country for their potential to develop ecotourism, thus diversifying the nation's economy (Nichols 2002). In addition to the two national parks, the GCPA includes two of the nine Ramsar wetlands sites in Gabon, Petit Loango and Sette Cama, which are essential areas for wetland birds and breeding sites for species of migrating birds (Ramsar 2013).

The Rabi-Ndogo Lagoon corridor sits between the two national parks and includes logging concessions for trees above ground and oil concessions for below-ground resources (Lee et al. 2006). Since the 1920s, forestry companies have selectively logged, primarily okoumé (*Aucoumea klaineana*) trees, in the Rabi-Ndogo Lagoon corridor, whereas oil drilling commenced in the 1960s. SCBI studies showed that large mammals are abundant despite industrial activities (Laurence et al. 2006, 2008) and the corridor includes key wildlife habitats, such as Lake Divangi, for slender-snouted crocodiles (*Mecistops cataphractus*), and the Akaka wetlands for elephant feeding, especially in the dry season (Munshi-South et al. 2008). Combined with the shoreline of Ndogo Lagoon, the industrial corridor represents important riparian and connective habitat-sustaining biodiversity in the GCPA (Lee et al. 2006).

The area where SG operates within the GCPA has a rich biological diversity (Alonso et al. 2006; Ward et al. 2003). SG operates several exploration and production fields, each having a unique history of development and environmental management. Oil development inevitably affects the environment negatively, primarily because of changes in land use, forest fragmentation, pollution from flares (i.e., burning flames), and oil spills. Secondary impacts, which tend to last longer, such as human colonization following urbanization and road construction, have been minimized in the GCPA through control-access gates where company roads connect to the national road system (Kolowski et al. 2010).

The settlement of Gamba had just a few families before the arrival of SG in 1960. At that time, residents there used available natural resources for subsistence, with minimal effects on the environment. With the arrival of SG and several supporting services companies, Gamba grew from a small fishing village to a town of more than nine thousand people, including

approximately two thousand living in outlying villages (Blaney et al. 1997, 1998). The number of residents grew fast at the beginning of the development program and has been maintained at that level for at least the last ten years (A. Alonso, personal communication). As the human population grew, the land was transformed into urban settlements supported by slash-and-burn agriculture, and the intensity of wildlife hunting for food and trade increased (Thibault and Blaney 2003). One of the best-known traditional uses of biodiversity that continues today is the use of the perennial rainforest shrub iboga (*Tabernanthe iboga*) in Bwiti spiritual practices (Samorini 1994).

The economy of Gamba is now based on the oil industry, with the coastal and lagoon fisheries providing an important source of protein for the local population. In recent years, efforts to diversify the local economy have led to the cutting of large swaths of forest for agriculture. Plantation owners cut large areas to make up for losses from elephant crop raiding and can easily do so because chain saws, fuel, and affordable labor are readily available. Protected species that had been available in the local market (Thibault and Blaney 2003) are no longer openly for sale there. Although the low human population helps minimize the threat to GCPA's biodiversity, careful land-use planning, awareness raising for conservation, and enforcement of laws will be essential to maintain wildlife populations and ecological processes in the GCPA. As one of the entrances to Loango National Park, Gamba has the potential for tourism.

In 2000, leaders of Ndougou Department created the Comité de Réflexion sur l'Après Pétrole (After-Oil Study Committee) to identify and implement nonoil-related economic activities to ensure sustainable income for people in the Gamba area once the oil is depleted or too expensive to produce. This initiative promoted the creation of the Programme d'Appui au Développement Durable du Département de Ndougou (Program to Support the Sustainable Development of the Ndougou Department), a partnership among local and national administrations (National Fund for the Expansion and Development of Small and Medium Companies, National Employment Office, Gamba Municipality, Ndougou Department Council), international development agencies (United Nations Development Program, Whole System International Consulting), the private sector (Shell Foundation), nongovernmental organizations (After-Oil Study Committee, Conjoncture-Observatoire des Organisations, WWF), and the academic sector (Omar-Bongo University). The program conducted training for local company managers, including microcredit and strategic planning for the after-oil economy. As a result, the Plan de Développement Économique Local (Local Economic Development Plan) of Ndougou Department was adopted in 2011 and released in 2013. It aims to strengthen local governance, open up the department for commerce, develop the local economy beyond oil exploitation, promote human development, and ensure a sustainable environment (Pandzou 2011).

The GBP

The main objectives of the GBP are to increase knowledge and understanding of biodiversity in the Gamba landscape through biodiversity research on and monitoring of species and habitats of conservation concern; apply research, conservation, and best-management practices to minimize the impact of development on biodiversity; increase local biodiversity conservation capacity; raise awareness of the value of Gabon's biodiversity; and foster partnerships with diverse stakeholders to support biodiversity conservation and sustainable development. From the start, SG and SCBI agreed that SCBI staff needed to maintain impartiality, objectivity, and transparency during the design, implementation, reporting, and publication processes for all aspects of the GBP. Therefore, financial and logistical support provided by SG has been in the form of sponsored research agreements (i.e., not contracts), which clearly affirm the scientific independence of the researchers to collect, analyze, and publish data independent of the company's reviews. GBP publications have gone through the typical scientific peer-review process. Technical experts and scientists have had ultimate responsibility for the content of the reports and publications.

The design and implementation of the GBP required that environmental and operational issues be considered at the same time. For this purpose, SCBI staff are housed at SG facilities in Gamba. The GBP team is currently composed of five permanent SCBI members, two based in Gabon, one research fellow, four long-term and multiple short-term contractors.

The first five years of the GBP were supported by a grant from the Shell Foundation and logistics from SG. The SG leadership team recognized the value of the relationship and has been supporting the program since 2005. This commitment, granted by four successive presidents of SG, with their respective leadership teams, has led to thirteen years of support, which has provided the human and financial resources needed to carry out the GBP, facilitated day-to-day project activities and logistics, and built credibility. Since 2005, the GBP has been operating under a five-year memorandum of understanding between SCBI and SG, while terms of reference are being signed on an annual basis, with both organizations agreeing on activities and budgets. The SCBI team works closely with the Health Safety and Environmental Department, ensuring that the GBP activities are linked to SG's environmental program. SCBI and SG personnel meet twice a month to discuss progress and address issues. The GBP presents quarterly updates to the leadership team to share results, ideas, and concerns, and gets feedback on the program. This approach contributes to an integrated SCBI and company program vision that fosters trust between the organizations.

SCBI asks national and international experts and leaders in the taxonomy and ecology of the region to collaborate in the GBP. To date, all invited researchers have accepted working in the GCPA, and most of their studies have been published. In the last three years, with the establishment of a

twenty-five-hectare forest-monitoring plot and an increased diffusion of the GBP results, more Gabonese and foreign researchers have been collaborating with the GBP, some of them bringing their own funding. To date, two proposed projects dealing with insects have not been conducted for lack of funding: one was an assessment of insect mortality due to the flares at Rabi, and the other was a test of a chemical known to be effective against the little fire ant (*Wasmannia auropunctata*).

Research Highlights

Biological Assessments

At the start of the GBP, knowledge of the types of plants and animals found in the GCPA was limited to few species of large mammals, such as African forest elephants and gorillas. The program launched ten major field campaigns over a period of two years to document the biodiversity of the area (Lee et al. 2006), with a focus on trees, fishes, amphibians, reptiles, and mammals (Alonso et al. 2006). We recorded 351 tree species in seventy-five 50 × 20 meter vegetation plots throughout the GCPA (Campbell et al. 2006). Seines, hoop nets, and fish traps caught sixty-seven fish species in rivers, streams, marshes, and lagoons (Mamonekene et al. 2006). The amphibian and reptile team used pitfall and funnel traps, as well as day and night searches, to record species, reporting seventy-eight species of amphibians for the GCPA, the highest record for any site in Gabon (Burger et al. 2006), and eighty-six species of reptiles (Pauwels et al. 2006). We used auditory and visual surveys and mist nets to locate birds, finding 317 bird species (Angehr et al. 2006). Using multiple sampling techniques, we found seventy-six species of terrestrial mammal fauna, including twenty-one species of small mammals (O'Brien et al. 2006), thirteen bats (Rodriguez et al. 2006), and forty-two medium-to-large mammals (Boddicker 2006; Lahm and Tezi 2006).

Species-Level Research

To better understand the role that the Rabi-Ndogo Lagoon industrial corridor plays as a connector between the two national parks, we conducted studies of the African forest elephant, a species that plays a major ecological role in African forests and might be affected by extractive industries. The first study evaluated elephant distributions with respect to environmental and human factors and found that human activities had a stronger effect on elephant distributions than environmental factors (Buij et al. 2007). The second study researched the effects that roads have on large mammals and found lower abundances of African forest elephants near roads than farther away, especially in hunted areas, outside the oil concession (Laurance et al. 2006). Using satellite telemetry, the third study documented the movements

of four elephants in oil fields where hunting was restricted and found that in a twenty-month-long survey the elephants had small home ranges with restricted movement patterns and spent nearly all their time in the oil fields (Kolowski et al. 2010). A fourth study investigated whether elephants in the oil concession had higher levels of stress hormones (i.e., fecal glucocorticoid metabolite levels) and found that elephants did not exhibit elevated stress hormones in areas with limited human disturbance (Munshi-South et al. 2008). A fifth study found that the Rabi-Ndogo Lagoon corridor between the two national parks provides a year-round habitat for some elephants and an additional habitat for others, whose primary range is in the national parks (Eggert et al. 2013). These studies demonstrate that extractive-use areas that do not allow hunting constitute important habitats for African forest elephants. The GBP is now collaborating with a Gabonese scientist from Gabon's Agronomy and Forest Research Institute in a pilot study using beehives to deter elephants from raiding crops.

Further studies of roads and other human disturbances at the community level demonstrated that elephants, buffalo, (*Syncerus caffer*), gorillas, sitatungas (*Tragelaphus spekei*), monkeys, and duikers were negatively associated with human disturbances or roads (Vanthomme et al. 2013). Positive associations were found with roads for duikers, red river hogs (*Potamochoerus porcus*), and some monkeys; with agriculture for large rodents, sitatungas, and small carnivores; and with industrial activities for red duiker, red river hogs, sitatungas, and side-striped jackals (*Canis adustus*). The GBP has shown that the environmental disturbances associated with focal natural-resource extraction in the Rabi-Ndogo Lagoon corridor has not, to date, significantly limited the viability of ecosystems and associated wildlife and biodiversity in the region. This is probably because SG operational areas are closed to public access for safety considerations; however, activities in the corridor must be carefully planned and operated to maintain water quality and ecological connectivity in the GCPA.

From the assessment and ecological studies listed above, the GBP contributed to increase the biological knowledge of the GCPA and of species of conservation concern, validated some of SG management practices, and documented species in the GCPA for the first time. These included the range extension of the striped jackal, the mandrill (*Mandrillus sphinx*), and the Congo golden mole (*Chlorotalpa leucorhina*); a new bird species, the African forest robin (*Stiphornis pyrrholaemus*); and five new species of earthworms of genus *Dichogaster* (Christy et al. 2008; James and Divina 2012; Schmidt et al. 2008). More than seventy researchers representing twenty-three organizations and research units from Africa, Europe, and the Americas have participated in the GBP, and it has produced three books and 139 publications, of which eighty-one are in peer-reviewed journals. Data generated from the GBP have been shared in more than sixty presentations in the Gamba area and Libreville and at national and international conferences.

GBP Contributions to Environmental Best Practices

Multiple efforts have been carried out to achieve the GBP's main goal of integrating conservation needs with development priorities at the operational level. One of these efforts was the development and implementation of a biodiversity action plan (International Petroleum Industry Environmental Conservation Association 2005). SCBI and SG personnel together produced a biodiversity action plan in 2003, but it had limited operational outcomes. As a consequence, SCBI members produced recommendation sheets with short, specific management recommendations. These sheets cover twelve topics: human-elephant issues in tropical oil-extraction sites, snake encounters in tropical oil-extraction sites, feral cats as a conservation and health problem in Rabi and Gamba, effects of roads on natural ecosystems, how to defeat the invasive redhead agama, Christmas trees and vertical pipes as wildlife traps, the animal trade, negative effects of forest edges on biodiversity, ways to reduce the spread of the little fire ant, the importance of reducing the spread of nonnative plant species, how to avoid propagating the exotic flowerpot blindsnake, and crocodiles and safety at SG. The documents outlined fifty-nine specific recommendations.

Following these recommendations, SG in 2010 developed and validated the SG biodiversity standard, which presents nine standards and seven recommendations that concern all SG operations, with specific recommendations for road construction and wellhead platforms and pipes. Via health safety and environmental newsletters to SG employees and their families, SG distributed suggestions presented in recommendation sheets but not included in the biodiversity standard.

The GBP has fostered partnerships since its inception. For example, GBP works with local wildlife authorities to remove illegal traps from the SG concession and meets quarterly with WWF staff to discuss conservation issues of the GCPA.

Promoting the Value of Biodiversity to Local Communities and the Nation

The GBP established a biodiversity center to share with the local community and visitors to the area information generated by the scientists in the field. Local SCBI contractors manage the center and promote environmental awareness during their presentations to the public. The center is open for visitors every Wednesday or by appointment. School groups visit it often, and its personnel, when requested, lecture at local schools.

The center maintains a small collection of specimens representative of the area's biodiversity, which allows visitors to have a close look at animals and plants that otherwise are hard to see in the natural environment. For example, the center holds a collection of insects that students and visitors can view under a microscope, learning to appreciate insect morphology and

the ecosystem services that these little creatures provide to humans, including pollinating flowers and recycling nutrients. On average, 350 people visit the center every year.

To encourage hands-on experience for elementary-age students, the center hosts a nature club that motivates children to learn about natural history. The club meets once a week for an after-school activity. Leaders and children go, for example, to a nearby garden and look for nests made by birds; children observe the types of materials used and the styles of the nests, which depend on the bird species.

The center holds training courses for Gabonese environmental practitioners. Topics covered include assessing and monitoring biological diversity, principles of conservation biology, and natural history principles for ecoguards. The center produces outreach materials for the general public, which are distributed at the center and environmental events in Libreville, as well as smaller cities and towns in Gabon. Outreach materials include seven posters (birds, insects, frogs, fishes, butterflies, large mammals, poisonous snakes); four checklists of species (mammals, birds, amphibians, reptiles) found in Loango and Moukalaba Doudou National Parks, the industrial corridor, and the Gamba area; and a checklist of the mammals, birds, amphibians, and reptiles found in all the national parks in Gabon (Christy et al. 2008).

The GBP has contributed to increasing the capacity of Gabonese interested in biodiversity assessment, monitoring, and conservation projects. Before the GBP biodiversity assessments, little was known about the flora and fauna of the GCPA. With the publication of peer-reviewed journal articles and contributions to newspapers and magazines for lay audiences, the GBP provided researchers and nature lovers with a wealth of information about the biodiversity of the GCPA. In addition, more than fifty Gabonese environmental practitioners and technicians from universities and government offices have participated in field GBP expeditions, training courses, and seminars. The percent of Gabonese scientists participating in biodiversity assessments has increased dramatically since the initial assessments in 2000–2002, when participation by Gabonese scientists was about 10 percent. In GBP biodiversity assessments completed in 2012, national researchers led 90 percent of the research protocols. The number of GBP-trained interns has increased from zero at the beginning of the program to two or three interns from the Gabonese National School of Waters and Forests (*École Nationale des Eaux et Forêts*, ENEF) and the University of Science and Techniques of Masuku (*Université des Sciences et Techniques de Masuku*, USTM) per year since 2008.

All research conducted to date has been approved by the Government of Gabon through permits to the GBP to conduct research. Good relations with government officials are maintained by making periodic visits and updates to key agencies to present GBP's results and by organizing occasional field visits for government personnel. The GBP has been presented as a case study at several meetings called by the Gabonese government.

Closing Remarks

Robinson (2012) analyzed the motivations and consequences of corporations engaging in partnerships with conservation organizations. He concluded that corporate social-responsibility approaches have had limited positive effects on biodiversity conservation; however, Pedroni et al. (2013) agree with our conclusion that partnerships founded in sound ecological science are needed to improve management practices and increase biodiversity awareness. The GBP has implemented better management practices and raised awareness of the biodiversity in the GCPA through researching and monitoring species of conservation concern, increasing national capacity to manage the use of natural resources in a sustainable manner, educating different stakeholders in Gabon about the value of Gabon's biodiversity and how individuals, communities, and organizations can help conserve it, and fostering partnerships with diverse stakeholders that enable the leveraging of resources, broadening the reach of initiatives, and generating widespread support for joint biodiversity conservation and sustainable development. We urge managers of the Rabi-Ndogo Lagoon industrial corridor to use best environmental practices to prevent environmental degradation. Given that governments and people are in favor of development projects, with or without guidance on environmental management, conservation organizations must consider partnering with corporations to sustain biodiversity.

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